Advances in Intelligent Systems and Computing 585

WonJoon Chung
Cliff Sungsoo Shin *Editors*

Advances in Affective and Pleasurable Design

Proceedings of the AHFE 2017 International Conference on Affective and Pleasurable Design, July 17–21, 2017, The Westin Bonaventure Hotel, Los Angeles, California, USA

Springer

Advances in Intelligent Systems and Computing

Volume 585

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ISSN 2194-5357 ISSN 2194-5365 (electronic)
Advances in Intelligent Systems and Computing
ISBN 978-3-319-60494-7 ISBN 978-3-319-60495-4 (eBook)
DOI 10.1007/978-3-319-60495-4

Library of Congress Control Number: 2017943018

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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8th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences

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Preface

This book focuses on a positive emotional approach in product, service, and system design and emphasizes aesthetics and enjoyment in user experience. This book provides dissemination and exchange of scientific information on the theoretical and practical areas of affective and pleasurable design for research experts and industry practitioners from multidisciplinary backgrounds, including industrial designers, emotion designer, ethnographers, human–computer interaction researchers, human factors engineers, interaction designers, mobile product designers, and vehicle system designers.

This book is organized into ten sections which focus on the following subjects:

1. Product Development and Design Process
2. Emotional Engineering
3. Emotion and the Qualitative Side of Experience
4. Material and Texture Exploration
5. Designing Affective and Pleasurable Design Interactions
6. Affective Value and Kawaii Engineering
7. Kansei Engineering
8. Integrated Design
9. Implication of User Behavior in Design Process
10. Affective and Emotional Aspects of Design

Sections 1 through 3 of this book cover new approaches in affective and pleasurable design with emphasis on product development and emotional engineering. Sections 4 through 7 focus on material and design issues in product, service, and system development, human interface, emotional aspect in UX, and methodological issues in design and development. Sections 8 through 10 cover Kansei engineering and user behavior in design process. Overall structure of this book is organized to move from special interests in design, design and development issues, to novel approaches for emotional design.

All papers in this book were either reviewed or contributed by the members of editorial board. For this, I would like to appreciate the board members listed below:

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This book is the first step in covering diverse topics including design and development of practices in affective and pleasurable design. I hope this book is informative and helpful for the researchers and practitioners in developing more emotional products, services, and systems.

July 2017

WonJoon Chung
Cliff Sungsoo Shin

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Designing Affective and Pleasurable Design Interactions

Affective Value and Kawaii Engineering

Product Development and Design Process

Exploring Two Design Processes: Slow and Fast

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Abstract. Responding to changes in industry that are driven by improving processes that cause the product development cycle to be compressed, design educators integrate new technology tools and techniques of product development to ensure that students will keep pace with professional practice. Two approaches for Slow and Fast product innovation projects and the student and faculty takeaways are discussed here - 'Kickstand' based on crowdfunding and self-manufacturing concepts in a fourth year industrial design studio (14 weeks), and 'Design Sprint' in a business/engineering studio (4 weeks).

Keywords: Design thinking · Collaboration · Innovation · Manufacturing

1 Introduction

Design educators continually integrate new technology tools and techniques of product development to ensure that students will keep pace with professional practice in industry. Two approaches, Slow and Fast, for product innovation and the students' emotional responses are discussed here - 'Kickstand' based on crowdfunding and self-manufacturing concepts in a fourth-year industrial design (ID) studio (Slow - 14 weeks), and 'Design Sprint' in a business/engineering studio (Fast - 4 weeks).

ID student teams, who have already been versed in traditional design processes, were charged with developing a product and manufacturing 15 units to be sold in a 'Kickstand' pop-up shop in the school gallery. They had full responsibility for design concept, execution, manufacturing, finance and marketing, providing these students with experience in real world design and decision-making processes.

Third year engineering and business students who are new to product development participated in a housewares product 'Design Sprint' meant to help them understand innovation, design thinking, and answer critical business questions through design, prototyping, and testing ideas with customers.

Student design projects can vary based on product complexity, outcome, and goals for learning. The student experience, how they perform brainstorming, and in fact, the entire design process can change dramatically depending on the project. 'Kickstand' and 'Design Sprint' were created to help students develop their problem-finding skills and to get past the obstacles of getting stuck, decision-making and falling in love with your own idea. Collaboration, trust, problem finding/solving, articulating ideas, and shared vision were some of the student takeaways from both of these projects.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_1

2 Kickstand

Entrepreneurship has been a big topic in design industries as well as design education. Crowdfunding websites, "an open call… for the provision of financial resources either in form of donation or in exchange for some form of reward" [1], have become a good source for people who have ideas but have limited budget to take their products to market. Because of the easy access crowdfunding structure, many design students have started dreaming of having their own business.

There is another aspect to adopting the crowdfunding structure for a new product into the classroom. Traditionally, the final outcome of ID students was to produce final appearance models. This practice can potentially mislead design students to focus only on the product's appearance, ignoring how the manufacturing process can influence the final design. This project causes the ID students to understand the product development process from concept generation, through manufacturing, as well as marketing and sales and how these aspects impact the final design of the product.

2.1 Kickstand in an Education Setting

Kickstand utilizes the concept of a crowdfunding structure where innovators design, develop, manufacture, launch and sell their products online, usually with the intent to create market desire and funding for mass-production.

Project Constraints

- Length = 14 weeks.
- Each team will have to manufacture 15 units of the product they design.
- Products can only be sold at campus 'Pop-up Shop' (no online or phone sales allowed to prevent their parents/family from making bulk purchases).
- All 15 products must be sold.

Project Outline

1. Companies are formed by random selection of 4–5 students. Each company, to promote a professional atmosphere, creates titles such as Head of Research, Director of Design, etc.
2. Each company performs brainstorming to find product opportunities based on their target audience of college students, faculty members and staff.
3. A business model canvas is constructed to understand their business components; key partners, key activities, key resources, value propositions, customer relationships, channels, customer segments, cost structure, and revenue stream.
4. Market research and surveys are conducted to validate their value propositions.
5. Sketch models are created for evaluation of design, manufacturing feasibility and product performance.
6. Based on their research and evaluation of concepts, companies explore:
   a. Design/form/material.
   b. Method of manufacture and materials required.

7. Multiple iterations of products are evaluated in the process of design and manufacturing.
8. Marketing plans are developed that include social media, email, and posters around campus.
9. Each company completes manufacturing a run of 15 units of their final product.
10. All products are sold in a 'Pop-up Shop' on a university campus.

2.2 Kickstand – Educational Values

The Kickstand project aims to teach design, manufacturing, and business including project planning. The company members were assigned randomly, which means their teammates might not be their best friends resulting in students having to learn how to work with a variety of people.

2.3 Project Planning

The goal of the planning phase of a project is to prepare the structure for project execution and control. Planning is an important factor for project success [2–4] and as such is recognized as one of the critical success factors of project management [5–8]. Students often don't realize that there are differences between the planning and execution stages of a project. During studio projects, students often discover through errors, unforeseen accidents, and other uncontrollable outside factors that they have failed to plan adequately. This project was in part designed to help the students learn that many errors and accidents can be prevented from carefully calculated project planning.

2.4 Design Process

Traditional outcomes for ID studio projects are 3D renderings, physical prototypes, a presentation and a process book. In many cases, students have researched new technologies, materials, and science to come up with concepts. Students frequently choose to focus (or are directed to focus) on blue-sky concepts 'of the future'. This leads to solutions that are 'could be' concepts that give students limited hands-on product development experience.

The Kickstand project was focused on developing products that solve current needs in our lives. Because the end goal was to produce 15 identical units, the students' design research processes needed to be more hands-on, collecting meaningful and relevant data rather than just browsing the Internet for cool ideas. This encouraged the students to go out into the marketplace to see what their 'competitors' were doing and to observe consumers' behavior to set appropriate target segments for their products.

2.5 Manufacturing

Students entering ID programs often don't recognize the role that manufacturing processes will have on the ways products are designed, perhaps even believing the old

paradigm 'the factories will figure things out.' However, it is critically important for them to learn that to carry their designers' intent from concept through production, they must have essential knowledge about manufacturing processes.

The requirement for making 15 copies of their product in the Kickstarter project meant student 'companies' needed a sustainable way to manufacture their products, as opposed to making one single final appearance model. This challenged them to be consistent across the manufacturing processes and meet the quality levels people expect for products they purchase, leading each company to perform its own quality control. Previous to this project, mass-production and quality were topics outside their perspective; however, in Kickstarter students realized that they were critical components to their success and this caused them to be more creative and innovative to meet the deadline as well as product quality.

2.6 Business

It is suggested that successful business strategy should create and deliver value to the customer [9]. While ID students are taught to use a human-centered approach to their designs, they are not used to thinking about delivering value to the customers. Zott and Amit define a business model as "the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities" [10]. With the introduction of the crowdfunding structure in the design industry, 'business plan' has become an important keyword for designers. This influences design education as more design students take business classes or minor in business. Industrial designers in industry frequently take on roles beyond 'design' as multi-players and cross-pollinators (Fig. 1).

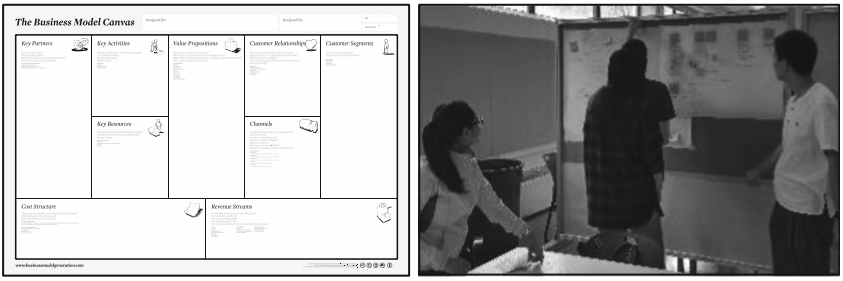

Fig. 1. Student 'company' developing their business model canvas.

Constructing the business model canvas [11] (0) was new for the ID students, but they were able to quickly grasp the concept because many components of the canvas are already covered in the design process (e.g. value proposition, customers). This became an effective and valuable tool for ID students to understand the connection between the design process and the overall business structures.

2.7 Kickstand - Result

Kickstand comprised 8 total companies, each with 4 members. Seven companies were able to sell everything they had during the 'Pop-up Shop' day (some taking orders for a future run of their products). Only one company could not sell all 15 units.

This project was an opportunity for students to think about design as a big picture and the overall student experience was very positive. The instructor's goal for 'companies' to choose their own titles was to create a professional environment and provide students with better motivation to perform. In fact, these students tended to take more ownership of their projects and be more responsible for the tasks assigned. However, one side effect of this 'company' structure was that some students tended not to help in areas for which they were not responsible.

Observing student progress across the 14 weeks of this project, it was interesting to see how collegiality among the teammates (or lack thereof) affected several companies' overall performance. In the beginning of this project, most companies didn't seem to have any issues between teammates; however, 6 out of 8 teams started having problems when there was lack of participation or responsibility taken by the team members. The peak of this discord occurred about the 10th week.

In the follow-up survey, students indicated that going through full spectrum from a product planning, through manufacturing, to sales was impactful. They reported the biggest challenge was managing their time well and working with team members. Over the course of this 14-week project, they collaborated with their teammates for a longer time frame than they were used to (typical team projects run 5–6 weeks).

Experience analysis gives an interesting insight (Fig. 2). All student companies had issues with both team and personal progress when they approached to 7–8 weeks where all students were stressed out, and many students also had emotional issues with teammates. Once they resolved the issues (with some counseling assistance from the instructor), both team and personal progress improved. During the 11th and 12th weeks,

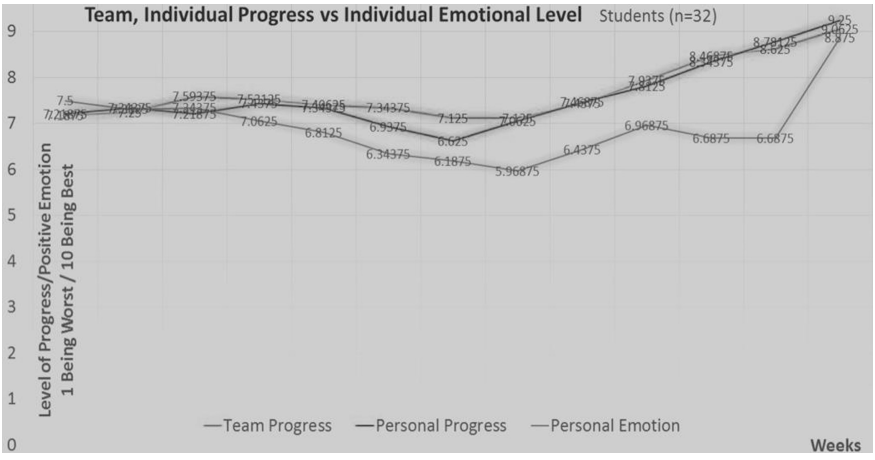

Fig. 2. Team, individual progress vs. individual emotional level based on survey (1: Worst/10: Best)

exams for other classes caused additional stress. As the deadline approached, team and personal progress improved and the instructor noted team members started being more collegial and helping each other. Students reported improving personal emotion that hit the peak during the 'Pop-up Shop' day where the students presented their products to public and had interchanges with actual customers (Fig. 2).

The other distinction from typical studio projects was that the final requirement to personally manufacture 15 units caused the product planning stage, including brainstorming, to be significantly different. It led the companies to come up with realistic product opportunities based on team members' capabilities of manufacturing and access to technologies. All companies went through several iterations for their manufacturing method to find a sustainable way to create 15 identical units. Ultimately, 7 companies made craft-like products and one company used several manufacturing processes including sewing to make 15 backpacks, see (Fig. 3).

Fig. 3. Each 'Company' created 15 units of their product and sold them in a 'Pop-up Shop'.

3 Design Sprint

Teaching New Product Development in an educational setting is an iterative process. Students must learn the elements of design thinking while they develop skills to communicate in both two- and three-dimensions (drawing, physical modeling, computer modeling). They need an understanding of users, learning empathic research strategies [12] to uncover unmet needs. At the same time they are acquiring knowledge of manufacturing processes and an understanding of how design, manufacturing and marketing can influence a product's success or failure. Decision-making at critical points is difficult for students who are just beginning to understand the design process. Faculty have found that these 'lost' time frames slow down student progress and can even completely sidetrack their development. Students are able to gather interesting data using solid research methods and can work through an effective summary process in order to reach engaging conclusions. However, when it comes to converting those conclusions into "insight" (a level of understanding that motivates towards action), many students seem to hit a brick wall" [13].

Although project deliverable dates are defined around the faculty's reasonable expectations of time required to complete each aspect, workload for other courses that students are involved with is a factor in when and how they decide to proceed with a project. Lack of effective time management skills frequently causes students to start and complete projects 'just-in-time' or perhaps even without enough time allotted to complete the task well.

For inexperienced students, the tendency to fall in love with their ideas can be a very difficult hurdle and can cause them to make poor decisions early or even stunts their ability to explore other ideas or solutions. The act of designing forces the designer to understand user needs; however, students are frequently reluctant to speak with real users and tend to fall back on their own perceptions or those of their roommates, classmates or parents [14], especially in design education where typically there is no real client [15]. 'Millennials' born between 1980 and mid-2000 value active learning; to sit just listening is not their style [16].

The design sprint project was conceived in the fall of 2014 to help students get past these obstacles and to develop their *problem-finding* skills along with their already developing *problem-solving* skills. The authors developed the project briefs, deliverables and methods for selection of ideas, modeling this sprint exercise from their professional and academic expertise.

3.1 Design Sprint - Professional Background

A search of literature following the first iteration of this fast paced educational project shows there are similar concepts used in professional practice, both in developing digital computer technology/programs and in physical forms of new products.

On the digital front, one example is Google Ventures Design Sprint, which they describe as a method for teams to prototype innovations in a fast-paced implementation of the design process in five days using a process that includes Unpack, Sketch, Decide, Prototype, and Test [17]. The foundation of a design sprint is built upon design thinking that "combines empathy, creativity and rationality to solve human-centered problems" [18]. Rapid product development in object technology (an umbrella term for object-oriented programming, databases and design methodologies) [19] also relies on what Meyer describes as "User-interface Design Principle: Do not pretend to know the user; you don't." He professes that assumptions made for a specific group "simply do not hold for a larger audience" [20, p. 12]. Imposing constraints such as time in a design project can lead to great design decisions, forcing you to view things from a new perspective. This can stimulate the design process rather than debilitating it [21].

In the 2015 book Design Sprint: A Practical Guidebook for Building Great Digital Products, the authors describe a design sprint in five phases that are similar to Google Venture: Understand, Diverge (empathy, ideation) Converge (decision), Prototype, Test. This design sprint process echoes early design charrettes (collaborative meetings to share design ideas), as well as the 'deep dives' that design firm IDEO 'pioneered' in the 1990s for physical products (think shopping cart). Designers collapsed the time frame in order to come up with better solutions in a shorter time [22]. These authors individually and collectively have experience running design sprints with clients from Fortune 500 companies as well as venture capital startup companies.

3.2 Design Sprint in an Educational Setting

A design sprint project has been implemented in 5 different studio courses over the course of 3 years – three cohorts of Technology Management (TM) students in their

3rd year of study at the University (TM studios are roughly equal cohorts business and engineering majors with no previous new product development experience) and two cohorts of ID students in their capstone year.

Each project starts with one overarching product *'category'* for which teams of 4 to 5 students are provided with thought provoking *'areas of focus'* to encourage problem-finding in the initial days of the project. (Categories = bathroom, tractor cab, housewares; Areas of Focus = technology or waste management, social connectedness, cleanliness, storage, relaxation, entertainment…) The tight time constraints require students to work inside and outside the classroom with deliverables each class period. A rapid exploration and mapping of the product space and analogous products provides a jumping-off place for the group's brainstorming, mind mapping and divergent thinking. To better understand that they are NOT their user and push them out of their comforts zones, students personally use empathic modeling to simulate having a disability [23]. Team members individually create rough concepts that are then funneled through a stage-gate (peer review) decision-making process. Students practice convergent thinking as new ideas are developed and iterated through sketching, modeling, and prototyping. Two additional peer reviews funnel the concepts to a final direction to be developed and delivered (Fig. 4).

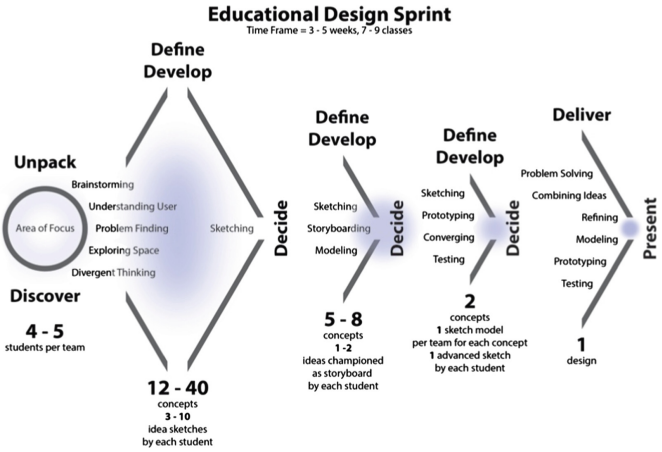

Fig. 4. Overview of the educational design sprint process. Source: Thomas 2017

3.3 Project Plan [24]

1. Class Day One: product category introduction and brainstorming areas of focus—Problem Finding, Discovering, Unpacking
2. Class Day Two: preliminary product research—Discover, Unpack
3. Class Day Three: understanding the user and sketch ideation—Define, Develop, Sketch, Decide
4. Class Day Four: progressing the idea through storyboards—Define, Sketch, Decide

5. Class Day Five: advancing the ideas through low fidelity prototypes and sketches—Define, Sketch, Prototype, Decide, Problem Solving
6. Class Day Six (Plus Seven and Eight Depending on the Overall Length of Project): Develop, Prototype, Test, Problem Solving
7. Class Day Seven (or Nine Depending on the Overall Length of Project): Deliver/Present

This project plan was designed to help students think and work quickly, providing them with an example of real world design and decision-making processes. Might suggest that single segments of the sprint may be a linear process; however, the overall design process is quite iterative with each step potentially moving the project forward, or sending it back for more discovery or definition. "Inside stages, there is much looping, and back-and-forth play as the project proceeds; some activities are undertaken sequentially, others in parallel, and others overlapping" [25] (Fig. 5).

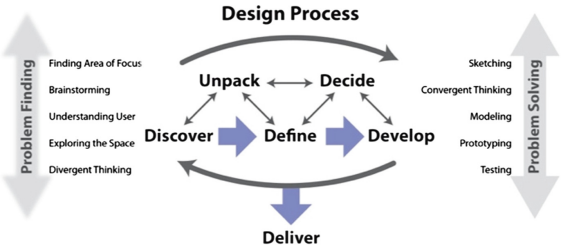

Fig. 5. Iterative design process [25]

3.4 Design Sprint in a Business/Engineering Studio

This business/engineering studio is the introduction to new product development for a cohort of TM students who are very focused on their professional futures and excelling in their majors. This course timeframe is scheduled as a lecture and thus has half the hours in class than a normal ID studio. Students in their third year of college majoring in business (e.g. finance, accountancy, supply chain management) and engineering (e.g. chemical, computer science, mechanical) were rapidly immersed in this project using design thinking, drawing, and modeling tools that were mostly unfamiliar to them at the start of the course. Nearly every activity forced most of this group outside of their comfort zones and required physical deliverables and visual communications that were new to them (Figs. 6, 7, 8 and 9).

Considering only the images in Fig. 6 through Fig. 9 one might suggest that the work from the business/engineering cohort could not be of the same quality level as students at a comparable level in an ID program. While their visual representations (e.g. sketches, final models, graphic design) exhibit low skill level compared to the designers, the quality of the ideas developed overall was quite equivalent to the work created by design students. Perhaps due to their better time management skills, the business/engineering cohort actually delivered their work on time and followed directions. For example, for the initial design concepts 3 design and 2 TM cohorts were

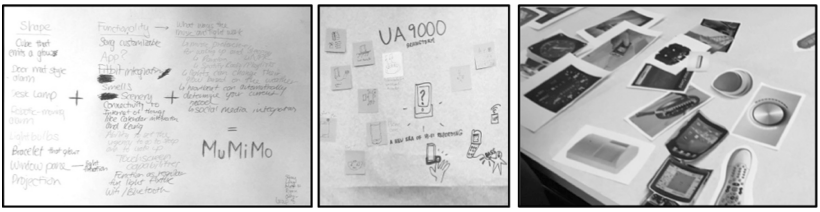

Fig. 6. The first phases involved teams brainstorming areas of focus and mapping existing and analogous products to discover unmet user needs and product opportunities.

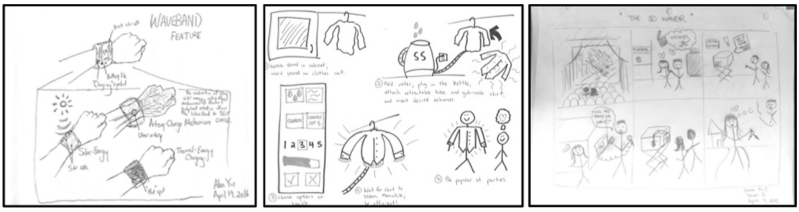

Fig. 7. Initial concept sketches (3–5) by each student were presented to 'Management' (other teams) who selected the 5–8 ideas to continue. This was rapidly followed by storyboards advancing each of the chosen concepts. 'Management' funneled this phase to 2 ideas to pursue.

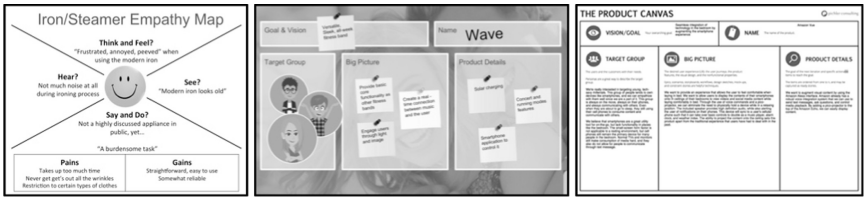

Fig. 8. Teams use 'tools' of empathy maps [26] and 'product model canvas' [27] to discover and describe product opportunities.

Fig. 9. Teams advanced their ideas through sketch models (low fidelity prototypes) with one final selection by 'Management' to pursue. In the final phase, more advanced models and drawings were created to describe the 'final' concept.

directed to deliver one concept per page: illustrated with a main diagram with callouts and notes; include an evocative title and state the problem; identify key stakeholders; and include their name. The technology and management students were more successful in meeting these requirements than the design students even when both cohorts were delivering their work 'just-in-time'. Similar to the design cohorts, some of the team projects in the business/engineering studio were more successful in innovation than others.

Reflecting on their experience in this design sprint several TM students suggested that they found the 'Management' decisions to be arbitrary and not taken seriously. However, the better teams seemed to push beyond these decisions and incorporate ideas that had been discarded along with their 'Management' direction to complete their new product development successfully. Comments from each of the students were pulled into a presentation to have an in-class discussion, which further explored the success and failures of the project. Some selected comments (positive and negative) follow:

"Having different ways of displaying the idea through sketches, storyboards, and models gave different criticism to help the product improve…"

"Many times [we] as designers fall into the trap of thinking that we understand the way in which other people think and operate, but that is clearly not true."

"The biggest strength of our team was our diverse backgrounds."

"… it was obvious there was a clear disconnect between what our ideas were and what people understood."

4 Learning Experience - Pros and Cons

See Tables 1 and 2.

Table 1. Industrial design

ID/Slow - Pros	ID/Slow - Cons
Initial motivation and passion high	Limitation of product concept
Full spectrum of product development	Limitation of brain storming
Conversations with real target users	Plan modified due to lack of experience
In-depth design research	Struggle with manufacturing
Iterative prototyping	Lack of business/marketing knowledge
Sustainable manufacturing research	Random selection of team members
Interaction with real customers	Final products tend to be craft-like
Solving issues rather than avoiding them and focus on products	Personal issues influenced team progress
Learning what went good/bad after review of sales	Customer tended to be college students – they were designing for themselves

Table 2. Technology management

TM/Fast - Pros	TM/Fast - Cons
Highly motivated business/engineering students	1 h 20 min. lecture class timeframe compressed all in-class activities
Teams assigned by instructor to equalize business and engineering members	Heavy core course loads made team meetings outside classroom difficult
Rapid immersion and ideation	No depth to initial idea development
Focus on a real user group	Limited opportunity to talk to real users - they were designing for themselves
Making sketch models to proof concept was completely new to this cohort	Making sketch models to proof concept was completely new to this cohort
'Management' evaluates concepts and determines course of development	Some students didn't take the activity seriously and made careless decisions
Good collaboration and pooling expertise helps teams to refine ideas to concepts	Human-centered design/form development design is rudimentary compared to ID students
High technical/engineering skills resulted in a few working prototypes	Some teams still fell in love with their idea, or alternately had no passion and both then missed the mark.

5 Conclusion

The experience of the faculty in the 'Kickstand' and 'Design Sprint' projects has been an increase in student collaboration and enhanced design thinking. Students explored many different ideas and used tools new to them (business model canvas, product canvas, empathy mapping) that encouraged innovation. 'Kickstand' in its first iteration engaged 35 students in the 'slow' design, manufacture, marketing and sales of a product. The highlight of Kickstand was to experience a full spectrum of design that the students particularly enjoyed. In the past two years over the course of the five studio courses 235 students have embraced the 'fast' sprint concept and produced high quality work in a very short period. Both projects succeeded in engaging students who were excited about the work they were producing. The students were able to conduct research, explore many design concepts and follow through an iterative design process rather than producing the final outcome in hurry without significant exploration. The faculty sees these 'fast' and 'slow' projects as valuable educational tools that they will continue to utilize in future educational settings.

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Rematerializing the User Interface of a Digitized Toy Through Tokens: A Comparative User Study with Children Aged Five to Six

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Abstract. This research aims to measure and empirically validate the effect of tangible interaction on children's play experience. During this study a Research Through Design approach was followed. A prototype of a programmable toy train with a Tangible User Interface based on tokens, was build. Afterwards a comparative user test with 34 children aged five to six, was carried out to verify the prototype. The prototype was compared to two similar established toys, one with a Physical User Interface and one with a Graphical User Interface. After the user tests, the participants were questioned to gain insight in which type of user interface is preferred and why. Preference was asked with the use of the This-or-That method. Insight into the reasons of preference towards a user interface was gained through a Laddering method.

Keywords: Empirical validation · Research Through Design · Tangible interaction · Children · Laddering · Comparative user test

1 Introduction

Now that microcontrollers have found their way into almost every consumer product, among which also toys, interactive technologies are increasingly pervading children's lives [1]. There is very little dispute that interactive technologies can have great potential for children's play experience. By digitizing play more interactive, engaging and challenging toys can be created [2]. Yet, the use of interactive technologies by children have raised fears about the perils of exposing children to them [3]. After all, by adding digital functionality to a toy, not only the User eXperience (UX) increases, but the interaction with the toy transforms entirely. The physical toy dematerializes and shifts towards a screen based interface with push buttons. These type of interfaces present data and information in a graphical manner, and are referred to as *Graphical User Interfaces* (GUI). While the specific physical shape of traditional toys offered affordances [4] that appealed to the bodily skills of the child, the interaction with GUI's is limited to button-pushing or a set of standardized gestures on a display [5]. As a

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_2

result of dematerialization [6], physical play decreases. Movements become very precise and take place at finger level rather than at hand, arm or body level [7]. Piaget states that the cognitive and psychomotor development of young children roots on physical manipulation and handling of objects [8]. For this reason, toys with a GUI are not appropriate for young children [9, 10]. An alternative for the GUI which doesn't feel computer-like, but instead stimulates physical play, should be used when designing digital toys for children.

Lately, a number of alternative interaction styles among which *tangible interaction* have emerged. These new interaction styles aim at leveraging human skills in interaction with technology [11]. In particular, a *Tangible User Interface* (TUI) can be seen as a promising alternative for the GUI, when designing digitized toys for children. Tangible interaction is an interaction paradigm that integrates the digital world and the physical environment. It strives for interaction with digital information in a non-digital, physical way by giving computational resources and data material form [12]. Tangible interaction strives towards more matter instead of less. In that way, it makes a move towards *rematerialization* [13] and thus physical play. It is argued that tangible interaction can offer several benefits for children's play experience. Not surprisingly many research studies regarding tangibility and children have been carried out in the past. Yet, the results from these studies are often contradictory [14]. These contradictions are partly caused by poor empirical validation on whether it's really the tangibility that is causing the positive effect [15]. An enhanced play experience can also be caused by brand awareness, previous experiences with the product, usability and various other reasons. Furthermore, a thorough description of the research method is often missing [16].

This research aims to measure and empirically validate the effect of tangible interaction on children's play experience. In order to measure the effect, a prototype of a digitized toy with a TUI was build and tested. For this, a *Research Through Design* approach [17], wherein knowledge is gained through the process of designing, building and testing, was followed. First, a prototype of a programmable toy train with a TUI based on tokens [18] was build. Secondly, the prototype was compared to two established counterparts, one with a merely physical interface and one with a GUI. Multiple *comparative user tests* with children aged five to six were carried out. Finally, after the user tests, the participants were questioned to gain insight in which type of user interface is preferred and why. Preference was asked with the use of the *This-or-That* method [19]. Insight into the reasons of preference towards a user interface was gained through a *Laddering* method [20].

2 Methods and Materials

2.1 Construction of the Prototype

A programmable toy train with a TUI based on tokens was developed and prototyped. The prototype consists of three different type of game elements.

The first type of elements are *non-interactive construction elements* or traditional building blocks. Two different train tracks – a turn and a straight track – with which one

can build a railway, were developed. These tracks do not contain any computational components and are thus not interactive.

The second type of elements are *tokens* or digitized blocks, that can be identified by an electronic reading system. These tokens can be placed into the train tracks. Each of these tokens embody a different music note or sound sample. The RFID tag with print is located on top of the token and represents the data – note or sound sample – with which the token is associated. These tokens are graspable objects used to access digital data stored inside the memory of the electronic reading system. This way tangible interaction with digital data is allowed.

The third element is an *electronic reading system* that can read, interpret and act in response to the tokens. An electronic toy train that contains a RFID reader which can identify the tokens in the tracks, was build. It responds to a token by playing the note or sound sample it represents. By pushing the train forward, a sequence of tokens will be identified and as a result the train will play the constructed melody. The train contains all the electronic components (power supply, RFID reader, microprocessor, speaker,…) (Fig. 1).

Fig. 1. Prototype of a programmable toy train with a TUI based on tokens. Three different type of game elements. *Left* non-interactive construction elements. *Central* tokens. *Right* electronic reading system.

The prototype can be seen as an exemplary case for digitized toys with a TUI based on tokens. It distinguishes itself from other digital toys by its tangible interaction and its non-digital appearance/form. First of all, the interaction with the digital toy doesn't feel computer-like. The children don't need to navigate through menus or press combinations of buttons, to address to the product's functions. Instead, they can create their own sound compositions by grasping, placing and shifting physical building blocks. Unlike graphical symbols, these building blocks potentially fit our bodies and our repertoire of actions. They are directly graspable and afford to build constructions and therefore stimulate the child to constantly explore new musical possibilities. Furthermore, the prototype is characterized by its traditional, non-digital look. Digital products typically contain a display and/or push buttons. Therefore, the user interface of digital products often look highly similar and need to communicate their functions through icons and text labels, requiring reading and interpretation. The prototype of the programmable train however, communicates its functions and how they should be addressed through its physical form.

2.2 Comparative User Study

To validate the UX of the prototype a comparative user study was carried out. Comparative evaluation studies have the potential to provide more confidence regarding claims for tangibility [15]. Also by providing alternatives, children can compare product attributes and therefore more easily discuss their opinions and experiences [16].

Tested Systems. A comparative user study was carried out with following systems:

- *System 1 - PUI: LEGO duplo train.* Construction toy that allows children to build a railway for a motorized train. Although the train is motorized and can generate sound, the user interface of the toy is merely physical. After all, the game focuses on building a railway with the non-interactive construction elements.
- *System 2 - TUI: prototype of a programmable train.* Prototype of a construction toy, with which children can construct and play their own sound compositions in an intuitive and direct manner. In this study the prototype represents a toy with a TUI.
- *System 3 - GUI: TuneTrain.* An application whereby children can create and play a tune by moving a virtual train over a graphical stave. The touch screen of the smart device allows children to draw a path for the train. The game layout visualizes a musical stave. By pressing on the play symbol, the train follows the path and plays the tune. The interface of the application is graphical (Fig. 2).

Fig. 2. Tested systems. *Left* LEGO duplo train [21]. *Central* prototype of a programmable toy train. *Right* TuneTrain [22].

Participants. The user tests were conducted at the third grade of kindergarten. Schools provide a well-known environment for the children, as well as adult teachers can help to organize the planned experiment. The testing took place on five days at two different schools located in Antwerp, Belgium. Three different classes participated. In total 34 children (17 boys, 17 girls) aged five to six participated.

Procedure. The participants had to play with each of the three presented systems for a maximum time of 10 min. After playing with each system, the participants were questioned to measure and understand which of the three tested systems got their preference and why. Each child did the test individually. This way the participants could not influence each other's behavior and responses. One facilitator was present to guide the child and to ask questions at the end of the test. The facilitator obtruded as little as possible and did not give any tasks during play. This way free play was encouraged. The tests and questionnaire at the end of the tests were filmed. Each test had a maximum duration of 35 min. At any instant the participants could indicate if

they don't wish to proceed. In that case, they could choose to switch to the next system or to stop the entire test.

Setting. The user tests were conducted in classrooms that were offered by the participating schools. The systems were arranged so that they each had their own place within the room. The camera was placed in the middle of the room so that the camera view could be easily adjusted when one switched to a different system. The interview was conducted in the same classroom where the test took place, in visual contact with all three systems (Fig. 3).

Fig. 3. Setting of the user test.

2.3 Measuring Effect and Validation

After the user tests, the participants were questioned to gain insight in which type of user interface is preferred and why. Preference was asked with the use of the This-or-That method. Insight into the reasons of preference towards a user interface was gained through a Laddering method.

This-or-That Method. The interview starts with asking the participants which system they prefer. To find out which system was preferred most, the This-or-That method was used. The This-or-That method is a comparison scale that is the least cognitively demanding questioning style for children [19]. A series of questions is been asked to the child. *Which game was most fun? Which of the games would you like to receive as a birthday present? Which game would you like to take home? Which would you like to play again?* [23] The child can indicate the preferred system simply by pointing. Afterwards the participants were asked, which of the two remaining systems they found most fun. They again had to answer by pointing. By giving three points for the first choice, two points for the second choice and one point for the last choice, a ranking order could be derived.

Laddering Method. After conducting the This-or-That method, insight into the reasons of preference was asked using Laddering. This method was validated by Vanden Abeele and presented as a promising empirical method to evaluate the effect of tangibility on preschoolers' UX [16]. This method typically consists of a *Laddering*

interviewing technique, where the user is asked to motivate the reasons why a product was preferred. Subsequently followed by a *Laddering data treatment*, where the Laddering interviews are transcribed and meaningful couplings between product attributes, consequences and values can be derived. These chains of attributes, consequences, and values are also referred to as Ladders. Sometimes the child could not give a motivation or gave a meaningless, random answer. In that case, the Laddering interview was ended quickly.

Statistical Analysis. Anonparametric repeated-measures Friedman test (IBM SPSS Statistics V24) was used to assess the effects of interface type (PUI, TUI, and GUI) on children's play experience (first, second or third choice). Wilcoxon Signed Ranks Test (IBM SPSS Statistics V24) was performed to evaluate within-group pairwise differences. Results are considered statistically significant when $P < 0.050$.

3 Results and Discussion

3.1 Results

Results After This-or-That Method. All of the 34 participants were able to give a first, second and last choice. The mean score is *68*. S1, S2, and S3 respectively scored *56, 67 and 81*. The Friedman test showed that the measured results are significant *($P = 0.010$)*. The P-value based on Wilcoxon signed ranks test varies for each pair *(S2–S1, $P = 0.218$; S3–S2, $P = 0.037$; S3–S1, $P = 0.009$)* (Table 1).

Table 1. Results after This-or-That method. Ranking and scores for the three tested systems.

Tested system	S1	S2	S3
User interface	PUI	TUI	GUI
First choice (3)	9	8	17
Second choice (2)	4	17	13
Third choice (1)	21	9	4
Total score	56	67	81
Difference from mean score	−12	−1	+13
Mean rank	1,65	1,97	2,38

Results After Laddering Data Treatment. In this study only system attributes related to the type of interface are taken into account. Other reasons of preference – for example previous experiences with the system – are not valuable within this study. In the table below, all the relevant Ladders are listed by system. In total six relevant Ladders could be put together after conducting the 34 interviews (Table 2).

Discussion on Results. The results of this study show that children aged five to six prefer a GUI over a TUI or PUI. Laddering revealed that the main advantages of a GUI resides in its versatile nature, many possibilities and high level of stimulation. The dynamic nature of a GUI allows to present multiple subgames and musical possibilities

Table 2. Results after Laddering data treatment. Schematic overview of the relevant constructed Ladders.

S	Product attribute	Consequence	Value	Score
S1	Motorized train	Fun to watch the train move on the track	Fun	7/34 = 0.206
S2	Tangible objects	Create something yourself, control, involvement	Fun	3/34 = 0.088
S2	Musical train	Experiencing extraordinary things, surprise effect	Fun	3/34 = 0.088
S3	Touch screen	Immediate feedback, user's actions and system responses are directly linked	Fun	3/34 = 0.088
S3	Large database	Many musical possibilities	Fun	3/34 = 0.088
S3	Versatile application	Many different subgames can be played	Fun	2/34 = 0.059

on one display. Furthermore, the multi touch screen of the GUI makes it possible to give immediate feedback on the user's actions. The user's actions and the system's responses are thus directly linked in time and location. A TUIs qualities, on the other hand, lies in its high level of involvement and surprise effect. The participants had to actually grab the tokens and place them into the tracks, in order to create their own melody. For playing the melody, they had to push the train forward. Their actions take place in the real world. Therefore, the participants got the feeling they were creating something themselves. Another advantage of a TUI can be found in its surprise effect. The participants did not expect any response coming from the non-digital looking train. The moment they heard the notes being played, while pushing the train forward, they were surprised. The difference in preference between a TUI and a PUI is not significant ($P = 0.218$). Mind that, seven of the nine times the PUI was chosen as first choice, was because of its only interactive element, namely the motorized train. It can be presumed that there would be a significant preference for S2 if S1 would not contain any interactive elements.

3.2 Design Recommendations for a Future Prototype

After the Laddering data treatment, multiple design recommendations for a future prototype could be derived. Laddering shows as such its usefulness within an *iterative design methodology* where a cyclic process of prototyping, testing, analyzing, and improving a product or process is performed. Following design recommendations can be formulated:

The train can be divided into a motorized locomotive and a non-motorized railcar which contains the reading system.

More tokens should be developed to enhance the musical and game possibilities of the prototype.

A *Hybrid User Interface* (HUI) [24] can be developed. A HUI is an interface in which users can switch freely between graphical and tangible elements. Elements of both a TUI and a GUI are combined, to take advantage of the best features of each [25].

3.3 Reflection on Method

All participants were able to give a ranking order. This supports that the This-or-That method is a suitable method for measuring children's UX. After the This-or-That method, Laddering was used to gain insights into the reasons of preference. Five of the 34 participants were not able to motivate their preference and thus failed to construct a Ladder that went beyond the choice of preferred system. Eight of the 34 participants' reason of preference was not related to the type of interface. 21 participants constructed a Ladder starting from an interface related attribute. So, in total 21 relevant Ladders were constructed. Like Vanden Abeele previously discovered, these results show that Laddering is possible with children aged five years and older. Furthermore, Laddering proves to be especially useful within an iterative design process.

4 Conclusion

In recent years, it has been argued that tangible interaction can benefit children's play experience. Not surprisingly many research studies regarding tangibility and children have been carried out in the past. Yet, the results from these studies are often contradictory. These contradictions are partly caused by poor empirical validation or deficient research methods. This research aims to measure and empirically validate the effect of tangible interaction on children's play experience. In order to measure the effect, a prototype of a digitized toy with a TUI based on tokens was build. Subsequently the prototype was compared to two similar established toys, one with a PUI and one with a GUI. The results showed that children prefer a GUI over a TUI or PUI. Laddering revealed that the main advantages of a GUI resides in its versatile nature, many possibilities and high level of stimulation. Whereas the main positive aspects of a TUI lies in its high level of involvement and surprise effect. The Laddering technique also allowed to derive multiple recommendations for a future prototype, such as the development of a motorized toy train. Laddering showed as such its usefulness within an iterative design process.

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Analysis of Emotion and Cultural Background on Affective Design Process

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Abstract. The interplay of several factors in design included designers and users shaped the outcomes of design development process. There are some studies provided evidenced that emotion and cultural values influence the roles in design over all aspects of living and it is assumed that the process of design is not exempted from these pervading effects. Yet, they were still not yet be the top concerned topics in the affective design process. Hence, a strategy is needed for making use of emotion control and recognition of cultural background effectively in the design process. This study aimed to examine need for new methods and recognize the relationships between emotion and recognition of cultural background for the changing nature of design. A field experiment was adopted to examine the proposed design process. The participants' feedback and reflection were collected by observation and self-report from the participants for developing further in-depth studies.

Keywords: Emotion · Recognition of cultural background · Creativity · Design process

1 Introduction

Satisfying the growing needs for creativity and interesting outcomes was one of the challenges in nowadays society. In the case of design, designers are expected to come up with products that are both innovative and user-friendly to their users. In order to equip designers, the ability for generating innovative ideas, most studies have concluded that the creative processes and learning process in design study should include the training on the capability of cognitive thinking. This ability can leverage individual tacit knowledge. Most of these studies have advocated rational educating approaches. Similarly, most educators guide design learners in manipulating the learning process in design studies through problem-based creative processes methodology which focuses on training the ability of problem-solving skills [1–4]. Even so, many design learners still cannot resolve their design problems in a creative way. This implies the presence of other hidden factors hindering these learners' practice. Hence, identifying the hidden factors can facilitate design learners' creativity as well as enhance their design abilities as a result. In addition, although certain design scholars have investigated approaches for helping design learners, they have been forced to engage in cross-disciplinary research because of the lack of references or prior investigation under the topic of

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_3

creativity in the extant design literature. According to the insights derived from psychological studies, certain scholars have proposed that emotion and recognition of cultural background are involved in designers' thinking process. Emotion and recognition of cultural background are potential elements those affect how design learners generating ideas and their manipulation of their design processes. Therefore, this study proposed a strategy for emotion and recognition of cultural background development. A field experiment was conducted to examine how educators assist design learners to manipulate their design process by exploring the relationships between design, emotion and recognition of cultural background.

2 The Challenge for Conducting Creative Processes

It was commonly agreed challenge in design creative processes are improving the design process and design outcomes effectively. In order to overcome this challenge, it was essential to enhance design learners' project experience [5] and increase their familiarities on creative techniques and skills to master the complex design process. Therefore, some design scholars introduced the problem-based teaching and learning in design creative processes [6]. However, the educators still face the problems such as the method of providing a 'creativity stimulating environment', 'structuring the (design) processes', delivering and requesting information in an appropriate approach. It was understandable for the needs to encourage learns' creativity and innovative skills. The arising of the technologies lead the learners using various new media in their daily lives and their learning process. Such media-driven environment leads new challenges to learn and understand in different kind of methods. The educators, therefore, had the responsibility to lead the learning in a creative approaches and practices to get their attention. Creativity is one of the methods to create knowledge. Hence, the methods of simulating creativity have a spill-over influence on to support self-learning and even life-long learning skills.

3 The Current Creative Training Influence in Learning Programme

Conducted the review on the current studies, it was found that creativity, as a relatively complicated concept, involved several fields of studies [5–7]. Scholars studies various approaches to strengthen a relatively completed concept of creativity. The aspects of those studies were categorised as the followings:

- Psychometric approach: creativity theories of this aspect were regarded as a quality that can be measured.
- Psychoanalytic approach: creativity theories of this aspect were regarded as the unconscious execution for artistic design objectives.
- Self-expression with recognition of cultural background and mystical approach: creativity theories of this aspect were aimed to express oneself with unique methods.

- End-product approach; Creative experience was regarded as a kind of function to produce creative design experience which can satisfy the users' needs.
- Cognitive approach: this approach embraced 'phase-oriented studies', 'pragmatic methods' and 'thinking theory'.

Creativity was regarded as a miraculous talent of the individual. It attracted the interest of thinker for years. The research on creativity was started from the psychological studies [8]. Since the 2000s, design scholars started to investigate how creativity influence the design process. Since the publication of Goleman's book, Emotional Intelligence & Working with Emotional Intelligence, investigated the relationships between social interactions and emotional intelligence, learning activities focused on emotional concerns have been introduced in a more systematic way. Emotional intelligence was a concept which was developed on the foundation of Darwin's theories. Darwin proposed his investigation on the emotional expression for proposes of survival, in other words, to the capability of monitoring and discriminating the emotions of others' [10, 11]. Emotion was regarded as one of the factors to influence the manipulation of learning methods, such as problem-solving. Goleman's concept of emotional intelligence got the educators attentions and has been widely adopted in different disciplines. This led to the introduction of some emotional concerned concepts, for examples, emotional literacy, self-motivation, and emotional creativity. They are popular topics in the current creative processes al practices in England [12]. Emotion was regarded as one of the aspects of creative processes with policy (by using the term 'emotional intelligence'). It also regarded as a key aspect in primary and secondary curricula in Great Britain now. Design methods (e.g., problem-solving and creativity) have been adopted in certain courses as a tool to help learners understanding the concept of emotion and recognizing the emotional changes of themselves in the learning experience. In previous studies, emotional literacy strengthened learners' creativity and their decision-making ability. According to [13], emotional literacy was a concept which based on a positive emotion. They aimed to promote positive feelings in the learning process. They proposed that positive emotions can help learners to make relatively more effective decisions and creativity. In the reformed curricula, their concerns on positive emotion had been adopted in the creative processes al field. It was aimed to strengthen the abilities in problem-solving and creativity of learners.

1. Although designers' professional experience is crucial, they consider that their creative skills can be nurtured in design schools.
2. Some scholar tried to train up the creativity of learners through project-oriented pedagogy, which was executed as specific courses offered to design learners.

A study explored how training influence the creativity of learners [14]. They observed both the evocation processes of learners and the corresponding creative output. In the first part of their study, they invited 32 design learners and divided them into two groups. They were assigned to perform design task under the same requirement.

4 The Importance of Recognition of Cultural Background on Creativity

Recognition of cultural background is the foundation of the self-understanding of individual. It leaded the expression and reaction of people. Culture involved knowledge, experience, living, religious, history and meanings. Ho explored the emotion in design from the designer's point of view and invested how emotion and recognition of cultural background related to the decision-making process in design process [15]. Ho proposed an in-depth model to elaborate the findings from the literature review and his empirical studies, to illustrate how designer's emotions influence their design process. Ho also found that stimuli in the daily life of design learners affect the emotional responses of designers and lead them to conduct the initial processing. The stimuli involved technological, social, cultural factors those compose the induvial experience of designers [15]. They elicited emotional changes of designers. The emotional changes lead the initial processing to conduct the thinking process in the working memory, which considers the internal factors in the design process included information processing, human resources and material allocation [15], etc. During the consideration of the internal factors, long-term memory included different categories like individual experience, value and missions, learned knowledge and skills are recalled. They were worked as references to the decision making. Hence, judgement and corresponding responses are generated. In the order words, stimuli in the daily life elicit emotions of designers which lead the designers to make various decisions which affected by the internal factors. As a result, the whole design process was changed.

5 Infusing Recognition of Cultural Background into Creative Processes

Enhancing the recognition of cultural background is one of the methods to enhance creativity [15]. It is one of the methods for inputting new ideas, challenging conventions and communicating effectively. There were some scholars in Europe suggested to enhance the thinking ability of learners through cultural activities. Hence, it is essential to consider the recognition of cultural background as important as the training of imagination, diversify thinking during the undergraduate creativity education.

6 Field Research on the Manipulation of Infusing Recognition of Cultural Background into Creative Processes

6.1 Research Aims

In order to understand how the recognition of cultural background contributed to enhancing creativity, a field experience on the manipulation of recognition of cultural background in the creativity process was conducted. Total twenty designer students (ten design students adopted the field research and ten design students finish the project without any guidelines about field research) were invited to attend a local Hong Kong

study Trip. The method of conducting field research was taught and practiced among the students during this study trip. Through the experience and sharing in the study trip, the different of culture and daily living among the undergraduate design students were understood. The students were undergraduate students in the level of year 3. They had some design experience and manipulated several design projects in the past two years. They had fundamental knowledge about design and opened for trying new design and research methods.

6.2 Research Process

The study trip was four weeks' projects. The research process included into seven main activities:

- Seminar: to understand the influence of historical and social changes on affective interface design.
- Workshop: to share the experience on creating new interface and introduce the basic concepts of how visual elements interact with human's senses.
- Visiting: to understand the influence of historical and social changes on citizen's living.
- Tutorial: to provide guideline on the field research on the investigation of the relationships between everyday life and affective interface design. It included the practical research methods under field research include observation and original sources collecting.
- Field research: to investigate users' needs, design concepts, outside the design lab.
- Design process: include two states, interaction and visual design, to design a set of new interface based on the inspiration obtained from the field experience.
- Usability evaluation: to obtain users' feedback on the prototype for improving the design.

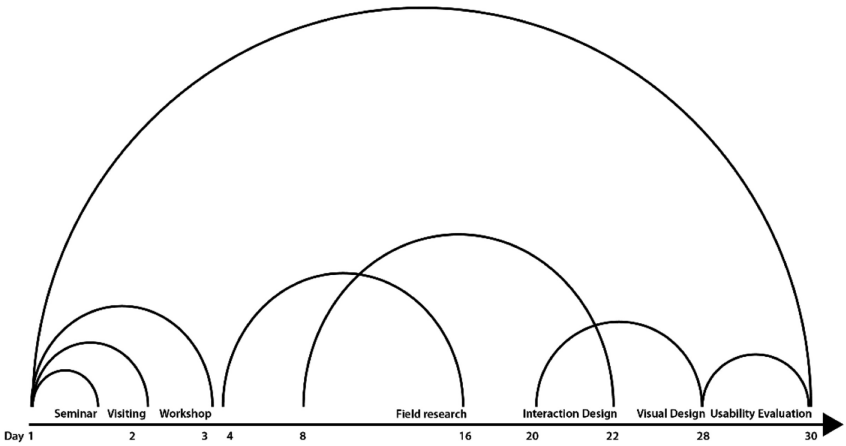

Fig. 1. Scheduled learning activities.

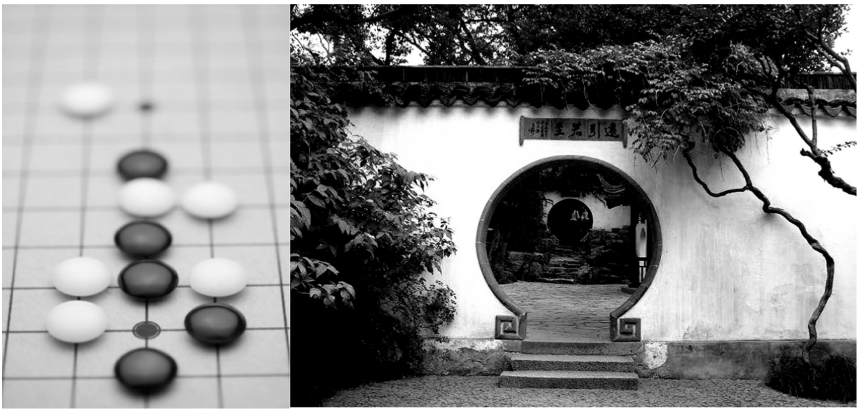

Fig. 2. This photograph of Chinese chess and gates in Chinese Garden, was captured on 13 July 2016 by student Helena Chan.

The activities were scheduled as the Fig. 1. On the first three days, students were invited to attend a general seminar, workshop and tutorial for creating affective interface design. Students were assigned to adopt field research for obtaining the cultural inspiration. From the second day to the fourteenth day, students conducted their research in various part of China. After obtaining the inspiration from the cultural elements, the participants developed them to a completed concept and they execute the design in following four weeks. On the thirtieth days, the students were gathered together and presented their findings those obtained from their research, concepts of their typeface design and the execution of the design outcomes.

6.3 Analysis Samples: Two Scenario Analysis Samples from Team a

One of the students, Helena Chan, visited Chinese traditional style garden. She photographed Chinese chess and gate (Fig. 2), which in local culture was believed to silent. Helena was inspired by the image; interfaces should be developed as a self-explanation system in terms of forms. She thus attempted to turn the symbol of silent found in Chinese traditional style garden with corresponding meaning. She applied this old-style decoration as the structure principle of her new interface design (Fig. 3). Thus, her field research observations provided her inspirations.

Similarly, another student, Anna Tan, was inspired by the old Chinese folk-style house (Fig. 4). Anna explored the spaces of old Chinese folk-style house and was interested in the usage of space and the living of local people (Fig. 5). These served as her primary design source, which she captured and analyzed.

6.4 Research Result

In this study, students provided their design process for field experience. It was obvious that field research would enhance investigation of creating Chinese typeface design in

Fig. 3. Interface design which based on the field research on 'silent'. This work was designed by students Helena Chan, 2016

Fig. 4. This photograph of an old Chinese folk-style house was captured on 14 June 2016 by student Anna Tan.

the daily living. The research processed and the found sources presented more in-depth perspective. Students could explore insights from the original sources. The research result with recognition of cultural background obtained from the field research provided strong foundation for the concept generations creatively. The students who adopted recognition of cultural background were easily investigating new concepts by themselves.

Fig. 5. Interface design based on the field research in old residential buildings in Yunnan. This work was designed by students Anna Tan, 2016

7 Conclusion

Creativity was concerned in the design studies for enhancing rapid knowledge driven society in the twenty-first century. It was believed that creative and innovation design contribute to economic and social changes as well as daily living. For equipping the competitive ability to designers, creative processes were regarded as the central in enhancing creative and innovative skills. Some scholars hence started to investigate more methods for increasing the designers' creativity including brainstorming, organizing on the thoughts and actions. It was found that different senses such as audio, visual, etc., all these types of connections influenced the level of creativity of the design. These experiences generally influenced much on the satisfaction of users on design. This could provide a new trend to the existing way of designing which emphasized on satisfying design functions and often ignored the resulted creativity. Researchers also revealed that at the heart of creativity, emotion and recognition of cultural background became a promising aspect and enhanced the influence of experience on the individual's memory. Studies in design and emotion and recognition of cultural background aimed to investigate how designed solutions could intentionally elicit emotion and recognition of cultural background of users. Design was shifted from its focus on generating outcomes with an attractive appeal to provide proper design solutions for satisfying users' needs in an innovative way; and further develop to the experience shaping. It was expected that designers are facing more difficulties than before. This study was the first step to learn about and introduce emotion and recognition of cultural background in enhancing creativity. Educators should have a strong awareness and in-depth understanding of the nature of creativity and the way of enhancing it. Judgment on the ideas' originality and the unexpected design experience are related to creativity. Therefore, the evaluation of creativity should be taken into

account learning and creative processes perspectives. This step had just been taken to address primarily understanding on how the emotion and recognition of cultural background to be the leading element of the training process of creativity.

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Design and Validation of Affective Warning Pictorials on Alcohol Container Labels

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Abstract. Affects in warning pictorials are essential in the warning effectiveness such as comprehension and hazard perception. The purpose of this research were to design and validate emotional warning pictorials for alcohol container labels in order to increase awareness of risks from alcohol consumptions. Survey and brainstorming techniques were used to collect the idea of possible affective warning pictorials. All ideas generated through those techniques were grouped for finding candidate pictorials. Sixty affective warning pictorials were designed and categorized into three affective state groups equally as positive, neutral, and negative. Forty Thai male participants participated in this study for affective warning pictorials' validation. Participants were asked with agreement to attend the affective manipulation by watching pictures from the International Affective Picture System (IAPS) to adjust participants' affective state as neutral state before starting the experiment. The Self-Assessment Manikin was used to assess valence and arousal of participants after seeing each of sixty affective warning pictorials. The result showed that affective warning pictorials were able to evoke specific affective state of warning pictorials to participants such as positive, neutral, and negative state. Affective warning pictorials from this research can be implemented as the alcohol container labels. The direction of future research will be focused on the study of comprehension, risk perception, and motivation to stop drinking alcohol after participants perceive affective warning pictorials.

Keywords: Warning pictorials · Affective state · Emotional response · Affects · Emotions

1 Introduction

Alcohol beverage is a popular beverage among all cultures. Worldwide alcohol consumption continuously increases and causes the burden of disease and death in most countries based on a survey report in 2005 [1]. Drinking alcohol leads to about 60 types of diseases and injuries, as well as causes 4% of death worldwide [1]. From the report,

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*, Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_4

male drinkers have a far greater rate of having diseases attributed to alcohol consumption than female drinkers [2]. However government policy and public awareness about the risks associated with alcohol consumption still remains relatively low [1, 3, 4, 5]. Lately some countries, such as France [1], Australia [6], Germany [7], and England [7] have started to regulate the alcohol providers to display either a warning message or a warning pictorial on the alcohol container label which is similar to the regulation of a tobacco container label [4].

Coomber and colleagues [6] found that warning message labels failed to effectively transmit messages related health issue, implying that warning message must receive attention and recognition from the people [4]. It is essential to design pictorials that allow people to recognize or be aware of the hazards and consequences of alcohol consumption [4]. On the other hand, some studies revealed that warning pictorials could communicate to people, allowing them to understand easily and effectively, in alcohol beverage [8] and in tobacco [9]. In tobacco container label case, there was a study reported that warning pictorials on cigarette label affect behavior of both smokers and non-smokers as they had more awareness about the risks associated diseases caused by smoking [10]. For non-smokers, the chance to initiate in smoking became less [10]. Thus, the warning message might not efficiently send a hint message to drinkers, yet the warning pictorial could communicate [6].

Warning pictorials are expected to knowledge in reducing or preventing accident and to increase human safety-behavior development [11]. There are 3 principles that must be considered in warning pictorial design. The first one is the characteristics of warning pictorials. Warning pictorials should be clearly identified its objective in terms of easily understanding, being attractive, and being acceptance by the audience [12]. Second is characteristics of receivers such as age, gender, occupation, and income [13]. The last one is characteristics of the situation. Jiamsanguanwong and Umemuro [14] found that people in positive affect condition perceived greater hazards from the warning signs than those in neutral affect condition or in negative affect condition. Another researcher also found that warning pictorial on tobacco label which contained positive affect condition was also perceived greater understandings from the people who noticed them than those labels in neutral affect condition or in negative affect condition [9]. The warning pictorial on the negative affect condition was perceived the greatest hazardous comprehension with the large arousal response [9]. These mentioned results indicated that emotion in warning pictorials or affective warning pictorials play an important role in human understanding or human information processing [15]. Thus, the purpose of this research was to design and validate emotional warning pictorials for alcohol container labels in order to increase awareness of risks from alcohol consumptions.

2 Methods

2.1 Participants

Forty Thai men participated in this experiment. Their age ranged between 18 and 44 years old $\left(\overline{X} = 23.95 \text{ and } SD = 6.36\right)$. Only male participants were included in this

research because Thailand survey result of alcoholic drinkers showed that the number of male drinkers was higher than the number of female drinkers significantly [16].

2.2 Stimulus Material

Affective Picture Stimuli. Ten International Affective Picture System (IAPS) pictures were selected based on the published valence and arousal rating score as neutral affect stimulus for male participants [17]. The valence scores ranged from 4.05 to 5.19 $\left(\overline{X} = 4.56 \text{ and } \mathrm{SD} = 1.54\right)$ and arousal scores ranged from 4.10 to 5.00 $\left(\overline{X} = 4.56 \text{ and } \mathrm{SD} = 2.02\right)$.

This set of pictorials was used to manipulate participants affective state as neutral before starting the experiment.

Warning Pictorials. Original ideas to design sixty warning pictorials were extracted from survey and brainstorming sessions. All relevant ideas from the survey for finding candidate pictorials were grouped together and were used as the source idea to designed warning pictorials into three affective state groups, positive, neutral, and negative (20 pictorials each). These pictorials were called as "before refining pictorials".

2.3 Apparatus

In this study, all stimulus pictures and warning pictorials were presented via Microsoft PowerPoint software with 42 inch full HD television. The experiments were conducted in the laboratory room with space of 50 m^2 (5 m $\times$ 10 m).

2.4 Measurement

The Self-Assessment Manikin (SAM) was used to assess the affective valence and affective arousal of the participants [18]. Affective valence scale was ranged from 1 (unpleasant) to 9 (pleasant). Affective arousal scale was ranged from 1 (calm) to 9 (excited).

2.5 Procedure

At the beginning, participants were given a set of documents, including a request for participation and a consent letter. The objective of the research, the instruction, and the purpose of emotion manipulation were explained and participants were also allowed to interrupt and have questions. Then, participants were asked to read and sign a consent form for their agreement and participation. One example pictorial (IAPS) was shown and Self-Assessment Manakin (SAM) questionnaire was distributed to participants for practicing. Then, they were asked to complete the Self-Assessment Manakin (SAM) questionnaire in order to rate their emotional valence and arousal (SAM I) after

viewing 10 neutral affective pictures which each was presented for 6 s, with 2-s interval between pictures.

After that, all sixty pictorials were randomly presented for 20 s, each with 10-s interval between pictures. Participants were asked to immediately response to SAM II in order to rate their emotional valence and arousal responses to each warning pictorial. The number of participants in each experiment was strictly limited not to excess five persons.

3 Results

3.1 Affect Manipulation

To confirm that all participants were in neutral state, they were asked to complete SAM I before experiment began. Participants rated their emotional state after viewing all 10 neutral IAPS pictures. The results revealed that all participants were in target state as neutral affective state. The valence scores ranged between 3 and 6 $\left(\overline{X} = 4.68 \text{ and } SD = 0.69\right)$ and arousal scores ranged between 1 and 9 $\left(\overline{X} = 4.15 \text{ and } SD = 1.66\right)$. These results indicated that all participants were successfully manipulated their emotion to neutral affective state.

3.2 Affective Validation

Two participants were identified as outliers $\left(\text{out of } \overline{X} \pm 3\,SD\right)$ and excluded from the analysis. Results of valence and arousal responses for each warning pictorial group were shown in Table 1. Positive warning pictorial group showed higher average valence score $\left(\overline{X} = 4.76 \text{ and } SD = 1.21\right)$ than neutral warning pictorial group $\left(\overline{X} = 3.95 \text{ and } SD = 0.97\right)$ and negative group $\left(\overline{X} = 3.06 \text{ and } SD = 0.62\right)$. For arousal scores, participants rated highest score for negative warning pictorial group $\left(\overline{X} = 5.84 \text{ and } SD = 0.66\right)$. Neutral warning pictorial group showed higher score $\left(\overline{X} = 5.09 \text{ and } SD = 0.56\right)$ than positive group $\left(\overline{X} = 4.96 \text{ and } SD = 0.43\right)$.

Table 1. Descriptive statistics (*Max*, *Min*, Mean $\left(\overline{X}\right)$, and Standard deviation (*SD*)) of valence and arousal scores of each warning pictorial group.

Before refining pictorials						
Warning pictorial group	*n*	Score	*Max*	*Min*	$\overline{X}$	*SD*
Positive	20	Valence	7.08	2.68	4.76	1.21
		Arousal	5.53	4.08	4.96	0.43
Neutral	20	Valence	5.50	2.34	3.95	0.97
		Arousal	6.11	4.21	5.09	0.56
Negative	20	Valence	4.16	1.74	3.06	0.62
		Arousal	7.42	4.82	5.84	0.66

The data collected from SAM II, then, were analyzed the differences among groups (positive, neutral, and negative) of each dependent variable (valence score and arousal score) by One-way analysis of variance (ANOVA). Results revealed that there were differences among valence score groups on affective warning pictorial conditions ($F_{(2, 57)} = 15.36$, $p < .001$) and among arousal score groups on affective warning pictorial conditions ($F_{(2, 57)} = 14.34$, $p < .001$).

From the post hoc analysis, shown in Fig. 1, the results showed that participants perceived positive warning pictorial group more positive in valence than other groups. Participants rated significantly higher valence scores for positive warning pictorial group than negative group ($p < .001$) and participants rated significantly higher valence score for neutral warning pictorial group ($p < .001$). On the other hand, negative warning pictorials had significant higher in arousal score than positive group ($p < .001$) and neutral group ($p < .001$). These results implied that affective warning pictorials in this experiment successfully evoked affective state on participants. The results revealed in this part of research also showed similar perception trend of affective warning pictorials which conducted on tobacco case [9].

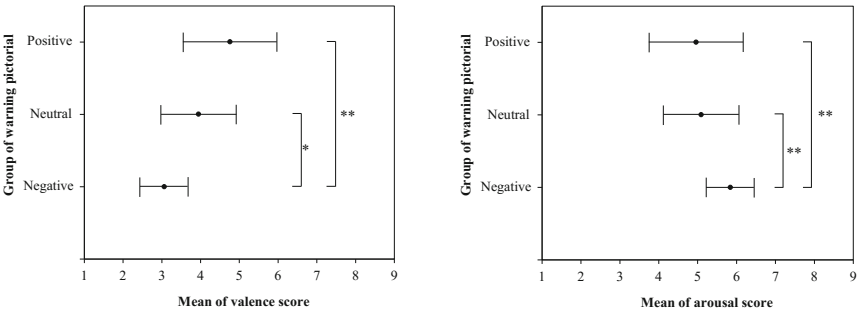

Fig. 1. Mean differences between affective warning pictorial groups (a) Valence score (b) Arousal score; *significant at $p < 0.05$ and **significant at $p < .001$

3.3 Refining Affective Warning Pictorials

Ten warning pictorials from each affective warning pictorial group were selected as the final affective warning pictorial sets (positive, neutral, and negative sets). The criteria used for selecting the final affective warning pictorials in each group was based on their target valence score [9]. The descriptive statistics of valence and arousal score of each warning pictorial group was shown in Table 2. Positive warning pictorials with top ten highest Mean valence scores among other pictorials in positive group and within the range of seven to nine scales were selected. These pictorials in positive group were related to health issue (no. 1, no. 4, no. 6, no. 8, and no. 10), family relationship (no. 2 and no. 7), and finance (no. 3, no. 5, and no. 9). All pictorials were presented in the positive way such as happy family picture. For positive warning pictorial group, two

pictorials were only chosen regarding mentioned criteria, however, data of all top ten highest Mean valence score pictorials were illustrated. Neutral warning pictorials with least absolute error of five valence score (neutral score on SAM scale) were selected. Warning pictorials in neutral group were about safety awareness at work (no. 1) and while driving (no. 2 and no. 6), harm to health (no. 4, no. 5, no. 7, no. 9, and no. 10), and two pictorials about action against law (no. 3 and no. 8). Negative warning pictorials with top ten least Mean valence scores were chosen. Warning pictorials in this group were presented as severe incidents (no. 3 and no. 6), severe health issue (no. 7, no. 8, and no. 10), and high possibility to commit suicide (no. 5 and no. 9), crime (no. 2) or death (no. 1 and no. 4). Descriptive statistic data of all pictorials after refining were shown in Table 3.

Table 2. Descriptive statistics (Mean $(\overline{X})$, Standard deviation (*SD*), and *Absolute error score*) of valence and arousal score of each warning pictorial group, after refining pictorials

No.	Warning pictorial group												
	Positive				Neutral					Negative			
	Valence		Arousal		Valence			Arousal		Valence		Arousal	
	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*Abs. error*	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*	$\overline{X}$	*SD*
1	7.08[a]	1.26	4.18	2.08	4.97	0.03	0.28	4.55	1.67	1.74	1.06	7.42	1.76
2	7.08[a]	1.53	4.26	2.10	5.24	0.24	1.67	4.21	1.45	2.11	1.18	7.13	2.02
3	5.71	1.51	5.18	1.67	5.32	0.32	1.19	4.55	2.14	2.13	1.14	6.29	1.99
4	5.61	1.33	4.92	1.65	5.45	0.45	1.72	4.61	2.18	2.37	0.91	6.71	1.87
5	5.47	1.81	5.18	1.84	5.50	0.50	1.20	4.47	1.84	2.55	0.98	6.32	1.89
6	5.45	1.57	4.87	1.85	4.42	0.58	0.95	4.92	1.44	2.79	0.81	6.03	1.94
7	5.45	1.43	4.08	2.01	4.42	0.58	0.92	4.63	1.63	2.87	0.99	5.95	1.61
8	5.08	1.58	4.74	1.86	4.21	0.79	1.76	5.39	1.65	3.00	1.29	5.87	1.68
9	4.97	1.61	5.26	1.78	4.18	0.82	1.27	5.13	1.46	3.03	0.94	5.61	1.48
10	4.92	1.12	4.58	1.54	3.87	1.13	1.09	5.00	1.77	3.16	1.08	5.39	1.87

Remark. [a]Selected as pictorials in the final set of positive group

Table 3. Descriptive statistics (*Max*, *Min*, Mean $(\overline{X})$, and Standard deviation (*SD*)) of valence and arousal score of each warning pictorial group, after refining pictorials.

After refining pictorials						
Warning pictorial group	*n*	Score	*Max*	*Min*	$\overline{X}$	*SD*
Positive	2	Valence	7.08	7.08	7.08	0.00
		Arousal	4.26	4.18	4.22	0.06
Neutral	10	Valence	5.50	3.87	4.76	0.60
		Arousal	5.39	4.21	4.75	0.35
Negative	10	Valence	3.16	1.74	2.57	0.47
		Arousal	7.42	5.39	6.27	0.65

4 Discussion

Twenty-two affective warning pictorials were selected as final warning pictorials, shown in Table 2 (only no. 1 and no. 2 for positive group). From the analyses, results confirmed that the final pictorials could evoke participants' affective states to specific target states such as positive, neutral, and negative emotions.

Two final pictorials in positive group were illustrated about family relationship. For example, an alcohol may harm to the unborn baby (no. 1) and family members gathering together on the dining table (no. 2). The pictorials implying the meaning of "alcohol may harm the unborn baby" received equally rating valence score to another pictorial implied "beloved people", yet lower in SD $(\text{no. } 1 : \overline{X} = 7.08, SD = 1.26$ and $\text{no.} 2 : \overline{X} = 7.08, SD = 1.53)$. These two pictorials might be positively sensitive to receivers as they appeared in terms of caring to the family members, love, and belongings.

Ten final pictorials represented neutral warning pictorials. These pictorials mainly presented the effect of drinking alcohol in terms of safety awareness at work and while driving, harm to health, and action against law. The results of arousal score in this neutral group $\left(\overline{X} = 4.75 \text{ and } SD = 0.35\right)$ and in positive group $\left(\overline{X} = 4.22 \text{ and } SD = 0.06\right)$ were not different, revealing that participants had similar level of arousal in viewing positive warning pictorials and neutral warning pictorials.

Another ten final pictorials were for negative warning pictorial group. In this warning pictorial set, the pictorials reflected the negative effect of drinking alcohol such as severe incidents, severe health issue, and high possibility to commit suicide or crime or death. A pictorial that could evoke negative affective state most was picture no. 1 (severe incident at workplace, the pictorial appeared with the death body). This pictorial had valence score at $\overline{X} = 1.74$ (SD = 1.06) and arousal score at $\overline{X} = 7.42$ (SD = 1.76), showing that this negative warning pictorial could truly evoke the target emotion of participants.

From this study, twenty-two final pictorials were proved to represent for positive, neutral, and negative warning pictorials. Moreover, they could evoke affective response on participants. Although, the result revealed that positive warning pictorials showed Mean score about 7.08 among other affective warning pictorials, the designer might consider putting the issue of family engagement such as strong relationship among family members and the responsibility for child, to design positive warning pictorials. The results also showed that pictorials of real situation with severe causality, such as persons in crime scene, a body in a severe accident, showed the least valence rating scores and high arousal rating scores comparing to others in the same group. This might possibly implied that negative warning pictorials could call attention from the participants since the Mean of arousal scores showed very high comparing to others. Thus, the comprehension test for each warning pictorial in affective group must be carried out in order to confirm the understanding of receivers after seeing the warning pictorials.

5 Conclusions

The present study aimed to design and validate emotional warning pictorials for alcohol container label. Twenty-two affective warning pictorials were selected as validated warning pictorials from sixty affective warning pictorials (groups of positive, neutral, and negative). The results revealed that these validated affective warning pictorials could evoke participants' emotion to target affective state, although, there were only two warning pictorials from positive group.

The limitations of this research were about the limited number of final warning pictorials in positive group, the gender of participants, and the comprehension of the warning pictorials. Designer might consider putting effort in creating more positive warning pictorials since positive warning pictorials provide better understanding in meaning [9]. Another issue was the pictorial comprehension. It is essential to provide warning pictorials that people can understand the meaning right away and have motivation to stop drinking alcohol after perceiving affective warning pictorials. Thus, the further research will be focused on comprehension study for these warning pictorials.

Acknowledgments. Authors gratefully acknowledge to the supporter, Pat-Arin Chanduen, for her invaluable inputs, suggestions, and supports based on her experiences in design affective warning pictorials in tobacco label throughout this research.

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Design Changing a Traditional Product in a Contemporary Way

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Abstract. Bobbin lace is a traditional handcraft from a small city located on the west coast of Portugal. Peniche has maintained this familiar activity throughout the centuries. The lace is still woven in the same way and with the same materials. Much in the same way, the finished product has suffered little to no change. Here, design is used to help prevent this product from falling into obscurity. To this end we introduce new materials into the practice of weaving bobbin lace. Breaking with the centuries-old tradition of using cotton, gold, silver and copper thread are used instead, as well as electrical wires. Employing an interventionist methodology we have obtained completely different results, maintaining the tradition of weaving but changing the final products. Presenting a traditional product in a modern and contemporary way.

Keywords: Product design · Bobbin lace · Tradition

1 Introduction

Peniche is a small city located on the west coast of Portugal. Due to its location, local activities are related to the sea. Fishing is one such activity which has been carried out over the years and was the most important economic activity of this locality for a long time. Fishing activity cannot be conducted throughout the year, and an off-season is thus observed. Similarly to fishing, another activity was also carried out: that of lace weaving. Both activities are related to the sea, in the relationship created between the stitches of the fishing nets and the stitches found in lace.

While the men went fishing, the women stayed at home and wove the lace. This activity, which at the beginning was a complement to the household economy, gradually became an important source of income [1].

"A piece of lace is an artistic composition expressed in twisted thread, just as a piece of wood-carving is the expression of the artist's idea in chiselled wood. Lace is not, like embroidery, an ornamental fabric; it is itself ornament. It is not the application of art to a craft; the whole pattern is the fabric, and the fabric is the pattern. It is this peculiarity that distinguishes lace from needlework and woven work" [2, p. 1] (Fig. 1).

To make bobbin lace, specific items are needed, such as the pillow, the pillow stool, the pins, the pricker, the outline (drawing used as a guide), the thread and finally the instrument that gives name to the lace, the bobbin. The bobbin is worked in pairs and the required amount of bobbin depends on the type of lace to be woven. There are

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_5

Fig. 1. Weaving bobbin lace. Source: the author. Photograph taken on 4 March 2015

pieces of lacs where hundreds of bobbins are needed. Most bobbins are popularly found in various types of wood. However, some are also made of ivory and other materials. Its shape and size may vary slightly. In the same way, each locality or country that has the tradition of weaving bobbin lace, employs a differentiated bobbin, appealing to creativity [3].

"Bobbins are made of bone, wood or plastic; some are highly decorated, others are plain and inexpensive. It is essential that the slim North Bucks bobbins are weighted with a rings of beads" [4, p. 2].

In the city of Peniche, few were the women who did not know to make bobbin lace. "(…) Some did it only for gracious entertainment, others did it because during the prolonged winters in which poverty loomed over the lives of the seafarers, the proceeds from the sale of the lace they wove were the sole source of income for their families" [5, p. 383].

This skill was learnt naturally, passed from mother to daughter, or through a close family member. There also existed schools where the mothers placed their children who were taught various activities like reading, writing, praying and weaving bobbin lace. Children were started on the bobbin lace from the age of 4 or 5 and after learning, they were required to do some lace production to help with family or school expenses. They received orders and actively participated in the local economy [5].

At the beginning of the 90s, vocational schools emerged. These schools were aimed at training experts in the entire process of weaving bobbin lace. The process involved drawing, creating the outline, weaving the lace and darning. Trade around bobbin lace took on great dimensions as the products were sold in several parts of the country through lace salesmen. These brought orders and delivered the products. This practice required the loyalty of some lace workers in order to satisfy demand [5].

2 The Process and Material

The bobbin lace was always woven with white cotton thread or sometimes in beige. The range of woven products was also fairly small. Lace workers made sheet folds, baptism towels and naprons. Bobbin lace was part of the of every bride's trousseau and was present in the house of the residents of this city.

However, bobbin lace did not keep up with modernity and it went through several stages of decline over the course of its history. The Municipality of Peniche intervened various times in order to avoid this decline from affecting the history of lace weaving. To this end, it organizes an annual outreach activity named "Lace goes to school" and directed at children, the "International Lace Show", where talents from different countries gather, it maintains the Lace School and it dynamizes protocols with some entities to promote innovation in lace.

3 Innovation

The economy has changed over the years. In these changes, we persistently observe the presence of innovation as part of the economic development process, in companies, in the creation of new products and in the creation of jobs [6].

For bobbin lace to remain present in the history and in the life of the people it is necessary to commit to innovation. The search for new materials that can be woven is part of this stage. Weaving bobbin lace using only cotton or silk thread does not result in products which are attractive to the younger generations. According to Stoneman "innovation in a 'global' sense is defined to occur when new products, processes, raw materials, and management methods are first introduced to an existing or new market" [7, p. 2].

The most important feature of the material to be woven is that it not have elasticity. They can be spun in various thicknesses and have the most diverse colours. Recommend the lace workers try the variety of threads that have appeared on the market in the last 10 years. Even if the weaving process is more complicated, the result may be more appealing. "These yarns have opened up new possibilities for lacemakers, taking the craft into its rightful place in the twenty-first century" [8, p. 10].

Through an interventionist methodology, we propose to replace cotton thread with gold thread, silver thread, copper thread and even electrical wires. The threads were chosen intuitively according to the thickness and malleability required for bobbin weaving. Through these tests, we intend to change the usability of bobbin lace. Currently, naprons, towels, some lace for clothing and some accessories such as brooches

are made. All made with 100% cotton thread. We would like to change this view and propose new products for the market. Thus inviting younger generations to become consumers of these new products. Since they are the most affected by the lack of demand for products with bobbin lace. In order for the lace to have continuity, it is necessary to captivate the younger generation with bobbin lace products, since they do not have the same preference as the older generation.

4 Results

4.1 Electrical Wires

The thinnest electrical wires available on the market were chosen in order to reduce the coarseness of the weave as much as possible. In this manner, we sought to ensure the delicacy of the lace was preserved. As a result we can describe that the electrical wires limit the number of stitches that can be woven. Due to low malleability, it was only possible to make a few stitches such as the braid, tessellation, row and embroidery stitch. The resulting weaves are larger due to the thickness of the threads. In the same way, the weaves could not be finished in the same fashion as traditional lacework (Fig. 2).

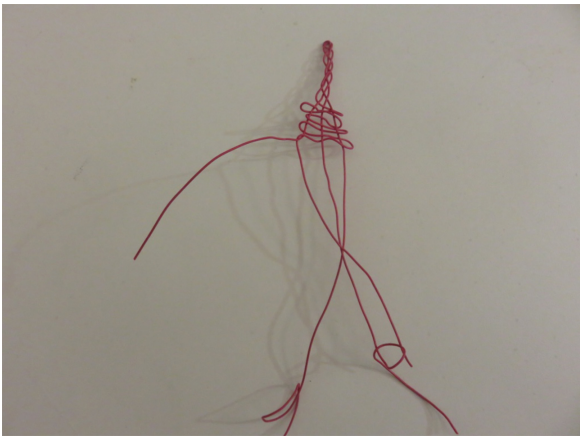

Fig. 2. Test performed with the electrical wires. Photograph taken on 7 July 2015. Source: the author

4.2 Silver Thread and Gold Thread

The chosen silver and gold thread has a thickness of 0.25 mm. The thickness was chosen in order to make weaving possible. It is not possible to make very twisted stitches with the silver thread and the gold thread, due to the rigidity of these materials. This way, limiting the weaving of the stitches. Possible stitches are open rows, closed

rows, “pãezinhos antigos” stitches, braids and tessellation. Even if a wide range of stitches cannot be woven, investment in product innovation is possible.

The use of gold and silver thread makes bobbin weaving more glamorous, placing it at a higher and refined level, and thus making it more appealing to market (Figs. 3 and 4).

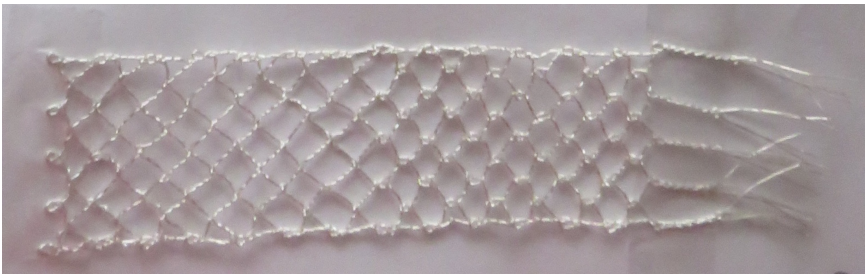

Fig. 3. Test performed with silver thread. Photograph taken on 20 April 2016. Source: the author

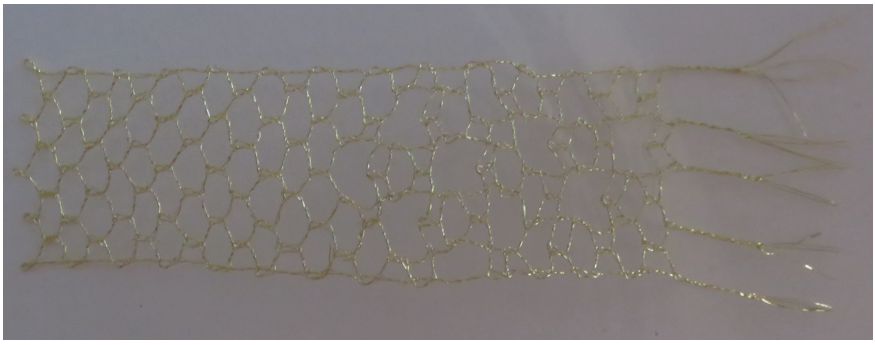

Fig. 4. Test performed with gold thread. Photo taken on 16 April 2016. Source: the author

4.3 Copper Thread

The chosen copper thread had a thickness of 0.20 mm. It is possible to weave some stitches from the range of traditional stitches used in Peniche. The chosen thickness makes the thread weak, easy to break and hard to twist. Copper is not as noble a material as gold and silver thread, making the lace more fragile when exposed to the elements. The thread may oxidise and become darker in colour, losing its natural properties. It should be used alone without the addition of glues and moisture capable of accelerating the oxidation (Fig. 5).

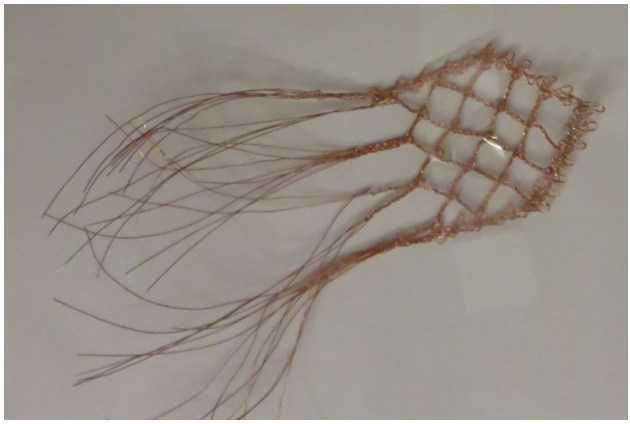

Fig. 5. Test performed with copper thread. Photograph taken on 8 November 2015. Source: the author

5 Work Proposal

5.1 Electrical Wires

Even though only a few stitches can be woven, we propose the development of larger dimension products. The products may be screens used in decoration, to separate environments, in decorative panels and on walls, or also, suspended nets, because the resulting product has a certain malleability which allows it to acquire shape.

In this manner, we will move beyond the small formats of the bobbin lace woven until the present days. As a solution to the difficulty in finishing the weaves, we propose the use of other materials as frames in the decorative panels, wood as a way to frame the screens and ropes at the ends of the nets.

5.2 Gold and Silver Thread

Weaving with gold and silver thread enables bobbin lace to be used in fashion accessories. Thus, we can create jewellery, such as bracelets and earrings from the tests performed. The use of these threads makes bobbin lace a refined object and the number of potential applications in objects and fashion accessories are limitless. Bracelets, earrings and brooches of the most diverse types and formats can be created – elegant products with commercial value.

We also propose that precious and semiprecious stones be included in the weaving of the lace. As an example we can cite the bracelets in gold thread with crystals. This effect will make the piece even more creative. Copper thread:

Even if the material is fragile, new products can be created from it, such as jewellery, or fruit baskets with a bulging shape, or even bulging objects to pack other objects.

We also suggest making a decorative candle holder that can also be woven with gold or silver thread. The empty spaces outlined by the lace allow light to shine through, transforming its environment with a decorative effect.

6 Conclusion

Through the proposal of the new products, woven with thicker materials, we will obtain products with bigger dimensions. However, this proposal abandons the usual small dimensions of the fabrics woven with the traditional thread. Thus obtaining innovative products for the market.

We know that the proposed products are not as easy to work with as cotton thread. They are stiffer and lack the same malleability. This process of changing materials requires lace workers to adapt. However, always doing the same thing will always produce the same result. We propose new products using the new materials, thus reaching out the younger generations. In this manner, products will become more appealing to market and also contribute to revert the current decline in demand.

Acknowledgements. Thanks to Capes Brasil for supporting Isabel Bieger Ph.D. at University of Lisbon.

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Emotional Engineering

Semantic Influence of the Radiator Grille on Vehicle Front Design in the Course of Current EV-Design

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Abstract. This study focuses on the semantic importance of the radiator grille of a vehicle. To this end, a methodological approach for grille categorization is presented. We generate vehicle front views with different grille designs and with various kinds of "no-grille designs" and use them for a detailed evaluation with test subjects. The results show a significant influence of the size and presence of the radiator grille in relation to the attractiveness of a vehicle. Furthermore, the characteristic shape of the grille influences the perceived attractiveness and sportiness of the vehicle front. At the same time, the grille design has a low influence on the aspects of perceived security, performance and comfort. We thus conclude that the grille design has a considerable influence on the effect of vehicle design. To this day it is still a long way to a broad acceptance of this new look of vehicle front design without a grille as an outstanding design element.

Keywords: Vehicle design · Electric vehicles · Aesthetics · Attractiveness · Design methodology · Semantic

1 Introduction and State of the Art

Hybrid and particular electric vehicles (EVs) are increasingly designed with purpose design. This means that the vehicle is build up as a complete new car [1]. Looking at the exterior design of vehicles with alternative drivetrains, new proportions are possible or even usual [2]. A methodical prediction of future developments of exterior vehicle bodies leads to the assumption that other proportions and dimensions are possible and expected [3]. With regard to the radiator grille as a design element, additional changes at the exterior are possible. Although EVs need radiator openings for cooling, an EV needs less cooling capacity in comparison to conventional combustion engine vehicles [4]. Less cooling capacity also leads to smaller aerodynamic drag [5]. Therefore, a substantially reduced radiator grille is possible as well as desirable for an EV. Current EVs already have a smaller radiator grille, like for example the Tesla Model 3 or the Hyundai Ioniq (Fig. 1). Additionally, many vehicles have radiator openings in the front spoiler. Using such openings, a vehicle with sufficient cooling air supply is feasible even in the absence of a separate radiator grille.

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Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_6

Fig. 1. Examples for vehicles with no-grille design: Tesla Model 3 [6] and Hyundai Ioniq [7].

Besides these technical aspects, the radiator grille is an important design element in transportation design. Especially regarding corporate design the grille is essential [8–10]. In the 70s, it nearly disappeared, but in the 90s the grille experienced a revival [11]. In combination with the lights, the grille has a high potential for representing the vehicle brand [12]. An eye tracking study actually showed the importance of the grille for visual perception [3]. The subjects in the study saw abstract vehicle illustrations in the oblique front view and the majority of them were focused on the area comprised of the grille, up to the driving mirrors and side windows. Especially for the vehicle front, anthropometric associations are likely. A study with 40 participants indicated that 60% saw a face in 70% of the vehicle patterns [13].

This begs the overall question whether it is necessary to keep the grille as a design element. Previous studies have shown that the radiator grille is a distinctive form element of the vehicle front. However, in view of the new technical developments in cooling design, the semantic relevance has to be questioned.

2 Methods

As a systematic approach, a method for grille categorization is presented. Based on this categorization we choose important grille designs and generate detailed vehicle illustrations. These vehicle patterns are then used for a detailed investigation with 65 subjects. In this study, the participants rated the vehicle pattern with a questionnaire for the aspects: attractiveness, sportiness, safety, performance and comfort. This chapter outlines the methodical approach as well as the preparation and execution of the study.

2.1 Categorization of Grille Design

The categorization of grille designs uses initial shape elements like circle, rectangle, triangle and trapezoid. These elements were morphed in length and width as shown in Fig. 2. In the following we select useful shape elements for grille design, which will be colored in anthracite. In the second step, we adapted the chosen shape elements to vehicle front designs. It was found that three different types of integration in the vehicle are possible: singularly, divided (one half/two half) and as an integrated design element.

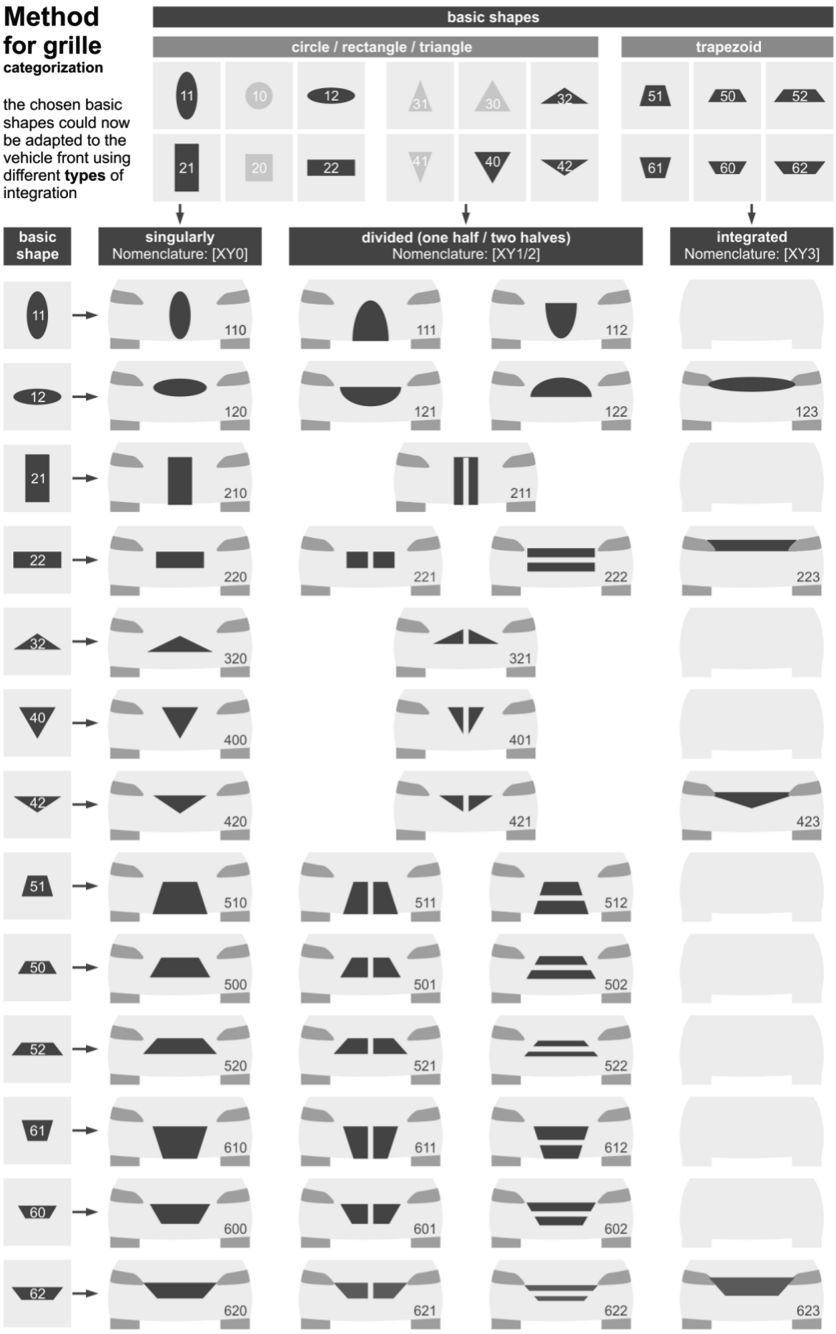

Fig. 2. Method for grille categorization with basic shape definitions.

2.2 Basic Vehicle Illustration

Given the possible grille designs, the most important grilles are generated for the study in an abstract manner. In the first step, a basic vehicle illustration has to be designed. The generated illustration shows the vehicle front with all important exterior elements. This view with a projected vehicle front is a common pattern for studies of the vehicle front [10, 13, 14]. For further studies a neutral design and appropriate degree of abstraction is indispensable [15]. This guarantees that the focus will be on the radiator grille design. Moreover, a generic, neutral design is independent of corporate design elements of the manufactures, so that the association with real vehicles can be reduced.

The dimensions of the illustrations resemble a combination of real dimensions of actual vehicles from the upper middle-sized class and the compact class. To achieve a realistic look we used shapes with joint lines and crease lines and by using depth effects like shadows. Details like headlights complete the realistic look but are shown in an abstract way. The lower air-inlet is designed in the style of the radiator grille, so that it can be recognized as a related design element.

The basic vehicle illustration facilitates vehicle front designs with different shapes of radiator grilles as well as vehicle front designs with no-grille designs.

2.3 Vehicle Pattern with Different Radiator Grille Designs

The variations of the radiator grille refer to grill size and shape. Additionally, vehicle front designs without a radiator grille are generated, the so-called no-grille designs.

For the radiator grille designs five especially important shapes of the categorization are selected and generated in the manner described above. These selected shapes reflect the actual diversity of radiator grilles on the market and are based on a detailed benchmark. The numbers for the chosen shapes are 121, 220, 520, 602 and 623. Combined with the three sizes: large (L), medium (M) and small (S) this results in 15 different grille designs.

The basic size (L) is based on an average radiator grille size as determined by a detailed benchmark. For this, we analyzed the size and shape from 26 actual vehicles from the upper middle-sized class and the compact class. The grille size value is a combination of the size of the lower air-inlet and the radiator grille size itself. In total it amounts to 3.77 sq ft. The size of the lower air-inlet is constant for all designs. The second design size is a reduction from the basic size by 0.2. This factor is based on the benchmark analysis, which yielded that 20% of the full radiator grille size is covered with plastic inlays. The small size is half of the large one and visualizes a noticeable reduced grille size.

In addition to the radiator grille designs there are five no-grille designs to represent possible electric vehicles. The characteristic shape details of these no-grille designs are generated with differently arranged and partly curved lines.

A detailed overview of the 20 different designs for the evaluation is shown in Fig. 3.

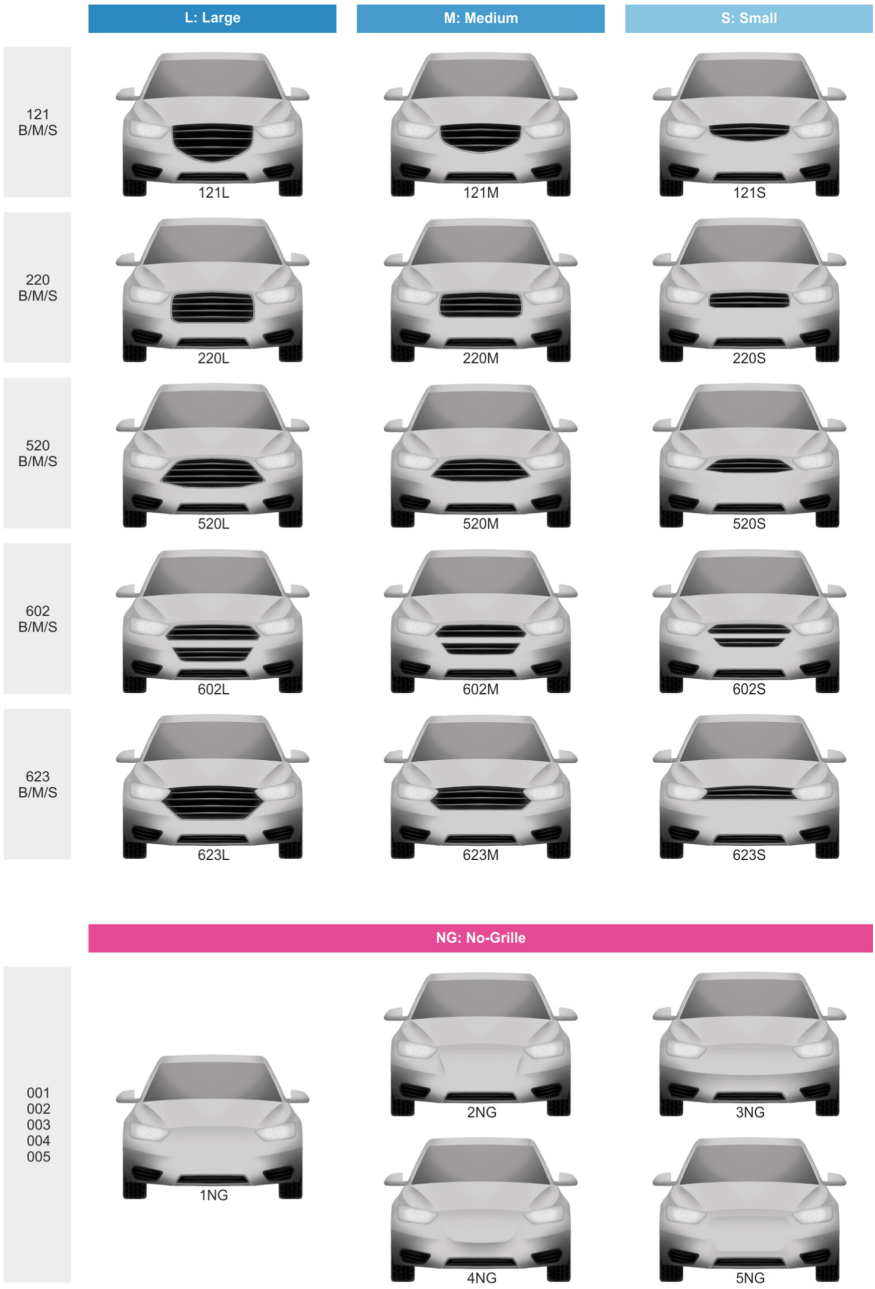

Fig. 3. Systematics of all vehicle patterns with large, medium and small grille design as well as no-grille design, illustration according to [16].

2.4 Experiment and Study Design

The design of the experiments includes all vehicle patterns combined with a question-matrix to measure the perception of and reactions to the different vehicle front designs. We measure the assessment with a 6-point Likert-scale (cf. [17]). The scale's range goes from "applies strongly" to "does not apply at all". The attributes are attractiveness, sportiness, safety, performance and comfort. The perception of each vehicle pattern is measured on a single page, which means that the subject saw each design pattern by itself during its assessment. The order of the design patterns was chosen at random and remained the same for every test subject. The design patterns and questions were presented with a printout to guarantee a constant quality of each illustration.

The study was performed as a personal interview to clarify all questions during the test. A pretest with four subjects revealed an ideal test duration of 15 min and confirmed the comprehensibility of the questionnaire. The sample of the study contains 65 participants, 43 male and 22 female, in the age of 18–63 years. All questionnaires were checked for completeness and accuracy by the interviewer.

3 Results

The following results show the participants' reactions to different radiator grille designs and illustrate the semantic influence. All replies are initially aggregated according to grille size and semantic aspects. Afterwards we analyzed the individual grille designs for each semantic aspect. Finally, the significant influence of grille size and presence were shown with a Friedman-Test [18] and a Bonferroni-Post-Hoc-Test with the Dunn-Algorithm [19, 20].

3.1 Semantic Influence Concerning Grille Size

The semantic influence in the context of radiator grille size is shown in Fig. 4, where the data is aggregated according to size and semantic aspects. It becomes clear that the grille size influences the overall attractiveness of the vehicle front. The majority of the subjects rather associated a large- or medium-sized grille with attractiveness, whereas the acceptance is lower for the smaller grille. Especially the no-grille designs yielded low attractiveness levels. The aspect sportiness shows similar results, but the no-grille design yields slightly better ratings. Looking at the aspects safety, performance and comfort, we can see few differences concerning the grille size. Even the no-grille designs have similar approval ratings.

The visualization in Fig. 4 focuses on the grille size. For a more detailed look at the different shapes of grille design, we now visualize the values for each grille design and each aspect in single Box-Plots.

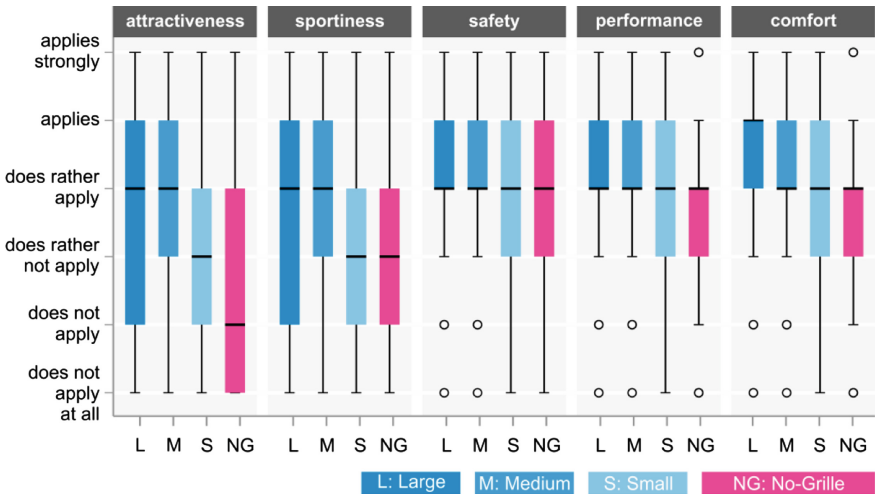

Fig. 4. Box-Plot with median for the approval ratings of all grille designs aggregated for the sizes large, medium and small and for the no-grill designs.

3.2 Semantic Influence Concerning Grille Shape

The first detailed Box-Plot focuses on the aspect attractiveness (Fig. 5). All no-grille designs have obviously low approval ratings. The best design of all low rated no-grille designs for the aspect attractiveness is the no-grille design 3NG, which emphasizes the horizontal lines of the vehicle front. Although the aggregated box-plot yields lower approval ratings for smaller grille designs (Fig. 4), the detailed box-plot shows deviations from this tendency. For example, the trapezoid 520 or the divided trapezoid 620 show relatively high approval ratings. The overall best rated grille design is the medium, integrated trapezoid 623M. The worst vehicle pattern with a radiator grille is the small, rounded trapezoid 121M.

Concerning the aspect sportiness, the aggregated small grille designs and no-grille designs are assessed worse (Fig. 4). A more detailed look at Fig. 5 shows that, notwithstanding the no-grille design 3NG has not so poor approval ratings. The grille designs with integrated trapezoid 623 and the divided trapezoid 602 have higher values than the rounded trapezoid 121 and the rectangle 220. The integrated and divided trapezoids convey the most dynamic vehicle front design.

As described in Sect. 3.1 the aspects safety, performance and comfort present very similar approval ratings for the different grille designs and no-grille designs (Fig. 4). Looking at the detailed Box-Plots (Figs. 6 and 7) it becomes clear that the interquartile ranges are also very small, which suggests that the subjects did not want to rate extremely low or high values. In summary, the semantic influence of the grille designs concerning the aspects safety, performance or comfort is low.

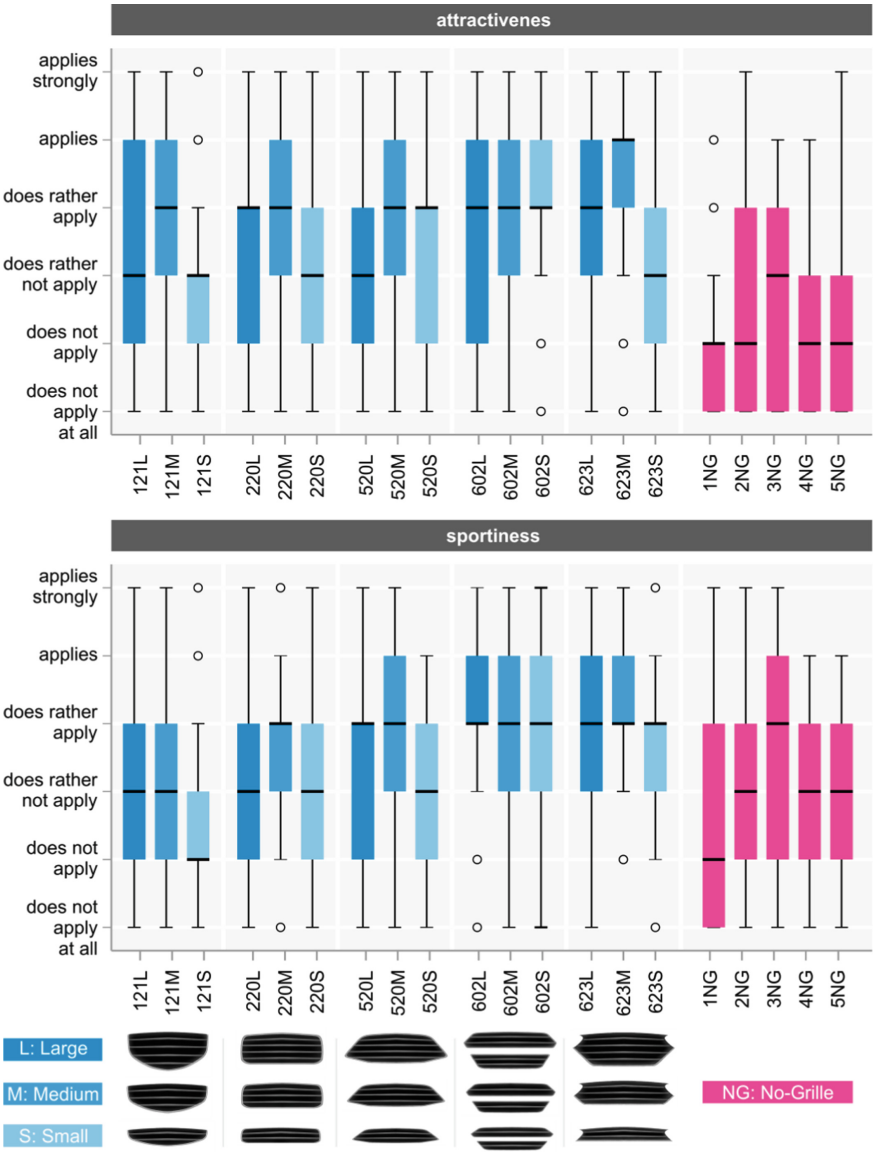

Fig. 5. Box-Plot with the medians for the approval ratings of the aspects attractiveness and sportiness.

3.3 Significant Influences Concerning No-Grille Designs

The approval ratings concerning attractiveness suggest pairs of grille designs with significantly different ratings. The remaining aspects suggest less significant pairs. To figure these out, a nonparametric test for the ordinal Likert-Scale is used. The Friedman-Test [18] analyzes the complete sample with all vehicle patterns. The overall

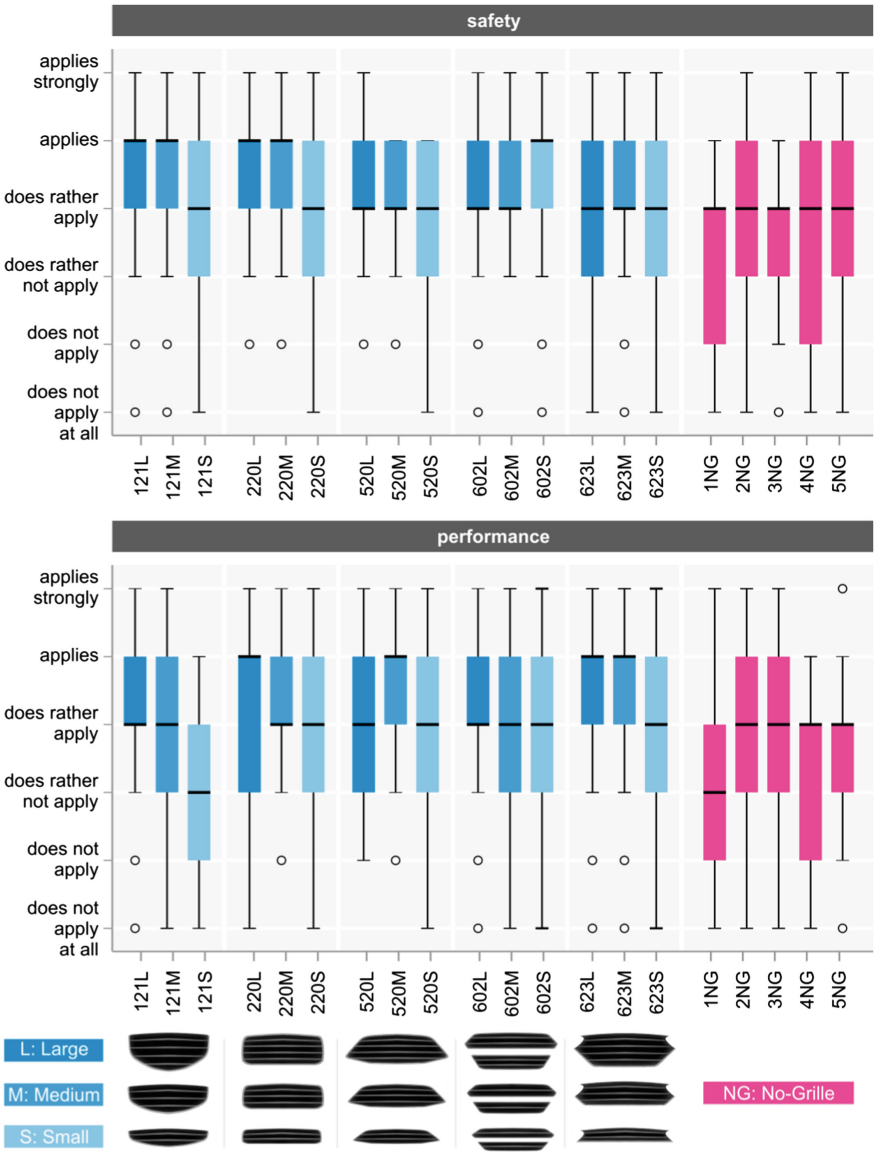

Fig. 6. Box-Plot with the medians for the approval ratings of the aspects safety and performances.

Friedman test yields significance for all aspects. This leads to the more interesting question: Are there any significant pairs of vehicle patterns regarding the approval ratings. For this, the Bonferroni-Post-Hoc-Test with the Dunn-Algorithm [19, 20] is used. The Dunn-Bonferroni-Post-Hoc Test yields 62 significant pairs for attractiveness, 51 for sportiness, 25 for safety, 38 for performance and 40 for comfort.

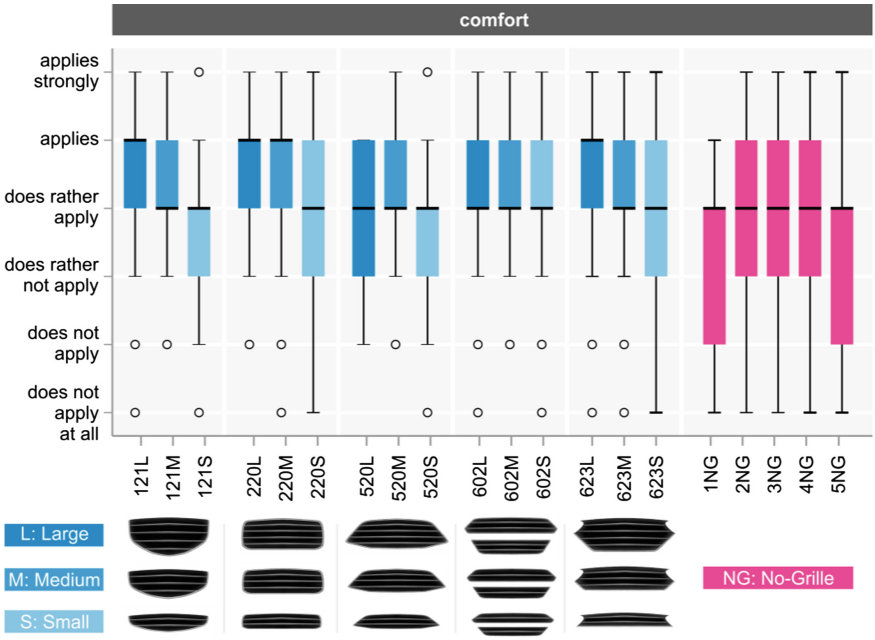

Fig. 7. Box-Plot with the median for the approval ratings of the aspect comfort.

Focusing on the acceptance of EV's no-grille designs, the significant results concerning attractiveness are specified in Table 1. The most significant pairs emerge between high-rated medium or large grille designs and no-grille designs. Some small grille designs like 121 or 220 also generate significant pairs with higher rated medium or large grille designs. The nonparametric test reinforces the very different perception of vehicle front designs with and without a radiator grille.

Table 1. P-values of the pairwise post-hoc-test for the aspect attractiveness. Values marked yellow are significant.

	121L	121M	121S	220L	220M	220S	520L	520M	520S	602L	602M	602S	623L	623M	623S	1NG	2NG	3NG	4NG	5NG
121L		1,000	0,166	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,408	1,000	0,000	0,901	1,000	0,004	0,037
121M	1,000		0,017	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,000	0,124	1,000	0,000	0,003
121S	0,166	0,017		0,389	0,000	1,000	0,840	0,000	0,295	0,000	0,000	0,000	0,000	0,000	0,664	1,000	1,000	1,000	1,000	1,000
220L	1,000	1,000	0,389		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,175	1,000	0,000	1,000	1,000	0,010	0,094
220M	1,000	1,000	0,000	1,000		0,055	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,000	0,001	0,016	0,000	0,000
220S	1,000	1,000	1,000	1,000	0,055		1,000	0,011	1,000	0,175	0,008	0,004	0,134	0,000	1,000	0,010	1,000	1,000	1,000	1,000
520L	1,000	1,000	0,840	1,000	1,000	1,000		1,000	1,000	1,000	1,000	0,618	1,000	0,073	1,000	0,000	1,000	1,000	0,028	0,222
520M	1,000	1,000	0,000	1,000	1,000	0,011	1,000		1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,000	0,000	0,003	0,000	0,000
520S	1,000	1,000	0,295	1,000	1,000	1,000	1,000	1,000		1,000	1,000	1,000	1,000	0,234	1,000	0,000	1,000	1,000	0,007	0,690
602L	1,000	1,000	0,000	1,000	1,000	0,175	1,000	1,000	1,000		1,000	1,000	1,000	1,000	1,000	0,000	0,003	0,057	0,000	0,000
602M	1,000	1,000	0,000	1,000	1,000	0,008	1,000	1,000	1,000	1,000		1,000	1,000	1,000	1,000	0,000	0,000	0,002	0,000	0,000
602S	1,000	1,000	0,000	1,000	1,000	0,004	0,618	1,000	1,000	1,000	1,000		1,000	1,000	0,783	0,000	0,000	0,001	0,000	0,000
623L	1,000	1,000	0,000	1,000	1,000	0,134	1,000	1,000	1,000	1,000	1,000	1,000		1,000	1,000	0,000	0,002	0,042	0,000	0,000
623M	0,408	1,000	0,000	0,175	1,000	0,000	0,073	1,000	0,234	1,000	1,000	1,000	1,000		0,097	0,000	0,000	0,000	0,000	0,000
623S	1,000	1,000	0,664	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0,783	1,000	0,097		0,000	1,000	1,000	0,021	0,171
1NG	0,000	0,000	1,000	0,000	0,000	0,010	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000		0,451	0,035	1,000	1,000
2NG	0,901	0,124	1,000	1,000	0,001	1,000	1,000	0,000	1,000	0,003	0,000	0,000	0,002	0,000	1,000	0,451		1,000	1,000	1,000
3NG	1,000	1,000	1,000	1,000	0,016	1,000	1,000	0,003	1,000	0,057	0,002	0,001	0,042	0,000	1,000	0,035	1,000		1,000	1,000
4NG	0,004	0,000	1,000	0,010	0,000	1,000	0,028	0,000	0,007	0,000	0,000	0,000	0,000	0,000	0,021	1,000	1,000	1,000		1,000
5NG	0,037	0,003	1,000	0,094	0,000	1,000	0,222	0,000	0,690	0,000	0,000	0,000	0,000	0,000	0,171	1,000	1,000	1,000	1,000	

4 Conclusion and Outlook

This study examined the development of the vehicle front design focusing on the design element radiator grille, with a particular emphasis on EV. To specify the semantic influence of the radiator grille, we detailed different grille designs with the help of a custom characterization method. The method starts with variations of basic shape designs and presents different ways of integrating them in the vehicle front. Based on these vehicle front designs, the most important grille shapes were chosen. We designed the vehicle patterns for the experimental study as front views in an abstract way, varying the grille design in size and shape. The study with 65 participants revealed the semantic influence of the radiator grille on the vehicle front design. In summary, the attractiveness and sportiness are strongly influenced by the presence and shape of the radiator grille. The study also showed a significant influence of the presence and size of the radiator grille design on the attractiveness. The aspects safety, performance and comfort have less dependence on grille design.

In conclusion, test subjects in the study rejected designs where the radiator grille is absent and the shape of the radiator grille has a measurable effect on the attractiveness and sportiness of a car. Regardless of the fact that the attractiveness of no-grille designs was rated low in this study, the possibility of a modern appearance of the vehicle front without a radiator grille cannot be ruled out, an aspect which was not evaluated in this research. It should also be noted that the acceptance of no-grille designs could rapidly increase with an increasing exposure to such designs, i.e. with more no-grille designed vehicles on the road. The study also showed that the kind of no-grille design plays a role for the semantic appearance of the vehicle.

It will therefore be interesting in which time frame and with which specifications the new no-grille designs occur. The study has shown that it will not be a sure-fire success and further research and creative processes are necessary to reach an aerodynamic front design with a vehicle front that will be perceived as aesthetically pleasing.

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A Mahalanobis Taguchi Approach to Human Motion Control

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Abstract. The problem of motion control is very difficult because the number of degrees of freedom is too large. There are researches using EMG, motion capture, etc. But these approaches are pursuing from the outside how we can control our motion successfully and they are analyzing the problem item by item. But we take the other way around and we attempted to pursue the problem from the inside and we introduced a holistic pattern based approach. The motion is represented as a pattern and successful motions are assembled and averaged to make up a standard pattern. And each time he moves, its pattern is compared with this standard pattern using Mahalanobis distance. If the distance is within an allowable distance, then his motion is successful, but if it exceeds the limit distance, it warns him that he has to adjust his motion and how much he has to.

Keywords: Human motion control · Somatosensory system · Proprioception · Pattern approach · Mahalanobis Taguchi System · Recognition Taguchi method · Quantitative evaluation

1 Introduction

Polanyi [1, 2] pointed out that there is tacit knowledge in addition to explicit knowledge, which can be approached rationally. Machine motion control is a typical example of explicit knowledge. System parameters are identified from the outside and motion is controlled rationally, based on this model. This is system dynamics and it has progressed remarkably.

On the other hand, progress on human body motion control is very slow, although there are many researches using motion capture, EMG (Electromyograph), etc. But human body motion control is very important as skills in many fields such as manufacturing, sports, medical operations, dancing, etc.

This paper proposes a new approach which is the other way around from traditional approaches. Traditional approaches observe the system from the outside and identify system parameters. In our approach, however, we pay attention to the internal sense of balance of humans and we do not identify specific system parameters. Instead, we represent movements as patterns and we control our motions based on these patterns. The analysis of human motion is very difficult because it involves very large degrees of freedom, but by introducing a pattern based approach, we can reduce the number.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_7

The greatest problem in human motion control is we cannot evaluate quantitatively how good our movement is.

In machine motion control, its trajectories are specified and the motion is repeated in the same way. But in human motion, humans move differently from time to time. Thus, it increases the number of the degrees of freedom and their motions are unpredictable. But humans keep their balance and they move as they wish, although their trajectories vary from time to time.

Although no quantitative measure is provided, we somehow manage to move as we wish. Therefore, it is presumed here that we have our intrinsic model and its parameters. Although physiology, etc. are progressing rapidly, we still do not know how it is working inside of us. Therefore, we introduced a pattern approach to help us recognize our motions more easily.

Still the problem of how we can evaluate our movements quantitatively remains.

Mahalanobis Taguchi System provides a solution to this problem. Mahalanobis distance reduces multi-dimensional information into one dimension and it can evaluate the difference of patterns quantitatively.

This paper describes the difficulties of human motion control and how we can characterize human motions and proposes a new approach to measure quantitatively using Mahalanobis Taguchi System.

2 Difficulty of Analyzing Human Motion

The difficulty of analyzing human motion is due to its very wide variability.

When we hammer down, we move a hammer in many different ways. But near the target object, we repeat our motion in the identical way. Thus, if we just note how we can hit the target object, we can automate the motion. But away from the target, we move in very different manners. This is what Bernstein [3] made clear using cyclogram (Fig. 1).

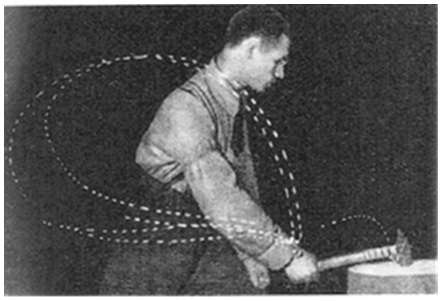

Fig. 1. Cyclogram of our motion

Bernstein pointed out that the difficulty comes from the very large number of degrees of freedom. We can understand from motion capture data for example, what are successful motions. But unlike machine motions, our motions are not reproducible. We control our motion by trial and error to move successfully. So, what is needed most for

us to control our motions is to provide a measure to compare each motion to let us know how we should control our motions.

Most of motion capture approach pay attention to the movements of our joints. Thus, it provides a clue to how we should move joints to be successful. But it does not provide any clues to how we should coordinate them. Such information about coordination or balancing is lacking. But if we look at these data as patterns, then it helps us to recognize how we should coordinate our motions.

The next problem is how we can measure quantitatively. To borrow quality management system terms, pattern representation solves the issue of validation. But we need to verify to secure the quality of human motion. Mahalanobis Taguchi System provides a solution.

3 Why Pattern Approach?

Our previous research on detection of emotion from face led us to this pattern approach. Detection of emotion from face has the same issues as those in human motion control. It is very difficult if we apply the conventional image processing techniques. But we demonstrated that if we use a pattern based approach. i.e., a cartoon face model, we can easily detect emotion from face [4, 5].

Our faces are composed of many muscles and they are different from person to person and even in one person, their movements vary from time to time. So, the application of image processing techniques itself is very difficult and time-consuming, even when the image does not vary. But in reality, the image of a face varies very extensively so that its difficulty is overwhelming.

But while we were struggling, we came to realize that we can understand the emotion of characters in cartoon very easily. Their faces are quite simple. Thus, we became aware that we can identify emotion if we note patterns. So, we simplified our face into patterns and we compared such a simplified real face pattern with the typical (cartoon) face pattern. In this way, we could extract emotions from face quite easily (Fig. 2).

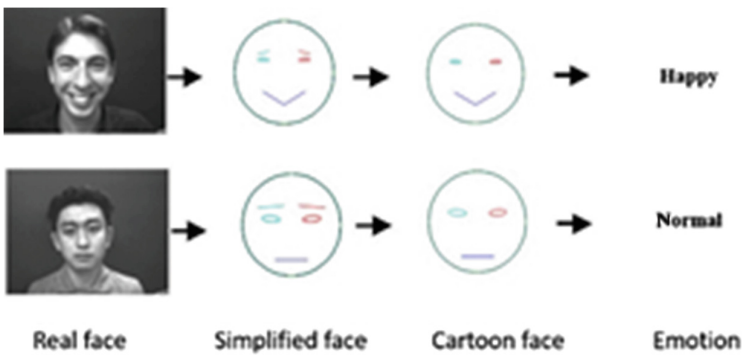

Fig. 2. Detection of emotion from face using cartoon face model

If we use patterns, we can recognize multi-dimensional information at the same time. Until then, we were trying to analyze rationally, i.e., using an explicit knowledge approach. Emotion is certainly verbalized but face expression and the word expressing its emotion are not corresponding one to one. Furthermore, in the case of human motion, the problem is more difficult. There is no word to express its movement. Thus, we realized that a pattern approach will be the best choice.

And if we do not care too much about details, then emotion can be detected easily, no matter how faces are different from person to person or from time to time. In fact, we observe a face holistically how the eyebrows, mouth, etc. move. We do not have to pay attention to particular details and its greatest advantage is we can recognize at once. We do not detect emotions by observing face parts one after another.

4 Mahalanobis Taguchi System (MTS)

Mahalanobis Taguchi System or MTS [6, 7] is a very unique technique for pattern recognition. It introduces Mahalanobis Distance (MD), which reduces multi-dimensional information into one dimension and enables us to compare different patterns quantitatively with one single measure MD.

The basic idea of MTS is to define Unit Space and to compare a sample with this Unit Space using Mahalanobis Distance (MD). MD shows how much a sample pattern is similar to the Unit Space (ideal pattern). If the MD of a sample pattern is smaller than this MD threshold, then a sample pattern is determined to belong to the Unit Space pattern (Fig. 3).

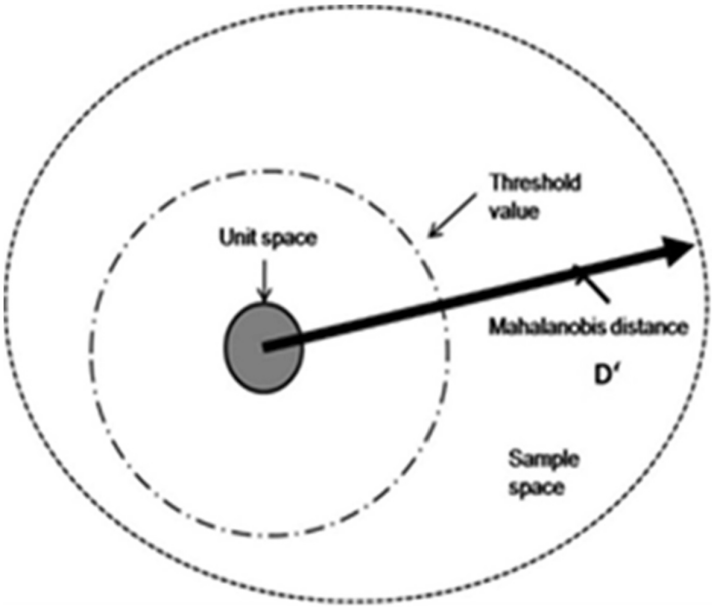

Fig. 3. Mahalanobis Taguchi System

For example, if we are going to recognize the image of a numeral, first we divide the imaged of numerals 0, 1, 2,…, 9 into pixels. We collect these unit space samples and average them and obtain Unit Space for 0, 1, 2,…, 9 (Fig. 4).

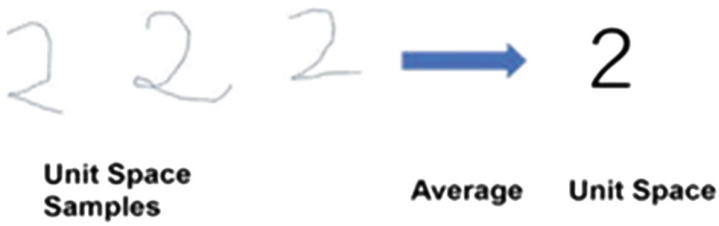

Fig. 4. How to obtain unit space

5 Recognition Taguchi (RT) Method

MTS developed from MT method to MTS method, and further to old MTA method, new MTA method, TS method, T method (1), T method (2) and then to Recognition Taguchi (RT) method. RT method is the newest which was developed very recently. RT method serves for the current purpose.

The procedures of RT method are as follows.

1. Determine feature items to define a pattern
2. Collect sample data to constitute Unit Space
3. Define Unit Space
4. Calculate Mean MD (MDmean) of Unit Space samples
5. Determine Threshold MD (MDthreshold) based on MDmean.
6. Calculate MDsample for a sample

To illustrate the procedures in the case of recognition of numerals, we compare the numeral image sample with these Unit Spaces and calculate their MDs. The smallest MD leads us to recognize what number it is.

In motion control, we have to coordinate our motion pattern so that it falls within this threshold value. In other words, MD provides an allowance for our movements.

The primary benefits of RT method are

1. We can prepare a large number of unit spaces.
2. They can be processed very rapidly.

For example, if we process numerals, we only need to prepare 10 (0 to 9) sample spaces. But in the case of body movements, we need to prepare a huge number of sample spaces, but they can be accommodated and processed rapidly without any mathematical difficulty.

In fact, we can process 10 s of thousands of unit sample spaces. This is very much different from other MTS methods. Most of them need to limit the number of unit sample spaces and their processing speed is slow.

6 Proprioception

Most pattern recognition studies are carried out from the outside. But what we are discussing here is a cognitive pattern approach from the inside.

Gallwey published a book "The Inner Game of Tennis" [8]. He is a famous tennis coach. But he does not teach how to recover from failures. So, someone asked him "Why don't you teach us how to recover from failures?". His answer was "Muscles are different from player to player. So, you have to learn by yourself how to recover from failures". Thus, he emphasized the importance of learning from failures and the importance of intrinsic cognition.

In the traditional engineering approach, we have been pursuing how to succeed, without paying much attention to how we learn from failures. In other words, our engineering has been very much goal-oriented.

AI is getting wide attention these days, especially Deep Learning. But this learning is not learning from failures. It processes enormous amount of data to identify the features. If we use the term of game theory, this is a complete information game.

The challenge of human body motion control is it is a game of incomplete information. Thus, we have no other choice than to proceed by trial and error or by learning from failures.

There are many simulators for motion learning. They provide an excellent environment very true to the real world, but how we learn to coordinate our movements are left entirely to us. Support for helping us to recognize how good or bad our motions are is not provided at all. They only indicate whether the motion is a success or failure. In mechanical parts, we can find control points which can be rationally processed so that we can coordinate motions of many different parts.

Thus, the issues of human body motion control are

1. The difficulty of identifying control points.
2. How balancing or coordination of these control points can be secured.
3. Providing a human with the quantitative measure for coordination.

Interestingly enough, although they discuss the same issue, brain scientists call it Motor Control. They observe how brains work. So, it is expected that in the future these researchers will reveal how our brains work to cope with body motion control.

Most probably, a pattern is created in our brain and brain parts collaborate to coordinate or balance body motions. Our somatosensory system, especially, the sense of balance plays an important role in such body motion control as swimming, bicycle riding, etc.

It is assumed in our approach that the problems (1) and (2) are solved internally within human, although its mechanism is still a black-box. Therefore, this approach focuses on the problem (3), i.e., how we can help a human to realize how much successful he is. In other words, what we developed here is a human-in-the-loop system with special attention paid to proprioception.

And it should be added that if we develop a device based on this idea and add it to simulators, then they will become more useful, because it will facilitate our learning in body motion control.

7 Summary

Human motion control is very difficult due to its tremendously large degrees of freedom and its extensive variability. Motion varies not only from person to person, but even in one man, it changes from time to time.

Most researches have studied human motion from the outside in an effort to identify system parameters and to establish a rational model. We paid our attention to the inside of us. To express it more accurately, we paid attention to somatosensory system or proprioception to be exact and we made our efforts how we can facilitate our recognition.

Our previous research on detection of emotion from face, which share the same issues as those in human motion control, demonstrated that a pattern approach is very effective to this kind of problems. And indeed, it works very effectively for helping us to recognize whether our motion is good or bad. But to improve our motion, we need a quantitative measure. Recognition Taguchi method, one of Mahalanobis Taguchi System, is very effective because it reduces multi-dimensional information to one dimension. It provides a degree of appropriateness of the motion quantitatively as Mahalanobis distance. Thus, if the system is introduced into simulators, it will help us to learn how we should coordinate our motion in a more effective way, because it makes it possible to evaluate our motion quantitatively.

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Eye-Tracking Analysis of User Behavior with an Active Display Interface

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Abstract. Various kinds of audio/video communication systems have been developed and are available today. These systems could offer an identical environment for remote communication just as a face-to-face meeting. However, two critical issues are pointed out. One is lack of existence for remote participants and the other one is lack of relationship with remote participants. This study proposes an idea of active display interface for remote communication system called ARM-COMS (ARm-supported eMbodied COmmunication Monitor System) to tackle these issues. The concept of an active display is to enhance the existence of a digital object shown in the screen by physical movement of the display. The idea of ARM-COMS comes from this concept, and enhances the existence of a remote person by mimicking the physical movement of the remote person using the active display. In addition to this basic feature, ARM-COMS shows the relationship with the remote person by an entrainment control of the active display. This research investigates how users interact with the active display using eye-tracking and motion tracking experiments, and gain insight into user behavior to study the effectiveness of ARM-COMS. This paper presents the initial results of entrainment control and discusses the future works.

Keywords: Active display · Entrainment · Human interface · Tele-presence robot · Robotic arm

1 Introduction

Tele-presence robots [1] offer a new environment to make video calls as opposed to the conventional video calls using a laptop computer. For example, Kubi [2], a non-mobile arm type robot, allows the remote user to "look around" during their video call by commanding where to aim at the tablet using intuitive remote controls over the web. Double [3] tele-presence robot makes it possible to roam around on a two-way video call without having to schedule a meeting beforehand. The issue of "lack of tele-presence" as a drawback of video call is expected to be solved thanks to the idea of these tele-presence robots technologies. However, the lack of feeling for relationship with the person or the robot is still an open issue.

The concept of an active display is to enhance the existence of a digital object shown in the screen by physical movement of the display [4, 5]. The idea of

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_8

ARM-COMS comes from this concept, and enhances the existence of a remote person by mimicking the physical movement of the remote person using the active display [6]. In addition to this basic feature, ARM-COMS shows the relationship with the remote person by an entrainment control of the active display.

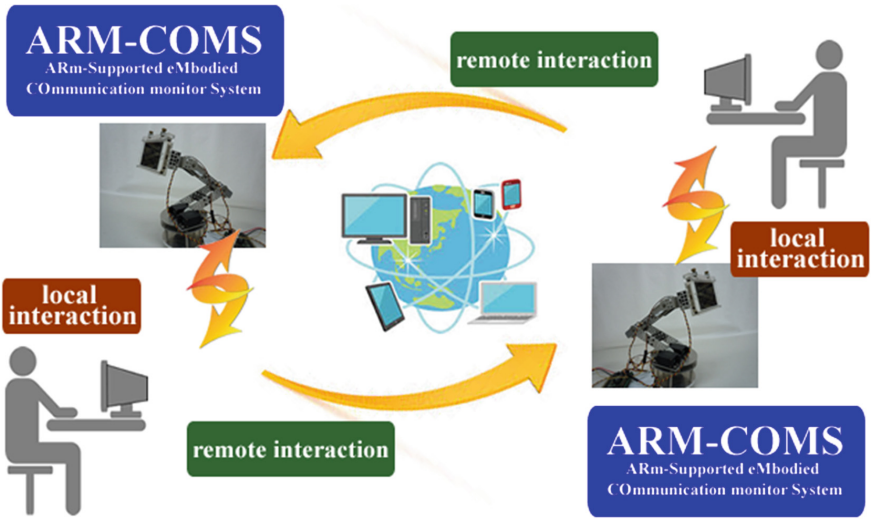

Fig. 1. Local/remote combinated interaction through ARM-COMS system.

This research tackles this issue using the idea of augmented tele-presence systems, which is called ARM-COMS, or ARm-supported eMbodied COmmunication Monitor System [7] as shown in Fig. 1. First, this paper overviews ARM-COMS, followed by the critical three functions under the two types of modes. Then this paper investigates how users interact with the active display using eye-tracking and motion tracking experiments, and gain insight into user behavior to study the effectiveness of ARM-COMS. What ARM-COMS is pursuing is not only the tele-presence feeling of a remote person, but also implicitly shows the relationship between the remote person and the local participants by way of the entrainmental behavior [8] of a table PC manipulation. This paper presents the initial results of entrainment control and discusses the future works.

2 An Active Display System: ARM-COMS (ARm-Supported eMbodied COmmunication Monitor System)

2.1 Basic Concepts for ARM-COMS

ARM-COMS is an autonomous robotic arm [9], which holds and positions a tablet PC, such as a smart phone, and performs as an avatar of a counterpart person over the phone as well as an ITC partner device for local use.

Just like a mobile telepresence [10] robot, when a user logged-on to a client ARM-COMS, it can mimic the motion of its master user on a remote site [11]. Through the network connection, the client ARM-COMS behaves as if it were an avatar of the master person [12], by mimicking the head movement of the person as well as autonomously interact with the remote person.

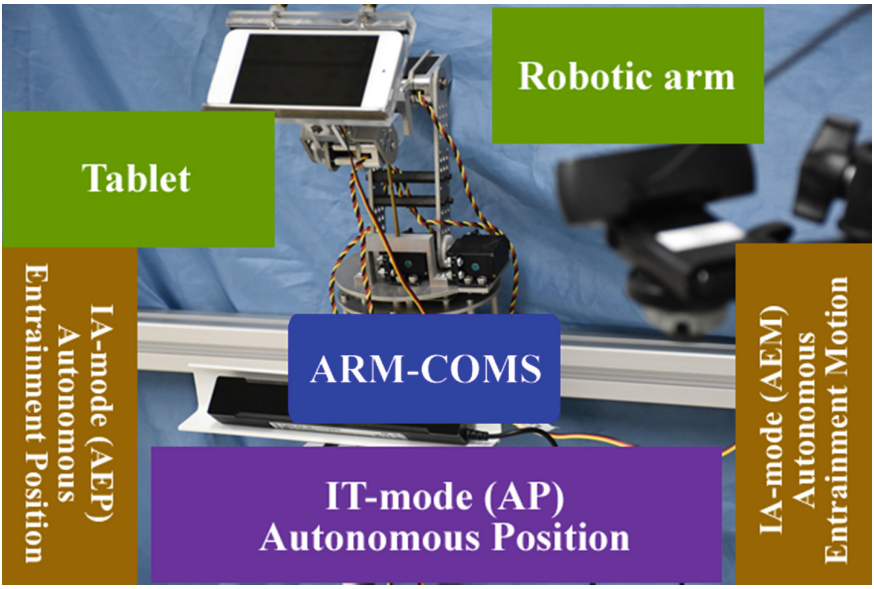

Fig. 2. Overview of ARM-COMS prototype system.

2.2 Overview of ARM-COMS System Architecture

Figure 2 shows the overview of the basic concept of ARM-COMS mentioned in the previous section and a physical prototype of the system. The physical components of ARM-COMS is a general tablet PC and a robotic arm. As for IT function on a local site, ARM-COMS works as an intelligent, attentive, and mobile ICT device, and supports user's ITC operation through friendly interaction. This feature of ARM-COMS is called Autonomous Position (AP) control in "IT-mode". ARM-COMS also works as an intelligent avatar on a remote site when a user logged-on to a remote client ARM-COMS during video conference communication. For avatar function, ARM-COMS performs its avatar role in "IA-mode", which is composed of two types of functions; namely, autonomous entrainment motion (AEM) and autonomous entrainment position (AEP) functions.

In AP function of IT-mode, ARM-COMS performs autonomous position control, where a tablet PC on ARM-COMS autonomously and automatically approaches to the user without disturbing him/her when he/she needs it as if ARM-COMS understands its master user. Tracking the head movement of a speaking person in a remote site, ARM-COMS manipulates the tablet PC [13] as an avatar to mimic the head movement

of the remote person so that entrainment emerges as if the local person interacts with the remote person locally. ARM-COMS controls a tablet PC to dynamically locate an appropriate position in space and to explicitly represent the relationship with other participants, by sending non-verbal messages.

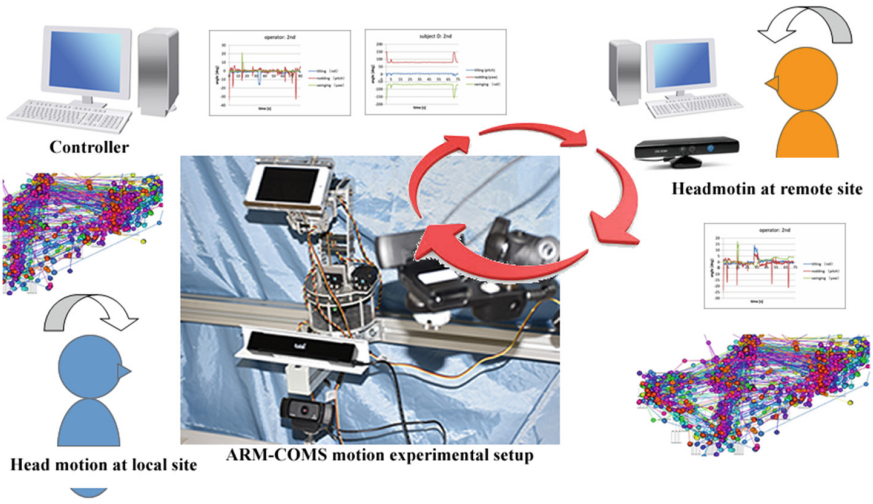

Fig. 3. Overview of ARM-COMS experimental setup for eye-tracking measurements.

3 Eye-Tracking Analysis of User Behavior Using ARM-COMS

This research investigates how users interact with the active display using eye-tracking and motion tracking experiments, and gain insight into user behavior to study the effectiveness of ARM-COMS. In order to do so, a prototype of ARM-COMS system is under development to study the feasibility of the ideas as shown in Fig. 3. The prototype system is designed based on a five axis robotic arm controlled by a microcontroller using signals from motion data received by general USB cameras at a local computer as well as a remote computer. The prototype ARM-COMS mimics the head motion of the connected user on a remote site, which enables the AEM function of ARM-COMS. AEP function on a local site is based on the combination of head movement signal on a local person and those signals of a remote person. Local interaction is used to narrow the time delay between the local and the remote sites.

Feasibility experiments of ARM-COM AEP/AEM function were conducted to compare the effect of ARM-COMS in video communication. The experiments collected user behavior data during video communication, which includes video recording data of head movement of the subjects, coordinate data of head movement during interaction, eye-tracking [14] data during interaction, etc. The collected data and its analysis will be shown in the presentation and discusses the feasibility of the propose idea.

4 Concluding Remarks

The paper presented an idea of active display monitor called ARM-COMS (ARm-supported eMbodied COmmunication Monitor System) to deal with the two types of issues, or lack of tele-presence and lack of relations. The basic features of ARM-COMS were presented with the two types of modes, or IT-mode and IA-mode, followed by the three functions featured on these modes. The future goal which ARM-COMS pursues is not only the tele-presence feeling of a remote person, but also the implicit feeling of relationship between the remote person and the local participants by way of the entrainmental behavior of a table PC manipulation using ARM-COMS.

Acknowledgements. This work was supported by JSPS KAKENHI Grant Numbers JP16K00274, JP26280077. The author would like to acknowledge Hiroki KIMACHI, and all members of Collaborative Engineering Labs at Tokushima University, and Center for Technical Support of Tokushima University, for their cooperation to conduct the experiments.

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Experimental Study on Color Preference and Visual Fatigue Against LED Lighting

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Abstract. In recent times, light-emitting diode (LED) lighting has been widespread in offices and manufacturing buildings, but for assembly operation in manufacturing situations, it has not yet been explored. In this study, we measure color preference and visual fatigue to evaluate LED task lighting for assembly operation. We conducted an experiment to obtain subjective responses to color preference and to measure visual fatigue under LED lighting. The participants were asked to assemble a gearbox model as a task under three different lighting conditions. As a result, lighting with high color temperature was rated with high visibility, fatigability, and low preference. On the other hand, critical fusion frequency, which indicates visual fatigue, was higher in lighting with low color temperature than in lighting with other conditions. This indicates that color preference as a subjective response discords from visual fatigue evaluated by biological information.

Keywords: Color preference · Visual fatigue · LED lighting

1 Introduction

In recent times, light-emitting diode (LED) lighting has been widespread in offices and manufacturing buildings. The sufficient illuminance for various work places and task types are specified in the joint ISO/CIE Standard or the Japanese Industrial Standards (JIS). Moreover, the color temperature and luminance of LED task lighting for video display terminal operation in offices are examined in several literatures [1, 2]. However, task lighting for assembly operation in manufacturing situations has not yet been explored. In the JIS, 750–1500 lx and 1500–3000 lx are recommended for precise and more precise visual operation in manufacturing buildings, respectively. However, the other characteristics of recommended lightings may affect a worker's visual fatigue and mental state (such as emotions or feelings), but this has not yet been examined in current literature. Therefore, this study aims to examine the relationships among visual fatigue and mental states under multiple LED task lighting conditions for assembly operation.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_9

In color science, emotional responses to color stimuli are referred to as color emotions. Color emotions are measured by using rating scales such as semantic differential (SD) scales, and they are often analyzed via multivariate analytical techniques such as factor analysis, principal component analysis, and multiple regression analysis. Through these analytical techniques, color emotions are typically divided into two categories: evaluative dimensions and descriptive dimensions [3]. Emotional scales such as "like–dislike" and "beauty–ugly" belong to the evaluative dimension category, while emotional scales such as "light–dark," "soft–hard," and "warm–cool," which are used to describe color appearance, belong to the descriptive dimension category. According to Sivik [4], while people are relatively concordant about attributes of color appearance such as "warm" or "cold," more emotionally evaluative scales such as "like" or "dislike" show a much smaller degree of generality. However, emotionally evaluative scales are still important for the assessment of a working environment. Therefore, we measure visual fatigue and color preference against multiple LED lighting conditions in manufacturing situations.

2 Preliminary Experiment

2.1 Settings and Conditions

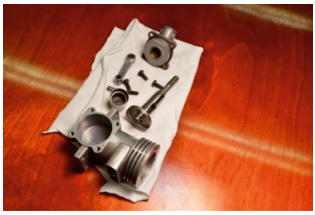
We conducted a preliminary experiment to confirm that LED task lighting influences a user's color emotions, including color preference. The participants were asked to evaluate the color appearance of assembly parts under an LED light (as shown in Fig. 1) and answer a questionnaire. The questionnaire was composed of seven SD scales that pertain to visibility, fatigability, conspicuousness, strongness, preference, beauty, and floridness. The participants included were three students.

Fig. 1. Circumstance of the preliminary experiment. The LED light illuminates the assembly parts as a task lighting.

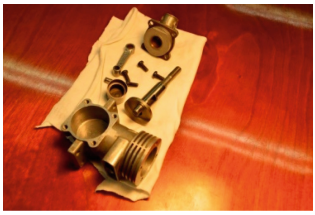
The LED light used in this experiment is a device that can control color temperature (SOL-1000P-M, Tsubosaka Electric Co., Ltd.). Two types of LEDs are implemented into this device while color temperature is controlled by adjusting their luminescence

intensity. In this experiment, we adopt three color temperature conditions: 5000 K, 4000 K, and 3000 K. Figure 2 shows the color appearance of the assembly parts under each of these conditions. Each color temperature condition was measured by a colorimeter and the illuminance was adjusted to almost the same level in the room by using a generic fluorescent lamp.

(a) 5000 K



(b) 4000 K



(c) 3000 K

Fig. 2. Color appearance of assembly parts illuminated by the lighting device.

2.2 Result

Figure 3 shows average SD scale results for each of the three conditions. The responses to the 3000 K condition indicate moderate scores in all the emotional scales. Furthermore, the responses to the 5000 K condition indicate a similar pattern as the responses to the 4000 K condition. The visibility, fatigability, conspicuousness, beauty, and floridness scores of both conditions are almost the same. However, there are differences found in strongness and preference scores. Specifically, the strongness of the 5000 K temperature is higher than the 4000 K temperature, and the preference of

the 4000 K temperature is higher than the 5000 K temperature. These results suggest that LED task lighting has a different influence on a user's color emotions for each color temperature.

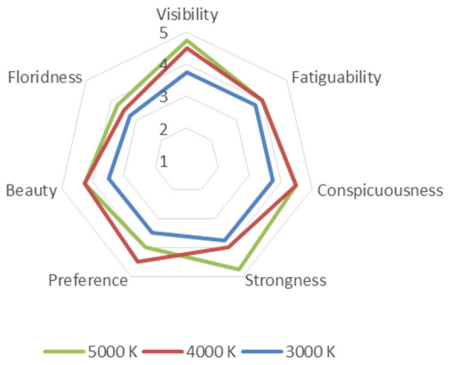


Fig. 3. Averaged values of subjective responses in preliminary experiment.

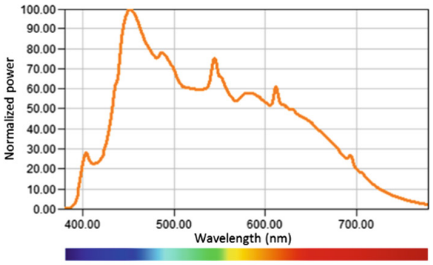
3 Experiment with a Physiological Function Test

3.1 Settings and Conditions

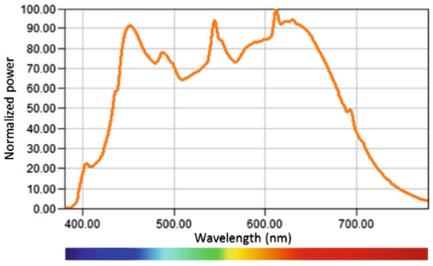
In the preliminary experiment, we found that LED task lighting affects a user's color emotions, and that each color temperature causes a distinct color emotion. This could be an aspect of a psychological reaction to the lighting. To confirm this physiological aspect of LED task lighting, we conducted another experiment with a physiological function test.

We conducted this experiment to obtain subjective responses on color emotions, including preference and to measure physiological visual fatigue under LED lighting. The color temperature conditions were 7500 K, 4500 K, and 3000 K. The spectral distribution of the 7500 K and 3000 K lightings exhibited peaks at around 450 nm and 650 nm, respectively. On the other hand, the spectral distribution of the 4500 K lighting has a trapezoidal shape with high power ranging from 450 nm to 650 nm. Figure 4 shows the spectral distributions of each color temperature. These were measured by using a spectral radiance meter (CS-2000, Konica Minolta) in the actual experimental circumstance. The luminance under a participant's hand was adjusted from approximately 350 cd/m^2 to 400 cd/m^2.

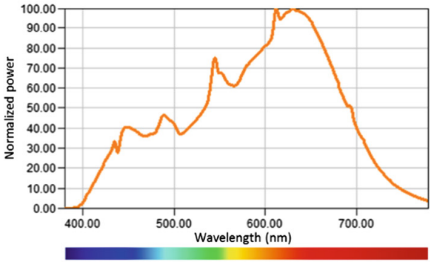
In this experiment, participants were seated at a desk which was surrounded by white screens in four directions. White light projected onto the screens was used as an ambient light, and LED lighting on the desk (which was the same as that used in the preliminary experiment) was a task lighting for an assembly operation (Fig. 5). The participants were asked to assemble a gearbox model as an experimental task under each of the three lighting conditions. The average time for all trials of the assembly tasks was 150.8 s. The participants included in this experiment were six graduate students (mean age: 22.67), and the subjective responses were collected using the SD



(a) 7500 K



(b) 4500 K



(c) 3000 K

Fig. 4. Spectral distributions of each color temperature.

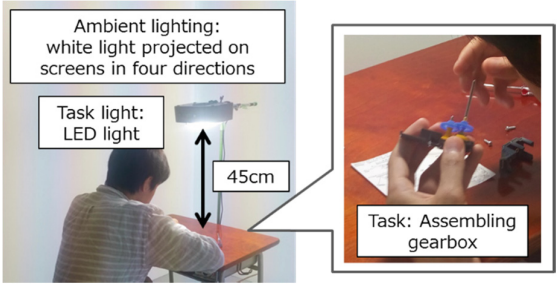


Fig. 5. Circumstance of the experiment with physiological function test.

method. The seven adjective pairs—pertaining to visibility, fatigability, conspicuousness, strongness, preference, beauty, and floridness—were used, which is the same as the preliminary experiment. The critical fusion frequency (CFF) was measured twice (pre-test and post-test) for visual fatigue using the flicker test apparatus (T.K.K.501c, Takei Scientific Instruments Co., Ltd.).

3.2 Result

Lighting with high color temperature was rated with high visibility, fatigability, conspicuousness, and strongness. Furthermore, lighting with middle and low color temperatures received high preference (Fig. 6). The responses can be divided into two patterns: high color temperature (7500 K) with high fatigability, conspicuousness, and strongness, and low color temperature (4500 K and 3000 K) with high preference, low fatigability, conspicuousness, and strongness.

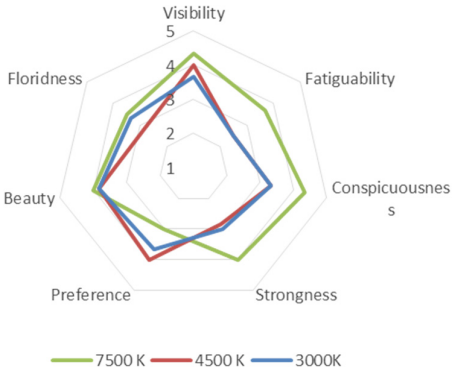


Fig. 6. Averaged values of subjective responses in secondary experiment.

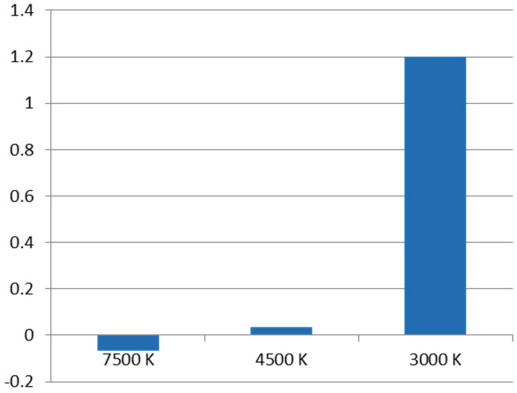


Fig. 7. Difference between pre-test and post-test CFF values.

The difference between pre-test and post-test CFF values are shown in Fig. 7. In this case, the difference is defined as the subtraction of pre-test values from post-test values. For example, a positive number indicates that the CFF drops to a lower value. Visual fatigue evaluated with the CFF indicates that the low color temperature condition (3000 K) gives a higher value than the other conditions.

4 Discussion and Conclusion

To elucidate the relationships between visual fatigue and mental states, we conducted a visual assessment pertaining to the color appearance of assembly parts and a physiological function test to measure fatigue.

First, the results of the visual assessment reveal at least two patterns of subjective response to color emotions. High color temperature in task lighting leads to high fatigability, conspicuousness, and strongness. On the other hand, low color temperature in task lighting leads to low fatigability, conspicuousness, and strongness, but it has a high preference. According to past literature, the conspicuousness and strongness belong to the descriptive dimension of color emotions and preference belongs to the evaluative dimension of color emotions. The results of this study seem to reflect the structure of color emotions. The subjective response of fatigability seems to be linked to both evaluative and descriptive dimensions. That is, task lighting assessed as low conspicuousness, strongness, and high preference has low fatigability when used in assembly operation.

Second, the results of the physiological function test using the CFF reveal that only task lighting with low color temperature leads to visual fatigue. These results of both the visual assessments and physiological function test indicate that the subjective response of visual fatigue discords from the physiological index. Moreover, the subjective response of preference also shows distinct characteristics from visual fatigue in a physiological manner. This is remarkable information for designing a working environment.

Unfortunately, the conditions of color temperature and the number of participants involved were limited in this experiment. Therefore, we will examine these results under more variable conditions in the future. Further empirical research focusing on subjective responses and physiological indices will lead us to a more precise understanding of color emotion and visual fatigue.

Acknowledgments. This work was partially supported by JSPS KAKENHI Grant Number 16K00367.

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Emotional Responses of the Disabled Towards Wheelchairs

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Abstract. Ergonomics should not consider the physical and cognitive aspects of the human personality only, but other aspects such as emotions and spiritualties in order to be accepted by people. In the 21st century, all designs are anticipated to consider emotions. The wheelchair industry in Algeria was initiated as a fully governmental industry, but lately, private manufacturing institutions have emerged. The aim of this paper is to answer the following questions: (1) What are the emotional responses of the disabled towards wheelchairs in Algeria? (2) Do these responses differ according to demographic characteristics (gender, and disability type)? A sample of 74 disabled wheelchair users were asked for their emotional response towards wheelchairs using Geneva Emotional Wheel. Results indicated that emotional responses of wheelchair users varied in terms of emotions and emotion strength. Also the emotional responses varied according to the type of disability and gender.

Keywords: Emotional design · Wheelchairs · The disabled · Algeria

1 Introduction

Despite the fact that many authors have given varied definitions of ergonomics [1, 2], the International Ergonomics Association has given a comprehensive definition as follows: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance" [3]. Though this definition views ergonomics as a science and an application, the applied side has almost dominated ergonomics for the last fifty years.

When emerged in 1949, ergonomics was mainly concerned with human anatomical, anthropometric, physiological and biomechanical characteristics in order to design

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_10

a workplace that fits man. The result was having more comfortable workplaces. This was called the physical ergonomics.

In the late fifties (1950s), especially when the logical positivism movement started to decline [4–6], when behaviorism reached its end [7], and when the cognitive movement flourished in human sciences [8], ergonomics in addition to the physical aspects of human beings, started paying attention to mental processes such as perception, attention, memory and other cognitive abilities. It wanted to fit the workplace not only in the physical aspects of man, but also his/her cognitive abilities. This was the cognitive ergonomics.

However, in the eighties and nineties, ergonomics started to move to the affective side of human beings. In addition to the physical and cognitive aspects of human being, ergonomists are considering emotions and mood of man. The idea is that a design well fitted to both the physical and cognitive aspects of man but neglects his/her emotional needs is doomed to fail [9, 10]. This has opened the door for emotions and mood to take place in both research and practice. The results were beneficial to ergonomics and other fields of research leading to the rise of emotional ergonomics [11] and emotional design [12].

Affective revolution is the concept that Barsade and Gibson [13], have used to describe what happened in human sciences in general, and in psychology in particular during the eighties and nineties. There was an immense interest in the emotional aspects of the human personality. The result being too many studies in the field [14–18], and many theories and models have emerged. For example mood management theory [19], affect infusion model [20], mood-as-input theory [21], three levels of processing model [12], basic model of product emotion [22], four pleasures framework [23], and three level hierarchy of goals [24].

In ergonomics, it has been found that products (equipment, tools, apparatus…etc.) evoke different emotions among people [22]. These emotions can either be positive (joy, interest, serenity, hope, gratitude, kindness, surprise (pleasant), cheerfulness. etc…), or negative (anger, rage, sorrow, grief, frustration, disappointment, discontentment, restlessness…etc.) If the product is able to stir positive emotions, it is usually loved [23]. On the other hand, if it stirs negative emotions, it is usually rejected [12]. At work, there are various equipment and tools that are part of workplaces. The worker is inclined to interact with those that he/she sees as pleasant, otherwise, he/she may pose negative attitudes towards them.

The idea that was common during the second half of the 20th century was that "the happier the worker, the more productive he or she is" [25, 26].

In a study, Erez and Isen [27], found that positive emotions enhance the performance of employees. In another study, Um et al. [28], studied the effects of positive emotions on learning performance. They found that positive emotions do not facilitate learning only, but also facilitate learning transfer to newer situations. In addition, the authors mentioned that the beautiful design of learning material helps increase positive emotions. Moreover, Kumar [29], found that emotional design of learning material, was beneficial to e-learning. Furthermore, Liew and Tan [30] studied the effects of both positive and negative mood on learning. They found that negative moods enhanced intrinsic motivation, but reduced learning transfer. While, positive moods improved intrinsic motivation and augmented learning transfer.

2 Defining Concepts

- *An affect:* is what an individual experiences in a particular situation. What he/she experiences can either be an emotion or a mood [31–33].
- *An emotion:* is an affect caused by a specific stimulus. It commonly takes place in a very short time (seconds or minutes). It can either be positive, or negative. In addition, it is usually accompanied by physical expressions mainly facial movements that convey the emotional state of the individual to observers [31].
- *A mood:* is also an affect but caused by a general/unclear stimulus. It lasts for a long time (hours or days). It may also be positive or negative. In addition, it is always expressed through body language, postures, and gestures [31].
- *Research problem:* Physically disabled people sit a lot of time on the wheelchair, especially those who work or study. Sitting so long a day, however being used to it, is not an easy task particularly if the chair is not well-designed. We believe that if the chair is not fitted to the physical, mental and emotional needs of users, it will not be comfortable and they will not enjoy sitting on it.

Research Questions. This study was carried out to answer the following questions:

1. What are the emotional responses of the disabled towards wheelchairs in Algeria?
2. Do these responses differ according to demographic characteristics (gender, and disability type)?

3 Method

3.1 Sample

A sample of 74 disabled individuals (males = 48, females = 26) who are dependent on wheelchairs in their mobility was contacted. 81% of them (60) are paraplegic, with a mean age of 33 years, and standard deviation of 7.12. However, 12% (09) are hemiplegic, with a mean age of 38 years and standard deviation of 5.36. Whereas 07% (05) were quadriplegic with a mean age of 29 years and standard deviation of 6.73. Subjects were chosen through a convenience sample that was obtained from the Algerian Federation of the Disabled Associations in the East (Setif City) and the West (Oran City) of Algeria. Each study participant signed an informed consent form prior to participation.

3.2 Tool

To collect the study data, the Geneva Emotional Wheel is used. This self-reported, categorical tool was developed by Scherer [34]. For reliability and validity of the tool, Sacharin et al. [35] consider it valid and reliable. In addition, it has been used by many other researchers [36–39]. With this tool printed on sheets, with demographic characteristics, the subject is allowed to identify the emotion or emotions he/she

experiences the time he/she is emotionally assessing his/her wheelchair. The number of emotions the tool comprises is 20 emotions: anger, interest, hate, amusement, pride, joy, pleasure, contentment, love, admiration, relief, sadness, guilt, fear, disgust, contempt, shame, regret, compassion, and disappointment.

3.3 Data Collection

Data collection was carried out in two forms manual (n = 32 sheets) and electronic (n = 42 sheets). Manual data collection was done through submitting the wheel sheet (Questionnaire) to the respondent in order to answer on the chosen emotion with the necessary intensity of the response. During filling the questionnaire, one of the researchers (L.B in Setif or B.M in Oran) was present to provide assistance if needed.

The electronic data collection was done through a tablet on which the respondent was to interact with an interactive digital version of the wheel. This procedure involved the creation of a portal where participants supplied their general information (demographics) like age and gender and also their emotional responses. Participants were able to simply click on the intensity of emotion and it gets highlighted; the highlights were coloured to ease usability of the system. The selection of emotional factors was not mandatory. Participants were free to choose what they thought was best to reflect their emotions. The data collected was stored in real-time in an open source database engine called MySQL.

The interactive Geneva wheel was made using HTML JavaScript (scripting language for browsers) and JQuery (a javascript library). The Geneva wheel was transformed to an image map with each scale of each emotional factor being an area for that map. A snippet of the code is below:

```
<map name="map">
<span id="anger">
<area shape="circle" coords="438,114,20" class="anger"
id="anger_5" name="anger_5"    href="#"/>
```

3.4 Data Analysis

Data analysis was carried out using the programming language “Python 3.5.0”. The data was read from the database using the module MySQLdb, and analysed accordingly.

Each row from the database was read as dictionary data type. For each factor an empty list was created to host the data obtained. The program would then loop through each row in the database and fill the lists.

In order to calculate the Mean and Standard Deviation the python library *Statistics* was used.

```
Import statistics
  statistics.mean(factor_name_list)
```

For the sum the python built-in method was used *sum(factor_name_list)*. For easier understanding of the result the library *"PrettyTable"* was used to textually visualize the result for each factor: a sample code is below:

```
table = PrettyTable(['Anger', 'Interest'])
for row_index in range(len(rows)):
    table.add_row([anger[row_index], Interest[row_index]])
```

For the manual analysis, the documents collected were manually inserted through the portal created hence allowing for all data to be grouped together and treated the same. The data was treated the same way the electronic analysis was carried out.

4 Results and Discussion

This study aimed to answer two questions:

1. What are the emotional responses of the disabled towards wheelchairs in Algeria?

   Results are displayed in Table (1).

Table 1. Results of the whole sample (n = 74 wheelchair users)

Statistic		Mean	SD
Years on wheel		10.3	8
Age		34	15.7
Emotions	Anger	4	0
	Interest	2.5	0.7
	Hate	2.5	2.1
	Amusement	1	1.4
	Pride	2	0
	Joy	1.5	0.7
	Pleasure	2	1.4
	Contentment	1.5	0.7
	Love	2	0
	Admiration	1.5	0.7
	Relief	1	0
	Sadness	2.5	2.1
	Guilt	2.5	0.7
	Fear	2	1.4
	Disgust	3	0
	Contempt	2.5	3.5
	Shame	3	1.4
	Regret	4	0
	Compassion	2.5	2.1
	Disappointment	2.5	0.7

Results indicate that emotional responses of wheelchair users varied in terms of emotions and emotional strength. They range from strong response (04) for anger and regret which are negative emotions, to weak response (01) for amusement and relief that are positive emotions. Thus, the emotional responses of individuals are predominantly of negative character.

One would expect that all or at least the majority of emotional responses would be positive as wheelchairs expand the spaces boundaries in which users move and assure independence. Besides, they help users to increase social interaction with others [40]. In addition, it has been mentioned that wheelchairs do not only increase the disabled ability to move, but also increase self-integrity [41], self-identity [42], self-esteem [43], [44], and self-efficacy [45]. Here, it would be a good thing to take into consideration the cultural aspects of disability. In developing countries including Algeria, many of the problems disabled people face, are to some extent associated with negative attitudes and bias of the able-bodied individuals [46–48]. These negative attitudes may be behind the negative emotional responses of the wheelchair users of this study. In developing countries, a lot of work is to be done to change the societal attitudes towards disabled in general and wheelchair users in particular so that inclusion (integration of people with special needs in the community) of the disabled is to be successful. This type of attitude and thinking will not help ergonomics to flourish in developing countries. Many authors [49–51] have shown that a good implementation of ergonomics needs positive attitudes towards it.

2. Do these responses differ according to demographic characteristics (gender, and disability type)?

Results are displayed in Table 2.

It can be seen that emotional responses of respondents vary according to type of disability and gender. For paraplegic males, interest was the common response as it got an average of (3.025) with an SD of (1.97). However, for paraplegic females, hate was the common response. It got an average of (2.95) (SD = 2.11). On the other hand, for hemiplegic males, the strongest emotional response was sympathy with an average of (3.5) and an SD of (2.07). But for hemiplegic females, the following three emotional responses were very common: disgust (mean = 3.3, SD = 2.8), contempt (mean = 3.3, SD = 2.8) and disappointment (mean = 3.3, SD = 2.8). Lastly, for quadriplegic males, sadness was the most common response (mean = 4.6, SD = 0.57). For quadriplegic females, both anger and regret were very common (mean = 4.0, SD = 0.0 respectively).

Although the emotional responses were more negative than positive, differential analysis provides more specific results than what was shown in the previous analysis. It seems that males are more positive about their wheelchairs than females. They respond to wheelchairs as they are their keys to the outer environment. They admit that wheelchairs help them to move, work and study. Without them, life would be very hard-hitting. On the other hand, females react negatively to their wheelchairs. They consider them a signifier of disability. They are usually embarrassed by the attention a wheelchair draws to them. This agrees with other authors' findings. Chaves et al. [52] found wheelchairs to prevent users from interacting normally with others. Also, Lanutti et al. [53] found females to be dissatisfied with their wheelchairs.

Table 2. Results of the wheelchair users according to the disability type

Disability		Paraplegic (n = 60)				Hemiplegic (n = 09)				Quadriplegic (n = 05)			
Gender		Males (40)		Females (20)		Males (6)		Females (3)		Males (2)		Females (3)	
Statistic		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Years on wheel		10.5	8.4	10.4	7.1	9.2	10.6	11.7	9.6	12.5	3.5	10.0	5.0
Age		34.2	15.4	31.7	17.4	43.0	11.7	34.3	5.5	29.5	17.7	27.7	15.0
Emotions	Anger	2.7	2.1	1.3	2.0	2.7	2.0	3.0	2.6	4.0	0.0	3.3	2.9
	Interest	3.0	2.0	1.2	1.9	3.0	1.8	0.3	0.6	2.5	0.7	0.0	0.0
	Hate	2.5	2.1	2.0	2.1	3.0	1.7	5.0	0.0	2.5	2.1	5.0	0.0
	Amusement	1.8	1.7	0.6	0.9	1.8	1.2	0.3	0.6	1.0	1.4	0.7	1.2
	Pride	2.1	1.9	1.8	2.0	2.2	1.8	0.3	0.6	2.0	0.0	0.0	0.0
	Joy	1.7	1.7	1.3	1.8	1.5	0.8	0.3	0.6	1.5	0.7	0.0	0.0
	Pleasure	2.2	1.7	1.3	1.5	2.0	1.1	0.3	0.6	2.0	1.4	0.0	0.0
	Contentment	2.4	1.8	1.1	1.7	2.5	1.5	0.3	0.6	1.5	0.7	0.0	0.0
	Love	2.2	1.8	2.0	2.0	3.0	1.8	0.0	0.0	2.0	0.0	0.0	0.0
	Admiration	1.9	1.7	1.1	1.3	1.2	1.5	0.0	0.0	1.5	0.7	0.0	0.0
	Relief	2.2	1.8	1.6	1.6	2.8	1.8	0.3	0.6	1.0	0.0	0.0	0.0
	Sadness	2.5	2.1	1.6	2.1	3.2	1.7	4.3	1.2	2.5	2.1	4.7	0.6
	Guilt	1.6	1.7	0.8	1.4	1.5	0.5	0.3	0.6	2.5	0.7	0.0	0.0
	Fear	2.2	1.9	1.7	2.1	3.0	2.1	1.7	2.9	2.0	1.4	1.7	2.9
	Disgust	2.2	2.1	1.4	2.0	2.3	2.0	3.3	2.9	3.0	0.0	3.3	2.9
	Contempt	2.0	1.9	1.2	1.8	3.2	1.8	3.3	2.9	2.5	3.5	3.3	2.9
	Shame	1.8	1.8	0.8	1.5	1.8	1.0	1.0	1.7	3.0	1.4	3.3	2.9
	Regret	2.0	1.9	1.0	1.6	3.3	1.2	1.7	2.9	4.0	0.0	1.7	2.9
	Compassion	1.8	1.8	1.0	1.7	3.5	2.1	1.7	2.9	2.5	2.1	3.3	2.9
	Disappointment	2.7	2.0	1.9	2.1	2.0	1.7	3.3	2.9	2.5	0.7	1.7	2.9

According to the Basic Model of Product Emotions by Desmet [22], the actual wheelchair users' emotional responses are the result of the interaction of three components: appraisal, concern, and product. The individuals first appraise the wheelchairs to see whether they are useful or not. Then, they may or may not give them a value depending upon whether they satisfy their emotional needs or not. Finally, how the product is seen? If it is significant, then a positive emotional response emerges.

This model suggests that wheelchair users have first appraised them to find that they are surely useful. Then, based on the obtained results, they most probably don't give them a value because they don't seem to satisfy their emotional needs. As a result, subjects consider their wheelchairs to be invaluable. Urgen [54], stresses that emotions are an important element for the success of any product. In this case, who is to blame for these results? The designers? The social attitudes towards the disabled? Or both? We think that changing these negative emotional responses towards wheelchair should be a collective fight every citizen should be involved with. Until all those who are interested in the handicapped make the required effort, this fight will never be a success.

5 Conclusion

Results of the present study indicate that emotional responses of wheelchair users especially females were generally negative (hate, disgust, contempt, disappointment, anger, and regret). Wheelchair designers are required to turn these negative emotions into positive ones. When trying to achieve this goal, designers ought to consider the emotional responses they get as a kind of feedback that gives them information about the malfunctioning of the man-machine system. Here, they may shed some light on wheelchair users' needs, especially emotional needs. When these needs are satisfied, people feel satisfied and happy. When unsatisfied, they feel unsatisfied and unhappy.

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Emotional Values of Ceramic Material for Product Design

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Abstract. Materials have been a substantial component in product design and they play a significant role in deciding the value of product and generating emotional impacts. This paper introduces a unique process of a ceramic product that was created in collaboration by two faculty members from Ceramics and Industrial Design program at Arizona State University in the USA. The primary objective of this paper is to discover the emotional value of the ceramic material on products and evaluate the level of emotion from users. Through this tangible ceramic-design pilot project, the overall form language, shape expression, design metaphor, and material aesthetic will be analyzed, and how those factors can generate design emotions to the consumers will be presented on the paper.

Keywords: Emotional response · Ceramic · Design · Material aesthetic

1 Introduction

People's emotional response is an essential part of connecting with consumer products. While this can be partly crafted by marketing, the product itself must be thoughtfully designed for its intended function and audience. It is oftentimes the story behind the consumer products that can generate an emotional response in people.

For example, tennis shoes can be purely functional and serve their purpose on a basketball or tennis court. However, Air Jordan basketball shoes come with a huge sense of the history and reputation associated with Michael Jordan, the professional basketball player and namesake of the shoe. One can feel a variety of emotions when wearing these shoes: a sense of validity, relevance, confidence, importance, athletic prowess, or superiority. All of these are emotional responses based on the design of the shoe and its affiliation with one of the best basketball players in the history of the NBA (Fig. 1).

Another example may be the "Dombo" cup by Dutch designer Richard Huuten [1]. This is a plastic cup with two unusually large round handles on each side of the cup. The cup was originally made for children because the large handles made it easier for small children to use. In addition, the cup comes in many different bright colors. The name of the cup references the Disney character Dumbo with his two large ears. It also references the term "domoor" which is the Dutch way of saying "idiot" in a playful way. This product became enormously successful, selling over a half million cups since it was put on the market in 2002. The main response people have had to the cup is that it makes them smile and feel happy due to the unusual design of the object (Fig. 2).

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_11

Fig. 1. Air Jordan basketball shoes

Fig. 2. Dumbo Mug Gispen, Plastic (2002) [1]

Some qualities can be more intuitively experienced based on the consumers' familiarity and history with an object. For example, consumer goods made specifically from ceramics can provide these emotional responses because of our life-long experience using things made out of this unique material. In many ways, ceramics has the ability to seamlessly blend into people's lives through its presence in domestic spaces.

Ceramic tile is an example of a product that many people live with in their homes but can sometimes overlook. It may simply be something that seamlessly blends with the architecture of a house. However, inside of a home in Mexico, there could be ornately decorated tile that references the culture and art of that region, so people may respond to it in a different way. They may feel a sense of comfort if the decoration was familiar, or they may feel a sense of pride if the tile was designed in a way that represented their culture (Fig. 3).

It is evident that emotional responses play a vital role in many consumer products, including ceramics.

Fig. 3. Handpainted Mexican talavera tile

2 Background

In 2013–14, Professor Chung and Shin who are the authors of this paper collaborated on a research project to design and create a ceramic design object that was realized through their respective areas of expertise; ceramic art and industrial design. Through the discussions and initial brainstorming, they decided to design a ceramic object that incorporated both hand-making skills and digital fabrication.

They decided to explore the design of a ceramic mountain made of translucent porcelain that would function as a light source. The prototype of the mountain was produced by hand forming and wire-cutting techniques from a solid mass of clay at a relatively small scale. The mountain was then 3D scanned, converted into 3D surface data, and then digitally manipulated in shape and scale in Rhino CAD modeling program. Once the digital model was finalized, it was 3D printed and a plaster mold was made from the printed model. At that time, the object was slip-cast in porcelain and fired to harden the clay and make it translucent. Finally, a light fixture was inserted into the hollow mountain form and a plastic cover for the light access opening was designed and 3D printed in plastic.

Throughout the research, collaboration was able to guide the direction of the concept of the object as well as determine the best experiments to pursue to reproduce the form based on what each of them understood about their own fields. Perhaps the most interesting aspect of working collaboratively was how they approached the design processes.

Professor Chung specialized in ceramic art and as a result, focused on a more unconventional approach to form when considering the mountain design. He was more conscious of the history of the ceramic material and its significance to the idea of what it represented. In addition, Professor Chung considered the modularity of the form and its ability to be presented in multiples. Overall, he was more curious about the formal qualities of the shape and how it would have a presence in a room when lit. These inclinations may have been due to him prioritizing his curiosity in how one would experience the object based on its formal and conceptual qualities.

Professor Shin specialized in industrial design and was focused more on the idea of how this object could be a consumer product. Functionality was of key importance to him as he considered the user experience. His priority during the design process was more about the transformation of an unconventional form into a form having conventional function. He was also more adept at considering solutions that could be imagined with respect to 3D printing processes. Professor Shin served a larger role as technician and engineer in completing the project.

3 Feeling vs. Impression

In assessing the difference between feeling and impression, feeling would be a more internal, emotional reaction versus impression, which would be more of a superficial observation of something. Feeling seems to derive from a direct experience with someone or something and is established once the experience is underway or completed. Impression seems to come from a more distant perspective where one may still

derive an opinion of someone or something, but it does not touch a person personally. Instead, it seems to happen without a deeper investigation or experience with someone or something.

Impression tends to preclude feeling, but they also can work together in sequence. One must have an impression of something in order to provide the psychological space for something to challenge an expectation, which yields feeling, or a more emotional response. Therefore, impression is based more on developing an understanding of something, whereas feeling is based more on a reacting to an impression of something.

These qualities of impression and feeling are important to the concept of the ceramic mountain light product the two scholars designed. The identity of the object as a recognizable form, a mountain, is important to develop one's impression of the object. One can see that the object is clearly a miniature model of a natural, geologic rock form. Therefore, one has developed an impression of what they think the object represents based on their past experience and understanding of the natural world. However, once one operates the mountain as a light, the translucency of the porcelain is revealed and one gets a sense of the material quality of the object through touch. The unexpected nature of a rock-like form, which is typically solid mass and dense, changing into something that is light and illuminating is antithetical to the idea of a rock and therefore creates an emotional response in the viewer. This could be one of surprise, delight, or peacefulness.

The way in which impression and feeling work together are important in determining how much one will be internally connected to an object outside of simply its functional purpose. This is what they attempted to achieve through their pilot study.

4 Emotional Responses in Ceramic Product

Ceramics has been used in numerous applications ranging from science to art. The aspect, which interests them the most is the emotional response incurred through an art/design object.

In considering the broad range of ceramic design objects that have the power to illicit emotional responses, they need to consider its unique range of characteristics: It can be hard, glassy, sanitary, rough or smooth textured, translucent, heat resistant and durable. It has the ability to conduct heat or cold, produce an acoustic surface and can be coated with glass (glaze) to render it water-tight. In addition, ceramics can occupy the domestic sphere in the form of dinnerware (cups, bowls, plates) and therefore have the ability to infiltrate the lives of people through their use (Fig. 4).

Fig. 4. Verge dinnerware of crate and barrel

These characteristics have been applied to ceramic objects in a variety of ways to illicit emotional responses. For example, there were Japanese porcelain cups produced in Arita, Japan in beginning in the 1800 s that had lithophane images of Japanese geisha on the bottoms of the cups. A lithophane is a photo-realistic image that appears on a translucent porcelain surface by altering the thickness of the porcelain in various parts of the image. This affects how much light passes through the porcelain and produces a photo-like image. As you can imagine, the user would drink the tea or sake from the cup and be pleasantly surprised by this photo-like image upon finishing one's drink. The novelty of this feature was unexpected and is one way the translucent material worked within the context of a drinking ritual to create an emotional response (Fig. 5).

Fig. 5. Vintage Japanese Geisha lithophane cup and saucer

Another example was from a project called The Democratic Cup created by potter, Ayumi Horie. The website's description of the project is as follows:

> "The Democratic Cup is a slow activism project that uses handmade cups to encourage people to become active and engaged citizens in democracy. We encourage person-to-person civil conversations about social and political issues. The cups have been collaboratively made by ceramic artists and illustrators based in the US who want to counteract the Trump administration's assault on civil liberties and civil rights. As a country, we need conversations and connections to reinforce the dignity and inclusivity of all Americans, regardless of race, religion, gender, sexuality, and culture. The Democratic Cup believes that these cups will act as agents of social change by generating positive political discourse. Join us in our effort to catalyze conversation and bring empathy back into politics" [2].

The various cups presented in this project are used to activate dialogue about the recent presidential election through the charged imagery on the cup and the activity of sitting down for a cup of coffee or tea with a friend or colleague. Below are examples of some of the collaborative cup shapes and images made by different artists (Fig. 6).

Fig. 6. The Democratic Cup collaborations, left cup: illustration by Ayumi Horie, cup by Birdie Boone. Right cup: illustration by Michael Corney, cup by East Fork Pottery

5 Ceramic Mountain

The ceramic mountain light product came out of a desire to collaborate and explore how an object can be born from merging the fields of art and design. Numerous discussions were conducted to see what kind of object would interest both of them. The idea for the mountain came out of Professor Chung's current body of ceramic art/pottery, which uses a cloud motif. The mountain was an extension of something from the natural world that also played a role in defining the landscape. These iconic forms from nature are immediately recognizable and have been so for thousands of years. There is also a sense of beauty and terror when contemplating mountains. Their majestic scale creates awesome and scenic horizons throughout many parts of the world, yet they are also to some extent, extremely dangerous and hazardous places to navigate.

The goal was then to develop a design process that would incorporate both of their respective areas of interest and expertise. Perhaps one of the biggest challenges was balancing an "artful" approach with a "pragmatic" approach in designing the object. However, this was also one of the benefits of the collaboration in that they were forced to determine an outcome where their individual preferences had to meet in the middle. They were both faced with conforming to a shared goal in merging the "artful" with the "creative" and as a result, ending up with an object that could only be born out of their combined efforts.

There were technical challenges constantly came up during the design process. Tests were conducted in numerous mold-making techniques ranging from using 3D printed models out of various materials, to actually milling the molds with a CNC router. It was evident that some materials (plastic) were better than others (Z-corp plaster) to produce models for their plaster molds. In addition, the short-run production of the lights was conducted in China, which was difficult considering the involvement of foreign collaborators (skilled artisans including mold-makers, slip-caster, glazers, kiln firers, etc.,) and foreign ceramic materials (porcelain, glaze). As a result, the porcelain clay would often warp when fired because of the way in which the model was designed. In addition, there was difficulty in sourcing a light fixture and bulb that were small enough to accommodate an opening on the bottom of model.

However, despite some of these technical flaws, the resulting objects were quite beautiful and reflected the amazing translucency of the Chinese porcelain. A special Chinese porcelain that could be cast very thin and white was used for the production in China. This was the same porcelain slip used by light cover manufacturers in Jingdezhen. Ultimately, they determined that the mountain lights would be more effective at a larger scale, and recreation of the same forms in a larger size was planned (Fig. 7).

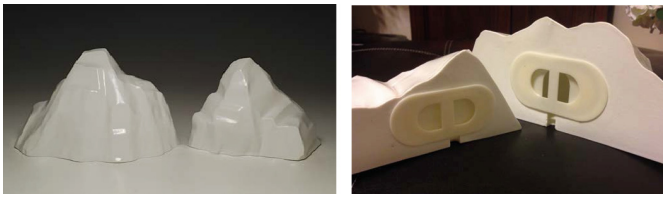

Fig. 7. Ceramic mountain light (Shin and Chung [4])

6 Design and Semantics

Ceramics has been used for millennia and it has played a vital role in the daily lives of humankind throughout history. Ceramic design has been represented by structure, color, decoration and material to reach expected functions of usage and aesthetics that represent cultural connotations and emotional experiences. Perhaps one of the first associations people have with ceramics is functional dinnerware; plates, bowls and cups have been used in the eating rituals of people around the world.

In the long history of pottery, pots have developed from rugged, rough clay to smooth, refined porcelain. It is the development of ceramics that brought upon a sense of connoisseurship within the history of pottery. Most notably, the development of porcelain by the Chinese in the 3rd century during the Han Dynasty was a significant discovery. The porcelain from China created a buzz of popularity throughout the world once it became a traded commodity during the Tang Dynasty (7th–10th Century). It became the material of choice for the imperial courts of China and the aristocracy throughout the world (Fig. 8).

Fig. 8. Chinese Han Dynasty in 3rd century

To this day, the sense of perceived "value" still exists in porcelain. Consider the "fine China" in your grandmother's hutch and how it is used only for special occasions. The same could be said for dining out. Eating off of a ceramic plate has more perceived value than eating off of a disposable paper plate. There is an inherent preciousness associated with ceramics that most people can identify with based on their familiarity and history with the material. A paper cup from Starbucks may function as well as a porcelain cup of tea, but most customers would be more careful with the porcelain cup and it could even elevate the formality of whatever experience they are having while using it.

Therefore, it could be argued that clay as a material can generate a unique emotional response when being used based on an individual's familiarity and history with this unique material.

7 Evaluation of Emotion

In the case of the Mountain Light, the creators are trying to generate a deeper sense of appreciation for the porcelain material out of which it is made, as well as allow for some contemplation over the long geologic history of the earth compared to the relatively brief moment in which the user is living.

Porcelain, if thin enough, has the unique quality of being translucent when projecting light in its path. The Chinese potters discovered this quality as they blended the perfect mixture of white Kaolin clay and petuntse stone, a material that would help melt and fuse the body of the clay to render it highly glass-like but not lose its shape through the heat of the kiln firing.

Translucency is not unique to this material as it can be achieved with numerous other materials such as paper and plastic, but porcelain occupies a unique place in history as a material that was coveted by people all over the world for its unique beauty, whiteness and translucency. Therefore, the material that was used for the Mountain Light was intended to create the same feelings of desire and draw out its beauty. The same emotional response was experienced by millions of people throughout the world when they first saw this material. This translucency was also the unique quality that related to the function of the design object, a light.

The act of using a porcelain object such as a porcelain cup is unique as well. Ceramic pottery is an object that can be viewed as a simple utilitarian object for consuming food and beverage, but within the scope of pottery, it has been developed into an art form where every aspect of a form can be considered when designing and creating the object. This is because ceramics has both a visual and tactile quality that can be experienced, and the tactility is the one aspect that can create the intangible part of how one is affected emotionally by the object. The ergonomics of a cup for example creates a dialogue with our hand and lips specifically. If those are designed with very specific qualities that enhance the function, users may have a much more intimate experience with the object or whatever circumstance they are experiencing while using the cup.

In returning back to the Mountain Light, this object could have been made from plastic or even paper, but the material was important to tell a historical and geologic story. The Mountain Lights were produced in the city of Jingdezhen in China, the birthplace of porcelain. The artisans in this city have used this material for generations, and it is made from the same Kaolin clay that was so desired around the world. It was said that the white Kaolin clay came from Gaoling Mountain in Jingdezhen. Gaoling was the namesake for Kaolin, so the selection for a mountain as a design object references the history of the material.

In addition, the object represented (a mountain) and the material used to make the mountain (porcelain) are both representations of geologic structures and materials. There is a conceptual connection between object and material.

8 Conclusion

In conclusion, the materiality of these objects played a role in telling the story of the product. In this case, the porcelain carried the historical significance of where it was produced as well as the beauty of the pure white color of Chinese porcelain. The fact that these design objects were produced in the birthplace of porcelain creates a sense of authenticity around the use of this material. In addition, clay or porcelain is a conceptually sound material from which to create the representation of a mountain. An earthen form is represented by earthen materials.

Also, the representation of a mountain as the shell for a light was important in creating an emotional response. Feeling or emotion comes out of an unexpected interaction with a person or thing, and in this case, the transformation of what is typically perceived as dense and solid, becomes hollow and light through its use. Irony can be a strong catalyst for generating emotion in a design. In this case, emotion could be one of surprise as a result of the mountain becoming illuminated, or peacefulness as a result of it representing a form that is often revered for its beauty in the natural world.

Finally, the sense of touch could also elicit an emotional response. Even though this light is not intended to be constantly handled, one would naturally want to touch the irregular surface of the rock-like surface of the mountain. One would discover that the surface is cold and glassy as opposed to how it would feel if it were made out of plastic or paper. The touch of porcelain can create a tactile feeling reminiscent of dinnerware and fine China, and therefore, one could associate it as a precious object similar to the dinnerware. The surface of the Mountain Light could also get warm and conduct heat from the light, just as hot tea would warm the surface of a cup. These associations create a familiarity with the material and thus, an emotional response, which may relate back to a previous experience using porcelain in another context.

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Research on the Space-Leaving Technique in Web Design

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Abstract. The space-leaving technique is a typical technique of freehand Chinese painting, which contains aesthetics and philosophical connotation, and has an important manifestation in the modern design as the art of the classic approach. Nowadays, there still lack the practice of guidance and norms of the space-leaving technique to the specific page of the various aspects. Based on the traditional philosophical ideas and aesthetic ideas, this paper analyzes the background and significance of the space-leaving technique in the web design. The method includes the rational design of web page visual architecture, page layout, interface color matching and using cognitive psychology to grasp the user emotional factors in four part. The aim of the paper is to combine the traditional Chinese painting art with the modern design, which could be used more scientifically in the modern network design process and improve the level of web designers.

Keywords: Space-leaving technique · Web design · Visual communication · Color · Layout structure · Cognitive psychology

1 Introduction

Web design plays an important role in web image and content delivery. It is the most direct representation of web contents and image. Web design is the production of network technology and design art. In web design, details determine success or failure. All aspects of a web page are details. During the process of web design, mastering audience's aesthetic psychology and habits will be good for improving the page views and enhance user experience. A good user experience enables users to be enjoyable when they are searching for information. Space-leaving technique will create a third dimension and construct a far-reaching mood so that it leaves more spaces for people to imagine. Designers can design more emotional page by using space-leaving technique in web design.

In literature, there are many articles concerning "space-leaving technique" and "web interface design". For example, in literature [1], the author analyzed web design from the definition and contents of art design in web design. In literature [2], the author analyzed the space-leaving technique in contemporary Chinese plane design from three aspects. He made people gradually understand the space-leaving technique in plane design through examples and analysis. In literature [3], the author analyzed the difference between modern plane design and traditional plane design from the expression,

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_12

operation, social function and other aspects. He also illustrated the relationship between its layout and color matching in detail. He put theory into practice, and applied it to the case of web design.

We can see that most researches are theories concerning webpage vision and web design principle itself, and ignoring the root reasons for the formation and application of space-leaving technique in modern design. This paper analyzes the development of space-leaving technique. Based on web design, this paper studies the application methods of space-leaving technique in web design, which have some significance on theoretical research and its practice.

2 Space-Leaving and Its Application in Web Design

2.1 The Fundamental and Concept of Space-Leaving Technique

The principle of space-leaving technique is similar to the principle of closure in "Gestalt" visual principle (Fig. 1). It is based on human's gestalt psychology, that is, people have special psychological phenomenon which people will sense the whole image or some relevant images when they just see part of an object. Designers need to screen out some parts that may represent the whole and guide people's imagination to improve their image in their minds. The most important thing for space-leaving technique is the extension of imagination.

Space-leaving technique is a concept with vast meanings. In literature, Space-leaving technique means "the shape and spirit of an object which are formed without any words"; in music, Space-leaving technique leaves space for people to sense the emotion, which is "right now, silence is better than words"; in visual arts, the author often leaves some Space-leaving areas to make the whole work become more harmonious and leave room for imagination. When design contents and fields are diversified, people can use the method of Space-leaving technique and create more works which are unique and artful.

2.2 The Function of Space-Leaving

The Expression of Space-Leaving in Traditional Eastern Art and Its Application in Modern Design. The art concept of space-leaving derives from traditional Chinese philosophy. For a traditional Chinese painting, clouds, water, fog, stone and other

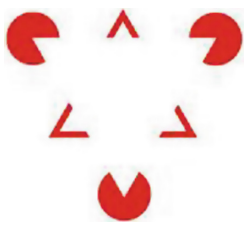

Fig. 1. Gestalt graphics

Fig. 2. Fishing along the Cold River Alone

scenes can be replaced by Space-leaving. This technique is more implicit than the method which author directly uses forms and colors to express it. When there is Space-leaving technique, the painting will be more harmonious and reduce the sense of oppression because of the fullness of a painting, and naturally attract readers' attention to the main body of the painting. In ancient China, Ma Yuan's (the Southern Song Dynasty (1127–1279)) painting, Fishing along the Cold River Alone, is a good example of Space-leaving technique. In this painting, there is only a boat with a man fishing on it, and other areas are Space-leaving without wind and water. But from this painting, people can feel the wide and misty river as well as the cold weather, which leaves vast room for people to imagine. It has a high aesthetic value (Fig. 2).

Another example is the Chinese diagram of the universe. It means the supplement of the black and the white, and the combination of virtuality and reality, It is the simple dialectics thoughts of confrontation and complementary that result in a change of artistic effect and an extension of the concept of color pun (decorated by using two complementary colors). Moreover, traditional Chinese calligraphy pay attention to being "sparse and thick", and being sparse is Space-leaving technique. The structure and overall layout of a word shall have its density so that it can achieve the effect of harmony and create artistic enjoyment.

Nowadays, after a long period of development and application, space-leaving technique has been deeply integrated into modern design. Many successful examples prove the charm of the art of space-leaving. Space-leaving technique not only increases the philosophical meaning of works, but also simplifies the design process for designers to some extent.

The Comparison between Space-leaving and Western Minimalism. Western minimalism used in landscape and architecture is similar to Space-leaving technique. The minimalism focuses on the whole feeling to simplify the building and pursue pure space. It is aimed at refining few structures and controlling material quality to coordinate the beauty and numbers by using, simplifying and abstracting geometry [4]. The classic theory of Ludwig Mies van der Rohe, "less is more", promotes simplicity and is against excessive decoration; a famous German Industrial Designer, Ditt Rums, who is one of the representatives of "new functionalism", puts forward some ideas: "a good design is little design" and "less but fine". Bauhaus argues that simple things often

Fig. 3. From the left to the right: salad material, salad in normal arrangement, Kandinsky's drawing, salad arrangement in reference to Kandinsky's drawing

bring more enjoyments for people and simplicity is over complexity. Moreover, the imprint of times on simple things is weaker. From ancient times, products and buildings using this idea and method are always popular among people [5].

As for the plate in western food, the application of Space-leaving technique is successful and experiences a long time. A psychologist in Oxford made an experiment. He used same material and put them in the plate in three different styles to test people's eating experience: (1) Directly put salad in the palate. (2) Piled salad up in normal arrangements. (3) Made salad in accordance with Kandinsky's painting (See Fig. 3).

As a result, the third salad was the most popular and people even believed that it was the most delicious so that they were willing to pay more money for the third salad. Therefore, the personality and beauty can increase its value to some extent. [6] Western food often use plates which are much larger than food, like strawhat-plate, pure and big plate and other plates, so the food is placed on the golden point or central point of the plate and arrange food in a beautiful way, and other places of the plate are decorated with vanilla or thick sauce. In this way, the food will be the focus and its value also increased. Now, most Chinese restaurants also use this. From the perspectives of "point, line and plane", the food—point, compared to the plate—plane, is especially significant. Combined with natural beauty, decoration beauty and interleaved, such food with rearrangement in plate is called artistic food.

2.3 The Meaning and Function of Space-Leaving in Web Design

Nowadays, with rapid development of globalization and information technology, such development is closely associated with the popularity of Internet. The newly established websites face opportunities and challenges at the same time. There is higher requirement for the standard and quality of web design. The rapid development of Internet and the spring up of new websites have higher standards and quality requirements for web design. With the fast promotion of information and the continuous improvement of computer language technology, website, as an information carrier, has been diversified. A large amount of information benefit users but users are hard to search useful information among this data world on the other hand. Optimizing the layout of web page can improve the efficiency of information transmission to users [7]. The information contents can be balanced by designing methods: when there is a large amount of

information, it's necessary to avoid these garish colors and redundant contents. Classifying complex information and arranging it in a hierarchical way, paying attention to its density and using simple background to highlight main contents; when there is little information, the use of Space-leaving technique can improve the sense of design and make up for the empty of few pages to improve the page readability.

In the layout of the page design, the correct use of Space-leaving technique can highlight important information to avoid overloading information. Information content is the core for web design regardless of the development of computer technology and carrier equipment. The final ultimate goal for web design is to achieve users' goals [8].

The use of space-leaving can increase the aesthetics and availability of webpage:

1. Aesthetics: web visual design is the most intuitive way to express web image, which attract users in the first time. The use of space-leaving technique creates the layering of a webpage among its words and pictures. As a result, they alleviate the visual pressure caused by a mess of information and give viewers pleasant feelings and unlimited imagination. It can maximize audience's imagination to better understand information. To achieve the balance of webpage, Space-leaving is used to show vitality and rhythm, so that all contents are arranged in a flexibility degree, giving audiences a sense of ups and downs and creating effects of virtuality and reality, thick color and light color, dynamics and statics, as well as lightness and heaviness.
2. Availability: The availability of web design is the basis of its aesthetics. Cognitive psychology studies have shown that people are more likely to notice those blanks when they are observing an object. Space-leaving can make a pause and emphasize important parts so that people can focus on the main parts. It can create a visual path: people firstly pay attention to the central elements and then move to weaker elements. Space-leaving can deliver the most abundant meanings and the most accurate information without wasting any elements so that audiences can obtain better user experience. Of course, concision is not simplicity. Web designers should have aesthetic ability that is highly generalized and concentrated. The generalization and reduction of the elements in interface design will little occupy bandwidth to make web surfing smoother.

3 The Space-Leaving Technique in Web Design

3.1 Establishment of Webpage

Web design is an "instantaneous art" where people only spend a few seconds on same information. If audiences cannot obtain required information, they will search for other information. The efficiency of information dissemination is very important. At the beginning of the website design, design structure is established by using space-leaving technique to create a unified atmosphere of visual communication, by which this design has a clear idea, forms a unique style and reserves an extend space for system. Space-leaving requires designers considering website structure from all aspects to achieve a comprehensive unification. Defining the cultural meaning of website as a whole, and the website will be more discernible.

3.2 Page Design of Webpage

The page elements of webpage are the same as plane design, in which the basic visual elements are point, line and plane [9].

Point. Point is concentrated and eye-catching. When an element is formed by numerous points, its weight sense will be increased to become the focus. For example, only put a few necessary elements in page design, rendering its background with a large area of simple colors or repetitive patterns. Highlighting the main elements with pure colors (Fig. 4). Different sizes of points can mark the strong and weak visual positions and their primary and secondary relationships, all of these can highlight the logic of the page; orderly and continuous points can guide audience's vision, while disorderly points can embellish details. The spaces around points can highlight products and brand logo. Simplify the decorations around the title and reduce the frame at the top of the page will spare more spaces for the whole page.

Line. Line is the production of continually spatial movement of points. The thinness and thickness of lines can give audiences different visual experience. Think lines play a role in emphasizing and guiding, while thin lines are decorations and separation. Straight lines have stronger advantages in symbolizing technology and speed in webpage with its solidness and strength, while curve lines better show its elegance or comfort with gentle experience (Fig. 5).

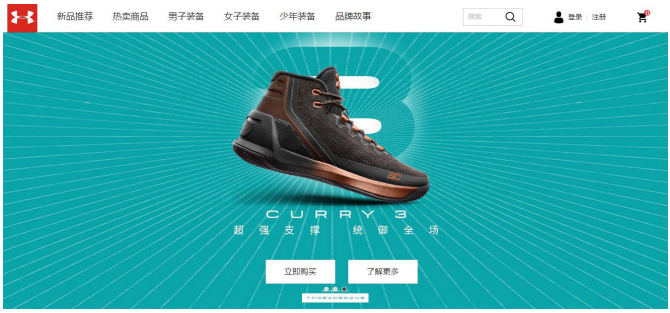

Fig. 4. Banner at the first page of under armour

Fig. 5. Banner 2 at the first page of under armour

Fig. 6. The webpage of MUJI products

Plane. Plane is the collection of lines. Among points, lines and plane, plane is the largest element which has distinct visual characteristics and emotional expression, so that it can easily form a visual area. Plane has many kinds of shapes, and more deformed graphics can be formed through different arrangements. It is the element that can appropriately reflect the function of space-leaving technique. The space-leaving of webpage background needs adequate spaces. This kind of space-leaving can be a large area of simple color, or a combination of regular graphics, or a picture with one color. For example, the web design of furniture prefers light colors, as a large part of clean color splits the page without any lines. Space-leaving technique is used in this kind of page structure to give people a sense of tranquility. Simple physical elements highlight main subjects of the whole page, so does the space-leaving parts (Fig. 6).

The page is divided into orderly sections through rectangular segmentation and different sizes of each section distinguish primary and secondary relations of these products. It is also an effective way for web design, which audiences will focus on larger areas or central area (Fig. 7).

The control of plane can not only help master the overall design of the page, but also effectively control details.

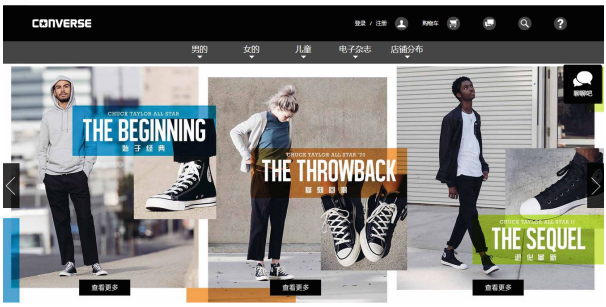

Fig. 7. Banner at the first page of converse

3.3 Interface Color Matching

Color matching is important in web visual design. Most human visual reactions and stimuli are from color [10]. Therefore, the basis of wed design is color. Color, as a basic visual element to convey design meaning, will achieve its artistic life through arrangement and matching. Color, itself, has its emotion. When people see some "warm-toned" colors, like red, blood orange, orange, yellowish orange and reddish violet, they often associate them with sun, flame, blood and so on have a sense of warmness, fervency and danger, and they also may be impulsive [11]. While some "cool-tone" colors, like blue, bluish violet and bluish green, they often associate them with space, snow, sea, etc., and often have a sense of coldness, rationality and calmness.

Through visual reflection, many psychological effects, such as excitement, calmness, warmness and texture, are achieved. Designers use colors to psychologically guide audiences to have deeper impression or psychological tendencies toward page information.

For a website, its visual design will not simply use one single color, nor use all colors. It is necessary to choose one or two main colors in accordance with its subject. For the whole visual design, its main colors play a role in guiding emotion and other subordinate colors. Based on main colors, adjusting other subordinate colors to avoid color mismatching in web visual design. Color matching is a professional skill for a web designer. Once main colors are determined, designer shall take the relation between main colors and subordinate colors into consideration, that is, the coverage and proportion of colors. In addition, it is necessary to consider those problems concerning the purity, brightness and appearance of colors.

3.4 Grasp User Psychology

The space-leaving in web design shall pay attention to some details to achieve the goal of parts pushing the whole. Repeatedly attaching great emphasis on headlines, stickers, patterns, without special effects like window frame, flow and color change. Using color lump rather than forms and lines to separate page so that the whole page can be more concise [12]. The size of text and picture shall be appropriate to avoid the extreme fullness of the page. Space-leaving technique can reasonably adjust the relations among different elements in the webpage.

Donald A. Norman mentioned that user's emotional experience was divided into instinctive layer, behavioral layer and reflective layer [13]. For a web design, after finishing instinctive layer and behavioral layer, designers shall consider reflective layer. It is web designer's responsibility to make users enjoyable while they are receiving information and obtain good user experience.

Virtuality and reality and space-leaving are several principles to follow aesthetics of form in web design. The more completed a work is, the little information it can express. It is often said that perfection is kind of imperfection. Psychologically, audiences indirectly participate in the creation of space-leaving parts. If there is no space-leaving, the extension consciousness will be loss.

4 Conclusion

This paper analyzes the current situation where space-leaving technique used in web design and the history of space-leaving technique so that it provides new ideas to web visual design.

The space-leaving concept in traditional Chinese aesthetics inspires contemporary web design and there is a long way to study it. Understanding and mastering traditional expressions of space-leaving technique and its design philosophy requires designers having deep knowledge and overall understanding on aesthetics. The integration and development of all cultures have to experience a long and complicated process so that designers should work together. We believe that the design concepts with national characteristics can spread and deepen national culture and provide new ideas and direction for international designs.

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Emotion and the Qualitative Side of Experience

The Pain and Pleasure of Autonomy: The Role of Negative Emotion in Serviced Reality Storytelling

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Abstract. Experience design often emphasizes pleasurable emotion. In this paper, however, we seek to explore the role of negative emotion in experience with the case of storytelling applied to "mixed reality" technology in service situations. While mixed reality is a technological term focused on media, we propose the concept of "serviced reality," which refocuses design on the needs and fulfillment of people who experience services across an organically unified virtual and real world. We introduce theories of storytelling to examine how stories connect negative and positive emotions in an overall flow that creates a sense of serviced reality. We discuss the role of negative emotion in the structure of autonomous experience based on Joseph Campbell's model of the Hero's Journey, with examples of student projects that applied this model to prototype service experiences.

Keywords: Service design · Experience design · Emotion and experience · Emotion and service · Service storytelling · Serviced reality · Mixed reality · Service accessibility · Service autonomy

1 The Role of Negative Emotion in Experience

Experience design often emphasizes creating positive emotions such as pleasure, a sense of fun, comfort, delight, or ease of use. Negative emotions such as displeasure, boredom, anger, sadness, or frustrations are interpreted as problematic states that need design intervention, or causes of stress that need to be eliminated from a designed experience. In reality, however, negative emotion always exists to some extent in our everyday lives and sometimes even enriches an experience as a whole. Mechanically avoiding pain can sometimes disintegrate experience and reduce the emotion to positive yet fragmented stimuli. For example, hiking up Mount Everest for many days is quite a painful endeavor, but once you reach the peak, all the pain turns into pleasure. If you used a helicopter to fly directly up to the peak, then the depth of the experience would not be the same. How do we explain then the role of negative emotion in an experience?

Daniel Goleman suggests that emotion helps us to be ready to act in events that we cannot handle with reason only. He says that negative emotions such as anger, fear, and

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_13

disgust in fact give us energy to act by bringing out the body's motor responses in urgent situations [1]. Therefore, these emotions are essential for human survival. Dewey suggests that emotion is not an entity but more of a "quality" that gives organic unity to the diverse parts of experience by moving and changing as its flow develops [2]. From this structural perspective, pain cannot be detached from pleasure – they coexist like the two sides of a coin. Together they form a magnitude that builds up as experience develops. This structural perspective resonates with the idea that negative emotion plays a key role in the theories of storytelling. The flow toward positive emotion at the climax and the sense of closure are built upon the driving force of negative emotion. In other words, negative emotion is a pre-requisite for positive emotion, without which the structure of experience cannot exist – no pain, no gain.

In this paper, we explore the essential role of negative emotion in the formation of experience structures that support people to autonomously discover and resolve needs. We present a model of service storytelling based on Joseph Campbell's model of the Hero's Journey [3]; and show how this model has been used in student projects. The Hero's Journey formalizes human experience into a circle that starts with an undiscovered need in the "ordinary world" and then crosses the threshold into the "special world" to fulfill the need before returning to the ordinary world. In this journey, negative emotion energizes the hero to move from recognition to action by successfully overcoming the barrier of crossing the threshold to the special world. Negative emotion also plays an essential role in creating a desire for the right to access the special world. Structured negative emotion transforms the meaning of access from that of physical navigation all the way to the philosophical notion of a human right.

2 Serviced Reality

We'd like to situate this study in the context of "serviced reality," which we propose as a framework of service experience that encompasses physical reality, augmented reality (AR), virtual reality (VR), and other realities mediated by technology. Currently "mixed reality" [4] is used as an inclusive term that refers to the combination of AR and VR technology. Mixed reality merges the real and the virtual worlds to create new possibilities that expand the service environment. However, it also presents new challenges because it maximizes the intangibility of experience, which requires more structural attention. While mixed reality is a technological term focused on media, we propose the concept of serviced reality that emphasizes the needs and fulfillment of people in the broader context of service experiences, where some of the touchpoints are supported by mediated realities. For example, Pokémon Go as a mixed reality game utilizes location-based sensing technology to juxtapose its game reality with physical reality through a mobile phone. In contrast, Pokémon Go as a serviced reality could be seen as a service that increases users' physical activity, where some activities would take place in the actual gym and some would be mediated by the virtual gym. However, currently Pokémon Go's virtual gyms, walking-distance based hatching system, and Pokéstops installed in city landmarks and some Cafe chains are not seamlessly integrated yet, because there is no overarching service storytelling.

AR and VR open up a new world with great potential to expand the service environment, but that potential has yet to be fully explored. There could be many reasons for the relatively slow adoption of these new technologies by the general public, including high prices and cumbersome interfaces; but above all, we would like to point to the lack of content that would create a cycle of returning users. Just like the earliest movie by the Lumière brothers focused on the exotic stimuli of a train running toward the audience, current early forms of AR and VR content often tend to emphasize the technological uniqueness of the new media. However, just as Pokémon Go fever continued only for a few months, the newness of exotic experience alone cannot keep rates of use without the support of a core service that maintains the necessity of use. Virtual content needs to make connections to real-world needs, so that people feel motivated to invest their resources and effort into adopting the new technology as a part of their own life contexts, rather than the other way around.

Current mixed reality content often focuses on bringing people into a separately existing virtual place that people cannot physically access [5]. For example, Facebook 360 provides panoramas of different places captured by other users. Discovery VR Channel focuses on travel experiences in places that are physically difficult to reach – for example, space (Journey to edge of space 2016), the ocean (New way to shark 2016), or the jungle. Museum content such as the Woolbert channel can also allow virtual transportation to real museums around the world, access to paintings not generally open to the public (WoofbertVR 2015), or views from museums of the past (Städel Time Machine 2016) [6]. Still, these types of content focus on translating physical reality into virtual reality and the user experience stays at the level of "emergence" as spatial navigation [7]. They provide a 360-degree simulacrum of a physical reality, but the experience could be further enriched by a structure that could transcend motion to enable action.

We propose service reality storytelling as a perspective that shifts the focus of such content from technology to people. The goal of technology in the end is to provide "service" across the layers of multiple realities to support people's actions. Therefore the experience needs to be structured based on the "why and how" of the service in addition to the "what" of the technology. The key to design then moves away from partial and attention-catching stimuli to relational aspects such as the holistic and seamless flow of the experience across realities, and how to connect one service to other services. Service storytelling can help make connections between these touchpoints, stakeholders, and technologies.

3 Storytelling and the Hero's Journey

The theory of storytelling can serve as the basis for an integrated flow across realities, as storytelling itself is an archetype of fundamental human experiences. According to Dewey, aesthetic experiences have a common pattern, regardless of subject matter, when properly organized and oriented. We as living organisms sense beauty in certain forms of experience that reflect the rhythms of nature. Rhythm is the most essential pattern of how a life relates itself to the environment. Dewey states that people reconstitute the rhythm of growth by overcoming challenges in the sense of "life as

drama [2].” This aligns with Aristotle’s view of drama as being “an imitation of an action” in reality [8]. A human being can perceive the causality of incidents by emplotting a story and then find ways for autonomous action to resolve a conflict or satisfy a need. In other words, storytelling reconstructs reality in a meaningful way.

Therefore, story is not just a mechanical aggregation of stimuli. Storytelling serves as a qualitative flow that unifies moments across time and space, thereby helping people grasp the meaning that permeates the parts. In “Poetics,” Aristotle proposes four causes and six elements of drama that narrow down the possibilities and strengthen necessity in a chain of cause and effect that moves along a path over time [8]. Even simple stories like folktales are created to relate people to a pattern of life that is often difficult to understand as a whole. Vladimir Propp’s research on folktales reveals a limited number of simple irreducible narrative elements that compose basic plots. Elements of the superstructure, such as the appearance, age, or gender of characters might differ, but their actions share common functions across certain patterns common to many folktales [9]. In other word, story is a kind of service that helps people reconstruct reality and autonomously solve their problems. By doing so, storytelling integrates a mixed reality made of technological resources into the human experience of serviced reality.

In this paper, we focus on Joseph Campbell’s model of the Hero’s Journey to investigate on the essential role of negative emotion in storytelling. Campbell’s model examines the archetype of “a journey of adventure” that commonly appears in myths across different cultures. A hero departs from an ordinary world to enter another world, and then returns to where he originally belonged, but with a changed self [3]. The fact that later Christopher Vogler applied this model to movies and Robert Mckee used it for screenplay writing shows that this model is applicable to transmedia storytelling, and can easily apply to new media such as augmented and virtual reality (Fig. 1).

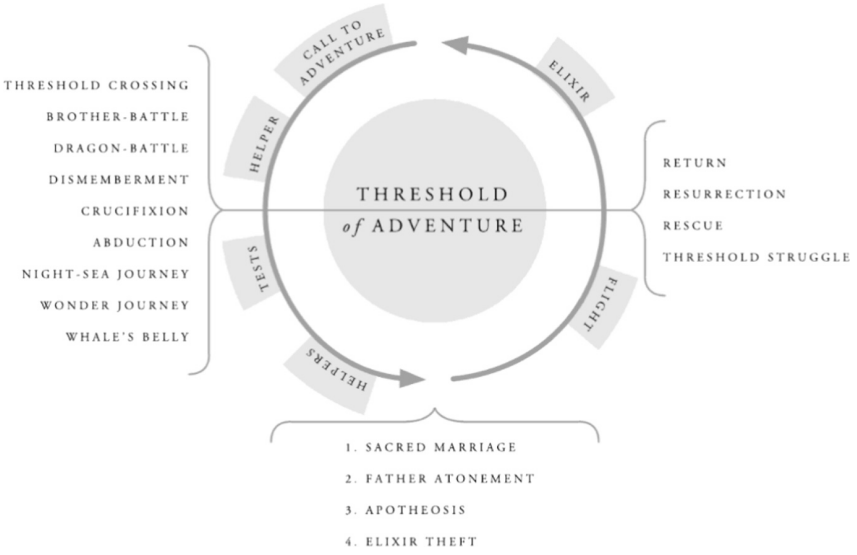

Fig. 1. Campbell’s Hero’s Journey [3]

Campbell's model also provides insight on the role of negative emotion in experience. Serviced reality is known to have a particularly high entrance threshold; people begrudge having to purchase a new device or enter a virtual space. Design has focused on maximizing pleasure and removing pain in order to remove this barrier to adoption. However, it is notable that people still hesitate, even when they know that the following experience will be enjoyable. The key, then, is to structure experience in such a way that the negative emotion serves as a foundation for a flow toward positive emotion, instead of fragmenting pleasure by forcefully separating out negative emotions from the experience.

4 The Role of Negative Emotion in Autonomous Experience

The Hero's Journey is a structure that supports the hero's emotional journey from recognizing a problem to challenging the barriers, developing herself/himself in order to solve the problem on a personal level, and then reaching a resolution on a community level. Negative emotion plays a key role in this process. The initial state may look stable but in fact there is a hidden problem in the everyday world. The hero discovers a deficiency through negative emotion. This emotion can be turned into energy for action when the barriers are successfully overcome with proper support from the storytelling structure. As the hero goes through the designed challenges of the service world, her/his mindset changes from one of passive exploration to that of an active journey. By confronting the ordeal, the hero overcomes the negative emotion and returns to everyday life, where she/he resolves the initial conflict through replenishment or forgiveness, which completes the cycle and alters the community (Fig. 2).

Fig. 2. Storytelling model for serviced reality, based on Campbell's Hero's Journey

4.1 Deficiency

The "Deficiency" part is comprised of (1) the hidden problem, (2) recognition of the negative emotion, (3) rejection of the problem, (4) acceptance of the problem with the help of a mentor, (5) decision to act, and (6) transition to a special world. Here negative emotion begins as a barrier to overcome, but when the hero overcomes that barrier, that emotion becomes the energy of autonomous action and growth.

The initial reason that the hero sets off on a journey is because there is something missing in her/his everyday life. Though the everyday world seems peaceful, there is an undiscovered problem, a need or desire with some negative emotion attached to it yet hidden. In *The Lord of the Rings*, for example, Frodo's life in the Shire seems perfect but there are undiscovered issue lying beneath the surface, like a suspicious ring, a missing uncle, and greedy relatives. Moreover, his peaceful life is threatened by the darkness approaching the world, although he does not know it yet [10].

A deficiency brings a "calling" to the service world. Interestingly, in Campbell's model the hero initially rejects the calling because it makes her/him realize the suppressed anxiety, fear, and hesitation that accompanies any conflict. For example, Frodo resists the calling of Gandalf. This rejection may seem like an unnecessary step, but the resulting deliberation at this step allows the hero to internalize the call.

The mentor is the person who helps the hero to overcome this initial negative emotion. Gandalf, Elrond, and Aragon all serve as mentors so that the hobbits can clear the emotional hurdles on each step toward Mordor. This guided overcoming prepares the hero to enter the special world. Positive emotion is less involved in this early stage of travel. In contrast, discovering and admitting the negative emotion serves as the main trigger of transition from the ordinary world to the special world.

4.2 Challenge and Accessibility

The second part, "challenge and access" is comprised of (7) barriers and challenges and (8) desire for access. Negative emotion plays an essential role in the hero's realization of a need for access. According to Lee, the desire for access is recognized only by the perception of barriers that prevent movement [11]. For example, the active desire to cross is only realized when a new border is created which was not there before. The negative emotion of being barred access evokes the sense of a "right to access."

By recognizing this desire for access, the hero transforms from the passive state of following the calling to an active state of leading her/his own journey through self-motivation. This recognition of the desire for access differs from the recognition of the calling. While the calling helps the hero discover unrecognized negative emotions that already exist, the desire for access more actively evokes negative emotions, such as anger, discomfort, and a sense of injustice. These negative emotions serve as energy for personal growth. For example, the hobbits were passively protected by the fellowship of the ring during the relatively secure and comfortable journey to the Caradhras Pass. However, through the emotional challenges of being barred from crossing the mountain and encountering the deaths of their companies, they become autonomous leaders. Only then is each of them ready to separate from the team and start his own journey to carry on his active duty.

4.3 Growth

In the hero's journey, what corresponds to Aristotle's climax would be (9) victory over the ordeal, and (10) transformation by reward. After developing her/his autonomy, the hero must overcome the main challenge of the quest to accomplish the given duty and reap the reward. "Ordeal" is the name originally given this step by Campbell, and means "something difficult or painful to go through." Negative emotion and tension reach their peak – but the harder the main challenge, the larger the accomplishment and the reward. The hero is ready for the challenge because she/he has grown up by going through the structured huddles in the previous two phases.

By successfully overcoming the main challenge and the ordeal of negative emotion, the hero gains a reward that can transform her/him into a new person. The hero is then ready to go back to the real world. For example, the main challenge in *The Lord of the Rings* is at the climax, when Frodo throws the ring into the crater of Mount Doom. This scene is the explosion of the main conflict built throughout the entire journey. As Frodo overcomes his ordeal, the complicated mix of emotions clears and the hobbits are saved by eagles. They are then rewarded in a glorious moment at the king's coronation.

4.4 Community Resolution

Even after the climax, yet another phase remains before the story ends. Now that the hero has changed, it is time to bring that change home. The hero returns to the ordinary world by (11) return home, (12) fulfillment of deficiency by elixir, and (13) resolution of the problematic situation. This phase closes the cycle of the journey by addressing the problematic state from which the deficiency arose.

After overcoming the ordeal and receiving the reward, the hero returns through the threshold to the real world by resurrection. In this process, she/he gains an elixir, a magic potion that is the ultimate answer to the deficiency. This elixir's function is different from that of the material reward given to the victory over the ordeal. It is a solution to the structural problem in the community which caused the negative emotion in the beginning of the journey.

For example, when the hobbits return home, the Shire is no longer the peaceful place it previously seemed to be. The hidden problem has been revealed – the party tree that symbolizes the community has been cut down, and the greedy cousin has brought evil to the community. However, the hobbits are able to transform the Shire with their gifts from the journey. The servants of evil are expelled, and the hobbits use magic soil and a golden seed to reconstruct the Shire. Through this process, the hobbits finalize their emotional journey and heal the everyday world to the peaceful state they desired at the start.

5 Examples in Student Projects

We applied this model to student projects in Northeastern University's Mobile Interaction Design class in Fall 2016. Students were asked to design a mobile service with the theme of a journey. One of the goals of the class was to expand students'

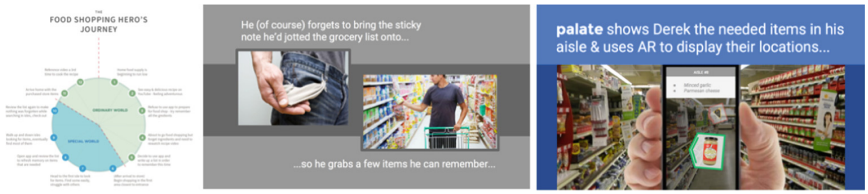

Fig. 3. A class example of serviced reality design for grocery shopping

Fig. 4. A class example of a serviced reality design for exercise

understanding of the concept of what is "mobile," from apps on handheld devices to broader services that support the human experience of freely moving between one place and another. The storytelling structure of serviced reality helped the students focus on the high-level service flow of their transmedia experiences.

Students were also asked to pay attention to the qualitative flow of emotion through the storyline, and resolve the emotional conflict at the end of the journey. By focusing on emotion, students could plan out the everyday world and the service world together instead of getting caught at one touchpoint. Focusing on the emotional change was an efficient way to determine where and how the new technology should be used. For example, Fig. 3 shows an experience prototype created for shopping as a journey. By demonstrating how the negative emotion caused by the deficiency changes through the intervention of augmented reality technology and design, the student effectively communicates the benefit of the proposed service.

Students also emphasized the role of the "mentor" who helps the user overcome the negative emotion and transition from a passive state to an active state in the experience. It was notable that their design ideas often focused on how technology could connect people in the servicescape as mentors by utilizing existing relationships or creating new ones, rather than having the technology itself mechanically fill the mentor role. For example, Fig. 4 shows an example of a serviced reality prototype that motivates the user to exercise. The virtual reality part of this service experience connects family members over long distances, so that they can serve as each other's mentors and motivate themselves to take walks together in a virtual world.

Students also focused on how the hero's journey forms a cycle that can encourage community growth and prompt customers to return to the service with more people. For

Fig. 5. An example of a serviced reality design for travel to a foreign country

example, Fig. 5 shows an example of a service for traveling to foreign countries. Some of the conflict moments are supported by augmented reality to help the users auto-translate languages and make connection to local translators. However, the long-term goal of the service is to help users make local friends who can introduce them to the culture and form communities around shared interests, so that the cycle will continue with multiple stakeholders returning to the service.

6 Conclusion

In this paper, we examined the role of negative emotion in the formation of autonomous experience using storytelling to determine the "why and how" of the technology. In our model based on Campbell's Hero's Journey, negative emotion plays an essential role, helping people recognize a deficiency in their everyday lives and begin their journeys to the world of the service. Negative emotion at each stage can become the energy for autonomous action when gradually overcome in a basic storytelling structure:

1. The user seems to be in a stable situation, but in fact she/he is in a problematic state without recognizing it. The service helps the user recognize the negative emotion around the need and admit the deficiency. The service then connects the user to a mentor who can help the user prepare to enter the world of service.
2. Upon arrival, an array of tasks and support functions help the user change her/his mindset from passive to active.
3. At the climax of the experience, the user resolves the main problem and achieves individual growth by overcoming the negative emotion caused by the initial deficiency.
4. In the end, the user returns to her/his everyday life and causes change on the community level, so that the structural problem from which the deficiency originated can be fundamentally resolved.

Finally, we would like to bring particular attention to the issue of accessibility in serviced reality. Service storytelling unifies emotions into a qualitative flow which reveals the relationships between causes and outcomes, so that people can understand why they might start a journey, how they would be supported in overcoming each challenge, and what would be waiting for them at the end of the journey. With this holistic perspective, people can realize the full potential of their autonomy in the experience. They are then able to transform the notion of accessibility from mere

physical availability to the basic human right of freedom. In the near future, when services are mediated by serviced reality, diverse realities will need to be designed from the perspective of access as a basic human right, just like access to mobile service apps is now essential to live in a society woven with services.

Currently many of the initial mixed reality contents are starting to enable users to navigate virtual spaces. In order to empower users to have autonomous experiences across virtual space and the physical reality in which their real-world problems are situated, service experiences need to be holistically structured to encompass both the everyday world and the service world. When service becomes a story that unifies multiple realities from a human-centered perspective, mixed reality becomes serviced reality, which can ultimately support the birth of the augmented human.

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Soma-Deep as a Marker for Idealized Experience

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Abstract. New haptic technologies have presented the field of modern design practice with new opportunities for body based interactions. In the following paper the author presents a case for a new focus of study, Soma Literacy, centered in the fields of Interaction Design and Experience. Pulling from the fields of somaesthetics (Shustermann), performance as practice (Schwiebert), and pragmatic philosophy (Dewey), the author presents a tier of experience, understood at the soma-level as the center of perception and action. The author proposes a study in soma-literacy, where the participant would be skilled to analyze, interpret, reveal, and make meaning through the bodied content present in all experience. The author then presents initial research in presenting the agenda in a participatory, body-in-motion, course format.

Keywords: Soma literacy · Interaction Design · Experience Design · Somaesthetics · Experience · Tiers of experience · Pedagogy · Design education

1 Introduction

In the following paper, I will present an argument for a renewed attention to an often assumed/overlooked/ignored soma-tier of experience and will further make recommendations as to the potential benefits of not only recognizing this tier, but also of developing skills to analyze and design within this level of experience.

Historic treatments of physical participation in HCI and IxD have often merely assumed the body. Throughout the 20th century, the body was viewed by the professions as a mere carriage, whose primary value was to carry around the intellect, often to the detriment of the carrier by actual physical harm or mere missed opportunity for significant or pleasurable participation. [10, 11] Whether it be the iPad, Google-Glass, the Fitbit, the Nintendo Wii console or even burgeoning AR and VR technologies, the body continues to be a simple carrier or mindless tool. These technologically driven experiences ask for physical participation yet seem blind to the actual experiencing body that has been invited to participate.

Despite such common oversight, there were no shortage of theorists and practitioners who were working to root out the fundamentals of the experiencing body. Husserl [1] tells us that "The Body is…the medium of all perception." Dewey recognized that experience manifests on a spectrum. He saw that there was experience and *an experience*. [8] Merleau-Ponty directed our attention to the essential body. He

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_14

"insist[ed] that the body is not only the crucial source of all perception and action but also the core of our expressive capability and thus the ground of all language and meaning" [1]. James states that the body is the center of our world. "The world experienced", he elaborates, "comes at all times with our body as its centre, centre of vision, center of action, center of interest" [1]. The French-Swiss theorist, pedagogue, and musician Jaques-Dalcroze stated that the body is the first instrument [2]; that is to say, before any experience is understood in the mind, it has to first resound through and be felt in the first experiencing instrument, the body. Jaques-Dalcroze and Sheets-Johnstone reinforced both Dewey and Merleau-Ponty while pointing out that the body is an instrument in motion and experiencing is dependent on kinesthesia.

The renewed focus on the body and soma-practice in Design is an exciting and essential course of inquiry [3, 4]. If one is attempting to work with affect or significance in experience, the role of the body and the designer's attention to the soma-experience should be recognized as fundamental. My current research is grounded in both (1) the depth, wealth, and wide range of potential interactions available to the experiencing body [9] and (2) this absolute kinesthetic-soma-requirement for any interaction to be recognized at all.

2 Range of Interactions

Current commercially available haptics continue to emphasize only the most superficial of body-implicated interactions. The most ubiquitous interfaces continue to utilize fingers on glass and the single dimensional buzz-vibration. From a bodied perspective, it is difficult to imagine a shallower and range-less experience. Compare these to the types of interactions that bodies have migrated toward over history. What amusement park specializes in subtle vibrations? What tango parlor attracts dancers interested only in experiences at the tips of their fingers? Athletics, arts, and all manner of leisure activities continue to exploit the body for the possible range of a body-possible event. Playground swings, football, Cirque du Soleil, and walks in the park…culinary tourism, horseback riding, jump rope, and clapping along at a concert…gardening, playing the piano, taking holy communion, and head banging…they all exploit a wide range of visceral interaction. Comparatively, the range of vibrations and pokes found in our devices are both shallow (in terms of the extremely limited types of interactions) and misguided in implying that the body is only implicated in instantaneous and cutaneous sensations. The actual phenomenology of touch extends far past the sensations on the skin. The experiencing body is primed for and even yearns for interactions realized in the experiencing instrument. These experiences realized in the body (i.e. as organs sloshing on a playground swing or the feeling of dread manifest as pressure on the chest), manifest as the inwardly directed sensation of kinesthesia are what I have called *soma-deep*.

An attention to the range of rich interactions could be so much more than a clever option for the modern designer. The sociology/philosophy of Dewey, Lakoff and Johnson, Shilling, Todes, and Flusser point us toward a world of experience that is dependent on these rich interactions. Whether engineers and designers build these into

the current systems and artifacts or not, the living public will continue to realize their experiences throughout the spectrum of merely tangible through embodied ecstatic experiences via both self-made and well-poised design interventions.

2.1 Somaesthetics

The philosopher Richard Shusterman continues the conversation when he claims: "the more the new communications media strive to free us from the need for physical bodily presence, the more our bodily experience seems to matter. The most advanced technologies of virtual reality are still experienced through the body's perceptual equipment and affective sounding board – our sensory organs, brain, glands, and nervous system…" [1].

A contemporary pragmatist philosopher, Richard Shusterman recognized the body as the experiential core of perception and action [5] as he presented the interdisciplinary field of *somaesthetics* with his book, Body Consciousness in 2008. As the Dorothy F. Schmidt, Eminent Scholar in the Humanities and Professor of Philosophy at Florida Atlantic University, Boca Raton, he lays out a clear argument for this new perspective on the body, the body-mind connection, the lineage of body centered philosophy from the West and the Eastern traditions, and implications for ethics, politics and a "Body Conscious" daily living.

Shusterman has presented this new field *somaesthetics*, and uses the term *soma* when referring to the body-mind being. As a disciple of Dewey, and greatly influenced by Merleau-Ponty, he regards the corporeal and the cognitive as a unified whole. It is not possible to have one without the other. The *soma* references to the "sentient perceiving 'body-mind'" [6].

He breaks the study into three foci: Analytic [descriptive and theoretical], Pragmatic [prescriptive, proposing interventions and comparative critique], and Practical [practice of self-improvement]. It is through the analytic lens that Shusterman the philosopher shows his depth and his brilliance. Surveying and critiquing the bodied foci of William James, John Dewey, Ludwig Wittgenstein, Maurice Merleau-Ponty, Michael Foucault, and Simone de Beauvoir, Shusterman brings together a compelling case for the centrality of the body in experience and lays the foundation for his Pragmatic and Practical agendas.

In addition to his credentials as a scholar, Shusterman is also a trained body therapist, specializing in the Feldenkrais Method. The Method, founded by its namesake Moshé Feldenkrais (1904–1984) is a meliorative body-practice that uses specific physical exercises, led by a practitioner to improve physical and psychological well-being. Pulling from his research into meliorative body-practices such as the Alexander technique, ancient Asian practices, and his own experiences as a Feldenkrais practitioner, Shusterman presents his Pragmatic agenda by lobbying for a heightened somatic awareness and somatic reflection. He recognizes the massive potential for designing of health and well-being, while also revealing ethical, moral, and political implications of the *soma*-minded interventions.

The third focus of *somaesthetics* is the Practical where the individual actor is encouraged to develop heightened somatic self-awareness and somatic self-reflection

so as to effect the personal experience of living and working. Shusterman distresses that "most contemporary philosophy of the body seems to ignore or dissolve the actual active soma within a labyrinth of metaphysical, psychophysical, social, gender, and brain-science theories" [1]. Despite all of the excellent scholarship, too little of the insights are ever presented in a manner that might effect praxis and Shusterman is highly concerned with the practical implications of his theories.

Shusterman recognizes not only the health and well-being results of a more mindful soma-centered experience, but also sees "somaesthetic training…[as] enriching our cognition and our global art of living. Improved perception of our somatic feelings not only gives us greater knowledge of ourselves but also enables greater somatic skill, facility, and range of movement that can afford our sensory organs greater scope in giving us knowledge of the world" [1]. And it is this combination of self-awareness and world-awareness that is at the heart of ideal design interventions.

3 Soma Literacy

If we consider the sentiments of Shusterman and the philosophers above, how is it that Interaction Design and Experience Design and work in Human and Computer Interaction has continued to overlook, merely assume, or diminish the role of the most critical participator and center of experience, the human soma, and what do we lose in the process? If we started to turn our attention to the body-in-motion as the center of experience, what would we focus on?

Visual Literacy is a concept that has been present in Graphic and Information Design at least since the 1970s. The skills gained when building a visual literacy allow the participant to analyze, interpret, reveal, and make meaning through content presented in visual image form. The attention given to an image is directed beyond the facade, that is, beyond the obvious initial message, and the frame is explored for deeper meaning, overt persuasions, historical implications, etc. Advertising, political propaganda, and even reading of social norms are all able to be analyzed through this type of attention.

Aural literacy, while not as established of a concept is also easily understood as it also allows a participant to analyze, interpret, reveal, and make meaning through content presented in as sound. This is characterized as attention to the aural tier of experience with the literate understanding how different aural variables can effect understanding, emotions, and meaning. The aurally literate individual would recognize that James Earl Jones' voice adds an air of power to the character of Darth Vader, solely because of the timbre, pitch, and pacing of his delivery.

Pulling from the fields of somaesthetics (Shustermann), performance as practice (Schwiebert) [11], pragmatic philosophy (Wittgenstein, James, Dewey), I am presenting a third tier of experience, understood at the soma-level as the extra-linguistic experiential core of perception and action [5]. I am proposing a study in *soma-literacy*, where the participant would be skilled to analyze, interpret, reveal, and make meaning through the bodied content present in all experience. I am developing a vocabulary and pedagogy for this study whereby one can separate out this soma-tier and analyze the range of experiences through the narrow lens of the fundamental sentient

body-in-motion. I am mapping the range of soma-experiences on a spectrum from cutaneous to soma-deep (the inwardly understood sensation of kinesthesia) and am overlaying that map with questions around meaning, significance, and function recognized in both individual (kinesthetic) and social (enkinesthetic) contexts.

3.1 The Somaesthetics of Calligraphy, A Vignette

The Chinese artist Pan Gongkai describes the somaesthetics of calligraphy when explaining how a student attempts to replicate the master. He states that, of course, the student is attempting to replicate the characters to look the same as the master. The Lan Ting Xu by Wang Xizhi (《兰亭序》,王 羲之), is considered some of the most important examples of Chinese calligraphy of the last 1000 to 2000 years. Gongkai states that all serious students of Chinese calligraphy have studied it. The study involves more than just looking at the composition of the characters. The study is primarily about replicating the action of the making of the letters. The student is attempting to embody the gestures of the master Wang Xizhi, to feel how he felt when making the calligraphic motions. "Because the total action of the original writing is full of rhythm, in very subtle actions, it is full of complementary, oppositional relations between control and lack of control (or a balance between control and release). So, this is a very subtle and superior part in Chinese culture" [7]. It is not the picture of the characters that is firstly significant, it is the embodied gestures of sentient heavy and light strokes, strokes that can only be created by the body-in-motion. Only the soma-literate individual would be able to separate the sensations of the heavy and light strokes from the resulting visual characters.

3.2 The Somaesthetics of Skate Boarding, A Vignette

I grew up on a dirt road in a decade that had not quite yet embraced skateboard culture. Growing into adulthood, I was aware of skate culture and knew some teenagers in my neighborhood who enjoyed the sport. On more than one occasion I watched these teens zoom down a sidewalk, only to thrust themselves out into semi-busy intersections, often appearing more dangerous than would be wise. The event was always rationalized to youth and immaturity and thrill seeking.

Some years later, in my 37th year I had occasion to learn to long-board, and through several serendipitous events found myself using the long-board for commuting purposes most days, 2/3 of a mile to and from my place of work. Participating in the practice revealed a whole new perspective on skateboards than I had ever considered. I too found myself zooming down sidewalks, only to be presented, mid-momentum, with semi-busy intersections and a split-second decision; Will I stop the inertia, stop the earned momentum, interrupt the grand literal gesture of my ride, or will I thrust myself out into the intersection and allow the gesture a more natural conclusion (hopefully not to be confronted with a fast-moving truck)? While it is possible that immaturity and thrill seeking could factor into such a decision, it became strikingly clear that there was another element at play, another tier of experience, a extra-linguistic, bodied, soma-deep

reality that not only existed, but in this particular case, defined the interaction. The gesture was begun and yearned for an organic resolution. Jumping off the board and halting before the intersection, halting before the natural closure of the phrase would prove as uncomfortable and an-esthetic as the rudest of interruptions. This yearning to complete the phrase could not be attributed to immaturity any more than could an opera singer completing an aria. The yearning for completion is a most natural of human instincts and worthy of study, a study that will involve the soma-tier of experience.

It is not the video of a skateboarder that is firstly significant in this vignette, it is the embodied soma-deep felt sensations of heavy and light kinesthetic awareness that can only be created by the body-in-motion. Only the soma-literate individual would be able to separate these sensations of forward momentum from the far more obvious descriptions of sidewalks and skateboards and traffic and teenagers.

4 Fundamentals of Experience

I am interested in this *soma*-tier of experience and to what extents Design can offer interventions to reveal, nudge, magnify, or diminish experiential gestalts through the manipulatible variables of the soma-tier, thus offering interaction design not just a renewed palette but the fundamental palette of human interaction factors.

What is an experience? Where is an experience? How does one experience? Consider any example that would fit the title of *experience*. Hearing a song, participating in a conversation, catching a fish, riding a bike, passing the test, getting goosebumps, breathing deeply, being frightened, taking a walk…. what sorts of variables do all experiences hold in common? What variables contribute to an experience becoming memorable or forgettable, exhilarating or boring, surprising or mundane? What sorts of experiences are we creating in HCI and IxD and what variables are we designing with?

In conjunction with the Carnegie Mellon University School of Design, I have started an investigation into these questions through a new unity of study currently titled *Fundamentals of Experience*. The unit is presented as an 8 week "mini" embedded in a course titled *Persuasion*, required of all undergraduate Junior design students (Communication Design, Product Design, and Environments foci). Taking inspiration from the somaesthetics of Shusterman, performance as practice of Schwiebert and Jaques-Dalcroze, pragmatic philosophy of Wittgenstein, James, and Dewey, I am investigating the body (soma) as the experiential core of perception and action [5].

The initial prototype of this "mini" was completed in the Spring of 2017. The teaching techniques are all inspired by the Eurhythmics of Emile Jaques-Dalcroze, a Swiss pedagogue and musician from the 1st half of the last century. While his work is most often presented as basic training for musicians, in the current conversation we could re-characterize it as soma-literacy for musicians. The course is taught in an open studio with no tables or chairs. The students are barefoot and are led through a series of body-in-motion exercises to direct attention to the soma-tier of the experiences. Through repetition and guided instruction, the students incrementally develop an awareness of the bodied sensations, separate from any cognitive descriptors that they

may also accumulate. Permitted enough time and repetition, students can develop not only awareness of these base sensations of experience, but they can gain skills in the variables at play such that they can manipulate the variables and as a result change the affect of the experience. *At this level, the participants are designing their own experience.*

Through the 8 week "mini" we explored fundamental concepts of experience such as tempo, cadence, beat, meter, range, crusis, phrase, rhythm, agogics, tension and release, rhythm, flow and interruption, ease and efficiency. The explorations were realized as participatory, extra-linguistic, kinesthetic and enkinesthetic (social) experiences before any cognitive reflection was invited. As of Spring 2017, the first study of a soma-literacy agenda and pedagogy was completed. The results were extremely encouraging. The students were assigned final projects where they analyzed mundane experiences through the lens of the body-in-motion, or the soma-tier of experience and then were charged with re-designing the chosen event by manipulating variables of this soma-tier and then discussing the resulting affect. A second round of participatory studies into design interventions at the soma-tier of experience are scheduled for Summer and Fall 2017.

If we recognize that there is an extra-linguistic tier of experience that contains distinct variables that can be analyzed and manipulated, then a window of opportunity is created for thoughtful design interventions at this tier of experience.

5 Conclusion

This then presents the design knowledge gap, the non-acknowledgement of the depth of the body-mind experience and the literacy required to recognize experience at the soma tier. By directing attention to the often-overlooked/assumed/ignored *soma* tier of experience, I am theorizing that we can become aware of a fundamental aspect of human being. I am speculating that empathy for the other (human and non-human), discovered through and understood at this most base level (soma) of the pushed and pulled, tossed and turned, enkinesthetic (social) body-in-motion, is potentially the most intimate interaction that can be designed. I am proposing a design focus that literally touches the personal and intimate through the manipulation of soma-deep sensation, and challenge the field to continue to search for ways to direct, harness, nudge, manipulate, and ride these kinesthetic and enkinesthetic sensations for preferred future states.

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Design for Dignity and Procedural Justice

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Abstract. The civil legal system exists to solve people's problems, like divorce, eviction, bankruptcy, and child custody disputes. But this system, in particular the courts, are difficult and frustrating to navigate, especially if a person does not have a lawyer. Our study reviews how people currently experience court Self Help Centers, and identifies opportunities to enhance them. It does this through a framework of Perceived Control, that considers how to give users greater understanding, options, and behavioral control over a difficult system.

Keywords: Human factors · Human-systems integration · Service design for legal system · Design for dignity

1 Introduction

Design and law both concern people's experience of systems, and how they could be made better. Legal scholars and practitioners frame this concern in terms of procedural justice, asking whether people experience the legal system as fair and dignified, and thus have a sense that the procedures are just. Designers frame this concern in terms of user experience, asking whether a system is usable, useful, and meaningful to a person. Both approaches consider the same matter: how a person can best use a system to resolve a problem, with a recognition that the quality of a person's experience of the system is a crucial metric by which to judge the system. Whether a system seems to be fair, transparent, and dignified will impact a person's perception of the system – and it is of concern to both the lawyer and the designer.

Courts' Self Help Centers are a ripe focus for a legal design approach. They are simultaneously a positive attempt by the legal system to provide support to lay people, while also a place where people's negative experiences with the legal system come to a head. Self Help Centers exist inside courts to give information and limited services to people without lawyers. People come to them as they try to decide what legal path to take, as they begin through complicated tasks, and as they prepare for hearings. Ideally, these Centers would ensure people prepare the person to do their best in their filings and appearances before the judge.

Our design research finds, though, that people have negative experiences in the Court, and that these Centers are not performing to their potential. Despite the services on offer, people struggle to use them effectively. They report being frustrated, lost, confused, and anxious during their court experience.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_15

This paper documents an approach, mixing a legal focus on procedural justice with a design focus on perceived control and human-centered services, that aims to improve the legal system, and people's experience of it. Our hypothesis is that service design work, guided by an emphasis on increasing users' perceived control within a system, can improve users' experience of the legal system, and then also the procedural justice of the system. We used two design cycles with two different courts to test this approach, with one class taught at Stanford in partnership with California courts, and one hackathon at Harvard Law School with Massachusetts courts.

Our paper confirms the value of design-driven approach, grounded in the notion of perceived control, to uncover key opportunities for increasing the procedural justice of the court system. It also defines specific interventions that demonstrate how to increase users' perceived control and positive experiences within a complex, bureaucratic system like the courts.

2 The Problem of Courts' User Experience

Justice is a fundamental value of the civil legal system. It is the metric by which to judge whether the system is successful: is it just to the people who are using it to resolve their issue? But how justice is measured can take different forms. If we use the notion of *distributive justice*, our focus is on the final outcome of a court proceeding [1]. Was the official law applied fairly to these people's unique situation? The system is just when people get the 'correct' outcome, and this justice in turn assures their personal dignity.

But if we use the notion of *procedural justice*, our focus turns to the entire journey of a court proceeding, not only the outcome [1]. Here, the justice of the system and the dignity of the people using it depend on the people's many interactions with the system, beginning with when they seek out help for their issue, through the many procedural steps of filing forms, serving documents, and holding hearings, and ending with the resolution of their case. According to this metric, the system is just if it makes this lengthy procedure transparent, navigable, and efficient for people.

2.1 The Problem of People in Courts

Our work begins with the problem that people currently have very poor experiences in the legal system, particularly if they are attempting to go through a procedure without a lawyer. The user experience is poor, and their sense of procedural justice is low. We observe this both in large surveys conducted about people's relationship to courts, as well as our own empirical design research into litigants' experiences attempting to navigate court procedures.

The overarching problem we observe is that the legitimacy of the civil court system is dropping, from the perspective of the public. According to recent studies, people do not expect the court to be efficient or effective in helping the public solve their issues [2]. In surveys conducted annually since 2012, the public reports that they receive poor customer service at the courts, that the courts are inefficient, and that they are not able to use technology or innovations well [3]. Additionally, they find that the courts are intimidating, and do not know how to effectively use technology to serve people.

This poor public impression can be linked to a legitimacy crisis of the courts, in which fewer people are filing cases or using the courts to resolve civil disputes [4]. For those that do use the courts, they have poor experiences. These problems of poor service and reduced usage of the courts is a longer term problem. The courts are a branch of government meant to serve the public, and create transparent, consistent rule of law. When people have poor experiences in the system, and begin stop using it, courts can lose funding from the legislature, and the service can deteriorate further. Their fundamental role in society is undermined.

Our preliminary qualitative research at courts affirms that people are dissatisfied with the services and feel that the system is overly complex, burdensome, and unresponsive to their needs. We conducted a class in Spring 2016 that conducted empirical, qualitative user research with people attempting to navigate procedures like divorce, child custody, child support, or evictions by using the local county court system.[1] This was further supplemented by a similar class taught in Autumn 2016, focused on people without lawyers attempting to use Boston-area housing courts to avoid eviction.[2] We used on-site focus groups, service safaris, over-the-shoulder observation, and interviews with court professionals and litigants.

From this design research, combined with a literature review of others interested in improving courts, we identified several core problems in the current user experience of the civil courts, that affect the procedural justice and legitimacy of the legal system.

2.2 The Promise and Problems of Court Self Help Centers

Self Help Centers have been a major innovation in the civil court system, to help people who cannot afford lawyers (or who otherwise are reluctant to hire a lawyer) to understand how the court system works, and to carry through the tasks necessary to use it strategically [5].[3] Yet despite the advantages they offer as a free and central location for legal help, the user experience of lay people using the Self Help Centers, and the civil court system more generally, has many problems. People come to the Self Help Center to learn what their options are, and what to do in order to protect their interests and get to their preferred outcome. However, often they are stymied by long wait lines, confusing buildings, a lack of privacy, jargon-filled forms, labyrinthine procedures, and cold referrals to other service providers.

Despite the best efforts of service-providers, litigants can leave the Center without a clear action plan to follow, and without information that they can understand. Oftentimes, they are not able to follow the instructions given to them, or to fill out the forms correctly, and thus suffer hindrances to their process in the form of delays, missed deadlines, or incorrect filings. We observe negative experiential outcomes in the

[1] This research was conducted in the Spring 2016 class Prototyping Access to Justice, at Stanford Law School.

[2] In Autumn 2016, we taught Access to Justice By Design at Northeastern Law School, in partnership with Boston Housing Court.

[3] Note that in other jurisdictions, this type of free, court-based legal help center are called by other terms. For instance, in Massachusetts, they are called Court Service Centers.

scenario, with emotion ranging from frustration around being lost or ignored, to feelings of anger, powerlessness, and injustice. People suffer from a dignity problem in the court as a whole, and they are not able to use the system to effectively get their legal tasks done or to have a positive experience.

2.3 The Current Approach to Services

Courts have attempted to improve Self Help Center experiences through information-deep-dives and technology-first solutions. They provide walls of handouts and forms, and sometimes, banks of computers to help people find legal resources. The hypothesis is that providing all of the information will help people serve themselves, do so privately, and will improve efficiency.

This approach comes from the assuming of understanding justice as distributive justice. Justice is seen as fair distribution of infrastructure and resource to support dignity as basic right. It therefore focuses on the end result of justice – whether people get the 'correct' allocation as the outcome of the system. This view also aligns the "functional quality" [6] or "outcome quality" [7] of service that focuses on the end result and efficiency.

But in practice these resource-walls and computer banks in the Self Help Centers go relatively untouched, and people seek face-to-face help instead. These tools seem to fail because they are not centered around the human experience of people who go through the service. They offer deep-dive resources for specific tasks without giving transparency to an overall process. People feel lost and powerless because they do not have a larger view of the system they're in. Additionally, the technology-first solutions do not provide an empathetic exchange that people are seeking. In our interviews with users and court professionals, we heard repeatedly that court users want interactions with people to listen to their stories, acknowledge the frustration, anger, and other emotions they were experiencing, and give reassurance about what path to pursue.

The challenge, then, is how to support people's sense of dignity in their experience of the system. This is related to the "process quality" [6] of service, in how people feel they are being treated and how fair the system is, as well as to the "outcome quality" that will vary based on how well the person can participate in the system.

3 Hypothesis: A Perceived Control and Dignity Approach

We argue that in order to improve the services of a system like the courts, we need to use an approach that prioritizes procedural justice, dignity of the individual person, and their perceived control within the system. This argument is grounded in the notion that a person's dignity is defined by their autonomy and agency. When a system, like the legal one, is overly complex and difficult to use, then it lessens the person's agency, harms their sense of dignity, and diminishes procedural justice.

A philosophical survey reveals that the basis of dignity is autonomy: the capacity of an agent to act in accordance with free will rather than external pressure [8]. The Roman notion of dignitas, as defined by Cicero, was a social virtue gained from fulfilling duty

[9]. In the time of Renaissance, dignity was more focused on an individual's capacity of choice [10], and the dignity of the Enlightenment, as proposed by Kant, was to act in accordance with ethical reason [11]. All of these definitions highlight autonomy as the central condition of dignity. Autonomy comes from self-control, freedom of creation, or right action according to self-imposed law [8].

We argue that in order to improve the legal system, we need to shift the focus from distributional justice to "procedural justice" to support this notion of dignity. To better design a legal system that is fair and legitimate, we must prioritize people's subjective experiences of the court and identify ways to enhance their autonomy and dignity.

Legal scholars who have studied litigants' experience of procedural justice in courts have identified four key variables by which to enhance procedural justice: their voice in expressing their views; the feeling of neutral application of law; individual's sense of respect; and their trust that authorities are sincerely trying to help them [12]. Of these factors, we find the common theme to be 'dignity'. A system that is procedurally just will give its users a sense of dignity, that their voice matters, they are being treated fairly, they are respected, and that they can trust the authorities.

Our starting proposition is that design interventions that focus on improving litigants' experience of court procedure can enhance their sense of dignity in the legal system, and the procedural justice of it. If we craft new resources and tools with this mandate to enhance dignity and autonomy, we will improve people's ability to navigate processes easily, and thus also improve the fairness, justice, and legitimacy of the public legal system.

Our second proposition is that the concept of "perceived control" can be a central frame to guide both design research and interventions to lead to greater justice and dignity. Perceived control is defined as "the belief that one can determine one's own internal states and behavior, influence one's environment, and/or bring about desired outcomes" [13]. Psychological studies suggest that a person's subjective beliefs about her control over a situation has been found to be more effective than the actual coping mechanisms themselves at dealing with stressful situations [14, 15]. Customers' perceived control is an important determinant of service quality, especially in relation to service delivery failure and recovery situations [16, 17].

This is a crucial idea for service designers to understand, as control beliefs are key to quality service experiences. Our goal is to give people a sense of perceived control in order to prevent problematic states, like poor user experience, confusion about the process, or inability to correctly follow the process. The purpose of the study is to refine this framework into more particular design strategies to use, in order to provide court users with perceived control, and thus a more dignified user experience. We use the design work to evaluate the validity of the framework, and to help refine it as a tool to improve litigant experience and legitimacy of the system.

4 Method

Our study uses the notion of Perceived Control, in combination with Design Research experiments and evaluation, in order to explore how giving autonomy to people in the legal system can enhance their sense of dignity and procedural justice. We conducted a

10-week class at Stanford Law School and Institute of Design (d.school), in combination with a one-day design sprint at Harvard Law School. Each of these events focused on how to use human-centered design to create and vet new service design concepts for Self Help Centers in courts.

These design cycles were used, first, to assess our approach's relevance. We could see how often notions of dignity, autonomy, and perceived control arose as key factors of litigants' user experience of the legal system. We could also observe how useful the design teams found these notions as foundational principles for good design interventions. Secondly, they were used to generate new concepts to give greater perceived control to users of the court system and to improve their user experience. By examining the various design teams' prototypes and rationales for them, we could discern what designs best enhance perceived control, dignity, and procedural justice.

4.1 The Perceived Control Framework

To operationalize the notion of Perceived Control, we defined a framework that could guide our design work. This framework was used to direct design teams about what they should aim to create with their new concept proposals, as well as how they could evaluate the status quo of the court's service design.

We presented the Perceived Control as a central value and heuristic of service design, particularly in regard to complex, bureaucratic services like the legal system. To assess and improve Perceived Control, we use three main factors [18].

1. Behavioral control: Do users of the service have opportunity to act and directly impact the events it entails?
2. Cognitive control: Do the users have enough information to understand what is happening in the service, and interpret it to their specific situation?
3. Decisional control: Do the users have choices and alternatives laid out clearly?

Having introduced these factors to participants as a guiding framework, we also used it as a heuristic with which to evaluate the concepts they proposed.

4.2 Prototyping Access to Justice Course

In the Winter 2017 Stanford class Prototyping Access to Justice, we had six design teams working to craft new interventions for people in the courts without a lawyer. The class specifically focused on a person who was beginning their journey through filing for divorce or resolving a child custody or child support case.

Each team was given a different design brief, focused on a different key moment in a litigant's initiation of a case in the state court. For example, a team was focused on how to prepare a person before they came to the court the first time, another on the arrival at the court building, another while waiting in line to be served, another while working with volunteers to diagnose their issue and fill in forms, and another as they left court and planned for next steps. During the class, each team mapped out the status quo of how the legal system provided service to users around their specific scenario.

They conducted service safaris, user interviews, expert interviews, and secondary research of other proposed interventions. The teams cycled through three rounds of creating prototypes and testing them with court experts, designers, and litigants.

Throughout their design process, we introduced the Perceived Control framework to them, and then regularly asked them to reflect what types of control issues they observed as problems in the situation they were researching, and what types of control issues arose in their proposed design interventions. We had class discussions with the student teams, the partners from the courts, and the expert coaches about how the perceived control framework related to the challenges of court service. In addition, we used the framework to evaluate the ideas proposed by the students using the framework. This allowed us to observe how useful the framework is in understanding the legal system and crafting new solutions that enhance justice and dignity in it.

We also observed in our user research and feedback sessions, as well as our reviews by legal and design experts, how much reference was made to the ideas contained in the perceived control framework. Even if the concept or not phrased identically to those in the framework, we were observant of when people made reference to control, or a sense of oversight and confidence and using the system. In addition, we made questions about perceived control central to the feedback sessions, in which we were asking people about their experience of the legal system and whether our proposed interventions would be of value to them.

4.3 Harvard A2J Lab Hackathon

The other design cycle to evaluate our approach was at Harvard Law School's Access to Justice Lab. In February 2017, the Lab hosted an interdisciplinary, one-day sprint to evaluate how people without lawyers currently use a particular legal process, and to determine what could serve them better. The focus of the hackathon was on the legal process of "service of process in a guardianship", in which a person who is applying for custody over a child or an adult have to notify all other potentially related people about their proposed guardianship. The goal of the session was to document the main fail-points in litigants' attempts to "serve process," and to identify ways to make it easier for a person to follow through on this process without a lawyer.

At the hackathon, there was a mixed set of participants, including litigants, legal aid lawyers, court specialists, web developers, user experience designers, and research scientists. The teams identified what the litigants' experience was around taking care of this particularly hard part of getting a guardianship. The participants asked the litigants to define the steps they took in the legal process, and what the emotional valence was of these different steps, as well as what they got legally right or wrong when trying to complete them. This helped to define the main points of frustration, confusion, relief, and failure, and then led to concept brainstorming for new designs. We used the hackathon to test whether our approach corresponded to litigants' and court professionals' experience of the system, and to examine what types of insights and prototypes emerge from a focus on dignity, control, and procedural justice.

5 Findings and Analysis

In our design work, we gathered qualitative research about what approach has promise for crafting interventions in the legal system. The framework of Perceived Control resonated with court users' and professionals' experience of how the system currently has problems. This framework, along with the use of dignity and autonomy as a central heuristic, proved to be useful to the teams as they crafted new proposals for improvements to the legal system. Our research confirms that a core problem affecting procedural justice is people's lack of autonomy, and that interventions that prioritize litigants' control have great promise to enhance procedural justice.

5.1 A Lack of Cognitive Control, with High Intimidation and Lack of Trust

In both design cycles, the themes of Perceived Control recurred as dominant ones in how the status quo court system provides poor user experience. Users who have gone through family law procedures highlight the lack of autonomy, control, or oversight that they had in the process as a central reason that they had poor service experiences, as well as why they failed to complete the process correctly and efficiently.

Among the people coming to Self Help Centers for family law cases, the two dominant emotions we heard about were (1) the emotional stress of the family situation, often in the form of apprehension about what will happen and how painful or demanding it will be, mixed with (2) the intimidation of using the legal system to deal with this problem, because of how complicated the procedures are, how unfamiliar the language is, and how challenging it seems to be to get everything done 'right'. These emotions reinforced a lack of cognitive control.

In both the class and the hackathon, the theme of **lack of control** and overall understanding was a constant. Litigants expressed that they felt at a loss in the process, and that they didn't know what was happening to them. They get a huge amount of paperwork and tasks to do, but are unsure of how to do this correctly. They don't have a sense of the stages that they would have to do to get things correct. Litigants feel confused because there is too much information, too many forms, and too many things that can go wrong. One litigant at the hackathon mentioned "a lot of paperwork," the problem of "filling out the forms," and too many "damn forms."

Fear was another main emotion throughout the whole process. The stakes of the process are very high, in terms of a person's family arrangement, finances, and housing situations. People felt they had a lot to lose, and were stressed that they might screw something up and suffer. The fear of having kids taken away or losing one's home means that people are in a high-stress state, and they fear the power of the courts to take these 'punishing' actions against them if they make a mistake.

A complementary theme was that not only did the litigants feel they did not have personal control in the system, but that they also didn't trust the system to protect their interests. One litigant complained that some of the service-providers who helped her had actually "screwed" the process when she let them do the paperwork. These mistakes led her to miss a court date, and she had to start the process all over again which

caused a 6-months delay. The person refused the suggested idea of online system because she needs face-to-face human communication which would give her the trust ("I need to know the face, who the heck you are") and sense of transparency. She expressed the need for "having more help from somebody to talk to."

5.2 A Desire for Behavioral and Decisional Control, to Be Strategic

Parallel to the lack of cognitive control, people also expressed the desire for more oversight of the system, combined with better ability to focus on one procedural step at a time. This insight emerged both from interviews as well as from testing of new concept designs. At the start of going through the process, people want to see the big picture of the system. But then as they start doing tasks, they want a more bordered, focused-in view. They don't want to be distracted, and they want to only see the tasks immediately at hand so that they know precisely what to do.

A recurrent request was for services to help people gain confidence and strategy. In the current system, people feel a lack of confidence in their ability to do the tasks correctly. They're fearful that they might get stuff wrong and then have to start over. We heard from one person, "I'm not a paperwork person. I have others do my taxes, I'm not good at this." Even if they begin to understand the cognitive model of the system, they need behavioral support to check their work and reassure them. They aspire to be in control, with a clear view and a game plan, and reassurance that they are behaving wisely in this unfamiliar territory.

5.3 Design Strategies to Improve Dignity and Procedural Justice

As the design teams gathered these insights about fear, confusion, and lack of trust, combined with a desire to be wise and in control, they developed new digital, paper, and service interventions to enhance people's experience at Self Help Centers. There were several guiding design principles that the teams used in their efforts.

1. *Convey a Mental Model through Visuals of the Process.* Give the court users a sense of what the legal process will be, to develop an accurate mental model of it. Ideally, this will be through a bird's eye view display that lays out pathways of discrete tasks to take a person from start to finish.
2. *Give them self-service opportunities*, in which they can accomplish tasks on their own. While people do not respond well to large amounts of information given to them, or a bank of computers offered to them, they do want a well-defined pathway to to follow, with coordinated support from people and technology.
3. *Help them form strategies for their custom situation through modeling*, to understand how to apply the rules of the system to themselves. This entails conveying information through scenarios of other people, and then allowing the person to compare themselves, choose among these scenarios, and take learnings from them. People want to craft strategies through peer comparison, and to follow others' models of what is 'normal' and 'correct'.

4. *Give them clear options in the given scenario*. The litigants we spoke with requested visual, clear layouts of what paths were open to them, like in a board game, to figure out what they could do, the pros and cons, and what to expect.

These principles pointed the teams to interventions that can enhance people's sense of control, reduce negative emotions, and enable them to better navigate the system. Proposed paper-based tools include process maps of the legal procedure; eligibility flowcharts to help people identify the best options for them; cover sheets for all forms that explain when and how to use them; model packets that give 'correct' versions of completed paperwork; binders that lay out tasks step-by-step and keep focus on one at a time; photo storyboards that show a model person going through the process; and checklists that provide guidance for steps. Proposed digital tools included online versions of the paper tools (like maps, checklists, and models); messages with reminders and coaching tips about the procedure; virtual check-ups that would scan the user's actions and see what best fits; and database screening to see what the person is eligible for and what options best suit them.

The design teams tested these tools with litigants and with court professionals, and received positive feedback about their value. Some of the prototypes that received the best reviews were of *process maps*, in the form of wall posters, booklets, mobile apps, or even business card-sized paper, that would give people a model of the system and let them follow along on their case. The maps received high reviews because of the sense of oversight it gave to users, to help them make sense of what was happening to them and feel like they were an 'insider' who saw how all the pieces worked together. The map is a central tool for perceived control, in that effectively conveys a model to the user and lets them plot a course along it.

Another intervention type that received very positive reviews was a *step-by-step coach.* Even if this was an automated bot or a paper-based packed, rather than a real person, the litigants said they would appreciate the sense of someone shepherding them through a maze, and that they wanted this coach-tool to tell them exactly what they were supposed to be doing or choosing from at points in the process. The reminders, hints, warnings, and instructions from the coach-tool would give a sense of behavioral and decisional control to the person. It would reduce the amount of information the person was expected to understand to just that needed for the given context, and it would serve this information up in a clear, bite-size display.

These principles and design patterns affirm the importance of Perceived Control in the system to a person's experience and their evaluation of how fair or trustworthy the courts are. If people are able to get a greater understanding of the system's model and how to do discrete tasks, they are able to get through the process more efficiently, with less corrections or stops-and-starts, and thus they have a greater sense that the system is fair. In this way, improved user experience can improve procedural justice.

6 Conclusion

In this paper, we explored the concept of Perceived Control as a framework to design a more dignified experience in the courts' Self-Help Center. We found that the framework helped the design teams to frame their research and craft new, promising

interventions to enhance litigants' sense of control and dignity in the courts. Using the framework, our design teams were able to draft principles and patterns for new interventions in the legal system, that can make it easier for a person to navigate the complex procedures efficiently and with a positive emotional experience.

We established the insight that court user experience affects efficiency. Certain design patterns for legal resources can enhance procedural control, which in turn can improve the speed and experience of a person going through the courts. Now that we have run initial qualitative testing of our new concept designs, our future work will involve more rigorous behavioral and quantitative testing of how working prototypes of maps, step-by-step coaches, and photo storyboard models fare in the field. This paper's design research lays the groundwork for further prototype work, pilots, and research that can study these interventions and their effect on perceived control, dignity, and procedural justice.

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Ritual Design: Crafting Team Rituals for Meaningful Organizational Change

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Abstract. Culture in an organization is hard to grasp due its intangible nature, but it can have huge influence on the organization's success and people's experiences. We proposed a ritual design framework to craft more deliberate organizational culture, and ran a two-session-class in partnership with a large corporate organization. The results showed that organizational rituals can be designed deliberately and organically when employees have a safe, structured environment to play with new cultural rituals, and they are given license to challenge the status quo. This initial design research shows that organizational rituals are most desired for increasing creativity, resilience, and cohesion among team members. It also shows that a ritual design framework can allow for organic, democratic culture-building.

Keywords: Human factors · Human-systems integration · Systems engineering

1 Introduction

An organization's culture is hard to define but essential to the happiness and productivity of its members, and the success of the group. A successful culture can show in an organization's ability to adapt to transitions in management, workforce, customer needs, or reorgs. It shows in how people of diverse backgrounds are included and respected, and how cohesive a sense of community there is among the members. And it can show in its members' creativity and ability to innovate, to create new, successful products and services.

This intangible thing of 'culture' has an enormous effect on people's satisfaction and the organization's well-being. The challenge then is, how can an organization craft a culture that is strong and flexible, that supports resilience, diversity, cohesion, and creativity?

Our hypothesis is that good organizational culture can be created with intentionality, and that using a framework of ritual design is a promising way to do so. This hypothesis is in alternative to a 'default strategy' of following the default practices, habits, and events of the people in an organization. It is also an alternative to a top-down strategy, in which a central group of leaders attempt to define a culture and impose it top-down on an organization. Our proposition is that an organization can

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_16

provide structured, deliberate framework with which to empower people of all levels of its members to define rituals that will contribute to a better culture.

This paper documents this approach and design research into its application at a large corporate enterprise software company. We developed a ritual design framework and proposed it as a hypothetical tool for culture change. Then we watched as interdisciplinary design teams attempted to follow it, to diagnose opportunities for interventions and then craft them. Our findings from the workshop show that there is great promise for an organization to use ritual design as a framework to encourage democratic culture-making, and to enhance its mission and spread its values.

In our earlier design research, we used a ritual design approach on a more personal, less organizational level. In that work, we showed how deliberately creating rituals can help individuals to craft new habits for themselves to create meaningful, momentous experiences for themselves as they tried to live their values [1]. Other design researchers have also written of the power of rituals to enhance the design of services and consumer products [2]. In addition, managers have observed how to use rituals derived from sport, religion, and other traditions to enhance community-building and creativity among their employees [3].

In this study, we expanded upon the design of rituals from the personal to the organizational. Our research leverages participatory design and design thinking methodologies, to explore what types of challenges in organizations ritual design can best address, and what types of rituals may work to build good organizational culture. To evaluate our design framework, we ran a two-session-class in partnership with a large corporate organization. Student groups were paired with teams at the organization and scouted out issues for possible organizational change, and then prototyped new rituals to be implemented. We found the framework of ritual design to resonate with the designers and the corporate teams. The act of creating rituals was found to be empowering and constructive, and the rituals themselves were found to have most promise in enhancing cohesion and resilience in teams, while also potentially enhancing creativity.

Our work contributes to discussions of organizational culture-building, stimulating creativity, and change management. It also feeds into the smaller interdisciplinary community analyzing how rituals can be useful in design with regards to user experience and service design. Our experiments in crafting team rituals on site at a large corporation showed what methods, ritual interactions, and intervention points are most successful.

2 Organization Challenges as Our Starting Point

We began our study with the overarching question of how organizations culture can be defined in better ways, with a hunch that rituals play an important role in the creation and continuance of culture. This question is of interest because of the intangible nature of culture, mixed with the powerful influence it exerts. When we looked at the existing state of organizations, we observed several challenges with regards to meaning and culture.

First, the relationship between individual employees and the organizations is breaking. In the US workforce, for instance, the majority of employees (50.8%) are not engaged with their work. Moreover, 17% of them report being actively disengaged at work [4]. These findings have been flat for the last 15 years [4] Disengaged employees tend to have less motivation, which affects an organization's performance and cohesion [5]. There can be many reasons for such an acute crisis in the modern workplace, including job roles, organizational structures, work processes, and culture. We see that this lack of engagement signals a cohesion problem within the culture.

Second, organizations face challenges with resilience, because their staff and their fortunes are constantly changing. Their transitions might be based on internal forces such as the changes in the management and their workforce; or external forces such as shifts in technology, customer needs; or simply the macro level economies that they are functioning in. Think of organizations that are going through a re-org. According to research, 80% of reorgs fail to deliver the intended result, and they create stress and anxiety among employees. A re-org's consequences are even worse than layoffs, and can result in 60% decline in productivity [6]. During the transition times, employees usually are left to their own psychological rollercoaster, and lack tools for resilience.

Lastly, the nature of work is changing rapidly with technology and its societal implications. Thanks to automation and machine learning, job roles are getting saturated. According to research, non-routine cognitive jobs have risen to 60% of the employment within past two decades, whereas routine cognitive and manual jobs shrunk in the same period [7]. This means two things. Creativity becomes even more important to stay relevant as an organization. Secondly, productivity becomes a key benchmark to stay afloat during the transition to a machine-run world.

We shaped our inquiry and hypothesis around these three challenges that organizations face: cohesion, resilience, and creativity. We observed that the culture of an organization might be changed, in order to enhance these factors and to improve employees' work and an organization's success. In order to change the culture to achieve these outcomes, we supposed that the design of new rituals might be a key factor. As the next section delineates, rituals play a key role in an organization's culture. That led us to ask two questions. First, can rituals be designed for an organization, to set or change its culture? Second, can organizations craft a culture that has cohesion, resilience, and creativity using rituals?

To answer these questions, we first turned to the literature that discusses the role and power of rituals for organizational culture, to craft our hypotheses. Then we held an exploratory design workshop with a partner organization to test them and gather further insight about the power of ritual design to build better organizations.

3 Literature on Rituals' Role in Organizational Culture

Rituals are a repeated enactment of a particular set of behaviors, scripts, and interactions [8]. Though they may have been traditionally studied by anthropologists as ways to understand large-scale religions or nations, social scientists seeking to understand

modern companies and teams have also begun to examine them. The literature on organizational culture documents that rituals have a special power to bring people together and give them a sense of purpose, values, and meaning. As Turner finds, rituals can anticipate and generate change. Or they can be an enforcer of the normal order, by reinscribing what is normal and expected [9].

Especially in the realms of sports, politics, and religion, rituals unite people and bring out deep emotions, creating a shared identity [10]. Rituals decrease anxiety, and improve performance [11]. Rituals in the workplace can strengthen the organization's desired behaviors, by creating focus and a sense of belonging, and making changes stick [3].

Overall, rituals are found to be a crucial, if hard to evaluate part of culture. Organizational culture is "fiendishly difficult to define", and many formal scholars of organization economics and management are reluctant to examine the topic at all [12]. Heskett proposes a culture framework of visible and invisible forces that defines a culture. Visible forces are artifacts, behaviors, and metrics, invisible forces are beliefs, values, and assumptions [13]. Rituals exist as a bridge between the visible and invisible. They can help organizations to manifest their values in the everyday life of the company [14], and strengthen their culture [15].

A main question of rituals, and of culture-building generally, is the power dynamics of them. For example, Gideon brings a more critical lens to presentational rituals. He characterizes them as a vehicle for organizations to practice normative control over employees [16]. But there is a promise for a more bottom-up culture building centered on growth and needs of the employees [17]. One of the values that we hypothesized ritual design might bring, is that it could allow for employees to design the rituals, and thus the culture, that they want to see in their organization. Rather than only central management imposing rituals to define culture, could we democratize culture-building through design sessions in which all kinds of stakeholders can propose and implement new rituals?

This might be to enhance a person's sense of agency and meaning at work. Chalofsky identifies the needs for interventions in the workplace that provide people greater meaning at work. These types of interventions would give ways to people to express meaning and make sense of the purpose of work. These types of interventions can provide people intrinsic motivators to perform their work better, and more satisfaction in their working lives [18]. They will help a person integrate their sense of self with the work itself, with positive outcomes of a sense of balance, a feeling of being in control, and a sense of purpose and worth [18].

The literature pointed towards the possibility of rituals to make a more humanistic, holistic work-self workplace [15], or to allow for more democratic agency in asserting what the culture should be. We integrated these findings with the outcomes of our previous research into the design of personal rituals, in order to create a hypothetical framework for ritual design for organizational culture, with which we could test the value of designing rituals and how rituals might enhance creativity, cohesion, and resilience.

4 Our Proposed Ritual Design Framework

To explore these research questions of culture creation and the power of rituals, we drafted a framework of ritual design. It stems from our observations in the literature, as well as our previous design research into the creation of personal rituals. We hypothesized that this ritual design framework would be of use to people inside of an organization looking to create better culture, and also that it would lead to the development of sticky, effective rituals that could enhance cohesion, creativity, and resilience.

The core of our framework is the notion that rituals can be designed intentionally, using a design process. Ritual design is an approach to act more deliberately when designing meaning and culture. It brings rituals as a mindset and a lens for understanding any given design brief. It then applies ritual tools and mechanics to design interventions. Interventions live under the umbrella of experience design. The form of a ritual design can be many, from an interaction, to a product that embodies or enhances a ritual, to a service involved in one, to an organizational program that formalizes it.

We developed this framework in initial design research sessions on how people can craft rituals for themselves [1, 11]. These sessions showed that to design a ritual, there is a pattern of interactions. The designer needs to set a specific context, a prop, act, and a narrative goal. Context is the setting where the ritual will occur and the hook that will trigger it. For example, one context could be "the first day at work". A prop is a symbolic object or act, such as your orientation booklet. An act is a series of repeatable actions, such as repeating an oath. A narrative goal is what the individual or group wants to happen at the end of a ritual, such as feeling connected or instilling loyalty.

Having defined these steps to create a ritual, and observed the ability of people to craft rituals to improve their own personal lives, we decided to use this framework as a starting point to explore the power of rituals for organizational culture. Our guiding question was: will design teams and organization members be able to use this process to craft rituals that have value? And, secondly, will the rituals they craft be able to live up to the promise delineated in the literature, of promoting more democratic, human-centered culture?

In order to investigate how design thinking and ritual design approach could help craft meaningful rituals for an organization, we decided to run a two-day design studio class at Stanford d.school, in partnership with a large corporate organization located in Palo Alto. We planned the workshop as a two-day exercise, with the first day as learning the framework and using it to spot opportunities for rituals, and the second day as prototyping, testing, and refining new rituals.

To examine how rituals can be deliberately crafted, we structured our class exercises around context discovery, and design of a ritual through props and acts. Based on our literature review, we set out creativity, cohesion, and resilience as potential ritual goals. For context discovery, we deployed human centered design methods, including interviews, service safari, and experience mapping to help students to discover the right context for a ritual.

We also worked with our partner organization before the workshop, to determine how a ritual design sprint could integrate with their challenges. From these discussions, we distilled several key insights about how a design process can serve organizational culture-building.

1. *A democratic diversity of organizational perspectives.* Our partners in the organization specifically requested to include employees from different positions in the organization's hierarchy as interviewees and co-designers. They recommended that we include employees who are managers, team members, interns, and executives. They believed this diversity of roles would lead to a more meaningful selection of challenges that the teams would work on.
   The hypothesis was that team members would be most interested in creativity and productivity rituals, managers would be concerned about team cohesion and retention, executives would be interested in longer-term values and missions being upheld, and interns would be interested in team cohesion and creativity. The partners' diverse points of view would lead the teams to richer culture-building, and proposals that would more likely work with the various stakeholders and be 'sticky'. This finding from the partner reinforced our hypothesis that ritual design can allow for more democratic, open culture-building in an organization.
2. *A hunger for cultural tools and deliberate crafting, but not universally.* The people in the partner organization we spoke with were those employees particularly interested in culture. They have been thinking about the organization's challenge around bringing the best work from employees, and using organizational culture to do it.
   They felt, though, that they haven't had enough time to fully understand their current culture dynamics, or to craft a vision of the culture they wanted. They flagged that they were not necessarily representative of all managers or executives in the company. These discussions indicated to us that culture-building might not be an organization-wide priority, but that a self-selected set of people are passionate about it and are eager for experimentation with it.
3. *The importance of lightweight human behavior expectations*. Another concern from our partner was that the proposed rituals be light and uncomplicated. They predicted that the most successful rituals would not require too much effort from people, or disrupt their current behaviors too drastically. They encouraged us to adjust our framework, as a heuristic to judge proposed rituals by how light, non-demanding, and adaptable they are.
   This initial feedback from our partner organization helped to reaffirm our ritual design framework, with this select group of employees agreeing that they had great concern for their organization's culture and they saw value in setting about a deliberate design process to craft new rituals.

In our first day of the workshop, student design teams learned our framework. They then conducted interviews observations, and mapping with their corporate partners, to identify points in which a specific team's culture could be improved. We encouraged the teams to focus in on a local team's situation, rather than the entire company's culture. At the end of first day, each team identified a specific opportunity in which new rituals could enhance the company's culture.

- *Brief 1: Virtual Team Connections:* How can we connect a team that works virtually, potentially using their once-a-year in-person get together? (And especially with the condition that many of the team-members aren't confident in their English public speaking abilities?)

- *Brief 2: Spreading Design Thinking:* How do we help a team, who's tasked with bringing design thinking to their entire company, to help others level up their skills, and make design thinking less of a "check-it-off-now-I'm-done" experience, and more of part of their daily practice?
- *Brief 3: Onboarding New Employees:* How do we help a creative team, that's fairly large (around 40 people), effectively welcome a new team member—and help this new employee to feel part of the team more quickly and seamlessly?
- *Brief 4: Cross-Generational Team Bonding:* How do we help people of different generations in a team better find ways to hang out and connect? Especially when young people would rather go out after work to get drinks or dinner, but parents need to get home to their family and don't especially want to hang out after work hours.
- *Brief 5: Assignment Anxiety:* How do we help employees who are doing rotations or internships, who don't have a permanent team assignment yet, get a greater sense of continuity and confidence about their place in the org? And particularly when many of the employees in this cohort may be in competition with each other for placements?

These design briefs affirmed our hypothesis that rituals can serve culture. The students and partners identified the potential for rituals to enhance cohesion and community, as well as to enforce resilience, and in one brief, to enhance creativity.

On the second day, the teams used the ritual design framework to craft, structure, and test new rituals. After several cycles of sketching, enactment, and feedback, each team proposed a ritual for their partner group to implement.

- *Ritual 1: Circle Up,* to help virtual teams connect better when they have in-person sessions. The team comes together, sitting in a circle, and then each member takes a turn in the center to share out something small. Once the person shares, the rest of the team claps and cheers. It's about raising the energy level, celebrating each other, and increasing their bond.
- *Ritual 2: Design Thinking Drip*, with the team who's responsible for spreading creativity throughout an org now using special delivery boxes. After they train another team on design, they will then send them surprise, curated boxes of prompts, hints, tools, and gifts. These surprise boxes will be staggered, arriving at unexpected points after the training, to provide a delightful jolt of creative energy and resources.
- *Ritual 3: Crash the Desk,* to welcome new hires with a surprise treasure hunt on their first day at work. When the employee is distracted away from the desk, their team-mates fill up their sad, empty new desk with their own personal objects. Then the employee must go on a hunt, talking to all their new co-workers to try to find the objects' owners, and hearing stories about why they're special. The goal is to build more personal one-to-one connections, and reinforce the new bonds being made.
- *Ritual 4: One Box,* to connect random people inside a team for special occasion in a 'regular' way. Team members (or people in the same building) enter their name into a box. Each week, one employee draws a name from the box, to choose a 'work-date' thing to do, and co-worker to do it with. This might even just involve being each others' lunch buddy. The goal is to bring a spark of random connection,

while also making 'hanging out' part of work life, rather than something that happens only after hours for people without family obligations.

- *Ritual 5: Graduation Ceremony for New Talent,* to have a playful party when people on the 'new talent' track, after their first year rotation, are finally given their official, permanent assignment. The ceremony will make this transition time more of an official celebration, to give recognition to the anxiety and momentousness of it, from the employee's perspective. It should also lighten the competitive tension felt between the employees.

Each of these rituals was vetted by the partner team, and in some cases, were actively created along with partners as co-designers. The teams handed off video explanations of the ritual, for their partner teams to take, enact, and adapt going forward.

5 Findings

Reflecting on the design work and ritual output of the workshop, we found that the ritual design framework resonated with our design teams and our self-selected corporate partners. Those people who are interested in improving organizational culture found the focus on rituals to be quite useful and the design work in creating them to be enjoyable and fruitful. In our debriefs with the stakeholders, they affirmed that crafting small interactions, to embody and spread particular values, was a strategy they found to be very promising for their own culture. We identified several more specific insights about the design of rituals in organizations.

5.1 Ritual Design Framework Resonates

When we analyzed the flow of all the designed rituals, we observed that teams had employed the ritual design framework elements naturally. They prototyped the rituals as narrative arcs, with a context hook, symbolic prop, and repeatable acts.

The teams found that rituals would have particular strength during transition times, such as starting a new job. The framework could be emphasized particularly during an employee's transitions, or when an organization is going through a larger-scale transition.

Among the goals of the rituals, cohesion was the dominant theme. Teams found rituals to have promise for creating bonds, a sense of identity, and strengthening superficial relationships. Creativity was a less prominent theme, with a few teams highlighting that rituals could be used to stoke creative work.

We gathered an insight about the service design nature of many of the rituals. Though we had proposed the framework to be for an interaction that could be repeated, the teams crafted more 'ritual services' as ongoing programs. For example, the One Box and Design Thinking drip rituals were designed as ongoing services with multiple touch points. The New Talent Graduation Ceremony and Crash the Desk are part of an ongoing program. We will incorporate this insight, that rituals could be a service design, into our framework in upcoming workshops.

5.2 Rituals Are Strategies to Assert Culture

As we hypothesized based on our literature review, the design teams uncovered the democratic potential of rituals for culture-building. Ritual design can be a powerful means for an individual to assert the culture they want an organization to have. Regardless of their place in an organization's hierarchy, a person can craft these small, special interactions to make the organization more in line with the values and behavior they want.

Particularly for people who may feel stuck or unhappy in an organization, seeing culture through the lens of ritual design can help them figure out strategies to bring people together in better ways. It is proactive, it focuses on small interactions, and it brings a 'je-ne-sais-quoi' factor of meaningfulness and excitement.

As we heard from some of our student participants, in past working environments they found the status-quo of relationships in teams to be toxic—without respect, with adversarial competition, and a lack of a 'team' culture. This is where they found that a ritual design framework could help. It puts anyone inside an organization as an agent of positive culture change. You do not have to wait for the culture to change for you—you can quickly, creatively prototype your own relationships and team culture. Ritual design can be a tool-set to playfully craft new interactions, and embed new values into the day-to-day.

5.3 Low Barrier Prototyping

Another observation from the workshop is that the process of ritual design can be a cheap, quick, meaningful way to spark new culture. A design workshop is relatively cheap and informal, but it provided valuable 'safe, creative space' for reflecting on current culture and playing around with new behaviors, is very valuable. Prototyping new rituals is quick and free, because they are small interactions. They do not require intensive technology or expertise. Rather, what is needed is more in terms of human capital: buy-in from some employees, who are willing to engage in brainstorming and improve, and who are open to spend time in design work.

Running a workshop also can bring out the people inside an organization who are potential culture-makers, but who haven't been given the opportunity to be so yet. You don't need a whole organization to engage in this kind of ritual/culture design—just a few ones who are passionate about better ways of working. It also benefits from having outsiders co-design with employees. The students helped bring a fresh, naive perspective, that encouraged the employees to reflect more systematically on what was going on in their work culture. They also brought creativity and their own experiences to spark good ideas for rituals.

As one of the students observed, what's really necessary for a ritual design's success is a person in the org to be passionate and charismatic about it. One person can craft a ritual and then spread it outward—as long as they can get others to suspend over-thinking and inertia, to join in.

In our debrief with our partners, we formalized this process so that it can be repeated throughout the organization. A ritual design workshop can be easily repeated,

through setting out some constraints (quick deadlines, going through the steps of the design process, and ending up with a 1-minute video), and supplying the participants with a little training, some brainstorming prompts, and some coaching. The workshop itself can be a force of positive change, helping employees give voice to where they think culture is breaking down, and then giving them creative agency to make small, funny, delightful new rituals that would improve their work-life.

5.4 A Mindset of Ritual-Spotting

Another insight that emerged was that culture can be crafted in even more everyday ways than a design workshop. Once a person has gone through this process, they have a powerful mindset with which to spot and foster organic rituals. Put simply, ritual design can be an intentional way to get to organic organization culture. Seeing the workplace through the lens of rituals—and with the knowledge of the design process—can help an employee see good things that already exist, to build from one-off interactions into regular rituals. We call this ritual-spotting.

Alternatively, this lens can help them to see breakdowns, fail-points, and let-downs that they can then target with a new ritual as a design intervention.

We heard from several of our participants that they were most excited about developing their own toolbox of strategies and practices to develop better work-lives and team behaviors where they work. By playing with ritual design, they started to realize that one important strategy can be converting their routines to rituals.

The workshop helped them understand difference between routines (actions that get repeated regularly, like stand-up meetings) and rituals (actions that carry a je-ne-sais-quoi factor of meaning, magic, or values). They were able to see this special power that rituals have, to bring values out through behaviors, and to bring people together and give them a unique sense of satisfaction and bonding. With that insight, they started to think of strategies to make the things that they do on a regular basis (rather thoughtlessly) more meaningful by layering a ritual into them.

5.5 An Alternative to Top-Down Culture, Culture by Default

In our debrief, the participants reflected that ritual design can be an alternative to more top-down, heavy attempts at culture-building. Rather than company retreats, centrally-planned events, and other big attempts to set culture, when employees themselves craft and spread rituals, they're much more likely to get engagement, and they will have more meaning and resonance for the teams.

This leads to our final big takeaway: ritual design can be an antidote to "culture by default". If an organization is not intentionally crafting rituals that reflect their values and mission, it's likely they have rituals that don't actually serve them. For example, in our background research, we heard many examples of org rituals that involve heavy drinking, or the manager's personal preferences. In many cases, an org's culture is set by rituals that have been inherited from fraternity and college rituals, or that are built too closely around the manager's defaults.

Going through a ritual design process helps to think more deliberately about what kind of values and experiences the culture should embody—and then what kinds of behaviors would best serve this—and especially with an eye to the diversity of the employees in the org. Not everyone wants to celebrate successes, say goodbye to departing team-members, or bond with co-workers through alcohol, or through after-work parties, but often these are the go-to rituals that pop up. With more intentionality, creativity, and co-design, an org can make sure that its rituals reflect its employees' preferences and its own values.

6 Conclusion

When we think about the big challenges facing modern corporate organizations, around retaining talent, weathering transitions, and improving engagement, culture and rituals can address them. We argue that intentional use of the design process to craft new ritual interactions in the workplace can allow for democratic, organic culture-building. It is a strategy to allow for people from various levels of hierarchy in an organization to assert the types of values and behaviors that they want the culture to be. Rituals have particular power because they can be modest, easily prototyped interactions, but they can hold tremendous significance and emotional sway. The ritual design framework that we have refined lays out a clear path with which to craft new rituals, making it easier for teams to reflect on their current culture and then prototype and refine new rituals to address problems.

Our workshop demonstrated that rituals are designable, and that, at least for people who are interested in matters of 'organizational culture', the process can be lightweight and satisfying. Our next round of research will examine which of the designed rituals succeed, insofar as they are embraced and practiced by the partner teams. We will evaluate which of the rituals continue to be performed after several months, or if they are adapted. We will also experiment with rituals in a longitudinal manner for the 'stickiness' factor in rituals, and inquire into the qualities of rituals that stick. We are not defining success as widespread adoption throughout the organization, but rather by whether a specific group practices the ritual. If they do, this will demonstrate that the ritual provides them value.

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Material and Texture Exploration

New Typographic Experience in the Post-digital Age with 3D Printing and Ceramics

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Abstract. This research explores unconventional methods of creating three-dimensional type with materials and techniques unique to type design, such as ceramics and 3D printing. Today, technological convergence and new manufacturing processes using computer numerical controls have broadened creative possibilities and the perception of the three-dimensional experience for artists and designers. With the development of digital technologies, letters can be printed in three-dimensional space, and this will cause a paradigm shift in the typographic experience regarding the development of material and manufacturing technologies.

Keywords: Typography · Lettering · Design · 3D printing · Ceramics · Custom tool · DIY · Post-digital · Exploration · Computer numerical control · Technology

1 Introduction

My research explores unconventional methods of creating three-dimensional type with materials and techniques unique to type design such as ceramics and 3D printing. This research began with two questions: Where does typography belong in the post-digital age? How do we combine digital and physical materials to enable a new typographic experience? There are a few ongoing discourses regarding the term "post-digital," and no one can authoritatively decide how to define the term. The debate focuses on a paradigm shift in the arts regarding the development of technology as the exciting and rapidly changing digital environment affects it. Today, technological convergence and new manufacturing processes using computer numerical controls like 3D printing, CNC milling, and laser cutting have broadened creative possibilities and the perception of the three-dimensional experience for artists and designers. Three-dimensional printing in particular has become more refined, common, accessible, and cheaper. These new technologies have introduced new tools for pushing the boundaries of the medium both in terms of concept and materiality. In response to this movement, this research infuses 3D printing into the field of typography and ceramics.

Specifically, these new technologies will bring us into a transformational experience that allows us to talk about the notion of printed letters. For decades, many graphic design professionals and type designers have worked exclusively in two-dimensional

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_17

space to create type. This practice has somewhat influenced the "glass box," which limits type creation to the high contrast between type and background as most type has been printed on flat surfaces. However, with 3D type, as opposed to type printed on paper, letters do not lie on the static surface of a page or a screen. For artists and typographic practice, 3D type is convergent and incorporates artistic expression, construction technique, three-dimensional experience and materiality. Thus, these letters acquire new characteristics such as texture, structure, volume, dimension, and even interactivity with their physical tangibility. With the development of digital technologies, letters can be printed in three-dimensional space, and this will cause a paradigm shift in the typographic experience regarding the development of material and manufacturing technologies. This research will provide inspiration and a frame work for designers and artists who are interested in building their own custom tools in the post-digital age.

2 Creating the Tools

For this research, I decided to build my own tools including a custom desktop 3D printer and my own paste extruders in order to produce 3D ceramic type and objects, as a ceramic 3D printer was not affordable or accessible. To build my own ceramic 3D printer, I researched the RepRap project as it is one of the most famous open source projects on building 3D printers and provides resources for designers, artists, and makers to build affordable 3D printers. The most exciting feature of these Do-It-Yourself 3D printers is that you can build your own machine and customize it to your individual creative practices. The custom-built toolkit produces quality prints comparable to commercial ceramic printers.

2.1 The 3D Ceramic Printer

I needed to make my own tools[1] for my research in order to investigate the concept, and there was no 3D printer that could print clay. Many design professionals have used premade software and hardware as these components are not easy to create on their own. The 3D printer is one of these components, and it is beneficial many designers. In 2014, I made handcrafted ceramic pieces in order to create 3D modular ceramic type; I made plaster molds and casted piece by piece. These practices also lead to an interest in the possibility of combining typography, ceramics, and 3D printing as an alternative way of using high-tech features. Desktop 3D printing caught my attention because it does not need the space and equipment for a clay studio. I can make more intricate and more varied modular designs with this new tool.

The first ceramic 3D printer was built based on a delta style 3D printer. In the summer of 2015, I purchased a DIY 3D printer kit. I had been playing with the open source delta style 3D printers to figure out what I could do with this new technology.

[1] It is condensed and updated version of the article that posted on makezine.com in September 2016. This Custom Machine 3D prints Incredible Ceramic Sculptures.

There are several different types of 3D printers, and RepRap is one of the most highly regarded. RepRap printers are able to produce some of their own parts and make them self-replicative, and they are one of the most affordable 3D printers. After I made a decent number of small prints, I wanted to build a scaled up version that could print small and medium size ceramic objects. I realized that my 3D printer was able to produce parts to build a new printer, and I fabricated a bigger version of the delta style 3D printer. It involved considerable troubleshooting to build and run my own DIY tools. This is one of the benefits of building your own printer.

These are 3D printers I have built to print ceramic type and objects. The left one is the medium scale printer (print volume: 300 mm diameter and 300 mm tall) and the small one in the middle is made for workshops and demos (print volume: 160 mm diameter and 260 mm tall). The taller one is the latest one I built to print bigger ceramic type and objects (print volume: 320 mm diameter and 1050 mm tall) (Fig. 1).

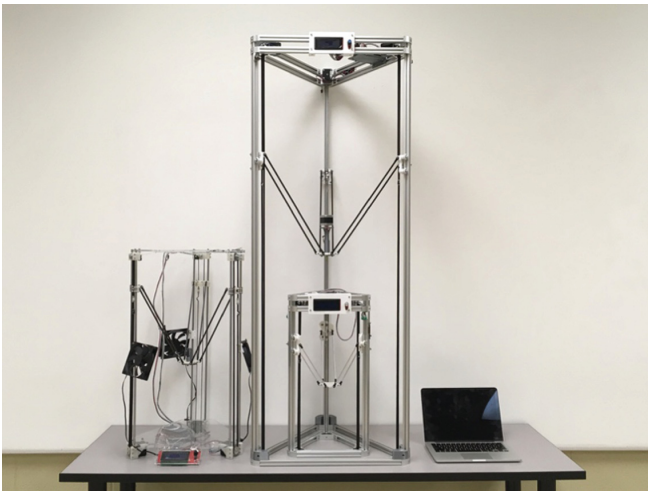

Fig. 1. 3D printers

2.2 3D Printing Clay and Clay Extruder

Clay is a fascinating and sensitive material. It is essential to find the right viscosity of clay. It should not be too soft or too solid. If the clay is too solid, it cannot be extruded smoothly; if it is too soft, it has a greater chance of collapsing while printing. I started with low fire white clay because it has fewer particulates and is soft enough to be easily extruded. Since the clay is normally not soft enough to be 3D printed, it should be mixed with extra water. As the early prints were small and simple geometric shapes, it was relatively easier to print them. However, as the prints got bigger, 3D models were not as easy to print because they would collapse.

In order to 3D print ceramic objects, it is crucial to extrude wet clay. Therefore, I made prototypes of a clay extruder with PVC pipes[2] since this is inexpensive and easy to get. However, it was still not easy to print wet clay because wet clay is very sensitive. It required several test prints to find the right Pound Per Square Inch to extrude clay and appropriate slicing configurations to generate G-code. Early works were simple geometric shapes, and I produced many misprints that collapsed and sagged while printing and after printing. I solved the problem with electric fans around the prints and by designing self-reinforcing structures. 3D design with self-reinforcing structures reduces the chance of collapsing and sagging. Also, it adds its own aesthetic to the ceramic typographic sculpture. Later, I reevaluated those misprints and created typographic sculptures that delivered new experiences.

This image describes how the auger system extrudes wet clay. Wet clay in the container is extruded with compressed air and an auger screw that is controlled with a stepper motor is extruding and stopping clay. The stepper motor is controlled with an Arduino board that is connected to a computer (Fig. 2).

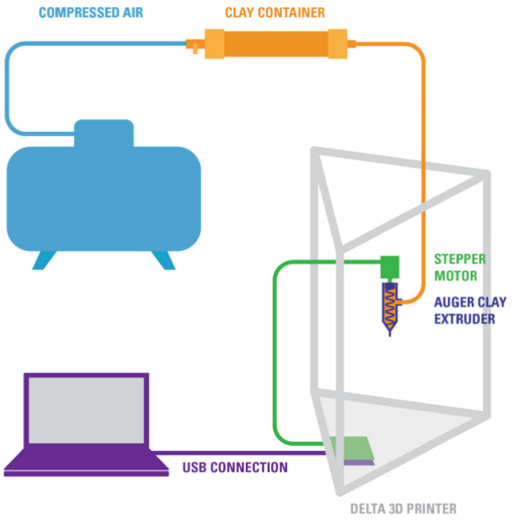

Fig. 2. How the auger system extrudes wet clay.

The first clay extruder was a simple pneumatic extruder with compressed air. It is good enough to print certain 3D type and vase like objects, but it is not able to print more complex letterforms. To print diverse and intricate 3D letters, I designed a new clay extruder that is using an auger valve to control paste extrusion. I took advantage of 3D printing—3D printing is also called rapid prototyping—to make my own tools. I designed auger screws and housing on CAD software and printed them out for testing.

[2] PVC pipe is not recommended and would not be safe material for use with compressed air. Copper, Stainless Steel, Aluminum are recommended.

For more than three weeks, I have designed and tested more than 60 different screws and 10 different housings. Since there was a leak on the extruder, I needed several tests to solve the problem. After resolving the issue, the auger extruder shows pretty impressive results.

2.3 Process of 3D Printing Clay

- Step 01: Produce a 3D model using Computer-Aided Design. Any CAD software would be okay if the software can export your design into STereoLithography file (STL).
- Step 02: Convert CAD design STL file, the most commonly used format for 3D printing. When the design is exported, the design will be turned into triangular mesh with tolerance. Depending on the resolution of the 3D printer that will print the design, you should choose the right resolution for your file. Less tolerance produces more triangles and the file size will be heavy. If the tolerance is high, the design could be very rough. Ceramic 3D printing with paste extrusion requires less resolution than common 3D printing.
- Step 03: Slice the 3D model and create G-code. Creating a tool path might be one of the most important steps before you start the printing. When the G-code is generated, you should make sure there are no glitches.
- Step 04: Setup machine and load clay into a clay extruder. It would be good to visually check the printer and open the connection from a computer that is connected to the 3D printer. Wet clay should be loaded to clay container. When clay is loaded to the canister, there should not be bubbles—very tiny bubbles would be okay.
- Step 05: Let 3D printer do its job. Printing time may vary depending on the complexity and the size. 3D printing clay takes relatively less time than printing PLA or ABS since it has a wider nozzle and is extruding more materials. However, someone should be watching the printing process. If it produces a misprint, the job should be stopped and restarted.
- Step 06: Remove the printed object from the machine and let it completely dry. If the printed object is not dry enough, it would be good to let it dry more before you remove the print. New prints are very fragile before fired.
- Step 07: The print should be bisque fired and/or glaze fired to mature the clay body. Different clay bodies require different temperatures to be vitrified. Depending on the design and the clay body, the prints could have 15–20% shrinkage rate (Fig. 3).

3D printed ceramic type and objects need to be fired when they are completely dried. Those prints are mid-range porcelain and they need to be fired at cone 6 (2232 °F) [1]. Shrinkage rate is between 15–20% depending on the clay body and the design. Depending on the scale and design, they could have sagging or warping.

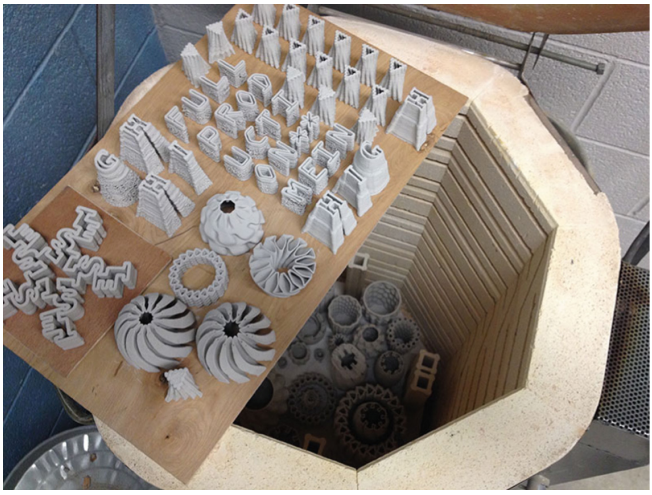

Fig. 3. 3D printed ceramic type and objects

3 New Typographic Experience in the Post-digital Age

Since the time of Gutenberg around 1450, hundreds of years have been spent developing impeccably proportioned, beautiful typefaces and print technologies to support the perfection of printed materials. However, type design has evolved with creative process, shifting the emphasis from two dimensions to multi-dimensions. Developments in digital and multimedia have pointed in the direction of dimensional typography. Because of animated letters on screen with dimension of time, three-dimensional letterforms became more common than before. Ironically, after many typefaces digitized and translated into digital data, letterforms recover the dimensionality with new technologies. As readers and audiences have been exposed to more complex and diverse visual environments, they are willing and able to deal with textual and dimensional visual elements in both physical and virtual environments. Today, it is not necessarily anymore important to have clear and transparent relationship between form and content. The importance of Beatrice Warde's crystal goblet metaphor [2] may be diminished because presenting a text in a straightforward manner is not strictly required.

Today, under the development of digital technology, the exciting and rapidly changing digital environment has influenced typography and typographic experiences. I asked two questions for this project: Where does typography belong in the post-digital age? How to combine digital and physical materials to enable new typographic experience? We cannot deny the rapidly changing digital technologies and its influence on art forms in the digital age. There are mixtures of hopes and concerns between being human or being digital.[3] Personally, I believe the debate should focus on the

[3] When this research project was introduced on online and has gone viral, it set an interesting discourse. Mainly, there are two different reactions. One side is very excited for printing ceramics and the other side expressed their concerns and worries about these new machine-driven crafts.

exploration of new avenues and possible ways to bridge digital and physical relationships. Digital environments enable us to make something we have only imagined or even have never imagined before, for the last decades. During the digital age, many analog and physical objects are digitized or simulated on screen. In my opinion, many things on digital would be translated into physical or combined into physical space in the post-digital age to bridge the gap between digital and analog. It is already undeniable to face a paradigm shift in many forms of art and design under the development of technology as the exciting and rapidly changing digital environment affects them, typography included.

3.1 3D Printed Ceramic Typographic Sculpture

This exploration provides a way to rematerialize type in order to translate the digital type design into tangible typographic form. Also, the use of digital fabrication pushes the boundary of the medium in typography both in terms of concept and materiality. Likewise, 3D printed ceramic type obtains materiality and dimensionality, so that this became an involved cross-disciplinary research effort. This chapter will introduce the actual three-dimensional letterforms that I have created.

The CAD design of "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG" was designed using Rhinoceros. The letters were stacked vertically in three-dimensional space and the outline of the letters are merged together. Spaces between words were wider and deeper. I was agonizing over how to write letters in three dimensional space and it is one of the solutions I found (Fig. 4).

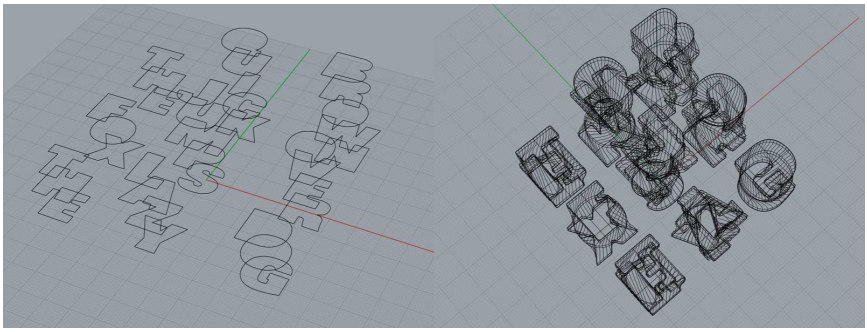

Fig. 4. CAD design

These tangible letterforms are designed on CAD software and 3D printed with ceramic. They say "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG." Before you pay a lot of attention on the three dimensional form, it is definitely not easy to notice what the texts are. The texts are not very straightforward (Fig. 5).

Fig. 5. THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG

These 3D modular letterforms show how to use modular construction for ceramic typographic sculpture. The modules could be rearranged to construct different letters [3]. Depending on the deeper understanding of modular construction, the alphabets that these modules can construct would not be limited to Latin Alphabets (Fig. 6).

Fig. 6. 3D modular letterforms

MESS to NEAT was printed after successfully printing ME IN FULL PRODUCTION. It is the result of a trial incorporating the meaning of the text and the form of the text. The print quality of the bottom parts is disorganized and gradually gets better toward the top. The transition of the print quality shows transition of the text and the meaning of the text as well [4] (Fig. 7).

Fig. 7. MESS to NEAT

As I mentioned above, I reevaluated the value of the non-linear character of clay and created this ceramic type. Those glitches created the interesting texture and added character as well. The glitch was made by manually controlling the extrusion, not from the software. Also, these ceramic 3D type are multi-dimensional because they involved time as an additional dimension. The time-lapse video of the printing process shows that the letters are moving through time and space [5] (Fig. 8).

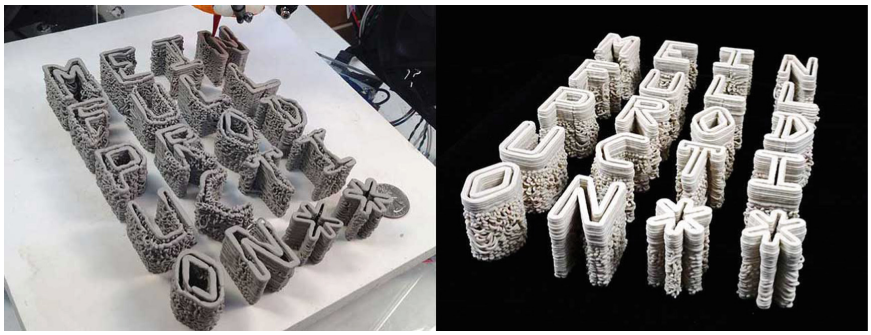

Fig. 8. ME IN FULL PRODUCTION

As I developed 3D printing ceramics process, I have tried more complex objects that are not easy to make with our hands and traditional ceramics techniques. The design of the three dimensional ceramic type became more abstract and sculptural. This is one of the successful prints from the trial and error process in order to produce a good. The form is inspired by letterform "X" and designed to have a self-reinforcing structure (Fig. 9).

Fig. 9. "XXXXX" as "XXXXX" is the tile of the work.

3.2 The Future of the Exploration

This research successfully finished the beginning and the intermediate stages. The next stage is aiming for larger scale prints and more durable structure and material in order to introduce this experience to a wider audience. Recently, I built a giant 5 ft tall 3D printer that can print ceramic objects up to 1050 mm (approximately 3.4 ft) tall and 320 mm (approximately 1 ft) in diameter. Also, a 6 ft tall 3D printer with more ridge frame is under construction. The next stage of this research foresees creating even larger pieces that can be placed in public space in order to allow people to touch and interact with the large-scale three-dimensional typographic sculptures, perhaps even using concrete as their material.

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The Black Color of Product Design and Packaging Research

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Abstract. This study investigated commercial technology products with respect to the impact of color on user perception towards product preferences. The study investigated semantic differences of headsets of black or white color with 16 kinds of psychological tests to obtain the best color matching for statistical analysis, and in order to design for cultural and creative design perspective and provide proper design alternatives. The headset design studies includes five kinds of packaging styles, with five the best color combinations to a total of 25 packaging designs, and applied Likert scale statistical data and analysis. The results showed that black headphones, with minimalist design and black color product packaging showed higher preferences.

Keywords: Product design · Technology products · Cultural and creative · Color · Packaging design

1 Introduction

In product design, the color matching properties in technology products has affected the mental and emotional states of the users and their purchasing behaviors. The hue of technology products, the brightness and color match of saturation can be crucial to the product design. Presented by each color match, the attractive features and mental feelings may vary accordingly. Using the product, the user emotion could have been affected.

Generally, the color black represents a stable and solemn manner, which leaves a prudent impression when it comes to color psychology and the triggered mental responses. The color blue represents technology and security. The color red represents love, stimulation and excitement. The color yellow represents cheerfulness and happiness. The color gold implies nobility, glory, splendor and brilliance. Therefore, ancient Chinese emperors normally would request their clothing to be made of the color gold. In many countries, the color gold reflects its color and represents money, fortune and capitalism. Compared to other traditional colors, the metallic colors such as champagne gold or rose gold, silver and silver grey became the popular colors after the

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_18

iPhone5 was produced. Color indirectly affects product emotion and also serves as a critical element for design. The color match attracts the attention of consumers and convinces them to buy the products. Consequently, successful integration of product emotions can be a critical process to help consumers choose the appropriate colors for product design to match the right color.

In this study, earphones as the research object were studies, where the color of the product design specification commonly used in professional color Pantone-based [10]. First, before performing the experiment, observe commercially available headphones common color matching. Choose 13 popular metallic colors and dark gray, black, white, 16 colors (metallic red 8445C, metal yellow 8642C, metallic orange 8962C, yellow and green metal 8683C, metallic blue-green 8285C, metallic blue 8181C, metallic violet 8162C, metallic purple 8082C, metal deep pink 8443C, rose gold, champagne, gold 874C, silver 877C, gray Cool gray 8C, black and white black C), metallic colors to choose colors from PANTONE metallic colors to experiment with the system.

In color matching the color black leaves an impression of nobility and prudent manner for most products. Examining the use of color for some technology products such as televisions and cameras, it is frequently assumed that the color black is used. Symbolizing purity and cleanliness, the color white is used to make bridal gowns for a western and Japanese wedding. This product research adopts a binary color matching by incorporating the color black or white with another metallic color or black or white. The color black is used with a metallic color to create an impression of nobility. The color white matched with a metallic color creates an emotion of elegance. The metallic color reflects the quality of the product and is also easily configured to match other colors.

2 Discussion

Color is an important aspect in product design, since product and packaging color selection stimulate the desire for the consumer buying experience, therefore the color of product and its packaging can encourage buyers and stimulate the growth of sales. Is a common trend that commercially available headphone products and their packaging are often found in black or white color, this coloring became a representation of often higher quality product in most cases. It was found that users connect these attributes to higher quality product or packaging, such as durability and professional performance.

3 Research Method

This study utilized an approach based on survey study to collect user preferences, which first examines the mental response to colors using the headset by comparing those headsets coming in other colors that are sold in the market. Statistics were used to describe the common color matching by applying 16 colors to run a mental test.

The Semantic Differential Technique was used to acquire the best color that could be applied to do statistical research. Next, the experimental approach to find a way of incorporating the elements into cultural creativity design was applied. Ultimately, statistics were used to describe the packaging template by selecting 5 different kinds of colored boxes for packaging. An experiment approach that allows the subjects to choose the most applicable template they wanted was applied to analyze the best product packaging structure for the user. Finally, using the Likert Scale to analyze the data, the best headset product was packed and manufactured using 5 packaging templates for its design with the 5 best color combinations, which could have created 25 packaging designs.

3.1 Research Purpose

The purpose of this study was to study the effect of colors such as black or white and the metallochrome colors, with customer acceptance for headset design and the emotional feature that entails each color match, and the best packaging template for the headset. This study also provided practical experience of the color matching applied to product design and learning method template for the packaging design. Therefore, the research purpose was described in three categories as follows:

1. Emotional feature analysis of the colors found in the products to discuss the emotional factor was applied to confirm the most popular headset color and ensure the color match used in black or white with a variety of metallic colors that could entail emotional features.
2. After confirming the best color match for the headset, an experimental approach to find a way of integrating the elements of cultural & creative design were applied to this study.
3. To ensure the slight differences found in various color boxes for the headset packaging, an experimental approach to find the best way of using the packaging template was applied to this study. It was suggested that applying a black or white headset with other matching colors to the product in the course of packaging design for the product based on the ideal emotional features of the product. Its packaging design was the most applicable approach to the learning colors.

3.2 Design of Experiment I

After matching black or white with a variety of metallic colors, an experiment was conducted to examine the emotional features arising from the colors was applied to this study in two sequences. Researchers first found color matching in dark grey, black and white with 13 other metallic colors announced by Pantone [10]. A total of 16 colors to run the color-matching test were applied to this study to examine the emotional factors of a variety of colors and evaluate the emotion entailed in the color of a headset product. Next, an experiment was designed to determine the emotional feature after matching the color white with a variety of metallic colors (Fig. 1).

Fig. 1. Black and metallic color matching experiments

First of all, the subject of this study was requested to choose from one of the questionnaire surveys using the Likert Scale. The purpose of this study was to describe the aesthetics and quality using a psychological test known as the color test. The topics of this experimental research in Q1 and Q3 were described as extremely artistic, quite artistic, slightly artistic, moderate, not so artistic, not quite artistic, and not artistic at all in the 7 levels of the scale. 16 colors were used to test the mental response. A total of 64 tests were designed with 4 topics per test to find the most acceptable color for the headset (Figs. 2 and 3).

There were 50 subjects of this color experimental test, 25 male students and 25 female students participated in this research project. Aged from 18–22, these subjects were the sophomore students of the Department of Design.

The entire aesthetical test of color match shows that the color white and metallic green (1.85) color matching group and the color black and metallic green (2.32) color

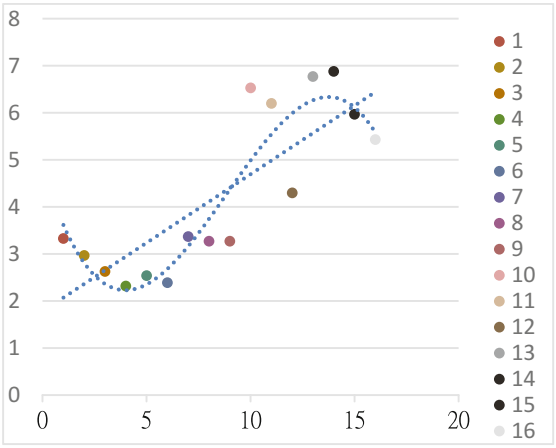


Fig. 2. The beauty of the color black and metallic color of the sample in Fig. 2 Q1

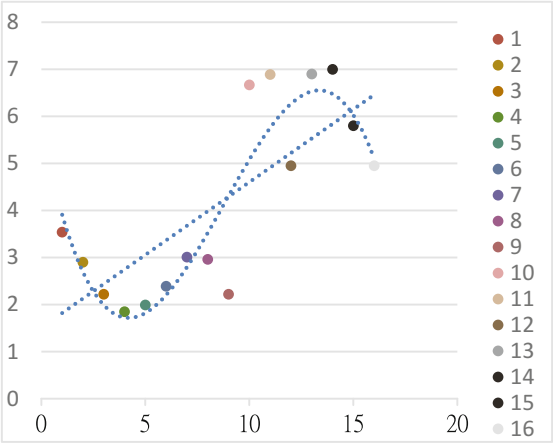


Fig. 3. Q2 color texture of black and metallic color of the sample

matching group were assumed to be of less quality with the lowest score. On the other hand, the color white and rose-gold (6.67) color matching group and the color black and silver (6.77) color matching group were assumed to be quite popular. The color white and black (7) matching group and the black and black (6.88) color matching group were assumed to be very classy, which had received the most recognition. Apparently, the metallic colors such as the rose-gold and Champagne gold did not overwhelm the color matches found in non-metallic colors (Figs. 4, 5, 6 and 7).

The topics of the next experimental research in Q2 and Q4 were described as very classy, relatively classy, slightly classy, moderate, not so classy, not quite classy and not classy at all in the 7 levels of the scale. 16 colors were used to test the mental response. The color black or white with other colors representing the emotional feature were procured by their average score after calculation.

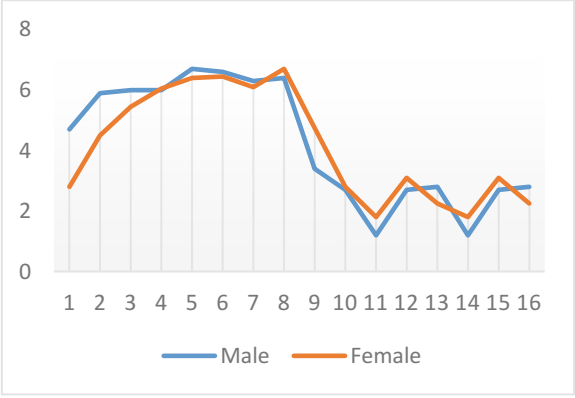


Fig. 4. Color sample survey of the average difference between men and women line chart

	White	Color	Pantone No.		White	Color	Pantone No.
1			8445	9			8443
2			8642	10			Rose Gold
3			8962	11			Champagne Gold
4			8683	12			Golden(874)
5			8285	13			Silver(877)
6			8181	14			Black
7			8162	15			Gray(Cool Gray 8)
8			8082	16			White

Fig. 5. White metal color matching experiments

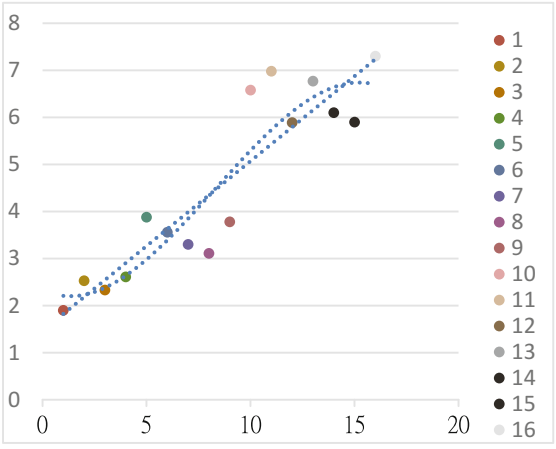


Fig. 6. Q3 beauty of the white color with metallic color samples of FIG.

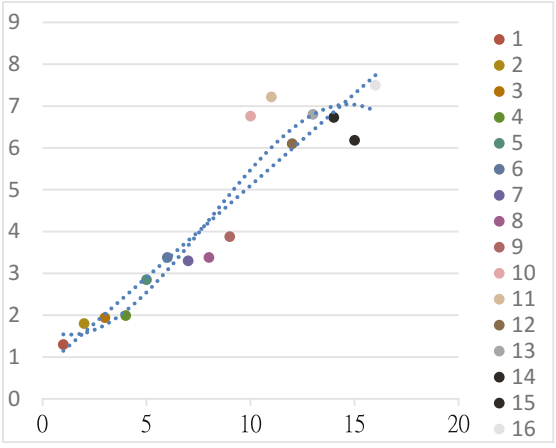
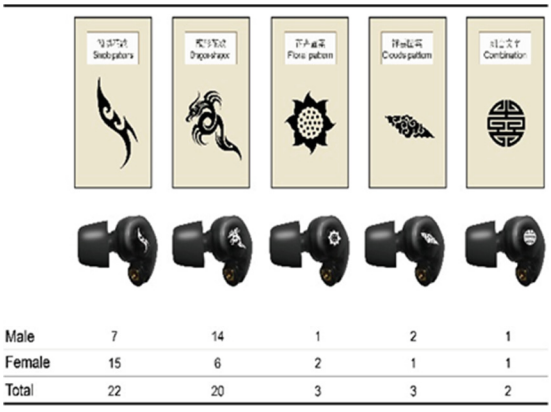


Fig. 7. Q4 white and metallic color matching color of the sample color

The entire quality test shows that the color white and metallic red (1.3) color matching group and the color black and metallic green (1.85) color matching group were assumed to be of the less classy with the lowest score. On the contrary, the color white and rose-gold (7.22) colors matching group and the color black and Champagne gold (6.89) color matching group were assumed to be quite popular due to the iPhone effect. The color white and white (7.5) matching group and the black and black (7.0) color matching group were assumed to be very classy, which had received the most recognition. Statistics of this experiment showed that the metallic colors such as rose-gold and Champagne gold did not overwhelm the color match found in non-metallic colors.

3.3 Design of Experiment II – An Experiment to Design the Cultural and Creative Elements

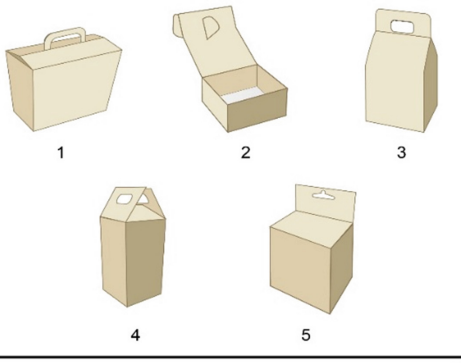
(1) Five cultural and creative patterns were described in this research design to do a statistical analysis on the experimental result using the questionnaire survey. The best packaging structure design found in 2 groups for creative design and best color matching colors found in 5 groups offered some new ideas to do the template for cultural and creative design. (2) Five packaging structural designs and five color matching groups and illustrations most applicable for the headset were described in the design to conduct an experiment for discussion on these 10 portfolios. There were 50 subjects of this experimental test, 25 male students and 25 female students, who participated in this research project. Aged among 18–22, these subjects were the sophomore students of the Department of Design from the University of Science and Technology. Finally, the completed statistical result was assumed to be the best and most applicable template for the cultural and creative pattern design (Fig. 8).



Male	7	14	1	2	1
Female	15	6	2	1	1
Total	22	20	3	3	2

Fig. 8. Five kinds of experimental images and illustrations chart 8 study

In the five experimental groups, these patterns mainly focused on the pattern, which could represent cultural and creative design. The selected patterns were described as simple floral pattern, dragon-shaped floral pattern, floral graphic, cloud graphic and coined word design. Statistics showed that the results of the traditional Chinese coined words were described as the most unpopular graphic design found on the headset, which appeared to be awkward. The simplified dragon-shaped graphic (20 points) was assumed to be the most popular design with its cultural creativity. On the other hand, the simple floral pattern (22 points) was assumed to be the most preferable design by combining the modern design graphics with traditional style (Fig. 9).



	Male	Female	Totel
1	3	2	5
2	2	1	3
3	7	5	12
4	2	2	4
5	12	14	26

Fig. 9. Headphone box style and color experiments statistics

An experiment on the color box template was applied to this study by selecting the 5 most commonly used square paper box packaging. The results showed that the simple square box was the most popular template.

Focusing on the 50 students from the Department of Design, this study adopted the Photoshop and Illustrator software in the stage 1 and stage 2 experiments for the color used in packaging. Students were allowed to create their packaging design based on the handout by following the steps listed on the demonstration. This study checked on student design colors, drafts, and graphics to see if these works contained any groundbreaking creativity. The yellow package was described as the template in stage 1 and the black package was the template in stage 2. Students were allowed to create their own headset packaging in stage 3 (Fig. 10).

The results of this experiment showed that the color yellow was applied to the package as a template in stage 1 based on the handout. The results of the packaging design made by the subjects showed that 31 colors used for packaging mainly

Pantone	1	2	3	total
White	5	8	11	24
Black C	6	34	29	69
104C	18	1	2	21
143 C	2	0	1	3
185 C	3	0	0	3
7680 C	1	0	1	2
375 C	5	1	2	8
653 C	3	2	1	6
653 C	5	2	2	9
877C	2	2	1	5
total	50	50	50	150

Fig. 10. Headset style and color box design experiments

concentrated on the colors yellow, green, and blue. The color black was applied to the package as a template in stage 2 based on the handout. The results of the experiment showed that 34 colors used for packaging mainly concentrated on the color black. The most popular color found in stage 3 after doing the color test and two experiments was the color black where the color white appeared to be the second popular color. Apparently, most students assumed that the most applicable color for packaging is the black color box after experiencing multiple colors effect.

4 Research Result and Data Analysis

In the experiments, this study showed that the most popular color match was assumed to be black with black after running a color test using 16 colors. The second popular color match was the white with white template. In the metallic colors, the black with Champagne gold and white with rose-gold color match were assumed to be the templates that received the most recognition. In the experiment of cultural and creative graphic design template, study showed that the simple graphic was described as the most preferable template. For the color box template, the simple square box was the most preferable.

5 Discussion and Conclusion

This study examined the emotional feature of headsets color selection with the color black or white in all varying metallic selections, to determine the color match in this study. The three main purposes are described to conduct two experiments for this study. First of all, using the Likert Scale Approach to evaluate the emotions entailed in the colors used for the product, this study incorporates some emotional factors such as the aesthetics and quality to run a psychological test known as the color test. Compared with other colors, the color black may have been assumed to be the most artistic and most classy color. Secondly, this study confirm that the cultural and creative graphic in a simple style may be the most popular template for the headset. Finally, the results of this experiment show that the most applicable packaging design template for the headset design may be the simple square box whereas the black color box appears to be the most applicable headset packaging design. The results of the statistics found in this experiment may be a template for the color design and learning based on this product design and packaging design experiments done under this research project.

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Research on the Application of User Experience Design in Agricultural Product Packaging Design

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Abstract. Bauhaus has indicated "The purpose of designing is human not the product". However as the development of science and technology, in real life, many designs violate this principle. Under the background of the Experience Economy, which proposed by American economist B Joseph Pine and James H Gilmore, "user experience", which means to meet the needs of users and user-centered design philosophy, has to appear. At the beginning, the "user experience" concept is used in the design field. The main content of the field is interaction design and ergonomics, the use of the package design field are few. This paper aims to illustrate the application of "user experience" design concept in the agricultural product packaging design, research the different psychological experience for consumers by using a different text, graphics, color, material and the packaging structure in agricultural product. Using "user experience" as a starting point, to help to understand the related disciplines such as psychology, marketing or sociology. This paper involves the design, psychology, packaging materials, aesthetics and other different fields, through the packaging design style of the current agricultural products, summed up the application form of "user experience" design concept in agricultural products packaging design.

Keywords: "User experience" design · Agricultural products · Packaging design

1 Background

Under the background of the Experience Economy, which proposed by American economist Pine and Gilmore [1], "user experience", which means to meet the needs of users and user-centered design philosophy, has to appear. At the beginning, the "user experience" concept is used in the interaction design and ergonomics field. The user experience is mainly referred to the subjective experience that a user gets from starting contact the product to using it. "User experience" design is a design approach, which focuses on users experience. The whole design should treat the user as the center. And the concept of user experience should run through the whole process from the early step of product development. From the user's perspective, the user experience is the performance of the products in the real world and the way of use, penetrated into all aspects of the user and product interaction, including the whole process of user connect

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_19

with the brand characteristics, not only the interactive experience with product, but also the sensory, cognitive and emotional experience which trigger during the interactive process.

In addition, the product packaging design is the first impression for a user of the product. Therefore, the designer should combine the attention of user experience with the product packaging design; even combine into the whole product life cycle. Be more specific, the product packaging is divided into inner and outer packaging, which also includes the structure of inner packaging, selection of packaging materials and the security and convenience of transportation and packaging production. Moreover, the user experience not only exists in the product itself but also generate in the period when the user interacts with products. At the same time, the psychological experience and perception, which bring the product are the real meaning of the user experience.

As the American scholar Jonathon and Vogel [2] mentioned in his publication "Creating Breakthrough Products", at the time of the Experience Economy, the function and form should equally, collectively follow the unifiable standard user's need to achieve one goal, which creates a useful, user-friendly and expects to own product for users. Users can enjoy the use of the experience in the process of using the product and to achieve some desire in real life. This heuristic view has a deep impact on modern packaging design. Many packaging of electronic product that influenced by this view has completed the transformation from the traditional to the modern. The traditional beautiful appearance and low-cost mode have become less practical. For instance, the inner and outer packaging of iPhone is a typical modern packaging example in structure and material. When user opens the package box, the first thing you can feel is the friction between box cover and box body; it is smooth but still can avoid the box body drop directly. Therefore, no matter how good the iPhone is, this detail could bring users a very good user experience, this packaging design can fully embody the concept of user-centered design.

However, with the packaging design in many industries is continuous upgrading, the packaging design in agricultural products is lagged. Because of the cyclical of agricultural product, the preservation period of some product is very short. Therefore, the packaging design in agricultural product does not receive enough attention. By contrast, Japan and Occident do more good in agricultural product packaging design. As for Asian country, especially China, belongs to agricultural country, as the development of economy, people's quality of life has been improved. An increasing number of agricultural enterprises began to pay attention to the agricultural product packaging.

2 Development Status of Agricultural Product Packaging Design

Due to the characteristics of agricultural products, and the type of it is defined as FMCG (fast moving consumer goods) by the agricultural enterprises. Usually, most agricultural products packaging is a carton style, with some natural or environment-friendly slogan write casually on the outside. For the inner packaging, there are some simple plastic packagings to prevent damage during the transportation of agricultural products. Based on a market research, which uses "the agricultural product packaging design of the user

experience questionnaire" as topic, more than 75.12% of the people who responded to the questionnaire think that this package is not environmental protection (Fig. 1). And the airtight packaging also makes agricultural products is not conducive to the preservation. Because of the demand for pollution-free, environmental-friendly, humanize and healthy product, the current agricultural product packaging needs to enhance the user experience. This reflects the fact that the packaging design of agricultural products does not grasp the kernel of user experience design.

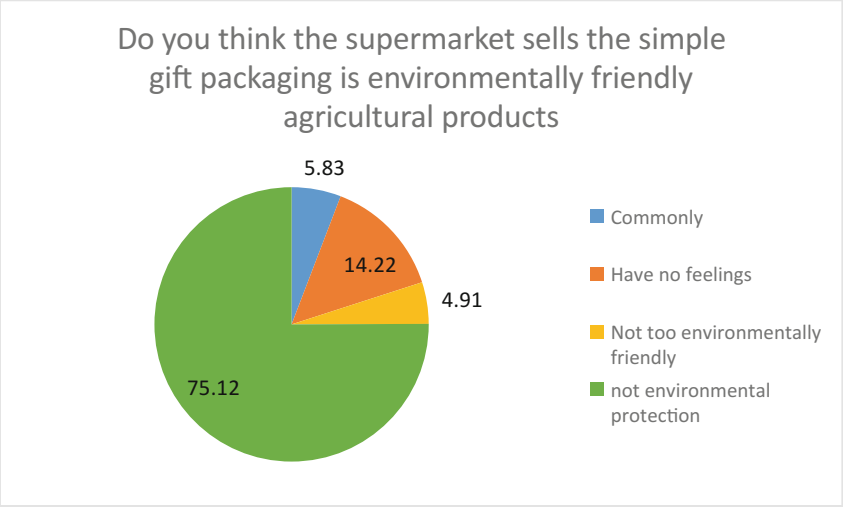

Fig. 1. One problem of the agricultural product packaging design of the user experience questionnaire

In addition, as the improvement of economic level, the environmental problem has become a serious issue. Therefore, people pay more attention to the fitness, and organic agricultural products onto the market. Different from the ordinary agricultural products, Organic agricultural products are natural, pollution-free, safe and nutritious food, also known as "eco food". It is produced based on the production mode of the organic agriculture principles and organic agricultural products standards and certified by organic food certification institution. As the security problems of food have become increasingly prominent these days, organic agricultural products have great market potential. The Organic agricultural products market is much more mature in Europe, Japan, and South Korea, but as a largely agricultural country, China is still in the primary stage. Except for the tea products packaging design, there are still two problems of organic agricultural products packaging design for other agricultural products.

Firstly, the packaging design does not discriminate the organic agricultural products from the ordinary agricultural products. It is difficult for the customer to distinguish those products in the vision. Secondly, the target group for organic agricultural products is mostly well-heeled, their tastes and requirements are higher than ordinary people. Nowadays, Chinese organic agricultural products market need to be developed,

most popular organic agricultural products sold on the market are imported product. The good packaging design accounts for a large part of the reason why import products were favored by customers. In fact, a product basically is unable to give users two impressions. One of the most important problems for China domestic organic agricultural products is that the lack of packaging design is unable to arouse the user's desire to buy. Most of the current packaging design is unable to achieve the request of high-end groups. This problem also appeared in many developing countries. Therefore, it seems that the packaging design of agricultural products in Europe and the United States has not only leading the technology of visual and material, but achieve the cognition of design product packaging based on the user experience, and this idea has been throughout the entire product design.

3 Case Study

3.1 Case 1: 2016 Red Dot Award- Best of the Best: Chu Cheng

In 2016, November 4, The Red Dot Design Award, which is regarded as the "Oscar" in design, was holding in Konzerthaus Berlin. The "Chu Cheng" orange packaging design, which develops by TigerPan packaging design Lab, stand out from over 5000 other entries from 46 countries, won the 2016 Red Dot Award. This is after winning the Gold Pentaword 2016, the TigerPan packaging design Lab stands on the stage of world-class design awards once again. As the organizer and CEO of Red Dot Design Award said "This packaging was developed for both transporting and selling. It convinces with its nice and simple two-coloured prints and graphic design as well as with an outstandingly clever functionality, highlighting the fruits by means of an easy mechanism, successfully convinces us."

The logo on the cardboard fruit boxes shows the woodcut of Chu Shijian who is the originator of "Chu Cheng". Different from the normal orange packaging design, the creatively designed boxes elevate the fruits automatically when unpacked with a simple pull for easy access. On top of that, every single orange comes wrapped in a well thought-out protective cover. This design not only convenient for customer to grab the orange but also benefits the seller to show and place in market. The inner packaging structure also reflects the turbulent business life of the originator. According to the outer packaging design, which shows in Fig. 2, those two colors are bright in the vision. In addition, the hexagon box design is very eye-catching and it also presents the freshness of orange. Internal packaging fully embodies the design considering about user experience, very convenient and considerate. The hexagonal structure has the advantages of convenient transportation and stacking, which can protect the orange during the transportation and prolong the storage time. This is a great breakthrough in Chinese fruit market, which change the situation that import fruit occupies the high-end market in China. The new package of "Chu Cheng" subverts the fruit brand impression in people's mind. It turns out a normal orange could actually have such a special design. Especially, the considerate and convenient experience brought by the structure design indicated the fact that user experience is a significant factor for packaging design. In the future, high-end agriculture is one of the new benchmarks for agricultural

Fig. 2. The "Chu Cheng" orange packaging design. 2016 Red Dot Award for best design [3]

development. The packaging design that based on user experience will become more and more popular.

The success of the new "Chu Cheng" packaging, not only reflects the designer's imaginative, more important is the observation on life, the consumer psychology and consumer behavior. Only from the user's perspective, to feel and experience, the designer could develop good works. When the designers design a product, they ignored the fact that they are also a user of the product. Therefore, only if the designer ponders as a customer during the design process, they can understand how to design is the considerate design, can provide convenience for the user or give the user better experience. The core of a good packaging design must be able to present and render the personalized elements of the goods and accurately interpret and express the humanistic spirit and connotation of the brand, with both can achieve a good package design.

3.2 Case 2: Gold Pentaword 2015: Fish'n Rice

Rice is the staple food of the Asian people, generally sold in the supermarket. Because it is one of the staple foods, usually the customer will buy in large quantities, and the packaging is normally of large size, which suttle weight is around four to five kg. The ordinary packing of rice is the compressed bag. It is difficult for an adult to deliver it to home. Recently, some rice packaging increased hand type design. This design makes the whole weight load at the side of the arm even the fingers. Many users reflect that everytime they deliver the rice home, the fingers will numb due to the weight of rice package. Those users who have bought rice will have very deep experience on this point. However, because of the daily consumption of rice is huge, it is time-consuming if you buy rice in small size several times a week. Therefore, the Chinese packaging designer develops a new rice packaging, which shown in Fig. 3.

Fig. 3. The side elevation of "Chu Cheng" orange packaging design, 2016 Red Dot Award for best design [3]

The rice packaging design integrates the auspicious implication "having more than need every year" in Chinese tradition culture. The "Fish" and "affluence" has the same pronunciation, which meaning the best wish for annual harvest. The integrated design changes the conventional square rice packaging design, very innovative. At the same time, it embodies the perfect sense of style. The most important are the packaging design completely solves the problem that the traditional rice packaging is not easy to carry and the poor user experience. The rice is divided into two sides, both sides sharing the weight and form a natural handle, which meets the need to carry the packaging. It can be carried in the hand or hoist on the shoulder, which shown in Fig. 4. It virtually decreases the difficulty of delivering the rice home, very thoughtful. The whole package structure is simple and easy to carry. The exquisite visual design is full of the characteristics of traditional Chinese culture. The material is original canvas and using the traditional batik technique. It full of craft-style and is also environmentally friendly. After the user eats the rice, the packaging could be used for another purpose. In addition, the rice and wheat pattern on the scales of the fish also represent the theme of the products and the high quality of the rice.

According to the above, it is obvious that a good packaging design must be humanized or based on the understanding and observation of life. Although there are a variety of packaging designs for rice package, the highlight of "Fish'n Rice" packaging design is that it can solve the difficulty of delivering the rice package. This observation of the small details, which are not easy to find in daily life, is the best embodiment of "people-oriented" principle for product design. Only based on user experience, designing every product considerately, the design would obtain the good effect of users and user experience (Fig. 5).

Fig. 4. The "Fish in Rice" rice packaging design. The gold award of Pentawards 2015 [4].

Fig. 5. The shoulderable design. The gold award of Pentawards 2015 [4]

4 Conclusion

Through the above analysis of the agricultural product packaging case study, we can conclude the main application forms of user experience design in agricultural product packaging. Firstly, in order to be centered around "user" and treat the user experience design as the design concept and run through the whole design process, except for the visual experience and sensory experience, the most significant thing is to enhance the user's psychological and emotional experience. In addition, when a designer creates a

new packaging design, they should focus on the detail design and the proliferation and ever increasing advancement. Furthermore, they also need to analysis the user behavior. Thirdly, the agricultural product packaging design should fully reflect the main connotation of the contents of agricultural products. A good agricultural product packaging design should be able to improve the brand image of the agricultural products and establish a complete brand impression in the mind of users.

In recent years, agricultural product packaging design receives a widespread concern of the community. Part of the reason is the increasingly serious food safety problem. Unlike other industrial products, which have many different functions and the use process. The purpose for most people to buy food is eating. Because of the consumption process is short. Many companies ignore the importance of agricultural product packaging design. As the rapid development of the economy, user experience has attracted attention from all walks of life. The agricultural product is the category that linked most closely with people's life. Consequently, the user experience should be a significant factor throughout the whole packaging design process. According to the analysis of the two cases in cases study section, we can conclude that: the user experience based design not only can give users a good experience or attract more consumption but also can exert the functionality of the agricultural product packaging, improve the saleroom of agricultural products and the enterprise benefits.

Acknowledgements. The project supported by the South China University of Technology under the Degree and Postgraduate Education Reform Research Project, Grant: No.: yjjg2016004.

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Analysis of Affective Evaluation for Material Perception of Resin Surfaces: Combined Effect of Tactile Sensation and Hue

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Abstract. We previously performed affective evaluation experiments on tactile material perception of bead-coated resin surfaces with different surface textures generated by such various physical attributes as resin materials, bead diameters and bead densities. Our results clarified the affective relation between beads-coated resin surfaces and related adjectives. In our new affective evaluation experiment, we added hues, which is one of the three elements of color, and performed two preliminary experiments to select appropriate adjective pairs for affective evaluation of the effect of hues and to select the hue candidates. With 21 adjective pairs (ex. masculine-feminine and relaxed-anxious), and seven hues (ex. yellow-red and blue-purple), we clarified the combined effect of the tactile sensation and the hues on the affective evaluations using combinations of actual bead-coated resin and 3D models. Our analysis results suggest that hue, bead diameter, and gender are important for affective evaluation.

Keywords: Bead-Coated resin surface · Hue · 3D model

1 Introduction

Kansei/affective values continue to attract attention as a new evaluation axis of commercial value. In conventional Japan manufacturing industries, the values of products are comprised of function, reliability, and cost [1]. However, the Japanese Ministry of Economy, Trade and Industry (METI) is striving to boost manufacturing industry by adding affective values. METI wants to offer new functions and competitive prices, and create new values that strengthen Japan's industrial competitiveness.

We performed affective evaluation experiments on the tactile material perception of bead-coated resin surfaces with different textures generated by such different physical

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_20

attributes as resin material, bead diameter, and bead density [2, 3], and identified how affective evaluations are influenced by physical attributes. However, since few studies have focused on color in surface-material perception research using visual and tactile sensations, we hypothesized that the hues in the three elements of color will change the appearance of materials and affect their affective evaluation.

In experiments that clarified the combined effect of tactile sensation and hues on the affective evaluations of surface-material perception with bead-coated resin samples and 3D models, we performed two preliminary experiments: the selection of appropriate adjective pairs for affective evaluation of the effect of hues, and the selection of hue candidates for our primary experiment. In our first experiment, we prepared four images of colored cylinders. The white cylinder was the standard, and the yellow, red and blue ones were comparison targets. We presented two cylinder images to compare the standard and target cylinders on a PC display. The background was an achromatic color with a brightness of 8 based on the Munsell color system. We displayed Japanese adjective pairs between the standard and comparison targets. We chose 61 pairs from previous research on visual and tactile sensations [4], warm-cool, unique-common, sharp-dull, for example. Participants watched a pair of cylinder images and a pair of adjectives, and orally evaluated the impression of comparison target on a 7-point Likert scale. They repeated this evaluation for all of the adjective pairs and all of the comparison targets, and made 183 evaluations (61×3). We randomly changed the order of the comparison cylinders to cancel any order effects, and performed our experiments with six Japanese males with normal color vision in their 20's. From the results of both correlation and hierarchical clustering analysis, we selected 21 adjective pairs, such as masculine-feminine and relaxed-anxious. In our second experiment, we prepared thirteen images of colored cylinders. The white cylinder was the standard. The colors of comparison targets were red, yellow-red, yellow-green, green, blue-green, blue, blue-purple, purple, red-purple, gray, black, and brown. We presented two cylinder images to compare the standard and target cylinders on a PC display. The background was an achromatic color with a brightness of 8 based on the Munsell color system, which was the same as the first experiment. We displayed Japanese adjective pairs between the standard and comparison targets. We chose 12 pairs from previous research on visual sensations, beautiful-ugly, pleasant-unpleasant, good-bad, for example. Participants watched a pair of cylinder images and a pair of adjectives, and orally evaluated the impression of comparison target on a 7-point Likert scale. They repeated this evaluation for all of the adjective pairs and all of the comparison targets, and made 144 evaluations (12×12). We randomly changed the order of the comparison cylinders to cancel any order effects, and performed our experiments with twelve Japanese males with normal color vision in their 20's. From the results of both hierarchical clustering and decision tree analysis, we selected 7 colors, such as yellow-red and yellow-green.

This paper describes our primary experiment based on our two preliminary experiments mentioned above. The analysis results of experimental data suggest that hue, bead diameter and gender influence affective evaluations.

2 Experimental Method

2.1 Samples and Models

Our experimental setup is shown in Fig. 1. For the affective evaluations, the participants touched the bead-coated resin surfaces of the samples in the real environment while watching 3D models in the virtual environment.

The samples are column-shaped objects with a resin side-surface (Fig. 2). The standard sample's resin had no bead coating, but the resin of evaluation target samples was bead-coated. We employed three bead diameters: 10 (FP-2), 22 (FP-4), and 93 (FP-7) micro meter. Each sample pair consists of standard and target samples that are fixed by magnets (Fig. 3) to be touched by the participants.

The hue of the standard 3D model is white and the hues of the evaluation target models are shown in Table 1, based on the result of our second preliminary experiment. Each 3D model pair consists of standard and target models displayed on gray background screen (Fig. 4), shown stereoscopically through a head-mounted display

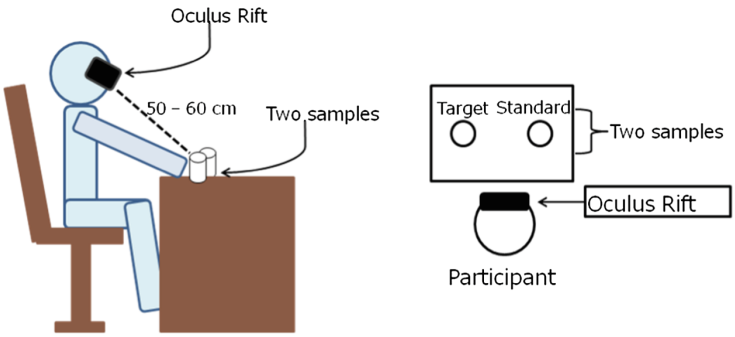

Fig. 1. Experimental setup

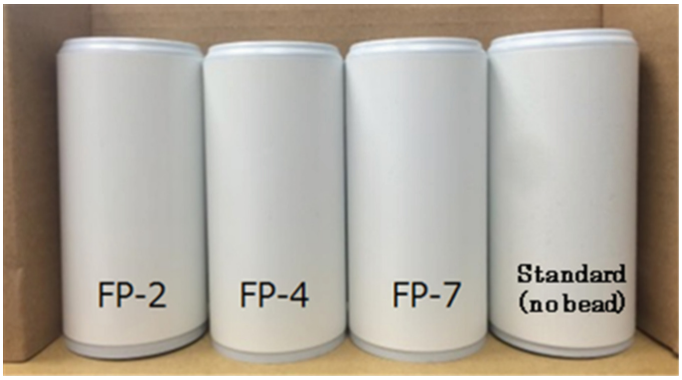

Fig. 2. Samples

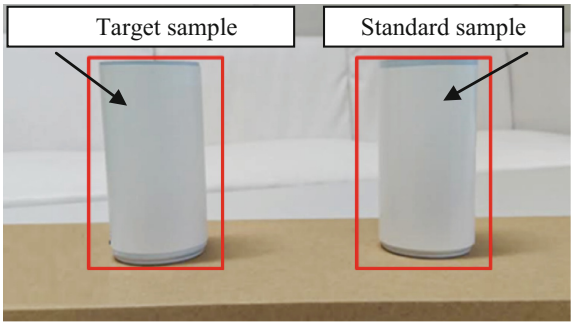

Fig. 3. Display of samples in real environment

Table 1. RGB values for hues.

Hue	R	G	B
Yellow-red	243	121	9
Yellow-green	128	197	34
Blue-purple	48	48	146
Black	35	35	35
Red-purple	163	13	76
Gray	160	160	160
White	255	255	255

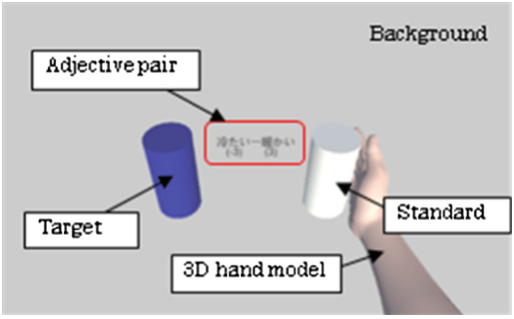

Fig. 4. Display of 3D models in the virtual environment

(Oculus rift dk2, HMD hereafter). We also showed a 3D model of the participants' right hands so that they can feel that their own right hand is touching the column's side surface. The following is the right hand model's motion:

1. Stroking the standard model's side surface three times up and down.
2. Stroking the target model's side surface three times up and down.

After this, the participants give their evaluation scores for each adjective pair.

Table 2. Adjective pairs.

Number	Adjective pair	Number	Adjective pair
1	Masculine – Feminine	12	Warm – Cool
2	Beautiful – Ugly	13	Active – Passive
3	Heavy – Light	14	Unique – Common
4	Gentle – Scary	15	Conspicuous – Inconspicuous
5	Pleasant – Unpleasant	16	Sharp – Dull
6	Healing – Non-healing	17	Cute – Not cute
7	Good – Bad	18	Expensive – Cheap
8	Fashionable – Sober	19	Delicious – Terrible
9	Moist – Dry	20	Wild – Tame
10	Bright – Dark	21	Artificial – Natural
11	Stable – Unbalanced		

2.2 Evaluation

We used the 21 adjective pairs in Table 2 that were selected in our first preliminary experiment [4]. Each adjective pair is shown between the standard and target models (Fig. 3) in the virtual environment. The evaluation is performed on a 7-point Likert scale from −3 to +3. Each participant followed the motion of the right hand model by his own hand and orally scored each adjective pair. Participants were also allowed to answer "I can't judge" in addition to scores from −3 to +3.

2.3 Experimental Procedure

The following is the experimental procedure:

1. Participants wore HMDs and watched a gray (brightness 8) background for 15 s.
2. They were shown both standard and target models and an adjective pair.
3. They moved their own right hands that followed the 3D hand model's motion to touch the surfaces of the two samples one by one.
4. They scored the target by comparing it with the standard for the adjective pair.
5. They repeated processes 2 to 4 for each adjective pair. The number of repetition was 21 because the number of the adjective pairs was 21.
6. After changing the target model's hue, processes 2 to 5 were repeated seven times because the number of hue was 7.
7. After changing the resin of the target sample's material, processes 2 to 6 were repeated three times because the number of material was 3.

The presented order of the hues and resins was set randomly.

3 Experimental Results

Twelve Japanese females in their twenties and twelve Japanese males in their twenties volunteered for our primary experiment. The experimental results were analyzed by ANOVA and regression analysis.

3.1 ANOVA Results

The evaluation results for each adjective pair were analyzed by a 3-factor ANOVA. The between-subject factor was gender, and within-subject factors were hue and bead diameter. The "masculine-feminine" result shows that hue and bead diameter have a significant main effect at a 1% level. Table 3 summarizes the ANOVA results. We obtained the following observations:

- Hue has significant main effect for all adjective pairs at a 1% level.
- Bead diameter has a significant main effect for all adjective pairs except "warm-cool" and "sharp-dull" at a 5% level.
- Gender has a significant main effect for "pleasant-unpleasant," "warm-cool," and "wild-tame" at a 5% level.
- These results suggest that hue and bead diameter have a stronger effect on affective evaluation than gender.
- Then we focused on the relation between hue and bead diameter, performed a multiple comparison, and obtained the following observations:
- The "masculine-feminine" pair has a lower score (meaning that it is more masculine) for red-purple than other hues at a 5% level.
- The "beautiful-ugly" pair, "pleasant-unpleasant" pair, and some other pairs have lower scores for larger bead diameter than the other diameters at a 5% level.

Table 3. ANOVA results.

Adjective pair	Diameter	Diameter *Hue	Diameter *Gender	Hue	Hue*Gender	Gender
Masculine	**			**		
Beautiful	**		**	**		
Heavy	**			**		
Gentle	**		*	**		
Pleasant	**		*	**		*
Healing	**	*		**		
Good	**			**		
Fashionable	**		**	**		
Moist	**			**		
Bright	**			**		
Stable	**			**		
Warm				**		**
Active	*			**		
Unique	**			**		
Conspicuous	*			**		
Sharp			*	**		
Cute	**	*		**		
Expensive	**			**		
Delicious	**			**		
Wild	**			**		*
Artificial	*			**		

Significant level *5% **1%

Table 4. Multiple regression analysis results.

Adjective pair	Constant	Diameter	YR	YG	BP	RP	Gray	Black	Female	
Y	a	b	c	d	e	f	g	h	i	R^2
Masculine	**−3.31	**0.46	**−0.10	**0.10	*0.27	**−0.26	**0.21	**0.20	−0.05	**0.46
Beautiful	**3.13	**−0.54	0.49	0.01	0.03	0.03	**0.18	**−0.15	*0.09	**0.35
Heavy	**−2.38	**0.31	−0.08	−0.09	**0.18	*0.11	**0.24	**0.34	0.04	**0.28
Gentle	**3.40	**−0.48	**0.15	0.05	**−0.15	−0.05	*−0.11	**−0.3	0.06	**0.37
Pleasant	**2.55	**−0.46	**0.20	*0.1	−0.05	−0.01	*−0.1	**−0.13	**−0.11	**0.31
Healing	**4.08	**−0.53	0.00	0.05	−0.08	**−0.19	**−0.13	**−0.25	0.03	**0.36
Good	**3.33	**−0.50	0.06	0.06	−0.06	*−0.12	**−0.15	**−0.22	0.05	0.32
Fashionable	**1.50	**−0.25	*0.11	0.02	−0.01	**0.17	**−0.28	−0.09	*0.09	**0.20
Moist	**1.04	**−0.32	*0.12	**0.22	**0.19	**0.15	**−0.15	*−0.11	−0.06	**0.24
Bright	**0.67	**−0.11	**0.24	**0.12	**−0.26	0.03	**−0.30	**−0.48	*−0.07	**0.47
Stable	**3.81	**−0.52	−0.09	−0.20	0.05	**−0.18	0.02	−0.07	0.04	**0.3
Warm	0.32	−0.04	**0.30	0.04	**−0.32	**0.17	**−0.13	*−0.1	**0.15	**0.30
Active	**−0.70	*0.09	**0.28	*0.1	**−0.18	**0.3	**−0.24	**−0.16	−0.03	**0.34
Unique	**−1.49	**0.29	**0.19	0.05	0.03	**0.19	**−0.23	0.02	−0.04	**0.21
Conspicuous	**−1.34	**0.17	**0.27	**0.16	−0.02	**0.29	**−0.2	0.00	−0.06	**0.24
Sharp	**−1.07	0.01	0.08	−0.00	0.06	0.17	**−0.17	−0.06	−0.05	**0.04
Cute	**2.60	**−0.41	**0.17	0.05	**−0.16	0.05	**−0.21	**−0.30	*−0.09	**0.37
Expensive	**2.44	**−0.37	*−0.13	**−0.16	0.01	−0.21	**−0.19	−0.01	**0.11	**0.18
Delicious	**2.05	**−0.36	**0.24	0.07	*−0.16	0.03	**−0.22	**−0.26	−0.05	**0.35
Wild	**−1.93	**0.42	−0.09	−0.03	−0.05	−0.06	*0.12	**0.17	**−0.16	**0.26
Artificial	**−1.21	**0.12	0.04	−0.11	0.10	**0.26	*0.13	**0.17	−0.04	**0.10

Significant level *5% **1%

3.2 Regression Analysis Results

We created the following regression formula by employing a common logarithm of bead diameter, hue, and gender as variables.

$$y = a + b\log x_1 + cx_2 + dx_3 + ex_4 + fx_5 + gx_6 + hx_7 + ix_8 \quad (1)$$

Where

y = expected score for each adjective pair,
x_1 = bead diameter (micro meter),
x_2 = dummy variable for yellow-red (1:yellow-red, 0:otherwise),
x_3 = dummy variable for yellow-green (1:yellow-green, 0:otherwise),
x_4 = dummy variable for blue-purple (1:blue-purple, 0:otherwise),
x_5 = dummy variable for red-purple (1:red-purple, 0:otherwise),
x_6 = dummy variable for gray (1:gray, 0:otherwise),
x_7 = dummy variable for black (1:black, 0:otherwise),
x_2 = dummy variable for female (1:female, 0:otherwise).

We estimated the partial regression coefficients for each adjective pair. The following are the coefficients for the "masculine-feminine" pair:

$$a = -3.31,\ b = 0.46,\ c = -0.1,\ d = 0.1,\ e = 0.27,\ f = -0.26,\ g = 2.1,\ h = 0.2,\ i = -0.05. \quad (2)$$

This result shows that masculine scores increased when the participant is male, the hue is blue-purple, and bead diameter is large. Table 4 shows the partial regression coefficients for all adjective pairs. We obtained the following observations:

- The larger the bead diameter is, the higher are "masculine," "heavy," "aggressive," "unique," "conspicuous," "wild," and "artificial" scores.
- Female gave higher scores for "beautiful," "calm," "gentle," "relaxed," "heavy," "warm," and "expensive."

Hue, bead diameter, and gender influence the scores of adjective pairs.

4 Discussion and Conclusion

We clarified the combined effect of tactile sensation and hues on the affective evaluations of surface-material perception by performing an affective evaluation experiment with 21 adjective pairs. We used 3D models with hues on their side surfaces in virtual environment and cylindrical samples with bead-coated resin on their side surfaces in a real environment. From analysis of the experimental results by ANOVA and multiply regression analysis, we obtained the following conclusions:

- Hue affects evaluations of all adjective pairs in Table 2.

- Bead diameter affects the evaluations for most adjective pairs, except "warm-cool," and "sharp-dull."
- Gender affects the evaluations for such adjective pairs as "pleasant-unpleasant," "warm-cool," and "wild-tame."

We also obtained multiple regression formulas for each adjective pair. Future work will consider the differences between generations.

The results can be applied to emphasizing the impressions of contents by their packages such as tea cans and cosmetic bottles.

Acknowledgments. We would like to express our sincere thanks to all participants in our experiments.

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Designing Affective and Pleasurable Design Interactions

Influence of Individual Fashion Item Images on the Image of Coordinates

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Abstract. Conventional coordination suggestion systems do not consider the combined effect of the images of the individual items. In this research, we clarify the relationship between the image of tops and bottoms and their combinations. Using the semantic differential method, a questionnaire survey was conducted for images of tops, bottoms, and coordinates, and principal component analysis was performed. Multiple regression analysis for each of the principle components showed that all the correlation coefficients are low, and no linear relationship could be represented. On comparing the principal component scores, the influence of the bottoms image was observed to be significant in the first main component. The arrangement and combination method affected the image of coordinates in the case of conspicuous components, while the focus of the image changed depending on the object to be evaluated in the final component.

Keywords: Fashion · Coordination · Image · Impression · Combination · Recommend

1 Introduction

Much of what we see is composed of combinations of various elements. For example, advertisements convey information by combining the content, shapes, and colors of text with images and photographs. The advertisement conveys information, but so does each element constituting it. In some cases, the information conveyed by each element can differ from that of the whole. A similar example is the clothes we wear. Items such as tops, bottoms, shoes, and accessories are combined together when coordinating an outfit. There are numerous potential combinations, which makes it difficult to choose coordinating items in accordance with the time, place, and occasion (TPO). Each TPO and schedule requires the projection of a particular image, to which the clothes should match. Thus, the demand for coordination proposal systems that use the image projected by a coordinated outfit as a search keyword has been increasing.

In a conventional system [1, 2], when a user inputs the image of the fashion coordinates, the following result is output.

- Coordinates in which part of the item projects the same image as that entered by the user
- Coordinates in which all items match the image entered by the user
- Coordinates that are similar in physical features to coordinates studied in advance.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_21

However, in these results, the image that the user wants to project does not necessarily coincide with that conveyed by the collective recommended coordinates. Hence, it is necessary to consider the effect of the images of the items to be combined as a whole.

In this research, we aim to clarify the relationship between the image projected by tops and bottoms, and that projected by the combination as a whole.

2 Impression Formation

The semantic differential (SD) method developed by Osgood, an American psychologist, is used for measuring the meaning of a concept. Factor analysis using data obtained by the SD method provides three basic factors—the evaluability factor, activity factor, and competence factor—that are commonly extracted as a single factor [3]. On evaluating a combination of different stimuli, a linear/additive relationship in terms of Osgood's activity and competence factors of individual item evaluations is observed. However, the evaluability factor is nonlinear [4].

This idea can be extended to fashion, where factor analysis can be used to clarify the relationship between the image projected by each item individually and the image achieved by each factor in a combination.

3 Experiment

Subjects were evaluated on their impression about a finite set of tops and bottoms, and combinations of the two.

3.1 Experimental Method

We prepared 20 pictures each of tops, bottoms, and outfits formed by combining them. We divided the subjects (20 female college students) into groups of 10 and a conducted a survey using a questionnaire. The questionnaire had a 5-point scale for evaluating each of the 30 images consisting of 10 images of coordinates and 20 item images. The evaluation scale used 14 adjectives to express Osgood's affective meaning (evaluation, effectiveness, and activity) and clothing impression. Images were randomly displayed for each subject. As a procedure, the 10 images of coordinates were evaluated after the images of the 20 items. The adjective pairs, which were found suitable for representing the image of clothing form [5] and used in evaluation, are listed in Table 1.

3.2 Experimental Images

Approximately 60 images of coordinates were collected from an Electronic Commerce site. The coordinates closest to the images was summarized by discussion with two females, and the images were divided into 8 groups from which two or three were selected. Hence, we used 20 types (A to T) of coordinates. Overall, 60 images were used in the experiment, including tops, bottoms, and coordinates.

Table 1. Adjective pair used in the experiment

No.	Adjective pair
1	soft – hard
2	sophisticated – indoors
3	formal – informal
4	delicate – dynamic
5	carefree – not easy
6	sporty – dressy
7	flashy – sober
8	novelty – old fashioned
9	beautiful – ugly
10	distinctive – general
11	active – modest
12	elegant – vulgar
13	strange – safe
14	realistic – romantic

4 Experimental Result

The experimental results are shown below.

4.1 Impression Structure of Items and Coordination

Principal component analysis was performed for all the tops (T_i), bottoms (B_i), coordinates (C_i), and data combining all of them (all_i) using the questionnaire. The extraction of the components was performed by the least squares method, using eigenvalues equal to or greater than 1. As a result, three components (i) were extracted for each component. The main component loading amounts of T_i, B_i, C_i, and all_i are summarized in Figs. 1, 2 and 3 for each component. Table 2 shows the correlation coefficients with all_i for each principal component (Fig. 2).

The correlation coefficients of T_i, B_i, and C_i with the main component loading amount of all_i were found to be high with a value of 0.92 or more. Therefore, the principal components extracted from each were consistent with the principal components extracted from all the data. Therefore, for the analysis, the principal component load amount and the principal component score extracted from all data was used (Table 3).

$$T_i, B_i, C_i = all_i, \tag{1}$$

where i = 1, 2, 3.

It is observed that the first component is static, the second component is conspicuous, and the third component is strong/weak. These could be related in turn to factors of Osgood's activity, evaluation, and competence, in that order. In addition, by using the principal component scores of the three components obtained by the above principal component analysis, it is possible to accurately show and compare the image of each item without using all the 14 evaluation values for each item.

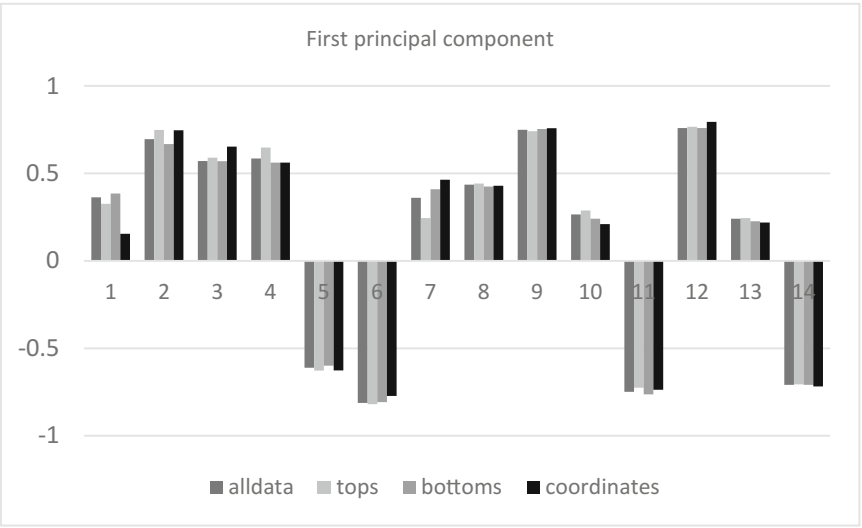

Fig. 1. Main component loading amount of T_i, B_i, C_i, all_i in the first main component

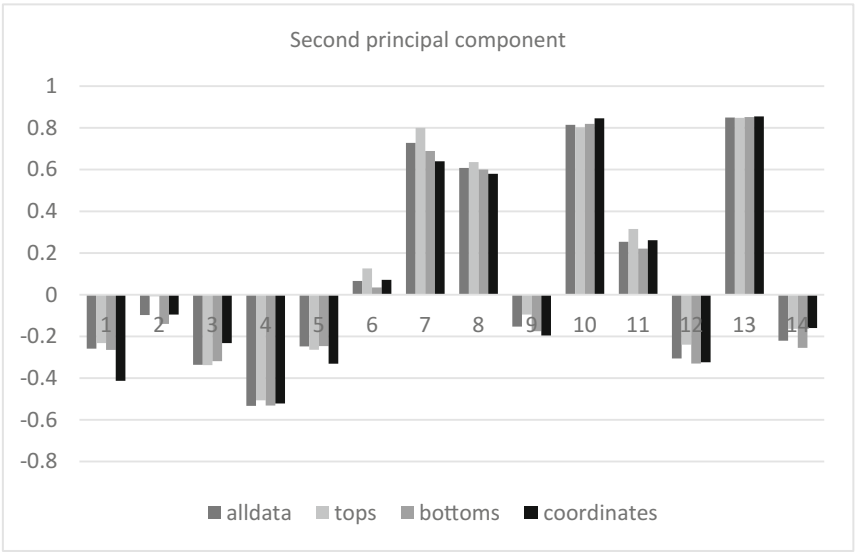

Fig. 2. Main component loading amount of T_i, B_i, C_i, all_i in the second main component

4.2 Relationship Between the Image of Items and that of Coordination for Each Principal Component

For each of the obtained principal components, multiple regression analysis was performed using the principal component score. The main component score of the coordination was taken as a dependent variable, while the principal component score of

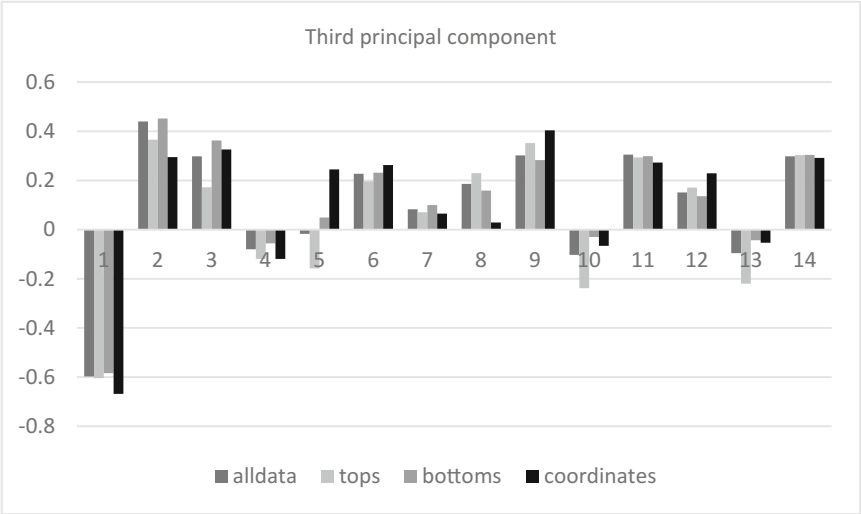

Fig. 3. Main component loading amount of T_i, B_i, C_i, all_i in the third main component

Table 2. Correlation coefficient of all data with the principal component load amount

	all_1	all_2	all_3
T_1	0.998		
B_1	0.999		
C_1	0.993		
T_2		0.997	
B_2		0.999	
C_2		0.991	
T_3			0.973
B_3			0.993
C_3			0.927

each item was taken as an independent variable. Table 4 shows the multiple correlation coefficient R obtained from each analysis.

On comparing the multiple correlation coefficient for each component, the first principal component is found to be the highest. This could be because the first principal component is associated with Osgood's activity factor. However, since all multiple correlation coefficients are low values, it is considered that the image of the item and the image of the coordinates cannot be represented by the linear/additive relation in any component.

4.3 Variation in Coordination Image by Main Component

The variation in the relationship between the image projected by the image of the individual items and that of the coordinates was discussed by expressing the principal

Table 3. Correlation coefficient of all data with the principal component load amount

Adjective pair	Principle component		
	First	Second	Third
elegant – vulgar	0.759	−0.306	0.151
beautiful – ugly	0.749	−0.153	0.302
sophisticated – indoors	0.696	−0.098	0.440
delicate – dynamic	0.585	−0.533	−0.08
formal – informal	0.571	−0.336	0.298
carefree – not easy	−0.611	−0.248	−0.017
realistic – romantic	−0.709	−0.221	0.298
active – modest	−0.749	0.254	0.305
sporty – dressy	−0.812	0.066	0.227
strange – safe	0.241	0.850	−0.096
distinctive – general	0.265	0.815	−0.103
flashy – sober	0.360	0.728	0.083
novelty – old fashioned	0.436	0.608	0.186
soft – hard	0.363	−0.259	−0.597
Contribution rate (%)	35.475	21.832	7.530
Cumulative contribution rate (%)	35.475	57.307	64.837

Table 4. Correlation coefficient of all data with the principal component load amount

	First principal component	Second principal component	Third principal component
Multiple correlation coefficient R	0.25	0.021	0.048

component score as a plus or minus. We computed this by combining the plus and minus of the main component score of tops and bottoms for each principal component.

The principal component score of the bottoms in the first principal component was first considered. It turned out that skirts are plus and pants are minus; this could reflect the perception that pants are suitable when exercising. It was also found that C_1 becomes negative for the combination $(T_1, B_1) = (+, +)$. However, coordinates tended to have a minus image if it included at least one minus image. This implies that coordinates will have a dynamic image, when combining a skirt with a quiet image, with tops with a dynamic image. Therefore, with respect to the statistics of the first principal component, the image of the coordinates is influenced by the bottoms significantly, and the relationship of the tops image is added to the image of the bottoms.

For the second principal component, C_2 is minus for the combination of $(T_2, B_2) = (+, -)$, and plus for the combination of $(T_2, B_2) = (-, +)$. This implies that conspicuous images are related to placement and that the influence of the image of the tops is high. For a combination of the same sign, C_2 tended to have a different sign. Conventionally, the combination of conspicuous items was conspicuous, and vice-versa.

However, since this is different from the result, we concluded that the combination effect of images must necessarily be considered. Consequently, the conspicuity of the second principal component is considered to change depending on the arrangement and combination of the images.

Finally, there was no particular trend for the third principal component. However, it seemed that the evaluation of the item alone was determined by the texture of clothes, while that of the whole coordinates depended on the atmosphere and personality of the person wearing it. Therefore, with regard to the sense of weakness of the third principal component, it is conceivable that the focus is different when evaluating individual items as compared to entire coordinates.

5 Summary and Future Work

In this research, we aimed to clarify the relationship between the image project by individual fashion items and complete coordinates. It was found that the image of coordinates could not be expressed by a linear relationship. In the past, the image provided by the combination was said to be the same as the individual images. However, as it was confirmed that the image changes on combining, it is necessary to consider the combined effect of the images of each item to be combined. In future work, it is recommended that experiments be conducted by increasing the number of examinees and coordination patterns, setting the attributes of subjects, color of items, and attributes such as design etc.

Acknowledgments. I am deeply grateful to the members of Human Media Engineering Laboratory of the Faculty of Science and Technology, Chuo University, and the Kansei Robotics Research Center, who are enthusiastic about research discussions and cooperation for experiments. This work was partially supported by JSPS KAKENHI grants, “Research on Sensitivity Symbiosis Mechanism within Groups in Real Space/Information Space” (No. 25240043) and TISE Research Grant of Chuo University, “KANSEI Robotics Environment.”

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Estimation of Unconscious Preference Judgment with Near-Infrared Spectroscopy

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Abstract. Conventionally, methods to investigate preference decisions, such as questionnaires and interviews, are used for estimating consumer preferences. However, there are many uncertainties in human decision-making, and the reasons for decision-making provided by respondents are not necessarily consistent with their original reasons. In recent years, neuro-marketing, which measures the brain's reactions and explores the process of consumers' preference judgment, has attracted attention. Through neuro-marketing, it is possible to estimate preference based on brain activity, which is not based on the consumers' conscious processing. As a result, potential preferences of consumers are clarified; these are expected to be useful for marketing research on newly marketed products and for development of new products. In this study, we reveal that there are changes in blood flow in the prefrontal cortex while viewing things of interest.

Keywords: NIRS · Oxygenated hemoglobin · Preference judgment

1 Introduction

Conventionally, methods for investigating preference decisions, such as questionnaires and interviews, are used for consumer preference estimation. However, there are many uncertainties in human decision-making, and the reasons for decision-making provided by respondents are not necessarily consistent with their original reasons [1]. Petter Johansson and colleagues conducted experiments that investigated the reasons for selection when subjects switched to a different image from an image that they had selected as a favorite previously. Their results suggested that people cannot identify clear reasons for their decisions [2]. Samuel M. McClure and colleagues let subjects drink Coca-Cola and Pepsi-Cola for comparison. They found that there was a difference in taste preference evaluation, depending on whether or not the brand name was displayed [3]. Therefore, the results of questionnaires and interviews do not necessarily reflect the preferences of respondents.

In recent years, neuro-marketing, which measures the brain's reactions and explores the process underlying consumers' preference judgment, has attracted attention [4]. Conventional questionnaires and interviews were methods that relied on linguistic reports. In neuro-marketing, it is possible to estimate a preference based on brain activity, which is not based on consumers' conscious processing [5]. As a result, potential preferences of consumers can be clarified, and this approach is expected to be

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_22

useful for marketing research on newly marketed products and for development of new products. In this study, we reveal that there are changes in blood flow in the prefrontal cortex while viewing items of interest. We attempted to estimate the unconscious preference of a subject through analyses of visual and brain activity after visual stimulus presentation.

2 Previous Research

Yamada and colleagues examined prefrontal activity at the time of emotional evaluation using NIRS. They selected 15 images, each evoking pleasant feelings, uncomfortable feelings, and neutral emotions from international affective picture system (IAPS), and showed the subjects the images for a period of 6 s per slide. The results suggested that the central part of the prefrontal cortex may be activated when any emotion was evoked [6]. However, there is no clear the relationship between the emotional state and the activated prefrontal cortex. Those authors stated that there were cultural differences between subjects who perceived images from IAPS.

Sakamoto and colleagues attempted to evaluate participants' emotional state while watching TV, from both a physiological and a psychological perspective. They showed the subjects 4 types of movies, inciting fear, healing, excitement, and relaxation. They examined the left and right prefrontal activity using NIRS while the subjects were watching these movies. For psychological evaluation, they also used a questionnaire and interview to pose questions to participants after watching the movies. They show that it is possible to estimate emotions, such as comfort or discomfort, like or dislike, tension or relaxation, by monitoring cerebral blood flow [7].

From these previous studies, it seems that there is a relationship between evoked emotion and brain activity. Emotion can be estimated by monitoring the brain activity in the prefrontal cortex.

3 The Present Study

In this study, we examined the relationship between brain activity of participants presented with a visual stimulus, and the subject's preference judgment.

3.1 Visual Stimulus

Using entertainers in television (TV) commercials is one of the most effective strategies for increasing awareness. In addition, awareness is closely related to distribution, price, and brand strategy [8]. Thus, preference evaluation of entertainers used in TV commercial is important for advertising strategies. Mitsui and colleagues revealed that there was a relationship between the favorability of a TV commercial and brain activity [9]; however, it has not been clarified which elements of TV commercials evoke brain activity.

In this study, we focused on the person, as one of the important elements in TV commercials, and verified the relationship between preference judgment and brain activity.

3.2 Measurement of Brain Activity

In this study, brain activity during presentation of a visual stimulus was measured using near-infrared spectroscopy (NIRS) (Fig. 1). The NIRS device records the concentration changes in oxy-hemoglobin (Hb) and deoxy-Hb in the cerebral blood flow. The near infrared light irradiated to the head is absorbed, diffused, and approaches the cerebral cortex. Thereafter, it is condensed onto optical fibers on the head surface. Because the absorption spectrums of oxy-Hb and deoxy-Hb differ, NIRS can measure changes in the amount of oxy-Hb and deoxy-Hb. Brain activity is also measured using positron-emission tomography (PET) and magnetic resonance imaging (MRI). However, these approaches measure brain activity with the subject's body restrained, and thus it is difficult to measure brain activities in a natural state. In comparison, NIRS has the advantage that brain activity can be measured non-invasively without placing constraints on the position and orientation of the body.

Fig. 1. NIRS (ETG-4000 Hitachi Medical Co.)

4 Experimental Method

The subjects included 11 right-handed university students, including 2 female and 9 male students. They viewed alternate rest images for 25 s, and person images for 15 s, as a visual stimulus (Fig. 2). We generated 10 pairs of rest images and person images. We selected images of 5 favorite entertainers and 5 disliked entertainers as person images; these were selected so that 5 of these individuals were male and 5 were female. Person images were shown randomly, to avoid the order effect. We instructed the subjects to view person images while thinking the answer whether they liked the image, or not. Cerebral blood flow was measured with NIRS at the time of visual stimulus presentation. We used a measurement probe with a 3×11 holder and acquired

cerebral blood flow data from 52 channels. In accordance with the International 10–20 system, we measured activity in the prefrontal cortex. We located the middle of channel 5 and channel 6 at Fpz.

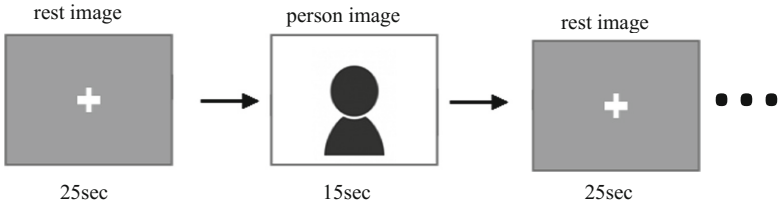

Fig. 2. Initially, the rest image was presented for 15 s. Next, we presented the person images for 25 s. We presented the rest images and the person images alternately.

5 Analysis Method

Analysis was carried out using the Platform for Optical Topography Analysis Tools (POTATo) analysis software for NIRS. We analyzed the data from 10 subjects, excluding the data of a subject who fell asleep during the experiment. Firstly, we divided the data into two. One data set were the cases where the subjects answered "like"; this was termed the "like condition". The other were the case where the subjects answered "dislike", and were termed the "dislike" condition. Secondly, a high-pass filter (0.0017 Hz) was applied to the oxy-Hb data to remove low-frequency drift, which was longer than the duration of one sequence (rest and person images). Additionally, a low-pass (0.8-Hz) filter was applied to the oxy-Hb data to remove components that were higher than the frequency of the heartbeat. Thirdly, we eliminated noise due to body movements and then obtained a moving average for 1 s. Fourthly, we blocked the data so as to include data from 5 s before the stimulation started until 15 s after the end of the stimulation. Next, we removed the data in which the hemoglobin concentration varied by 0.1 or more in 0.1 s by Amplitude Thresholding (Max: 0.3). Finally, we corrected the baseline of the data. We then performed a *t*-test to compare the like and dislike data sets. Unique differences were detected between viewing of rest images and person images. We tested the null hypothesis that the average of the difference of Hb data would equal zero.

6 Results and Discussion

We found that some channels showed significant differences between viewing rest images and viewing person images (Table 1). In the like condition, there was a significant difference in channel 11, 19, 20, 42, 47, and 49 (Fig. 3). In the dislike condition, there was a significant difference in channel 2, 4, 9, 14, 25, 36, 37, 39, 47, 48, and 49 (Fig. 4).

Table 1. Summary of the *t*-test results for brain activity when presenting a rest image and a person image.

Like condition		
ch	t-value (+ or −)	p-value
11	+	**
19	−	*
20	+	**
42	+	**
47	+	**
49	+	*
Dislike condition		
ch	t-value (+ or −)	p-value
2	+	*
4	+	**
9	+	**
14	+	*
25	+	**
36	+	*
37	+	*
39	+	*
47	+	**
48	−	**
49	−	*

*p < 0.05, **p < 0.01

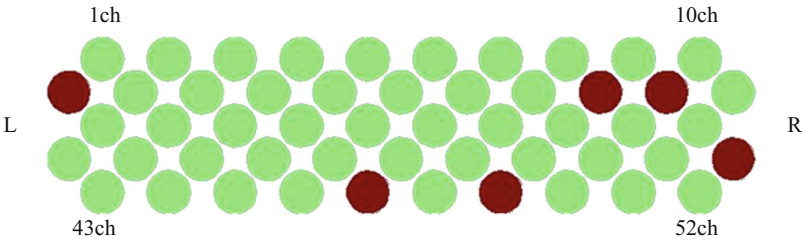

Fig. 3. The brown spots are channels showing significant differences under the like condition.

Significant differences were found in the pars opercularis of the inferior frontal gyrus of the right hemisphere under the like condition. This part corresponds to Broca's area. In the dislike condition, there were significant differences in the frontal pole and dorsolateral prefrontal cortex. Mitsui and colleagues had also reported that change occurred in the dorsolateral prefrontal cortex when subjects watched a TV commercial. Thus, the activity of dorsolateral prefrontal cortex may be influenced by the person appearing in the TV commercial.

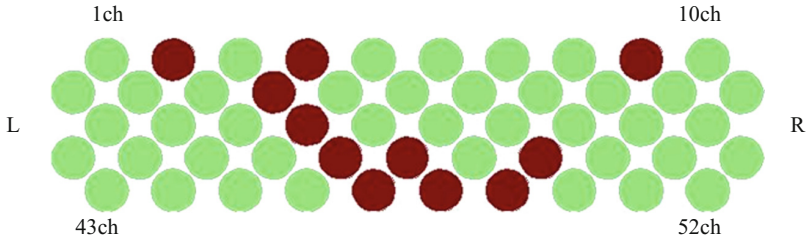

Fig. 4. The brown spots are channels showing significant difference under dislike condition.

7 Summary and Outlook

In this study, we investigated whether differences in brain activity is caused by evaluation of preference judgment of a visual stimulus. We found that there were differences when evaluating the stimulus as liked or disliked in different channels.

In the present study, the number of individuals from whom data were obtained for the analysis was small. In future, we will increase the number of subjects and verify our current findings. In addition, we will ask the subjects to view the visual stimulus without evaluating it, to identify the channels in which changes occur under natural viewing. By comparing gender data, we will further clarify whether there are different tendencies depending on gender. In the present study, we asked subjects to evaluation the person images dichotomously, as liked or disliked. In a future study, we intend to use a 5- or 7-point graded evaluation, and then verify the relation between brain activity and the degree of like or dislike.

Acknowledgments. We are deeply grateful to the members of Human Media Engineering Laboratory of the Faculty of Science and Technology, Chuo University, and the Kansei Robotics Research Center, for their participation in research discussions and collaboration in experiments.

This work was partially supported by a JSPS KAKENHI grant, "Research on Sensitivity Symbiosis Mechanism within Groups in Real Space/Information Space" (No. 25240043) and a TISE Research Grant from Chuo University, "KANSEI Robotics Environment".

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Analysis of Change in Purchasing Motivation by Tone of Product-Recommendation Agent in Electronic Commerce Site

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Abstract. In this study, we analyze the influence of the tone of agents' product recommendations on buyers' purchase motivation. The findings would help agents make more effective product recommendations. In this experiment, we used a simulated e-commerce website to elicit buyers' purchase behavior. Regarding tone of voice, I focused on intellectuality and friendliness, and made a tone of four patterns. As a result, it became clear that intellectual × friendly tone has a positive influence on purchasing motivation.

Keywords: Purchase motivation · Product recommendation agents · E-commerce websites

1 Introduction

In recent times, the purchasing behavior of buyers on e-commerce websites such as "Amazon" and "Rakuten" has garnered attention. Buyers' purchase behavior differs with respect to online shopping (i.e., e-commerce websites) and offline shopping (i.e., physical stores), which comprises of interaction with sales clerks. It is evident that interaction between buyers and sales clerks significantly affects purchase motivation in physical stores [1]. Therefore, research to simulate such interactions using anthropomorphic agents is being actively conducted [1].

In this research, we focus on the tone of sales clerks and analyze the influence of the tone of product recommendation agents on buyers' purchase motivation. By analyzing the influence of tone on purchase motivation, it is possible to make recommendations that encourage buyers' purchase motivation, and recommend products tone of personal tone.

2 Previous Research

Liang created six types of agents, which include a "human video," a "robot," an "anthropomorphic agent," "Buddha's image," a "dog," and "text," and compared the influence of each agent's product recommendation on buyers' purchase motivation [2]. This revealed that an "anthropomorphic agent" had the greatest influence on purchase motivation. However, in this research, the appearance of agents and their behavior

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_23

attracted more attention, but the behavior including the voice such as “agent speaks” was not actually verified.

Therefore, in this research, the agent recommends a product by speaking. Further, Forlizzi et al. conducted an experiment using a “female-human agent,” which had an effect on buyers’ purchase motivation [3].

3 Experiment on the Degree of Influence of Tone on Purchase Motivation

In this experiment, we used 20 college students as subjects.

3.1 Experiment Preparation

Following Yoron, we considered the two elements of “intellectual” and used “familiarity” as another element [2]. The tone of the agent is classify on four patterns: ① “intimate × intellectual” tone, ② “intimate × non-intellectual” tone, ③ “other person × intellectual” tone, ④ “other person × non-intellectual” tone, with a focus on “use of polite language,” “intelligence,” “extend endings” or “voice height.” The voice was relayed by reading constructed product recommendation sentences. In addition, we analyzed the validity of the recorded tone after the experiment with the help of the questionnaire. We created product recommendation content of about 150–200 characters for each item, which included information on product prices and sizes; for example, “introduction of the products” and “how to use products.”

In this experiment, we used a simulated e-commerce website, as depicted in Fig. 1, to elicit buyers’ purchase behavior. In the simulated e-commerce website, the product was displayed on the left, the minimum necessary information such as price and size at the center, and the related agent on the right.

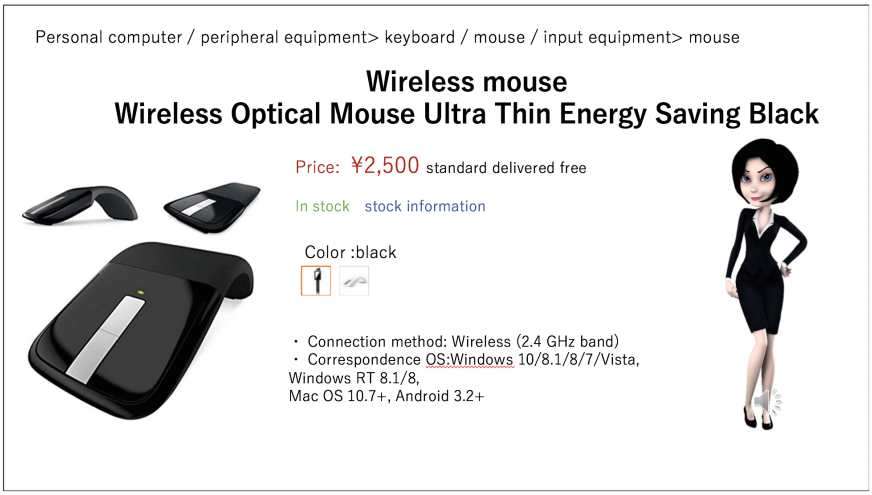

Fig. 1. E-commerce website created for the experiment

We considered the influence of tone for "miscellaneous goods," and "clothes." We considered the influence of "intellectual," "medicine," and "electronic equipment." We conducted experiments for each the six above-mentioned points of "book" and "food" that were likely to be affected.

As regards the questionnaire, we evaluated three items, "willingness-to-purchase," "tone," and "usability."

(1) **Purchase motivation.** To evaluate the motivation of the subjects for intuitive purchase, we draw a 10 cm long line as depicted in the following figure (Fig. 2).

Fig. 2. Evaluation of purchase motivation

(2) **Tone.** As regards the tone of voice, we evaluated the 15 impression words in the following table (Table 1) from the viewpoint of personality recognition in psychology [4].

Table 1. Impression words for tone

Social desirability	Sincere moral soundness intellectual trustworthy
Personal friendliness	Warm gentle distance of mind afable friendly
Activity	Outward socializing Active confident bold

(3) **Usability.** We used a method similar to that used for evaluating purchase willingness to determine usability, that is, whether the product recommendation system by voice was easy to use.

3.2 Experimental Procedure

As regards taste, ① "Friendly × intellectual," ② "Friendly × non-intellectual" tone of items: (A) "electronic equipment," (B) "medicine," (C) "clothes," (D) "miscellaneous goods," (E) "book," (F), ③ "other person × intellectual," ④ "other person × non-intellectual" into the following four groups.

- Group I: A - ①, B - ②, C - ③, D - ④, E - ①, F - ②
- Group II: A - ②, B - ③, C - ④, D - ①, E - ②, F - ③
- Group III: A - ③, B - ④, C - ①, D -②, E - ③, F - ④
- Group IV: A - ④, B - ①, C - ②, D -③, E -④, F - ①

In the experiment, we demonstrated that the product was screened by the subject and recommended by the agent. A questionnaire round was conducted after the voice was played to evaluate purchase motivation and the tone for the products. This was repeated for all six items. After completing the questionnaire for all the products, we conducted a questionnaire round to evaluate usability.

4 Results and Analysis

4.1 Relationship Between Purchase Motivation and Tone

The central value of the purchase willingness data was set at 0, "I want to buy" was assigned a value of +5, "I do not want to buy" was assigned a value of −5, and an average value was assigned for tone quality × goods.

As it was necessary to consider variations in the subjects, we used data in which the numerical values were normalized.

Table 2. Tone × data on purchase motivation for products

	tone①	tone②	tone③	tone④
(A) electronic equipment	0.08	−0.38	0.51	−1.06
(B) medicine	−0.16	−0.47	−0.36	−0.81
(C) clothes	−0.524	0.80	1.18	−0.23
(D) miscellaneous goods	0.18	−0.76	−0.10	0.50
(E) book	0.015	−0.07	1.41	0.25
(F) food	0.27	0.68	0.85	0.17
Sum	−0.14	−0.20	3.45	−1.17

T-test was conducted to confirm the significant differences between each tone in Table 2. A significant difference was found between tone ③ and tone ④ ($p = 0.0312$), tone ③ and tone ② ($p = 0.0165$ at 5% confidence level), and a dominant tendency was observed between tone ③ and tone ① ($p = 0.0634$).

4.2 Tone

For the data on the impression words of the 15 items, factor analysis using a weightless least squares method was performed, the results of which are summarized in the following table (Table 3).

Table 3. Principal factors and factor load amount

	tone①	tone②	tone③	tone④
Intellectual	5.5	0	16	0
Distance of mind	13	17.5	0	16

4.3 Usability

The responses to the questionnaire on usability indicated an average of 0.895 and a standard deviation of 2.93.

5 Consideration

5.1 Impact of Tone on Purchase Motivation

From the results of the t-test, it was evident that the "other person × intellectual" tone promotes purchase motivation.

5.2 Impression of Tone

According to the tone used in the experiment, tone ② and tone ③ had the expected impression, as presented in Table 4. However, tone ① had a weak intellectual impression on the subject and tone ④ had a distant feeling. It was also suggested that the impression was on other impressive words as well as tone ② and tone ④ from the responses to the questionnaire on other impression words. This was not expected from the tone of voice (high voice, extended end tone), as the distant feeling is close to being felt.

Then, factor analysis was performed on the impression words data (Table 3), which yielded three factors: "seriousness," "sociability," and "activity." As regards "seriousness," there was a conflicting relationship between "intelligence" and "closeness of distant feeling" because of the sense of closeness (−0.732) and friendliness (−0.68) caused by negative influences. Using a tone that incorporates "seriousness" proved effective in improving purchase motivation, as the influence of factor 1 on "tone of other people × intellectual" tone had a significant influence on purchase motivation.

5.3 Usability

The e-commerce website that recommends products by voice received a high evaluation for ease of use ("easy to use"), despite its influence being small; however, due to large individual differences, we cannot claim that it was easy to use unconditionally. On the other hand, most of the subjects who chose "difficult to use" felt that text was easier to understand. Hence, it was considered that ease of use would be improved by recommending products through text.

6 Summary and Future Prospects

In this experiment, it became clear that "tone of others × intellectual" tone influences purchase motivation. In addition, the results of the factor analysis of the data on impression words, yielded three key factors, "seriousness," "sociability," and "activity": Tone ③ was clearly influenced by "seriousness," thus making it an important indicator of the tone affecting purchase motivation.

In the future, we believe that it is possible to measure the influence of tone on each product by reproducing the tone that did not meet our expectations in this experiment. Moreover, by increasing the number of subjects, it is possible to make more effective product recommendation to consumers with voice. We aim to create a recommendation system to promote.

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Interference Thermal Sensation Simulation Using Visual and Auditory Stimuli

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Abstract. Power shortage has become a perennial problem in Japan after the Great East Japan Earthquake. Energy saving measures adopted to deal with this situation have prompted worker complaints about the cold and consequent lack of concentration. In this study, we propose a way to change the perceivable temperature using a psychological approach rather than adjusting the physical temperature alone. Experimental evaluations confirm the effect of color and sound stimulation on thermal sensation. Participants indicated an increase in the perception of warmth when provided with a stimulus reminiscent of stove operation.

Keywords: Perceivable temperature · Infrared · Sound stimulus · Light stimulus

1 Introduction

In recent years, energy shortage has become a hot topic on a global scale. After the Great East Japan Earthquake, power shortage has become a routine state of affairs in Japan [1]. In this situation, several energy saving measures have been imposed, and cases such as workers complaining of feeling cold and being unable to concentrate on work, are increasing. In order to address such issues while maintaining the reduction in power consumption, it is necessary to adjust the perceivable temperature using a psychological approach. In this research, we aim to manipulate the perceivable temperature by taking a psychological approach instead of using the physical approach alone.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_24

2 Related Studies

The original factors that are considered to affect the perceivable temperature in reference environments of universal effective temperature (ETU) are the wind speed, clothing amount, air temperature, average radiation temperature, and relative humidity. However, some previous studies have considered the adjustment of perceivable temperature using a psychological approach. Yasuda et al. were able to change the sensible temperature using the smell [2]. Arimitsu et al. were able to change the sensible temperature using sound and light stimulus [3]. However, studies on perceivable temperature have primarily focused on temperature, and not on the feeling of temperature evoked by the method of transferring heat by radiation. For example, the perceivable temperature from a stove using radiant heat is different from that obtained using air-conditioning equipment. In this study, we focus on the effect of radiant heat on perceivable temperature. In addition, we analyze the effect of multiple stimuli, specifically, color and sound stimulation, on the simulation of radiant heat, and clarify their influence.

3 Preliminary Experiment

3.1 Heat Selection

First, we investigate the amount of radiant heat in order to determine the intensity of heat and the time of exposure to heat for this main experiment. We generated radiant heat using a carbon heater (manufactured by the UING Corporation), a radiation-type partial-heating appliance. In order to adjust the heat quantity provided by the carbon heater, slits were made in increments of 1 cm. Then, the size of the slit was varied and the perceived warmth was compared. Our findings showed that the difference in warmth was correctly perceived for slit differences of 3 cm or more, while the accuracy of perception was approximately 90% for a slit difference of 1 cm. From this, we concluded that discrimination is adequate even for a slit difference of 1 cm. Additional experiments were conducted to determine width of the slit used in this experiment. Pairwise comparisons were performed using 58 data values of warmth for three subjects and the results are shown in the table below (Table 1).

Table 1. Correct answer rate of temperature change at slit difference 1 cm

Slit width variation	1 cm vs 2 cm	2 cm vs 3 cm	3 cm vs 4 cm	4 cm vs 5 cm	5 cm vs 6 cm
Correct answer rate	100.0%	90.0%	70.0%	64.3%	75.0%

In order to make the experimental scenario close to the actual use situation, we wanted to conduct the experiment with the maximum slit size. However, according to Weber's law, people do not perceive the change when the ratio of variation is small. This tendency was also observed in this experiment, and the accuracy was low for the 4th slit width condition (4 cm vs 5 cm), which has a small ratio of change amount.

Therefore, this setting was considered inappropriate to investigate the influence of sound and light. Instead, we used the next highest and accurate rate, the temperature change of the 3rd slit width condition (3 cm vs 4 cm), in this experiment.

3.2 Experimental Result

Colors and sound stimuli that are reminiscent of warmth were used to increase the perceived temperature. With respect to color, two lights of red and orange were prepared using a source capable of adjusting RGB. With respect to sound, we used audio clips of firewood and carbon heater drive sounds. We conducted experiments to select one instance from each of these stimuli. We exposed participants to radiant heat, and collected feedback on which sound between the firewood and stove driving increased the perceived temperature. The results indicated that 75% of people associate stove sounds with increased warmth. We also conducted an experiment to select the color stimulus. The results indicated that, on exposure to radiant heat, the orange light was perceived as being warmer than the red light. Therefore, we used the driving sound of the stove as the sound stimulus, and the orange light as the color stimulus in our experiment.

4 Main Experiment

4.1 Combination of Experiments

A pairwise comparison of the perceived warmth was performed for the eight combinations listed in Table 2. A stimulus whose change can be clearly perceived within a range without discomfort is used to determine the strength of sound to be used. The weak light of the stove itself was used as the light source. Its intensity was determined as a stimulus capable of perceiving a clear change in the light amount of the stove within a particular range with no discomfort.

Table 2. Breakdown of the eight stimuli

	Heat (cm)	Sound	Light	*Heat*	
(A)	3	Low	Dark	3 cm	
(B)	3	High	Dark	4 cm	
(C)	3	Low	Bright	*Sound*	
(D)	3	High	Bright	Low	35.0 db
(E)	4	Low	Dark	High	36.0 db
(F)	4	High	Dark	*Light*	
(G)	4	Low	Bright	Dark	0.3 Lx
(H)	4	High	Bright	Bright	0.6 Lx

4.2 Experimental Environment

The stove was used as the light source. Subjects were asked to sit on a chair at a distance of 1.5 m from the stove, and the room temperature was fixed at 20 °C.

4.3 Experimental Procedure

The participants of the study included 23 men and women in their twenties. We randomized the order and the combination of stimulus presentation. The participants were subject to the following procedure steps.

i. Apply heat for 20 s to the left side of the body and ask participants to memorize the heat.
ii. Request participants to close their eyes, turn 180°, and rest for 15 s.
iii. Request participants to open their eyes and apply heat for 20 s to the right half of the body. Then, ask the participants to answer the question, "Which side, left or right, of the body is comparatively warmer" at the desired timing.
iv. Request participants to close their eyes, turn 180°, and rest for 15 s.
v. Request participants to open their eyes and apply heat for 20 s to the left half of the body. Then, ask the participants to answer the question, "Which side, left or right, of the body is comparatively warmer" at the desired timing.

Repeat steps II to V 55 times.

4.4 Experimental Results and Discussion

The probability of adopting the warm stimulus is summarized below (Table 3).

Table 3. Probability matrix of warmth

		The stimulus give earlir							
A stimulus given later		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
	(A)		43.5%	21.7%	17.4%	4.3%	21.7%	0.0%	8.7%
	(B)	65.2%		34.8%	21.7%	17.4%	8.7%	8.7%	8.7%
	(C)	60.9%	39.1%		30.4%	21.7%	17.4%	4.3%	8.7%
	(D)	78.3%	65.2%	52.2%		26.1%	21.7%	4.3%	8.7%
	(E)	73.9%	65.2%	34.8%	52.2%		13.0%	21.7%	13.0%
	(F)	69.6%	60.9%	60.9%	56.5%	56.5%		26.1%	17.4%
	(G)	82.6%	73.9%	78.3%	65.2%	78.3%	17.4%		17.4%
	(H)	78.3%	78.3%	52.2%	87.0%	52.2%	47.8%	56.5%	

A score of 1 was counted for "I got warm," and variance analysis was carried out using Scheffe's pairwise comparison method (Table 4).

From the table, significant differences were found in the main effect S α, main effect $\times$ individual S α (B), combination effect S γ, and order effect S δ. The psychological measure values of the stimulus of (A) to (H) are summarized in a Table 5. They are also represented on the straight number line in Fig. 1.

As seen from Fig. 1, stimulus numbers (A) to (H) showed an increase in warmth in that order. This increase is considered to be significant if the distance between the two measures exceeds the yardstick Y = 0.2155545. Therefore, significant differences were observed in combinations other than in (A)–(B), (B)–(C), (C)–(D), (F)–(G), and (G)–(H).

Table 4. Analysis of variance

Factor	Sum of squares	Degree of freedom	Unbiased dispersion	F0 value	P value
Main effect S α	317.4347826	7	45.34782609	66.51287	**8.250161847
Main effect × Personal S α (B)	138.5652174	154	0.899774139	1.319723	**0.008495756
Combination effect S γ	32.47826087	21	1.546583851	2.268416	**0.000931715
The order effect S δ	44.72049689	1	44.72049689	65.59275	**1.483162209
Order × individual S δ (B)	16.42236025	22	0.74647092	1.094869	3.45E−01
Error Se	738.378882	1083	0.681790288		
Total sum of squares ST	1288	1288			

**p < 0.01

Table 5. Psychological measure values for each stimulus

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
−0.505	−0.370	−0.190	−0.065	0.033	0.250	0.364	0.484

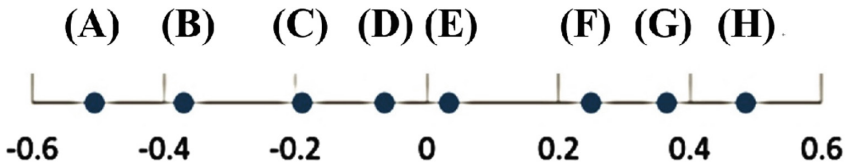

Fig. 1. Psychological measure values for each stimulus

i. About (A)–(C), (E)–(G)
   A significant difference was found between (A) and (C), (E) and (G). Therefore, it is obvious that providing light stimulus at the same temperature provides a warmer feeling.
ii. About (D)–(E)
   There was no significant difference between (D) and (E). Hence, it could not be determined if a dominant difference is obtained by the addition of light and sound for a slit difference of 1 cm.
iii. About the whole (A)–(H)
   As mentioned above, although there is no significant difference on both sides except for (E)–(F), when comparing with the same amount of heat, it is seen from Fig. 1 that there is a tendency to perceive warmth in the order of sound < light < sound + light.

Moreover, we plan to conduct this perceptual experiment with a large number of subjects, which might result in significant differences even in adjacent conditions.

5 Conclusions

In this study, we demonstrated that a specific thermal stimulus could be perceived as being warmer by providing additional light stimulus and sound stimulus. However, this finding was subjective, and we encountered subjects who were not able to perceive the change in the sound and light stimulus. We surmise that the awareness of the participant about change in the light and sound stimulus could influence his/her result. It may also be that the selection of the stimulus was not appropriate. It is impossible to judge whether the subject was able to perceive the stimuli change using the current method, and hence we plan to group subjects together in future experiments.

The purpose of this experiment was to make radiant heat perceived by participants warmer by using the stimulation of sound and light. In this study, it was clear that thermal sensation was influenced by light and sound stimulations. We will evaluate the effects of the light and sound accurately in our further studies.

Acknowledgments. I am deeply grateful to the members of Human Media Engineering Laboratory of the Faculty of Science and Technology, Chuo University, and the Kansei Robotics Research Center, who are enthusiastic about research discussions and cooperation for experiments. This work was partially supported by JSPS KAKENHI grants, "Research on Sensitivity Symbiosis Mechanism within Groups in Real Space/Information Space" (No. 25240043) and TISE Research Grant of Chuo University, "KANSEI Robotics Environment."

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Effectiveness of Communicating Personalized Values Related to Physical Exercise to Enhance Motivation

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Abstract. Recently, methods for motivating people who do not have an exercise habit have been attracting public attention, because lifestyle-related diseases are becoming a serious issue. While few people possess such a habit, frequent physical exercise is necessary in order to prevent lifestyle-related diseases. To address this issue, it is important to increase motivation for physical exercise. Yet, effective methods for creating this motivation have not been established. This research aims to clarify effective methods for motivating people who lack an exercise habit. We focus on the sense of value for physical exercise, and its use for motivation. The study results succeeded in increasing the amount of physical exercise completed by the subjects.

Keywords: Health care · Wearable device · Motivation · Physical exercise · Japan

1 Introduction

Recently, methods for motivating people who do not have an exercise habit have been attracting public attention, because lifestyle-related diseases are becoming a serious issue. According to a survey by the Ministry of Health, Labor and Welfare in Japan, over half of all deaths are attributed to lifestyle-related diseases [1]. For example of lifestyle-related diseases, there are cancer, heart disease, cerebrovascular disease. In order to prevent lifestyle-related diseases, frequent physical exercise is necessary. But only 33.8% of males and 27.2% of females have an exercise habit in Japan [1]. To address this issue, it is important to increase motivation for physical exercise. Yet, effective methods for creating this motivation have not been established and is the focus of this research.

2 Related Research and Research Approach

Research exploring exercise motivation in Japan has been conducted by Ito [2] and Ichimura [3], among others. Ito clarified enhancing motivation by understanding value why is task important. Also, Ichimura clarified enhancing motivation against to difficult task when subjects understand value for task. From this previous research, it is believed

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_25

that encouraging people by using value for exercise to enhance motivation to physical exercise. This research aims to clarify whether a sense of value for physical exercise is an effective personal motivation for engaging in physical exercise.

As the value placed on physical exercise depends on the individual, we must personalize the value when using it as motivation for physical exercise. For example, the value of physical exercise is thought of as being "For health," "For beauty," etc. As a result, attempting to motivate someone using the value of health will be futile if they value beauty as a motivator for physical exercise.

3 Methods

3.1 Planning

The subjects targeted in this study were individuals who feel that they should exercise: two males and one female in their twenties.

In our experimental plan, we first administered a questionnaire to clarify the value that subjects attributed to physical exercise. We then measured the amount of physical exercise that the subjects engaged in over a two-week period using wearable monitoring technology. While subjects' physical activity was being tracked, they were sent motivating instant messages to their mobile device by the researchers on even days of the experimental period. Our aim is to measure the effectiveness of motivating by comparing differences in the amount of exercise on even days and odd days (Fig. 1).

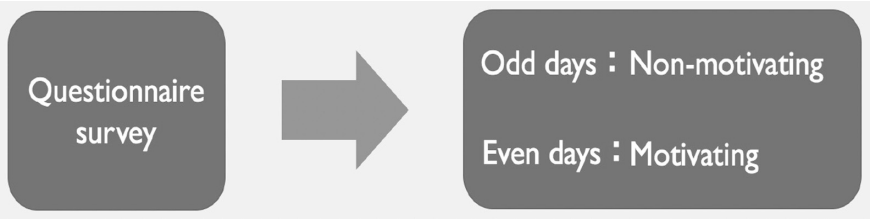

Fig. 1. Planning of experiment

3.2 Questionnaire

The multiple-choice questionnaire was conducted to clarify the value that subjects place on physical exercise. The questionnaire was developed drawing on the results of a 11,485 person survey conducted by the Nippon Life Insurance Company in 2013 which classified the value placed on physical exercise [4]. The flow of our questionnaire was as follows. First, participants were asked, "Do you think that exercise is necessary?" When the answer to this question was yes, we asked, "Why do you think so?" Participants answered from the choices: "For health," "For beauty," "For hobby," and "Other." When the answer for this question was "Other," we asked them to "Please specify." These questions were used to understand the different values ascribed to physical exercise by the subjects and use this to test different motivating approaches in the next phase of the study.

3.3 Motivation

In this experiment, we used LINE (an instant messaging service) to communicate easily with subjects. We created a temporary account to motivate subjects. Subjects added the temporary account as a LINE friend before starting the experiment. We synchronized the time for motivating subjects at 10AM. The different motivations used in the experiment are indicated in Fig. 2.

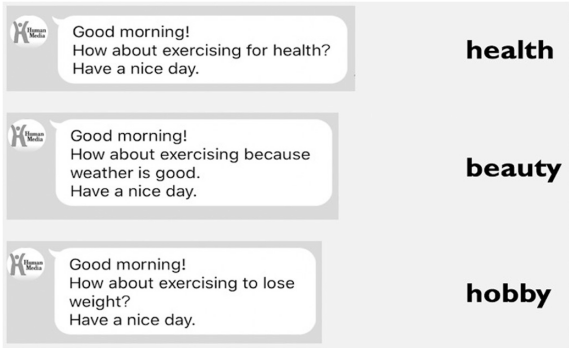

Fig. 2. Example of motivation used in the experiment

3.4 Measuring Amount of Physical Exercise

We measured the amount of physical exercise by using Fitbit Charge HRs. The Fitbit can measure "number of steps," "number of stairs climbed," "hours slept," "heart rate," "Calories burned," etc. We used these indicators to measure the amount of physical exercise completed by the subjects. Subjects were instructed to equip with the Fitbits at all times, with the exception of bathing. The devices are positioned 3 cm from the wrist as shown in Fig. 3.

Fig. 3. Position of Fitbit Charge HR

4 Results

4.1 Data

Below is the experiment data measured by the Fitbit Charge HR. This includes "calories burned" when motivated (Table 1) and not motivated (Table 2), "number of steps" when motivated (Table 3) and not motivated (Table 4), the "number of stairs climbed" when motivated (Table 5) and not motivated (Table 6), and "minutes of exercise" when motivated (Table 7) and not motivated (Table 8). On occasions when data was unavailable, because the subject forgot to equip the Fitbit, a diagonal line has been drawn in the table.

Table 1. Calories burned by exercise when motivated

Subject	Calories burned by exercise (kcal)						
A	680	1,163	457	424	1,887	1,937	258
B	712	939	658	615	802	503	
C	1,620	1,202	1,061	717	1,027	1,165	

Table 2. Calories burned by exercise when not motivated

Subject	Calories burned by exercise (kcal)									
A	360	298	1,548	441	192	646	211	1,670	343	190
B	731	866	763	1,413	659	815	733	179		
C	792	1,492	581	224	378					

Table 3. Number of steps when motivated

Subject	Number of steps						
A	1,580	5,262	2,507	2,680	13,153	11,673	942
B	7,581	10,582	8,386	7,705	11,002	17,836	7,124
C	12,078	9,438	12,122	2,159	7,859	11,648	

Table 4. Number of steps when not motivated

Subject	Number of steps									
A	2,601	788	8,762	2,636	637	3,108	839	9,402	1,388	644
B	7,167	10,059	8,594	17,861	9,449	10,300	8,975	1,803		
C	5,512	4,167	1,101	963	1,268					

Table 5. Number of stairs climbed when motivated

Subject	Number of stairs climbed						
A	1	2	0	0	42	2	0
B	14	36	24	21	22	24	14
C	26	39	81	22	60	92	

Table 6. Number of stairs climbed when not motivated

Subject	Number of stairs climbed									
A	1	1	15	3	1	4	0	1	0	1
B	12	20	16	28	39	15	29	3		
C	11	14	23	18	19					

Table 7. Minutes of exercise when motivated

Subject	Minute of exercise						
A	9	27	0	0	69	24	0
B	22	19	12	19	11	4	
C	44	19	61	0	15	55	

Table 8. Minutes of exercise when not motivated

Subject	Minute of exercise									
A	7	2	43	0	0	0	0	4	0	0
B	25	21	13	20	21	24	0			
C	19	32	0	0	0					

4.2 Analysis

We conducted a dependent t-test to determine whether motivation is effective by comparing differences of average. The results are shown in Table 9.

Table 9. Results of consumption calories by exercise

	Motivating	Non-motivating
Average	938	676
Variance	226306	206557
t-value	1.701	
p-value	0.053	

Table 9 indicates the possibility of increasing the number of calories burned by motivation with the p-value of approximately 0.05.

Table 10 shows an increase in the number of steps due to motivation with the p-value of under 0.05.

Table 10. Results of number of steps

	Motivating	Non-motivating
Average	8166	5735
Variance	20696660	21433967
t-value	1.934	
p-value	0.034	

Table 11 shows an increase in the number of stairs climbed when motivating with a p-value of under 0.01.

Table 11. Results of number of stairs climbed

	Motivating	Non-motivating
Average	26	11
Variance	696	130
t-value	2.762	
p-value	0.006	

Table 12 shows an increase in the amount of time exercised when motivated with a p-value of under 0.05. These results indicate that the motivation of subjects is enhanced by individually tailored motivation based on their values surrounding physical exercise.

Table 12. Results of minutes exercised

	Motivating	Non-motivating
Average	21	12
Variance	447	174
t-value	1.772	
p-value	0.047	

5 Conclusion and Future Research

This research aims to clarify effective methods for motivating people who do not have an exercise habit. We focused on the sense of value that individuals place on physical exercise and used this for motivation. As a result, we succeeded in increasing the amount of physical exercise performed by the subjects. Due to the study's small sample size, further research is necessary to confirm the results. We will increase the number of subjects to 20 in a future study in order to improve its accuracy.

The next steps for our laboratory team are to conduct research to build a system that makes physical exercise a habit without any stress. Ikeda, has already clarified what has reduced stress when people exercise. Shimazaki will conduct research on what timing is effective when motivating people. Oishi will conduct research on what kind of music is optimal when people exercise. Combining these research results with our research will provide a more holistic understanding of how to encourage physical exercise.

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Research on Memory Factors of City Souvenir

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Abstract. The city souvenir is developed as an indispensable product in every city, which is also regarded as the significant media of constructing the city image and delivering culture. However, it's a regret that the designs of souvenirs demonstrate great homogenization, whose boring and repetitive images cannot arouse interests and city memories from consumers nowadays and this has become a dilemma designers confronting with. In the design of "weight of Shanghai", we drew support of the questionnaires and case analysis to pick up the most recognized project that represents Shanghai. Then through comparison among the most frequently mentioned designs, we screened out the design elements. The interviewees were also required to marked the products based on the degree that how much the products can arouse their city memories, whose data can help build the relationship between the intensity of city memory and the related design elements, finally contributing to the final edition of design.

Keywords: City souvenir · City memory · Product design

1 Introduction

1.1 Definition of the City Souvenir

City souvenir attaches great significance of the commercial qualities of a certain product, alongside with its rich cultural meanings and commemorative characteristics. It shouldn't basically just be allocated to the common commodity as it's full of the commemorative meanings of a certain traveling, bearing the beautiful and special memory of a city. What's more, it's regarded as the significant symbol and direct reflection of the local customs and practices, cultural customs and natural views. From the communication science's perspectives, the innovation of city souvenir is beneficial for expanding and propagandizing the national and regional cultures, doing favor for the inheritance and development of our national culture. In terms of design science, it urges and promotes the ability of creativity, which is indispensable for enhancing the level of manufacturing techniques and cultivating design talents. On the other hand, the cultural protection experts might say that the city souvenir not only represents the

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_26

cultural connotation, artistic level but also demonstrates the utilization of material resources and craft skills. Hence, it cannot wait a minute for us to follow up the development of the era to satisfy the increasingly diverse purchasing requirements of tourists. More specifically, this target requires us to dig into the local culture, create and refine some representative cultural symbols to product city souvenirs with aesthetic, practical, regional, commemorative and cultural characteristics [1].

City souvenir is a significant carrier to highlight the characteristics of a city's culture while the city memory is the foundation to demonstrate the city's specialty. As mentioned in the "City Development" written by the eminent city theorists: the city survives for memories [2]. With the gradual transformation of China's tourism industry, tourism begins to vary from functional consumption to emotional consumption and the requirements of tourists change from mere visiting to experiencing. Thus, in the city traveling, memories can be sold as a component of the traveling production mix. This's true when concerning the historical cities, as the rich experiences of the city help us know, fell and experience, to better know its past, current status and the future. The memory of those who have connected with the city in the historical sections, has also become a shining point of the tourism. To sum up, picking up those exerting the most impressive factors of a city not only provides valuable and special thoughts when designing the souvenirs, but also helps completely and detailedly preserves the exclusive city memories [3].

1.2 The Relationship of City Memory and City Souvenir

In the view of social psychology, memories are variably considered to be manipulated to correspond with the experiences and personal views as a process that how human brains cope with the external information through coding, saving and extracting. In addition to the personal memory, there exists collective memory shared with a group of member [4]. Commonality is the starting point of collective memory, established by not an established concept, but a concept of social construction [5]. The architecture believes that the city is the place where the collective memories form, whose definition is refined distinguished from family memory and national memory. Besides, Le Goff concludes the five phrases of the development of the human memory, where the part related to city construction belongs to the second phrase, which is formed alongside with the presence of commemorative place [6].

In the design activity, since the development of the urbanization tide swept China, designers focus have serious biased, reducing the sense of culture, belongings and identity of the users. More seriously, this would lead to the lacking and fracture of the cultural and historical development of the city. Additionally, we notice that the changing environment has weakened the relationship with their memories used to locate the city, resulting into some difficulties of week memory and recognition. On the other hand, the history, culture and the material environment consist of the most important part of consent degree of personals and groups. However, the loss of modern urban culture has caused some difficulties of sense of identity and sense of

belonging when someone lives in a certain city. Under such a situation of lacking in collective memories and urban memories, the design of city souvenirs is somehow biased too [7].

2 Method

Our research starts from the perspective of users, with the methodology of case study and focus interview. In the meanwhile, with the thought of Kansei Engineering, we can draw a conclusion of the strong or weak relationship between the interviewees' urban memory and certain design elements, in order to find the theoretical support for the design of urban souvenir. Applying the method of analyzing "urban memory" to consumer analysis and product plot can help satisfy the emotional requirements of a urban souvenir and promote the sense of belonging and identity. The main procedures are as follow:

1. Find out what in the interviewees' mind that can represent Shanghai most through the focus interview.
2. Refine and classify couples of design elements with the thought of Kansei Engineering, based on the frequency of certain thing.
3. Select several cases whose design elements are corresponding to certain Shanghai souvenirs and ask the interviewees to score the products according to the degree that can arouse their memories.
4. Rank the scores given above and endow them with a certain degree of arousing city memories, then apply to the next design.

2.1 Collect the Design Elements

Considering the difference of objectives, we take two groups for comparison, the tourists group and the local group. Each one of group contains 8 persons, the former one consist of local citizens while the latter one is made up of tourists or undergraduate students from other cities. During the investigation process, they are required to describe couples of discrete things to best represent Shanghai (see Tables 1 and 2).

Table 1. The design elements collected from the tourist group

Oriental pearl tower	The bund	Jin Mao building	Expo building	Shanghai center	Fried dumpling
Shanghainese	Cheongsam	City temple	Rickshaw	Mahjong	Alley
Shikumen	Xintiandi	Huangpu river	Phonograph	Soup dumpling	Yangcheng lake crabs

Table 2. The design elements collected from the local group

Oriental pearl tower	The Bund	Jin Mao building	Expo building	Shanghai center	Fried dumpling
Shanghainese	Cheongsam	City temple	Rickshaw	Dashijie	Alley
Shikumen	Racecourse	Huangpu river	Bailemen	Soup dumpling	Yangcheng lake crabs

Comparing the results from the two groups, except for the traditional things, the most distinguished difference from the citizen group is that the tourist group highly value the mahjong, the Xintiandi and phonograph. Apart from the tourist group, the local group put forward the Dashijie, the Racecourse and the Bailemen. These result show that the ambiguity existing in the different group concentrates about the past Shanghai since the local can be more familiar with the eminent constructions of the old Shanghai while the tourist prefer some intentions of the Bund in the old Shanghai by mentioning mahjong, phonograph and rickshaw.

With the results above, we can classify them into three groups: the architecture group, language group and living group. Through sub-division, we get 9 design elements (see Table 3).

Table 3. 3 elements groups and 9 design elements

A: architecture group	B: living group	C: language group
A1: landmark building	B1: food	C1: character
A2: traditional building	B2: entertainment tools	C2: pronunciation
A3: building groups	B3: clothing	
	B4: transportation	

2.2 Case Analysis

For better research consumers' emotional recognitions of the combination of some certain design factors and the real production, our project picks up 12 representative modern souvenirs (see Fig. 1) and produces corresponding questionnaires for interviewees to marks the products, under the standard of the extent of representativeness. Ranging from 1 to 5, the higher score means a stronger consistence of the Shanghai in memory.

Then we calculate the expected value of the data collected, which shows that the items related to architecture score the highest and those related to language rank the lowest, while those in the classification of living earn a fluctuating result. The score of design elements ranges from high to low shows A1, A3, A2, B1, B3, B2, C2, B4, and C1 (see Table 4).

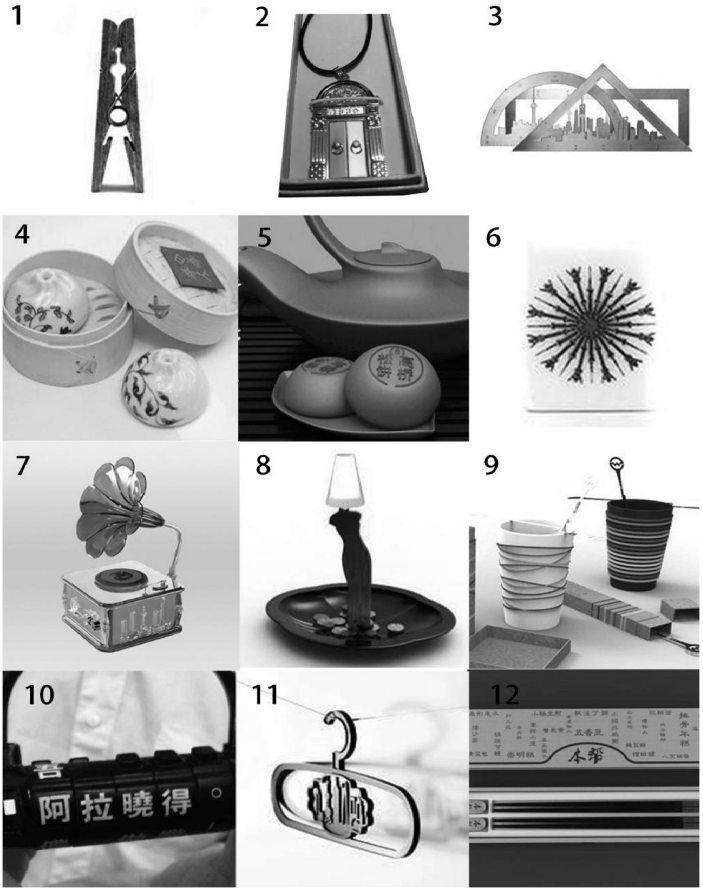

Fig. 1. Design cases of.12 representative modern souvenirs

Table 4. The ccorrespondences between cases and design elements and the score of design cases

No.	1	2	3	4	5	6	7	8	9	10	11	12
Design elements	A1	A2	A3	B1	B1	B2	B2	B3	B4	C2	B3 C1	B1 C1
Score	4.02	3.66	3.82	3.51	3.12	2.33	2.98	3.35	2.88	2.74	2.34	3.55

3 Design of "The Weight of Shanghai"

In the design contest of tourist souvenir of Shanghai city held by the Shanghai Tourism Bureau, the travel assistant product named "the weight of Shanghai" was certificated of the first round judgments, required to combine the theme of "the Memory of Shanghai"

to make further correction according to the committee. During the process of creating, they used the above mentioned research methodology and statistical conclusions, finally attaining the award.

Fig. 2. The souvenir design of "weight of Shanghai"

3.1 Selection of the Design Elements

Through the above investigation survey and statistical analysis, we found that the factors related to architecture got the highest mark, thus the products should design with more architectural elements. As for the single selection, although the modern erections got the highest mark, it shouldn't be selected as prior design factor since the design elements of high recognition are often in an excessive use in similar products, causing aesthetic fatigue. What ranks the second place is the building group and traditional architecture. Then we can also consider the delicacy in the living group with its satisfactory scores.

3.2 Design Performance

"The weight of Shanghai", an assistant product combining the memory of Shanghai and the modern urban life, whose main functions are weighting, lightening and charging. The final edition of "the weight of Shanghai" chooses the arch shape like "Shikumen" as the general image, with decoration of traditional pattern. What's more, in the front side of the panel, it chooses the architectural complex of the Bund and makes some abstract carving above. The designer makes some architectural elements and living factors on the strap portion of the product, abstracting the symbolic erections of Shanghai to arouse the memories of people (see Fig. 2).

4 Conclusion

In terms of the traditional image of the city souvenir, this essay starts from the user experience, analyzing the significance of the application of city memory to the design of city souvenir. More creatively, based on this I put forth some design of city souvenir with the support of our city memory research and some other existent product analysis, combining the design elements from Kansei Engineering. To be more specific, that is to split the current products into several parts corresponding to the elements in the city memory respectively, then through the investigation survey and interviews to analyze the consent degree of the whole product. With these statistics analysis we have concluded the effective factors of different city memories, which are quite indispensable for the latter directional design and finally help list the design procedures for the honored cases as a more reliable approach for the city souvenir design.

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Affective Value and Kawaii Engineering

Relationship Between Physical Attributes of Spoon Designs and Eye Movements Caused by Kawaii Feelings

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Abstract. Kawaii, a positive adjective that denotes such positive connotations as cute, lovable, and charming, becomes more important as one kansei value. It plays an important role in the success of many products. Based on this success, we believe that kawaii will be a key factor for future product design. In one of our previous study, we evaluated kawaii illustrations using eye tracking device. The result clarified relationship between kawaii feelings and eye movement indexes. In our other study, we evaluated kawaiiness of spoon designs focusing on their physical attributes. However, we have not employed the eye tracking in the study yet. Then, in this study, we evaluated the kawaiiness of spoon designs using eye tracking. The participant compared and selected more kawaii spoon designs from the pairs on the display, and eye movements had been recording meanwhile. Finally, we obtained the suggestions for the relationship between spoon design attributes and eye movement indexes for kawaii feelings.

Keywords: Kansei value · Kawaii · Spoon designs · Attribute · Eye movements

1 Introduction

For more than twenty years, affective engineering, which is a consumer-oriented methodology for product development, has been recognized as an important part in a broad range of Japanese manufacturing. Affective engineering is defined as "technology that translates a consumer's feeling (kansei) and image for a product into physical design elements" [1]. When added to ordinary products, kansei values can increase their economic worth. Based on their benefits, in 2007 the Japanese Ministry of Economy, Trade and Industry (METI) proposed kansei values as a new value axis, becoming the fourth most critical characteristic of industrial products after function, credibility, and cost [2]. Examples of kansei values that have been widely applied to products are enjoyment, coolness, and user friendliness. Kawaii is also considered as one kansei value that denotes such positive connotations as cute, lovable, and charming and plays an important role in the worldwide success of many products, such as Hello Kitty and Pokemon. Based on this success, we believe that kawaii will be a key factor for future product design and development.

In our previous researches, we clarified kawaii attributes for designing kawaii products [3]. In addition, we experimentally evaluated the kawaiiness of spoon designs focusing on

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_27

their physical attributes of handle's surfaces [4]. The results suggested important attributes to be considered in designing kawaii spoons. Moreover, we experimentally evaluated kawaii illustrations using the eye tracking device to record eye movements on PC display [5]. As the result, we determined the eye movement indexes for kawaii feelings. The result clarified the relationship between kawaii feelings and eye movement indexes, confirming that eye tracking is an effective method to evaluate kawaii feelings.

In this study, we experimentally evaluated the kawaiiness of spoon designs using the eye tracking. The goal of this study was to clarify the relationship between spoon design attributes and eye movement indexes caused by kawaii feelings. We used a spoon comparison system to consecutively display pairs of spoon designs. Eye tracking system tracked participants' eye movements during the selection of more-kawaii spoon designs from the pairs. The experimental results included the selections of more-kawaii spoon designs, the questionnaire result, and the eye movement data. These results were analyzed by employing the spoon design attributes and the eye movement indexes obtained from previous studies. From the analyzed results, we obtained the suggestions for the relationship between spoon design attributes and eye movement indexes of kawaii feelings.

2 Literature Survey

2.1 Affective Engineering and Researches on Kawaii Feelings

Affective engineering is defined as "technology that translates a consumer's feeling and image for a product into physical design elements" [1]. By making products to which affective values are added, products can provide greater emotional fulfillment and make a larger impact on first impressions, which is a key to motivate consumer purchases. Based on the success of many products that have kawaii as a key factor, we believe that kawaii will be important affective value for future product design.

In our previous research [3], we studied various aspects of kawaii feelings. It explored the idea of designing kawaii products by examining kawaii attributes for shape, color, size, texture, and tactile sensation. However, these researches only explored the relationship between kawaii feelings and the attribute one by one. The relationship between kawaii feelings and the combination of attributes has not been explored yet. Therefore, we experimentally evaluated the kawaiiness of spoon designs focusing on their physical attributes of handle's surfaces [4]. The results suggested important attributes to be considered in designing kawaii spoons.

Researches have systematically studied the kawaii feelings evoked by kawaii attributes in which the biological signals were employed including heart beats and brain waves [6]. Moreover, eye tracking has been widely used in various research fields which revealed that eye tracking can recognize human emotional states and preferences. Therefore, eye tracking is an effective method for evaluating the mental states or the implicit needs of people. In our research [5], we experimentally evaluated kawaii illustrations using the eye tracking device to record eye movements on PC display. As the result, we determined the eye movement indexes for kawaii feelings. The result clarified a relationship between kawaii feelings and eye movement indexes. Therefore, in this research, we experimentally evaluated the kawaiiness of spoon designs by employing eye tracking.

2.2 Experiment on Comparison of Spoon Designs

The experiment was performed in our previous study to compare spoon designs based on kawaiiness [4]. We employed 39 spoon designs from 182 designs drawn by female students at Tokyo Woman's Christian University. These 39 spoon designs (Fig. 1) were selected based on the majority of shape on the designs. They were divided into three groups: the flower group (13 designs), the heart group (13 designs), and the smiley group (13 designs).

We used a spoon comparison system to collect the comparison results of spoon designs from the participants. The comparison method used in the system was a quicksort algorithm. We recruited 40 participants, all of whom were university students in their 20's. They were divided into four groups: ten Thai males, ten Thai females, ten Japanese males, and ten Japanese females. The spoon designs were compared in pairs by displaying on a PC monitor. The participants compared the spoon designs and used keyboard's arrow keys to select more kawaii spoon designs (left or right) or equally kawaii.

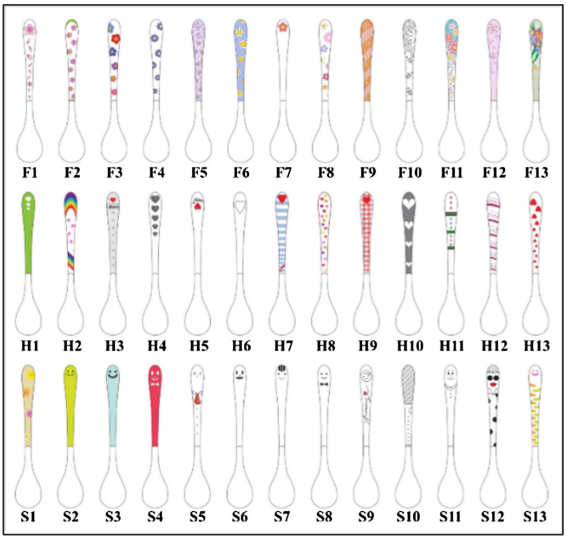

Fig. 1. 39 spoon designs used for experiment.

3 Experimental Method

3.1 Selection of Attributes for Spoon Designs

First, we employed 39 spoon designs from our previous experiment described in Sect. 3. Only the results of Japanese participants were used in this experiment. We divided 39 spoon designs into 3 groups based on their ranks: high-rank group, middle-rank group, and low-rank group. The spoon designs in high-rank group were selected from the top 13 designs with highest ranks. Similarly, the spoon designs in middle-rank and low-rank groups were the next 13 designs and the last 13 designs with lowest ranks, respectively.

Since we performed the experiment using eye tracking, the spoon designs should have a large difference in kawaiiness. Therefore, we used only 26 spoon designs from high-rank and low-rank group.

From our analysis of spoon designs in [4], we performed feature extraction to create the attributes of the spoon designs. This process transformed the input from raw data (i.e. images of spoon designs) into statistical data. We obtained the total of 33 attributes of spoon designs.

Next, we used the decision tree algorithm (C5.0) to select important attributes. The inputs were 26 spoon designs in which each spoon contained 33 attributes. The target was the rank group, either high or low. From the decision tree result, we obtained four important attributes as shown in Fig. 2. "Shape" was the most important attribute. For "flower shape," "with/without background color" and "number of shapes" were the other important attributes. For "smiley shape," "the ratio of shape area to colored area" was the other important attribute.

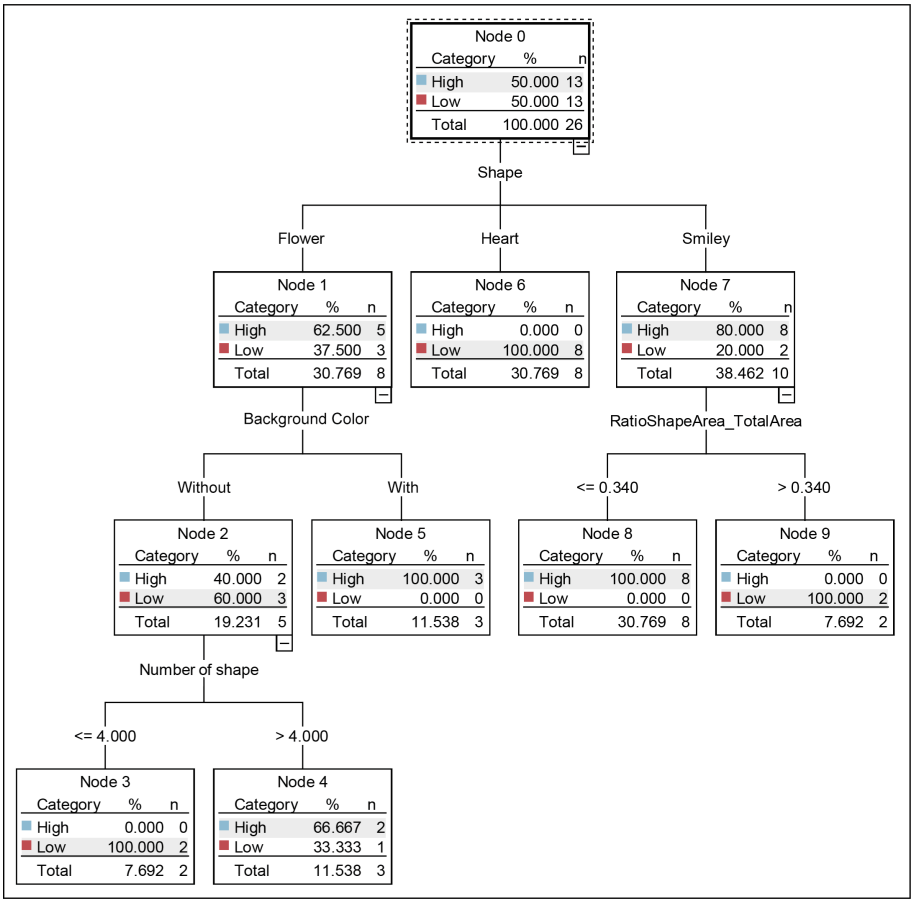

Fig. 2. Decision tree result

We made the assumptions from the decision tree result as follows:

- "Flower shape" and "smiley shape" are more kawaii than "heart shape."
- For the spoon designs in "flower shape," those with "background color" are more kawaii than those without it.
- For the spoon designs in "flower shape" and "without background color," those with "number of flowers" more than 4 are more kawaii than those of less than or equal to 4.

3.2 Candidates of Spoon Designs

In this experiment, only flower designs were employed based on their preferences in the result of previous experiment [4]. Then, we used two important attributes for "flower shape" ("with/without background color" and "number of shapes") to select the candidates of spoon designs.

To balance between the attributes, we selected four candidates of spoon designs as shown in Table 1. The attributes were balanced and average ranks were distributed. This average ranks were the results from 10 female participants in previous experiment (Sect. 2.2).

Table 1. Candidates of spoon designs with corresponding physical attributes and average ranks

Design ID	With/without background color	Number of shapes	Average rank
F9	With	> 4	8
F8	Without	> 4	19
F13	With	≤ 4	34
F7	Without	≤ 4	38

3.3 Spoon Comparison System

We modified a spoon comparison system from our previous study that evaluated kawaii illustrations [5]. The system used four spoon designs as visual stimuli (Fig. 3). The four spoon designs were displayed in pairs with left-right counterbalanced. The total number of compared pairs was 12. All of the system content was described in Japanese. The structure of the system is described as follows:

1. Top page: questionnaire explanation.
2. Consent form: brief explanation about experiment and permission to use their data.
3. Selection of participant's gender.
4. Instruction of how to select the spoon designs.
5. Spoon designs comparison:
   a. A cross sign (+) appeared at the middle of the display for 2.5 s to fix the eyes at the same position before each comparison.
   b. The pairs of spoon designs were randomly displayed with a 5-second countdown timer. Selections of more kawaii spoon designs were performed using the keyboard's left or right arrow keys (Fig. 4).

6. Questionnaire: three subjective questions were asked: reason for selecting the spoon designs (free description), most kawaii spoon design, and favorite spoon design.
7. Last page: the system explained that the comparison was finished.

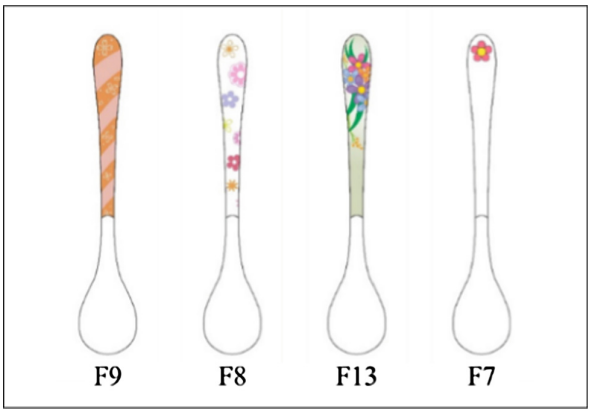

Fig. 3. Selected spoon designs for the experiment

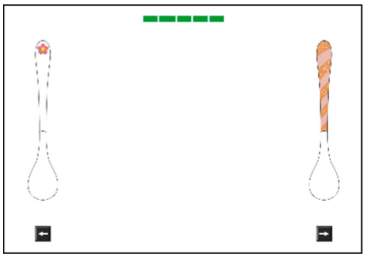

Fig. 4. Screenshot of spoon comparison system displaying two spoon designs and countdown timer

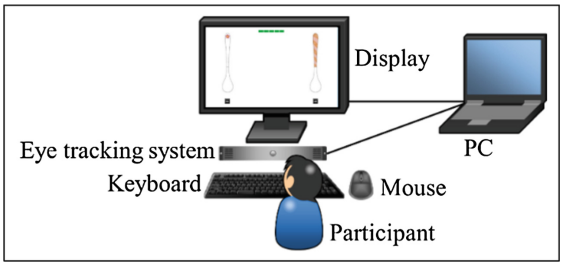

Fig. 5. Experiment setup

3.4 Experiment Setup and Procedure

Figure 5 shows the experimental setup. The web questionnaire was accessed from the eye tracking system through a web browser, i.e., Google Chrome, whose system ran on a separate PC due to limited resources. The eye tracking system employed the EyeTech TM3 non-intrusive eye tracker (EyeTech Digital Systems, Inc.) and QG-PLUS software (DITECT Co., Ltd.) to record the eye movements and display the eye tracking data. We used a 19-inch LCD monitor with resolution of 1280 × 1024 pixels.

The following are the experimental procedures:

1. Participant sat on chairs in front of the PC.
2. Participant read the explanation of the experiment.
3. We calibrated the eyes of the participant.
4. We showed the spoon comparison system and started recording eye movements.
5. Participant selected kawaii spoon designs from 12 pairs.
6. Participant answered the questionnaire.
7. We stopped recording the eye movements.

4 Experimental Results and Discussion

We performed the experiment with a female participant who was 19 years old. The experimental results are described in the following sections.

4.1 Cumulative Result

We collected the cumulative results (the kawaii scores) from the comparison of spoon designs. All combinations of two spoon designs with left-right counterbalanced were compared for 12 times. Each spoon design appeared for six times in total. The kawaii scores were calculated from the total number of selection for each spoon design from 12 times of comparison. The spoon designs and their kawaii scores were shown in Table 2. The order of spoon designs from highest to lowest kawaii scores was as follows: F9 > F13 > F7 > F8. From this order, only F9 resembled the average rank (Table 1). The orders of the other three spoon designs were different from the average ranks.

Table 2. Spoon designs and their kawaii scores

Design ID	Kawaii score
F9	6
F13	4
F7	2
F8	0

4.2 Questionnaire Result

The questionnaire results consist of three parts. Participant explained that the softness of color was the reason for selecting the spoon designs. She selected F9 as the most kawaii spoon design and F13 as favorite spoon design. From the cumulative result, F9 had highest kawaii score. Therefore, the cumulative result and questionnaire result were matched.

4.3 Result of Eye Movement Data

To analyze eye movement data, we employed fixation and Area of Interest (AOI). Fixation is defined as the eye state when it remains still or looks at the same spot over a period of time (threshold) that was set to 200 ms. AOI is defined as the area used to include certain segments from analysis. For this experiment's analysis, we defined two AOIs for the left-side and right-side illustrations on the spoon's handles (Fig. 6). The shape and the size of the AOIs were identical to balance the analysis areas.

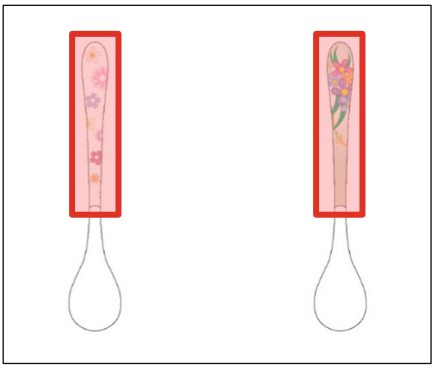

Fig. 6. Two AOIs with identical shape and size (red brackets) showing areas included in the analysis of eye movement data in a pair of spoon designs

We analyzed the eye movement data by employing the eye movement indexes obtained from previous study that evaluated the kawaii illustrations [5] in order to confirm that they are useful to evaluate kawaii feelings not only for kawaii illustrations but also kawaii spoon designs. In addition, in previous study, we employed only the eye movement data of the first half of comparison. The first-half eye movement data was meaningful because the participants actually considered the illustrations based on kawaii feelings. For the latter-half comparison, the participants only identified the illustrations and selected the ones that they already made decision as the most kawaii. Therefore, we also employed the first half of comparison in the analysis of this experiment. The results were described in the following sections.

Total AOI Duration. This index was sum of durations of all eye positions inside AOI. We analyzed the total AOI durations of each spoon design. Figure 7 shows the total AOI duration and the order of pair of comparison for 12 pairs. For the first six pairs, the total AOI duration of F9 tended to be higher than the other spoon designs, especially the 1st and 3rd pairs. Similarly, F9 had highest sum of total AOI duration among all four spoon designs (Table 3).

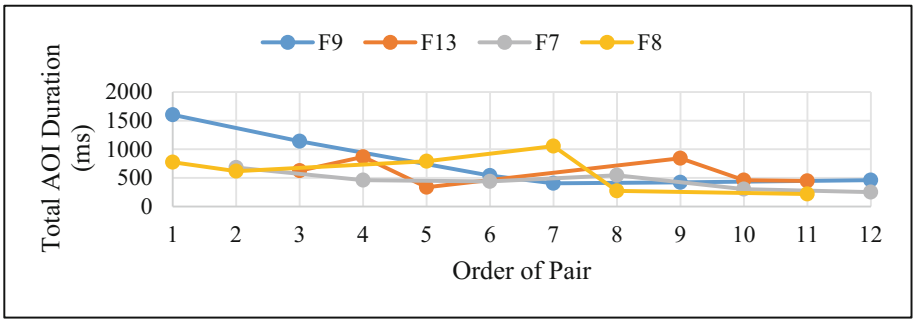

Fig. 7. Total AOI durations of four spoon designs for 12 pairs of comparison

Table 3. Sum of total AOI duration of four spoon designs for the first half of comparison

Design ID	Total AOI duration (ms)
F9	3281.25
F13	1828.13
F7	1578.13
F8	2179.69

On the other hand, F7 had lowest total AOI duration. The reason was possibly that this spoon design was much simpler than the other three spoon designs. Consequently, the participant did not need to take long time to consider. From this result, we suggested that the complexity of objects should be similar in order to compare their kawaiiness.

Total Number of Fixations. This index was sum of all fixations inside AOI. Figure 8 shows the total number of fixations and the order of pair of comparison for 12 pairs. For the first six pairs, the total number of fixations of F9 tended to be higher than the other spoon designs. Similarly, F9 had highest total number of fixations among all four spoon designs (Table 4).

For both total AOI duration and total number of fixations, the participant considered the kawaiiness of spoon designs only during the first half of comparison. Therefore, only the first-half eye movement data was meaningful for the analysis which resembled the result of our previous study [5].

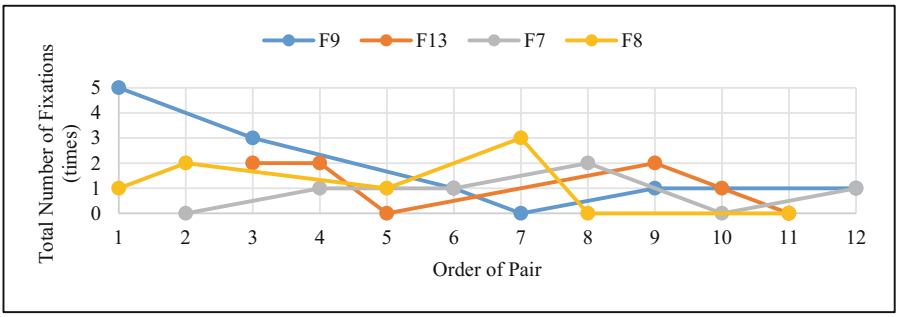

Fig. 8. Total number of fixations (times) of four spoon designs for 12 pairs of comparison

Table 4. Sum of total number of fixations of four spoon designs for the first half of comparison

Design ID	Total number of fixations (times)
F9	9
F13	4
F7	2
F8	4

In addition, the results between total AOI duration and total number of fixations were similar. The consistency between these two results indicated that these two eye movement indexes had similar tendency.

4.4 Comparison Results Among Physical Attributes, Cumulative Result, and Eye Movement Data

We analyzed the relationships between physical attributes of spoon designs (i.e. "with/without background color" and "number of shapes"), cumulative result (i.e. kawaii scores), and eye movement indexes (i.e. total AOI duration and total number of fixations). Table 5 shows the spoon designs that were ordered from highest to lowest

Table 5. Spoon designs ordered/grouped by kawaii scores, attribute and eye movement indexes

Physical attribute		Kawaii score	Eye movement index	
With/without background color	Number of shapes		Total AOI duration	Total number of fixations
F9, F13 (With) F7, F8 (Without)	F8, [F9] (> 4) F7, [F13] (≤ 4)	F9	F9	F9
		F13	F8	F8, F13
		F7	F13	
		F8	F7	F7

Remark. For "number of shapes" attribute, only the spoon designs without "background color" are applicable.

for kawaii scores, total AOI duration, and total number of fixations, and grouped by "with/without background color" and "number of shapes" attributes. The analysis results are described in the following sections.

Relationships Between Physical Attributes and Kawaii Scores. From the assumptions described in Sect. 3.1, we expected two following results:

1. F9 and F13 (spoon designs with background color) had higher kawaii scores than F7 and F8 (spoon designs without background color).
2. F8 (number of shapes more than 4) had higher kawaii scores than F7 (number of shapes less than or equal to 4).

As shown in Table 5, the kawaii scores of F9 and F13 were higher than those of F7 and F8 which supported our first expected result. Therefore, if we increase the number of participants, the assumption that "spoon designs with background color have higher kawaii scores" can be confirmed. However, the kawaii score of F7 was higher than that of F8 which conflicted with our second expected result. Further study is necessary to clarify the relationship between "number of shapes" attribute and kawaii scores.

Relationships Between Kawaii Scores and Eye Movement Indexes. In previous study [5], we concluded that the total AOI duration and the total number of fixations will be high if the kawaii scores are high. We analyzed the relationships to confirm whether the results of this experiment supported our previous study or not.

As shown in Table 5, F9 had highest kawaii score, total AOI duration, and total number of fixations, which supported our previous study. However, the tendency of the other three spoon designs was still unclear. If we increased the number of participants, we can confirm whether the results support our previous study or not, and whether total AOI duration and total number of fixations are useful indexes to evaluate kawaii feelings for spoon designs or not.

Relationships Between Physical and Eye Movement Indexes. From the assumptions described in Sect. 3.1, we expected the consistent orders for physical attributes, kawaii scores, and eye movement indexes. The expectations were as follows:

1. Spoon designs with "background color" had higher kawaii scores and higher values of eye movement indexes than those without it.
2. For spoon designs without "background color", those with "number of shapes" more than 4 had higher kawaii scores and higher values of eye movement indexes than those of less than or equal to 4.

From the order comparisons for physical attributes, kawaii scores, and eye movement indexes, the results were as follows:

- The order of total number of fixations was partially consistent with those of kawaii scores, "with/without background color" attribute, and "number of shapes" attribute. This result supported both expectations.
- The order of total AOI duration was consistent with that of "number of shapes" attribute, but different from those of kawaii scores and "with/without background color" attribute. This result partially supported the second expectation.

Besides, at least the orders of F9 were consistent among "with/without background color" attribute, kawaii scores, and two eye movement indexes.

The results mentioned above were obtained only from flower spoon designs and one participant, if we increase the number of participants, there is possibility to clarify some relationships.

5 Conclusion

This article introduced our study on the comparison of spoon designs based on kawaiiness using eye tracking. We performed decision tree to select useful attributes to design kawaii spoons. We selected the four flower spoon designs based on selected attributes. Then we experimentally evaluated these spoon designs using a spoon comparison system with eye tracking device. We built the system to clarify the relationship between attributes of spoon designs and eye movements. We used the cumulative result, questionnaire result, and eye movement data for analysis. Since the experiment was performed only for flower designs and one participant, we only obtained the suggestions for the relation between physical attributes of spoon designs and eye movement indexes caused by kawaii feelings. The results were described as follows:

- From cumulative result, the four spoon designs had different kawaii scores. F9 had highest kawaii scores which resembled the average rank and the questionnaire result. However, the orders of other three spoon designs based on kawaii scores were different from the average ranks.
- From the result of eye movement data, the results between total AOI duration and total number of fixations were similar which indicated that these two eye movement indexes had similar tendency for all spoon designs.
- For the relationships between physical attributes and kawaii scores, we made assumption that spoon designs with background color were more kawaii than those without it. The kawaii scores of F9 and F13, which were spoon designs with background color, were higher than F7 and F8, which were those without background color. This result supported the assumption.
- For the relationship between kawaii scores and eye movement indexes, our previous study [5] concluded that the total AOI duration and total number of fixations will be high if the kawaii scores are high. For this experiment, the result of F9 supported our previous study. However, the results of the other three spoon designs were still unclear.
- For the relationships between physical attributes and eye movement indexes, we compared the orders of spoon designs for physical attributes, kawaii scores, and each of the eye movement indexes. The order comparison for total number of fixations showed better result than that of total AOI duration. Besides, at least F9 showed consistent orders among "with/without background color" attribute and two eye movement indexes.

In addition, the complexity of objects, which had effect to eye movement, might be similar in order to compare their kawaiiness for future work.

For future work, we will employ more spoon designs and more participants to clarify the relationship between physical attributes of spoon designs and eye movement indexes caused by kawaii feelings.

Acknowledgments. A part of this work was supported by Grant-in-Aid Scientific Research Number 26280104. We thank the student of Shibaura Institute of Technology for participation.

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Are Kawaii Products Valuable to Chinese Customers?

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Abstract. This research studied how Chinese people perceived Kawaii, which was originally an important Kansei value in Japanese culture. An experiment was conducted among 30 young and 30 elder participants, including half male and half female. Three types of artificial products including spoons, blood pressure monitors and robots, with four designs for each product, were presented to the participants. Heart rate, heart rate variation and skin conductance were measured, and a followed up interview was conducted to collect participants' opinions towards the products. The results show that although most Chinese people know Kawaii, but the role of Kawaii in how much they like a product is not decisive. Compared to Kawaii, practicability and functionality are more valued by Chinese people.

Keywords: Kawaii · Biological measure · Chinese · Artificial product · Values

1 Introduction

Kawaii is originated from Japan and is spreading all over the world. People in different cultures learn Kawaii from Japan, and at the same time develop their own understanding of Kawaii. China and Japan are close in geography, and share East Asian cultural values. Therefore, Kawaii along with Japanese animations and dramas, is getting very popular among Chinese young generation in recent years.

In Japan there already exist researches about Kawaii. Kawaii was once considered as a feature that only appeared on living creatures like babies, animals and young girls. However, when we refer to Kawaii on artificial products, it is considered as a representative of Japanese Kansei design which can mean cute, lovely, and small related emotional values [1]. It is an affective concept that rooted in Japanese aesthetics, which is very hard to give a brief definition.

Experiments conducted among Japanese participants showed that shapes with curves and roundness were considered more Kawaii than shapes with straight lines. As for colors, warm colors were generally considered more Kawaii than cold colors. Gender also played a role in Kawaii color perception. Men preferred blue as the most Kawaii while women did not [1, 2]. In an experiment concerning Kawaii shapes, participants were asked to choose the most and the least Kawaii from four kinds of magnets with the same material but different shapes (cat, puzzle piece, whale and heart). Cat and whale got high Kawaii scores while puzzle piece got the lowest Kawaii score. Elder female participants gave high Kawaii scores to all the magnets, while male

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_28

participants in their early 50 s felt Kawaii only for living creatures (cat and whale), and one elder man thought it "hard to tolerate a heart shape at his age". The results indicated that elder men still held the original definition of Kawaii that it was only about cute animals, babies and girls, but felt hard to relate Kawaii to a kind of perception value on industrial products. Younger men in their early 20s also scored low for heart, but they rated similarly to female on puzzle piece, indicating that their ideas about Kawaii have developed and were different from those of elder men [1].

In addition to real objects, experiments were also conducted to study Kawaii perception in virtual world. When asked to give opinions on Kawaii of 2D and 3D objects shown on a film screen, participants still thought curved shapes as more Kawaii, but they preferred green and blue to red as more Kawaii, which was different from previous studies on real objects. In order to figure out the detailed preferences of virtual Kawaii colors, in another experiment 45 colors were carefully selected from the Munsell Color System, with five hues (red, yellow, green, blue and purple), three connected values of saturation and three connected values of brightness of each hue. The results showed that all hues were treated as the most Kawaii by some participants, and purple was the most preferred. When looked at the results by genders, purple was actually more welcomed by women while men preferred blue and green. In general, participants tended to think that colors with higher saturation and higher brightness as more Kawaii [3].

All the experiments mentioned above used self-rate scales to measure Kawaii. Although self-rate scales were cheap and convenient, it suffered from the disadvantages such as language ambiguity and unsimultaneous, which can be solved by physiological measures. Ohkura et al. [4] involved electrocardiogram (ECG), galvanic skin reflex (GSR), breathing rate, and electroencephalogram (EEG) in Kawaii studies. By dividing colors into Kawaii colors and non-Kawaii colors according to participants' ratings, heart rate showed a significant difference. Heart rates when watching Kawaii colors were significantly higher than watching non-Kawaii ones. Heart rate was also effective in distinguishing Kawaii perception towards sizes.

Although similar in cultural background, Chinese and Japanese aesthetics are not the same. In addition, compared to the younger generation, elderly Chinese people are not that familiar with Japanese culture. In order to investigate how Chinese people perceive Kawaii, an experiment was conducted between generations and between genders. In this study, we focus on Kawaii perception on artificial products, to see whether Chinese people can understand, and how they understand the Kawaii value on artificial products.

2 Methodology

In this study, 60 Chinese participants, including 30 young (age M = 23.6, SD = 1.7) and 30 elderlies (age M = 72.3, SD = 8.2), strictly balanced between genders, participated in the experiment. Participants in the young group were all students on campus, and participants in the elder group were recruited from elderly university and elderly activity center. All the participants were healthy in eyesight and did not have cardiovascular disease.

Three types of artificial products were selected as the materials, including spoons, blood pressure monitors, and robots. Spoons were commonly used by both young

and old, both men and women in everyday life, and the designs of spoons vary. In this experiment the spoons were described as specially used for stirring in order to reduce ambiguity. The blood pressure monitor is a medical device, which is also commonly used, especially among elder people. Designs of most medical device are usually insipid and similar, which may lead to boredom during long-term usage. It is interesting to see whether Kawaii can make a change on medical device design, and how Chinese people perceive it. Robot, as a representative of high-tech product, is usually expected to have a cool and mechanical design. However, robot is different from other high-tech product that sometimes the design of a robot imitates human beings and animals. Kawaii is commonly accepted as a feature on living things, so it is conceivable to add Kawaii into robot design. In this study the robots were further qualified as family care robot that have a human appearance. Each product had four different designs, shown in Figs. 1, 2 and 3. Real spoons were used while for the other two kinds of products, pictures shut on a screen were presented to participants. The distance between the participant and the screen was controlled for each participant.

Fig. 1. Spoons used in the experiment

Fig. 2. Blood pressure monitors used in the experiment

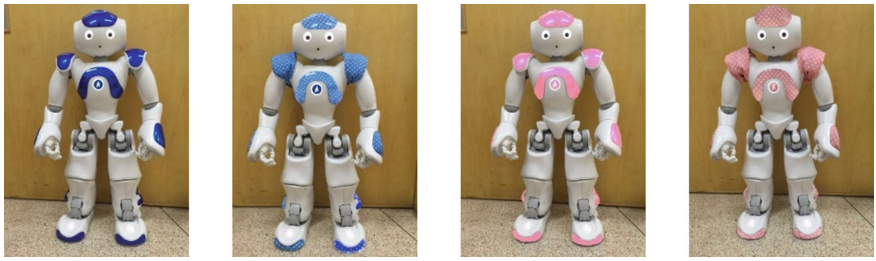

Fig. 3. Robots used in the experiment

Biological measurements and an interview were used to collect responses from participants. Thought Technology Ltd. ProComp5 Infinity multi-channel physiological measure instrument was used to measure biological measurements. Blood volume pressure (BVP) and skin conductance (SC) were measured by sensors equipped on participants' fingers. The expression of participant was recorded all through the experiment process by Face Reader 7.0. and a USB camera.

Because of the limitation of physiological measure instrument, every time only one participant took part in the experiment. At the beginning he/she was told about general process of the experiment, and signed an informed consent. Medical alcohol was used to clean the surface of participants' fingers and the sensors. After wearing and adjusting the instrument, the participant was told to just keep calm and sit still, and the data was recorded for 20s as a basic reference line for that participant. After a short introduction of the spoons, four designs of spoons were presented to the participant one by one, followed by the blood pressure monitors, and finally the robots. Each time the participant saw a product, his/her biological data were recorded for 20s. The orders of designs within each product group were random. After seeing all the products, the participant was again presented by all the four spoons, then all the four blood pressure monitors, and finally all the four robots. Finally, they were interviewed about their most liked and most disliked design for each product, and about why they made the choices. The whole procedure went for about 40 min for each participant, and after the experiment the participant can get 40 RMB and their favorite design of spoon as incentive. The experiment environment was shown in Fig. 4.

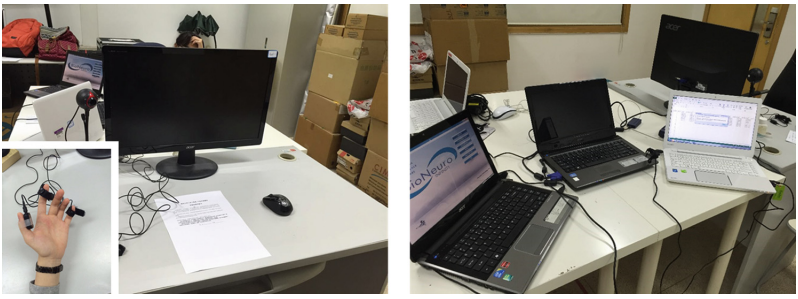

Fig. 4. The experiment environment (left-the participant view; right-the experimenter view)

3 Results

The frequencies of each design being liked and disliked in the interview were calculated and summarized in Table 1. The data was further grouped by age and gender, and summarized in Table 2.

Among the four designs of spoons, Design One was the most preferred and Design Four was the most disliked. The most frequently mentioned reasons for choosing Design One as the favorite spoon were "practical", "simple" and "easy to use". Two

Table 1. Counts of most liked/disliked designs in interview

Product	Like/Dislike	Design			
		1	2	3	4
Spoon	Like	25	12	17	6
	Dislike	9	11	10	31
Blood pressure monitor	Like	28	9	12	12
	Dislike	13	8	10	27
Robot	Like	28	16	7	10
	Dislike	11	7	11	31

Table 2. Counts of most liked/disliked designs in interview grouped by age and gender

Product	Like/Dislike	Group	Design			
			1	2	3	4
Spoon	Like	Young male	7	0	5	3
		Young female	1	6	6	2
		Elder male	7	5	3	1
		Elder female	10	1	3	1
	Dislike	Young male	3	7	1	4
		Young female	3	1	2	9
		Elder male	1	1	5	9
		Elder female	2	2	2	9
Blood pressure monitor	Like	Young male	14	1	0	1
		Young female	1	4	4	6
		Elder male	9	2	5	0
		Elder female	4	2	3	6
	Dislike	Young male	0	2	3	10
		Young female	5	1	6	3
		Elder male	2	3	0	10
		Elder female	6	2	1	4
Robot	Like	Young male	12	2	1	0
		Young female	2	7	1	5
		Elder male	9	2	5	0
		Elder female	5	4	2	4
	Dislike	Young male	1	2	3	9
		Young female	6	2	4	3
		Elder male	0	2	2	12
		Elder female	4	1	2	7

elder participants, one male and one female, described Design One as “the only one that is not designed for children to use”. On the other side, although six participants clearly put forward that Design Four was “very cute”, more than half of the participants

chose it as the most disliked one, because of "not practical", "over-designed" and "trouble to clean". For young males, the most disliked spoon was Design Two, because of "girly" and "the shiny material".

Twenty-eight participants most liked Design One of the blood pressure monitors, which was with a pure blue band. "Simple design" and "calm color" were most frequently mentioned reasons for choosing Design One. Nearly half of the participants disliked Design Four, which was with a dotted pink band, because "the color and texture looked old" and "disturbing". Opinions varied between genders. Males preferred blue and disliked dots. Twenty-three males chose Design One as the favorite blood pressure monitor, and no male participant chose Design Four. However, for both young and elder females, the most frequently chosen favorite design was Design Four, because it was "warm colored", "has affinity" and "has cute dots".

Among the four designs of robots, Design One was liked by the most participants, while Design Four was disliked by the most participants. Design One with pure blue was described as "cool", "reliable", "energetic" and "has a sense of technology", while Design Four with pink dots was "old looked", "feminine" and "not like a robot". Although the texture on the four robots were actually the same as on the four blood pressure monitors, this time all participants in the four groups preferred blue robots. Young females preferred the one with blue dots and the other three groups liked pure blue. Except for young females who chose Design One as the most disliked design, all the other three groups disliked Design Four, including elder females. The responses were different from those of the blood pressure monitors.

The biological data were recorded at 256 Hz. BVP was transformed into heart rate (HR) and heart rate variation (HRV) by Matlab 5.0. The first 10 s of skin conductance data and the whole period data were averaged, and labeled as SC10 and SC20, respectively. HR, HRV, SC10 and SC20 instead of the raw data, entered further analysis. For each of these four indexes, the result of the treated data (data recorded during watching a design) minus the reference data (data recorded before experiment during sitting silently), was divided by the reference data, to get a ratio, and this ratio was the variable that entered the final analysis. In this way the bias of personal differences can be controlled.

Mixed ANOVA models were established to test the effect of age, gender and design, for each product, with age and gender as between-group factors, and design as a within-group factor. However, no significant effect was found.

To slightly relax the standard, paired t-tests between each two designs were conducted to study the effect of design. Significant effect of design on HR was found. The heart rate when watching spoon Design Four ($M = 0.76$, $SD = 4.73$) was significantly higher than when watching spoon Design Two ($M = -0.36$, $SD = 3.43$, $t(51) = 2.29$, $p = .026$, $r = .09$). The heart rate when watching blood pressure monitor Design Two ($M = 0.64$, $SD = 4.43$) was marginally significantly higher than when watching blood pressure monitor Design Four ($M = -0.19$, $SD = 5.42$, $t(51) = 1.82$, $p = .074$, $r = .06$). The effect was not very large (according to the low effect size) because of the large SD compared to M, due to the specialty of ratio data.

4 Discussion and Conclusion

This research studied how Chinese male and female, the young and the elder, perceived Kawaii design in industrial products. Sixty participants took part in the experiment and were presented with 3 types of products. Both their biological signals and their opinions in the interview can tell their feelings and thoughts about Kawaii.

Previous researches gave evidence on which color and shape was more Kawaii, for example warm color was usually more Kawaii, and men preferred blue but women did not [1, 2]. The results of this research also support these findings, for example, males like blue and females like pink. The current study also finds that females are more acceptable of dots, while males aren't. This trend is especially obvious for the blood pressure monitors. Both young and elder men dislike Design Four, while for both young and elder women Design Four is chosen as the most liked design by the most people.

The results of the current study indicate that although participants can distinguish which design is Kawaii and which one is not, they do not usually choose the Kawaii design as their favorite one. For example, among the four designs of spoons, the result of biological measures tells that when participants see Design Four they have the highest heart rate, which is significantly higher than when they see Design Two. From previous study on Kawaii through biological signals, this result indicates that in these Chinese participants' minds Design Four is the most Kawaii design, which can make human mental states more active [4]. The statement that Design Four is the most Kawaii can also be confirmed from the results of the interview, in which six participants clearly elaborated that Design Four is "very cute". However, when the participants are asked to choose their most liked and most disliked designs, Design Four is the least frequently chosen as the most liked one, and at the same time the most frequently chosen as the most disliked one. Compared to their favorite design, the "simple" and "easy to use" Design One, Design Four is disliked for "hard to use" and "over-designed". This is also consistent for the other two products. Blood pressure monitor with blue band is preferred by some participants for the "cooling down" appearance while Design Four is disliked because "a blood pressure monitor doesn't need to be that fancy". Robots that look powerful and reliable are preferred to Kawaii ones. All these findings indicate that for Chinese people, functionality and practicability are the most crucial features for an artificial product. Kawaii is hardly considered when choosing a product that has a specific function, although most people can perceive it.

The focus on practicability and functionality leads to the phenomenon that people's preferences for color and texture depend on the types of products. In the current experiment the four combinations of color and texture for blood pressure monitors are the same as those for robots, but participants' preferences vary. For robots, participants regardless of both age and gender prefer blue to pink designs. In addition, both male and female elders prefer pure blue to dots, because it makes the robot more masculine and have a better technology sense. Although Kawaii can bring people a sense of warm and affinity, it is on the other side delicate and weak, which are not appealing features for a robot.

Due to the way to calculate biological measure ratios, the statistical tests don't give a high effect size, but in such a way the personal difference can be well controlled, which can make the result more convincible. The result of this research again confirm that heart rate can be a good index in Kawaii related research. Because the subjective preferences of participants are only collected in the interview and can only be treated as frequency data, there is a lack of further statistical analysis. This is a limitation of the current study. Later research can involve more quantized measurements, but an opening discussion or interview is still necessary, especially when we are still at an initial stage in Kawaii research.

The results of this research indicate that Chinese people can tell apart Kawaii and non-Kawaii designs, based on their own definition of Kawaii. Consistent to Japanese people, designs with cute animals are considered as Kawaii. Pink and dots are considered as Kawaii features, especially by females. Males may dislike these features because they are thought traditionally feminine designs. However, Kawaii is not a core concern when Chinese people judge an industrial product. Functionality and practicability are the most important features to consider. Kawaii sometimes even make a negative contribution to people's preference because of the possibility to influence practicability and the sense of useless over-design.

Acknowledgments. This study was funded by a National Natural Science Foundation China grant 71661167006.

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How to Model Value-Creating Communication: Coaching Process as an Example

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Abstract. The authors are conducting research on "Value-creating communication". Therefore, we analyze the career coaching process as an example of value-creating communication. First, we took notice of remarks and analyzed coaching process qualitatively. Then, we revealed three types of coaching pattern and we found that the career coaching process had two phases, in which under-standing and then consent is enhanced. Second, we modeled coaching process using Bayesian network and examined the validity and usefulness of the constructed model. As a result, we clarified the change of client's consciousness using mathematical method Bayesian network.

Keywords: Communication · Bayesian network · Coaching

1 Introduction

The authors are conducting study on value-creating communication. Value-creating communication is a process that people embody and clarify their own values and form new values through communication. It is defined as value creation including not only creation of new ones but also refinement of ambiguous ones. Here, the value handled in this study refers to internal value.

Coaching is a communicational method whose purpose is to generate client-based solutions, on the assumption that such solutions are theirs to find. There is an abundance of extant research on coaching, partly because there are often observable indicators such as sport scores or business productivity, which facilitate results evaluation [1, 2]. However, in career coaching it is important that clients determine values related to prospective places of employment, which makes it difficult to analyze career coaching because of its dependence on unobservable indicators such as the internal values of clients. Thus, it is unsurprising that career coaching has yet to have become an object of research.

Therefore, the purpose of this study is to analyze unobservable internal value creation in the career coaching process in a manner hitherto unattempted, and to clearly assess coaching effectiveness in this light.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_29

2 Coaching

Coaching is a communicational method whose purpose is to generate client-based solutions, on the assumption that such solutions are theirs to find.

The differences between coaching and counseling are often noted. Broadly put, coaching aims at improved future performance based on the present, while counseling seeks to understand the past in order to solve a present problem.

In addition, clients generate solutions through coaching; whereas in counseling, the counselor typically possesses the solution and advises clients about related countermeasures. Moreover, the coach stands in an equal relation with his/her client; while, in counseling, the counselor takes the lead and guides the conversation. For all these differences, however, there is much overlap in the two processes.

"Listening", "questioning" and "approval" are often cited as important skills in effective coaching. However, a host of other skills are discussed in books on coaching, and in coaching qualification guides; and coaching principles are applied in a variety of areas, such as education, medical treatment, welfare, health, and life training. The coaching process typically takes place in a one-to-one context (coach and client); however, a single coach will sometimes work with a group of people, such as families, teams, or project members.

3 Observation and Analysis of Coaching Process

We introduce the observation and analysis of the career coaching process we conducted. See [3] for details.

3.1 Observation Method

We posted announcements for students in job seeking situations, and recruited three clients for career coaching (two women and one man) through tuition of university and Facebook. All the coaches (two women and one man) who participated in the study had pertinent coaching qualifications.

The case of Ms. A provided a good illustration of value creation through coaching. Ms. A and her coach initially had a face-to-face coaching session, followed by Skype sessions thereafter. Coaching was conducted once a month, a total of six times. The conversations were recorded using a voice recorder and recording software, and we analyzed the transcribed data.

3.2 Case Study

In the first and second coaching sessions, numerous topics focused on Ms. A's experience, personality and values. Ms. A stated, "Airline work is one possibility because I like to travel"; and she had a vague feeling of wanting to "become part of a cabin crew." Ms. A said, "I have always wanted to become part of a cabin crew", but she did

not clearly understand why, or what was actually involved in the occupation. In addition, she had a negative impression of A Inc., as she felt that its employment was "temporary work and unstable". Thus, the coach said, "Imagine that you become part of a cabin crew", and Ms. A did so. Then, Ms. A imagined such a cabin crew member communicating with customers with a smile, and said, "My goal is to make customers smile." Ms. A noticed that a motivating force behind her wish to become part of a cabin crew was her desire to make customers smile; but she continued, "Is cabin crew work really suitable for me?", suggesting that something restrained her. In response, the coach said, "Is cabin crew work really your best choice?", "Many occupations involve work in foreign countries", and "You went to an excellent university, so there are other choices." Ms. A disagreed with the coach's line of thinking, and noted her most important value: "I would like to do what I want to do." The theme of the fourth coaching session was "Oneself in the future"; the theme of the fifth, "Career plan"; and that of the sixth, "Reason for working".

3.3 Features of Coaching Process

In order to clarify the characteristics of the coaching process, we visualized the process with the remarks of subject and coach as indicators. In this case, the client herself performed value creation, however the coach elicited the client's value judgments. Thus, we defined two broad categories: "Client value judgment" and "Coach's remark that elicits client value judgment."

As a result of visualizing the process, we found three characteristic patterns leading to client's sense of values: 'Pattern A', 'Pattern B', and 'Pattern C'.

1. Pattern A

The coach asks about the previous client remark concerning hobbies, tastes and experiences, and elicits the client's sense of values.

The coach asks directly for the reason and purpose behind the remark that implied a subjective judgment, and elicits the client's value judgment.

2. Pattern B

If the coach asks directly for the client's reason, purpose or meaning, but client is not able to answer or be satisfied, the coach elicits the client's value judgment by prompting the client to talk about some imagined situation.

The coach prompts the client to conceive of some imaginary situation(s) in detail, using questions or other remarks. The coach expresses his/her own feelings about these situations, or asks what the client feels about them; and thus the coach elicits the client's value judgment.

3. Pattern C

The coach determines (or narrows down) the order of priority in the client's sense of values.

The coach provides a new variable (or viewpoint) to the client, and makes the client talk about the value he/she attaches to the variable, through questions or other remarks.

The client speaks about the value he/she attaches to the variable, and thereby thinks about the order of priority among his/her values. Finally, the client distinguishes the most important element in his/her sense of values.

Further, pattern C was observed after pattern B in the third coaching session. In Pattern B, Ms. A determined that her most important value was "I want to make customers smile." After this, in Pattern C, she narrowed her sense of value and she realized that she would like to do what she wants to do. And then, she consented to become a cabin crew member. There were two phases, as stated above. In this way, in career coaching, we found that it is necessary to have two phases: understanding one's sense of value with regard to employment, and consent regarding working at a specific company.

4 Analysis and Discussion by Bayesian Network

4.1 Bayesian Network

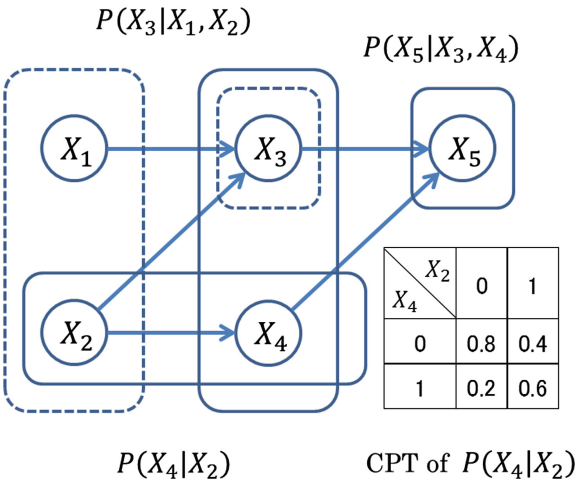
The feature of the Bayesian network is to predict the likelihood and possibility of occurrence of an uncertain event by expressing the causal structure as a network and then performing probabilistic reasoning [4]. The Bayesian network is a network-like probabilistic model defined by three variables: random variable, conditional dependency between random variables, and conditional probability. According to Motomura [4], the Bayesian network uses random variables as nodes and expresses dependency relationships between variables as effective links. For example, the conditional dependency between random variables is denoted by, and the node (in this case) that comes before the link is called a child node, and the node under the link (in this case) is called the parent node. When there are multiple parent nodes, let be a set of parent nodes of child node. The dependence between and is quantitatively expressed by the following conditional probability.

$$P(X_j | P_a(X_j)) \tag{1}$$

Furthermore, considering each of the individual random variables as child nodes in the same way, the joint probability distribution of all the random variables is expressed by the following equation.

$$\mathrm{P}(X_1, \cdots, X_n) = P(X_1 | P_a(X_1)) \cdot P(X_2 | P_a(X_2)) \cdots \cdot P(X_n | P_a(X_n)) \tag{2}$$

A probabilistic dependency between these variables can be modeled by a Bayesian network constructed by linking each child node and its parent node (Fig. 1). The probability distribution of all variables is obtained by calculating the previous joint probability distribution. In this study, we use BAYONET [5] to construct a Bayesian network. BAYONET is a Bayesian network construction support system implemented by Java developed by Motomura et al. [6–8]. In this study, "Reason" is a factor, "Evaluation" is the result. We analyze by Bayesian network by expressing the remarks in the consensus building process as a causal structure.



X_4 \ X_2	0	1
0	0.8	0.4
1	0.2	0.6

Fig. 1. Bayesian network

4.2 Constructing a Bayesian Network Model

In order to classify the "Reason" into several nodes, the KJ method was used. As a result, it could be classified into six categories: "Job description", "Corporate culture", "Salary", "Employment status", "Popularity/Image" and "Other". In addition, the seven added "Worthwhile" to the above five were adopted as the "Reason" node. Table 1 shows the classification method. Therefore, we construct the network using a node with "Worthwhile", "Job description", "Corporate culture", "Salary", "Employment status", "Popularity/Image", "Other", "Evaluation" (Fig. 2). The state of "Reason" is "A" if it is described for each item, and "None" if it is not stated. "Evaluation" status is "Positive" or "Negative". One sentence is one remark and the item of "Reason" necessarily selects "A" or "None." However, since BAYONET has a function to complement missing values using a neural network [6], "Evaluation" does not necessarily need to select a state and there may be a blank.

Table 1. Reason classification table

Worthwhile	On her aspiration to be CA, remarks about the most important sense of value or an ideal herself
Job description	Remarks on a service for customers
	Remarks on imagine about herself who wait on customers
Corporate culture	Remarks on corporate culture of airlines
Salary	Remarks on salary
Employment status	Remarks on employment form, occupation type, work style
Popularity/Image	Remarks on image and longing for CA
Other	Remarks on place of work, self-esteem etc.

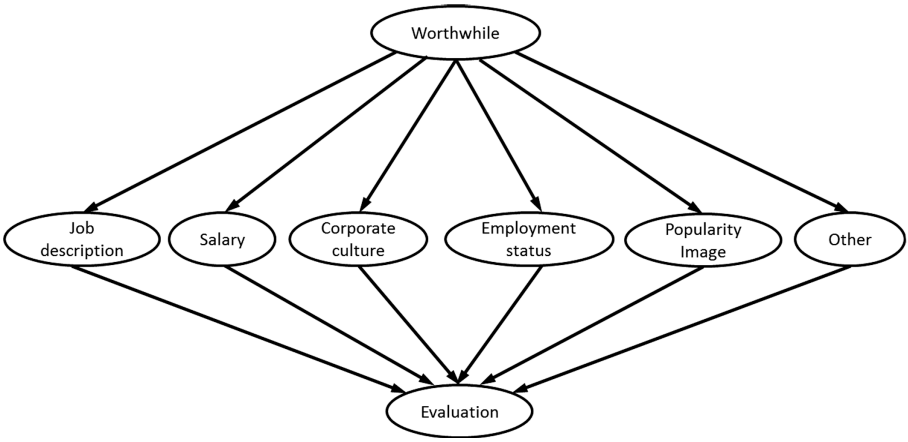


Fig. 2. Bayesian network model constructed

Table 2. Data used for analysis (Partial excerpt)

Number	Evaluation	Worthwhile	Corporate culture	Employment status	Job description	Salary	Popularity/ Image	Other
1	Positive	None	None	None	None	None	None	None
2	Negative	None	None	None	None	None	A	None
3	Negative	None	None	None	None	None	A	None
4		None	None	None	None	None	None	None
5	Negative	None	None	None	None	None	None	None
6	Negative	None	A	A	None	A	None	None
7	Negative	None	None	None	None	None	A	None
8	Negative	None	None	A	None	None	None	A

A part of the data used for the analysis is shown in Table 2. For example, the remark of number 6 in Table 2 is a classification of the remarks that "I was said by my father that CA is a contract employee (employment status), salary is also unstable (salary) and arrogant company (corporate culture)." Therefore, we set "Evaluation" was "Negative", "Employment form", "Salary" and "Corporate Culture" are "A", and the other nodes are "None".

4.3 Analysis Focusing on the Values that the Client Emphasizes in Each Phase

Sensitivity analysis was performed using the constructed Bayesian network model. Sensitivity analysis is a method of quantitatively calculating the influence of each factor in a model where an event is generated from a plurality of factors. BAYONET has a sensitivity analysis tool, it can infer with the specified explanatory variable and search for explanatory variable with a large influence on the objective variable.

Table 3. Sensitivity analysis result (First phase・Positive)

Number	Worthwhile	Corporate culture	Employment status	Job description	Salary	Popularity/ Image	Other	Evaluation	Probability value	Difference in probability	Lift value
1		A				None		Positive	0.582	0.096	1.198
2		A		None				Positive	0.571	0.085	1.175
3		A	None					Positive	0.560	0.074	1.153
4		A			None			Positive	0.557	0.071	1.146
5		A					None	Positive	0.556	0.070	1.144
6	None	A						Positive	0.551	0.065	1.133
7		A						Positive	0.551	0.065	1.133
8				None		None		Positive	0.515	0.029	1.059
9			None			None		Positive	0.514	0.028	1.057
10						None	None	Positive	0.513	0.027	1.055

Table 4. Sensitivity analysis result (First phase・Negative)

Number	Worthwhile	Corporate culture	Employment status	Job description	Salary	Popularity/ Image	Other	Evaluation	Probability value	Difference in probability	Lift value
1				None		A		Negative	0.575	0.575	1.119
2		None				A		Negative	0.563	0.563	1.095
3			None			A		Negative	0.563	0.563	1.095
4					None	A		Negative	0.559	0.559	1.088
5						A	None	Negative	0.559	0.559	1.088
6			A				A	Negative	0.557	0.557	1.084
7	None					A		Negative	0.554	0.554	1.077
8						A		Negative	0.554	0.554	1.077
9		None		None				Negative	0.535	0.535	1.040
10		None	None					Negative	0.528	0.528	1.027

In 3.3, we stated that there are two phases: clarifying the values about occupation in Pattern B, narrowing down the values in Pattern C and convincing you to work in a specific company they found out. Therefore, we use sensitivity analysis to clarify what clients are focusing on in choosing an occupation CA in each phase. We analyzed the objective variable as "Evaluation", explanatory variable as "Worthwhile", "Job description", "Corporate culture", "Salary", "Employment status", "Popularity/Image", "Other". In the sensitivity analysis, we make several pairs of values from explanatory variables and input them into the model to infer. Here, it is possible to specify the upper limit of the number of input values to the model, but in this study the maximum number of combinations is set to 2. This is because not the worthwhile which is an explanatory variable appears alone but the worthwhile often appears together with other items.

For each phases, a part of the result of sensitivity analysis is shown in Tables 3, 4, 5 and 6. "Probability value" in Tables 3, 4, 5 and 6 is the probability value (posterior probability) of the objective variable under the condition that the value of the explanatory variable is input. This indicates the probability that item is selected when a value of a specific explanatory variable is inputted. "Difference in probability" is the difference between the prior probability and the posterior probability for the objective variable. "Lift value" represents the ratio of the probability (certain posterior probability) of occurrence of a certain state when observation is input and the probability (prior probability) of occurrence of that condition irrespective of the condition.

Table 5. Sensitivity analysis result (Second phase)

Number	Worthwhile	Corporate culture	Employment status	Job description	Salary	Popularity/ Image	Other	Evaluation	Probability value	Difference in probability	Lift value
1		None					None	Positive	0.830	0.086	1.115
2	A					None		Positive	0.828	0.084	1.113
3	A						None	Positive	0.828	0.084	1.113
4	A	None						Positive	0.823	0.079	1.106
5	A		None					Positive	0.823	0.079	1.106
6			None				None	Positive	0.823	0.079	1.106
7	A			None				Positive	0.821	0.077	1.103
8						None	None	Positive	0.820	0.076	1.103
9				None			None	Positive	0.818	0.074	1.100
10	A				None			Positive	0.806	0.062	1.084
11	A							Positive	0.806	0.062	1.084
12		None	None					Positive	0.802	0.058	1.078
13		None				None		Positive	0.801	0.057	1.077
14					None		None	Positive	0.794	0.050	1.068
15							None	Positive	0.794	0.050	1.068
16		None		None				Positive	0.794	0.050	1.067
17			None			None		Positive	0.793	0.049	1.066
18				None		None		Positive	0.791	0.047	1.063
19			None	None				Positive	0.789	0.044	1.060
20	A			A				Positive	0.785	0.041	1.054

Table 6. Sensitivity analysis result (Third phase)

Number	Worthwhile	Corporate culture	Employment status	Job description	Salary	Popularity/ Image	Other	Evaluation	Probability value	Difference in probability	Lift value
1	A			None				Positive	0.859	0.113	1.152
2				None			None	Positive	0.850	0.105	1.141
3			None				None	Positive	0.831	0.085	1.115
4				None		A		Positive	0.814	0.069	1.092
5			None	None				Positive	0.808	0.063	1.084
6						None	None	Positive	0.805	0.059	1.080
7	None						None	Positive	0.805	0.059	1.080
8		None					None	Positive	0.801	0.056	1.075
9					None		None	Positive	0.801	0.056	1.075
10							None	Positive	0.801	0.056	1.075
11	A		None					Positive	0.796	0.050	1.067
12	A						None	Positive	0.794	0.048	1.065
13	A					None		Positive	0.794	0.048	1.065
14						A	None	Positive	0.789	0.044	1.059
15	A	None						Positive	0.781	0.036	1.048
16	A				None			Positive	0.781	0.036	1.048
17	A							Positive	0.781	0.036	1.048
18			None			None		Positive	0.780	0.035	1.046
19		None	None					Positive	0.777	0.032	1.043
20			None		None			Positive	0.777	0.032	1.043
21			None					Positive	0.777	0.032	1.043
22			None			A		Positive	0.774	0.028	1.038
23		None		None				Positive	0.770	0.024	1.033
24				None	None			Positive	0.770	0.024	1.033
25				None				Positive	0.770	0.024	1.033
26	A					A		Positive	0.768	0.023	1.031

That is, the higher the lift value, the greater the influence of the selected "reason" set on "evaluation". The data in Tables 3, 4, 5 and 6 are arranged in descending order of the lift value. In addition, the prior probability value at which the evaluation of the first period becomes positive (Table 3) is 0.486, at which the evaluation of the first period becomes negative (Table 4) is 0.514, at which the evaluation of the second period becomes positive (Table 5) is 0.744, at which the evaluation of the third period becomes positive (Table 6) is 0.745. According to Tables 3 and 4, In the first phase, for the occupation of CA, it shows that she has a positive impression from the viewpoint of "Corporate culture", but she has a negative impression from the viewpoint of "Popularity/Image". However, in the second phase (Table 5), the combination of "Worthwhile" and "Job description", and in the 3rd stage (Table 6), the combination of "Worthwhile" and "Popularity/Image" appear with high lift value. From this, Ms. A had a negative impression on choosing a job from the perspective of "popularity/image" in the first phase. However, in pattern B in the second phase, she noticed that "Job description" became "Worthwhile". And in Pattern C in the third phase, "Popularity/Image" which gave a negative impression in the first phase became positive to choose a job. It shows changes in client consciousness mentioned in 3.3 by Bayesian network analysis.

5 Summary

In this paper, as an example of "value-creating communication", career coaching process was taken up and analysis of value-creating communication was conducted.

We analyzed the coaching process in detail about unobservable intrinsic value in career coaching and visualized the process. Through this, we extracted the three coaching patterns that extract values depending on the client situation.

Also, it was suggested that two phases are necessary for career coaching. It is the phase of clarifying the values about an occupation and narrowing down the values and convincing you to work at a specific company. It is thought that this will strengthen "understanding and satisfaction" of the client. The client could not clarify the values from the beginning. However, compared the companies, and in the process of receiving coaching, she was able to clarify the values she wants to take most care of.

Finally, a coaching process model was constructed by Bayesian network. According to the sensitivity analysis, "Job description" is linked with "Worthwhile" in pattern B, and "Popularity/Image" is linked with "Worthwhile" in pattern C. This shows two phases of "understanding and consent" mentioned above, and it was possible to clarify the change of consciousness of the client by using mathematical method called Bayesian network.

In the future, we also analyze career coaching process and clarify the tendency of coaching process. We also analyze the value-creating communication process for participants who have various attributes and backgrounds, such as when they are in a hierarchical relationship or conflict relationship, or in a dialogue between experts and non-experts.

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Participation in a Virtual Reality Concert via Brainwave and Heartbeat

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Abstract. We proposed virtual concert experience systems in which visual effects appears depending on a user's brainwaves or heartbeats. The proposed system is composed of a simple EEG recorder, a smart watch measuring heartrate, a tablet terminal, a server and a 3D game engine on a computer, and an immersive head mounted display. We implemented the proposed systems, conducted experiments, and took a questionnaire on subjects. The results showed that generating visual effects by increase of beta/alpha ratios of brainwaves enhances the subjects' concentration and the subjects felt correspondence between their excitation and appearance of the visual effect when the system utilizes brainwaves. The results also showed that subjects felt fun in watching the concert with both the system utilizing brainwaves and system utilizing heartbeats.

Keywords: Virtual reality concert · Brainwave · Heartbeat · Immersive head mounted display · Brain-computer interface

1 Introduction

When participating in a real live concert, an important factor to acquire affective value in the concert is how a participant feels sense of unity via interaction between performers and audiences. For realizing the interaction, audiences make handclaps, shouts, and dances.

In recent years, virtual reality concerts have been emerged. A user wearing an immersive head mounted display can experience participation in a live concert as an audience virtually. However, viewing the virtual reality concert is passive behavior. In order that a user can feels sense of unity in the environment of the virtual reality concert, modality to realize interaction between the user and the concert is required. Some commercial games of virtual reality concert have introduced the modality by operating a game controller.

For realizing the interaction between the user and the concert, we proposed a novel virtual reality concert system with which a user can participate in a virtual concert via the user's biomedical signals, which are brainwaves or heartbeats. In the system, brainwaves or heartbeats of the user are measured while the user watched a movie of a virtual reality concert. Visual effects appear in digital contents of the virtual concert depending on states of the brainwaves or the heartbeats. The user can interact with the virtual concert directly via the physiological signals, which might reflect the user's affective state.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_30

We implemented the proposed systems and evaluated the physiological signals and subjective questionnaires when users play with the proposed systems.

2 Methods

2.1 System Configuration for Using Brainwaves

A type of our proposed virtual reality concert system utilizes brainwaves. We implemented the proposed system composed of a simple EEG recorder, a smart tablet, a 3D game environment in a computer, and an immersive head mounted display. Figure 1 shows a system diagram of the system. A homemade Android application running on a tablet terminal (ASUS, Nexsus7) receives row signals from the simple EEG recorder (B-Bridge, Brain ATHLETE) via Bluetooth. The application detects beta/alpha ratios from the row signals. The beta/alpha ratio was reconstructed from the row signal by using FFT with a 1 s time window, and updated every 1/16 s [1–3]. Depending on the beta/alpha ratio, the application generates one-byte commands, as explained below. The application sends the one-byte commands to a server running on a PC via TCP/IP. An application of a virtual reality concert developed by using a 3D game development platform (Unity Technologies, Unity) is running on the PC. The server converts the one-byte commands to operating commands of the game application. In the game application, the operating commands trigger generating visual effects in the virtual reality concert. An immersive head mounted display (Oculus VR, Inc., Oculus Rif) displays the advance of the virtual reality concert. The proposed system is a type of brain-computer interface game [4].

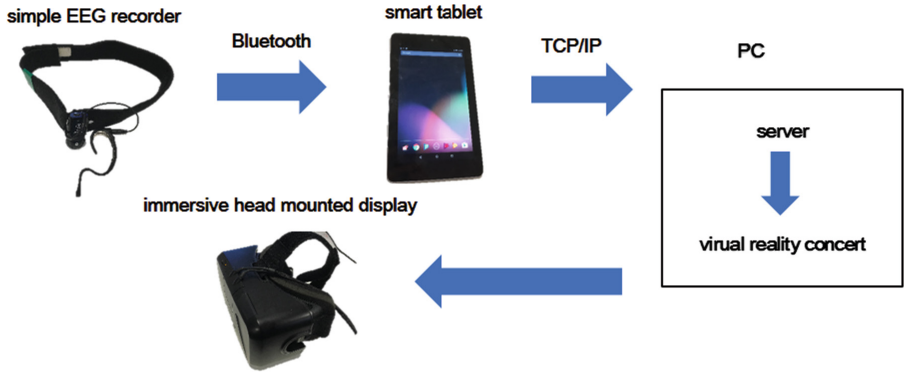


Fig. 1. A system diagram of our proposed system utilizing brainwaves.

2.2 System Configuration for Using Heartrates

Another type of our proposed system utilizes heartrates. The system configuration, shown in Fig. 2, is same with the system configuration for utilizing brainwaves except that we use a smart watch instead of the simple EEG recorder. A homemade Android

application running on the smart tablet receives heartrate from the smart watch (SAMSUNG, Samsung Gear Live). The application detects an absolute difference between the maximum and the minimum in heartrate during the past two seconds. We expected that the absolute differences reflect heart rate variability, and thus call the value heart rate variability in this paper. Depending on the heart rate variability, the application generates one-byte commands, as explained below. Communication among the application on the smart tablet, the server running on the PC, the game application, and the immersive head mounted display is same with one in the system for utilizing brainwaves.

In our proposed systems, both for utilizing brainwaves and for utilizing heartbeat, all of the components were available commercially at low cost.

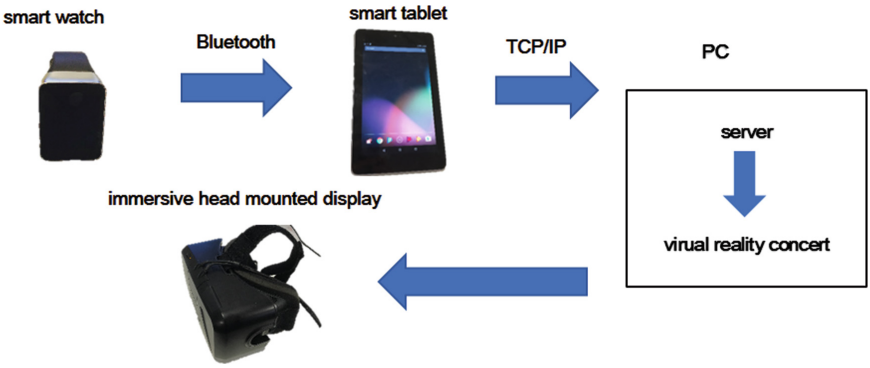


Fig. 2. A system diagram of our proposed system utilizing heartbeats.

2.3 Virtual Reality Concert

A movie used in the virtual reality concert was developed by using the 3D game development platform (Unity Technologies, Unity). A character of a dancing diva (Crypton Future Media, Inc., HATSUNE MIKU) was made on the platform by using a 3D CG software (HiguchiM, MikuMikuDance), a 3D model (Tsumidango, tsumishiki miku) of a character, and a 3D motion data (AHIRU anatroccolo, AHIRU version SENBONZAKURA motion). Additionally, light emitting performance of the stage and motion of chemical light of audiences were made.

2.4 Generating Visual Effects by Using Brainwaves

We used the beta/alpha ratio as degree of concentration. When a user concentrates, the beta/alpha ratio increases. In the virtual reality concert, a visual effect that stars are flown out from the character is show when the beta/alpha ratio becomes more than or equal to 1.3 and less than 1.4 (A scene was shown in Fig. 3(a)). A visual effect that hearts are flown out from the character is shown when the beta/alpha ratio becomes more than or equal to 1.4 and less than 1.5 (shown in Fig. 3(b)). A visual effect that petals of cherry blossoms fall from above of the stage when the beta/alpha ratio

(a) Stars flown out from the character

(b) Hearts flown out from the character

(c) Petals of cherry blossoms falling from above of the stage

Fig. 3. Visual effects.

becomes more than 1.5 (shown in Fig. 3(c)). To reduce consecutive generation of visual effects, visual effects were not generated within 2 s after generating a visual effect.

2.5 Generating Visual Effects by Using Heartbeats

We used the heart rate variability explained above as degree of excitation. We expected that the heart rate variability increases when a user gets excitation. In the virtual reality concert, the visual effect of "hearts" is show as explained above when the heart rate variability becomes more than or equal to 2.0. To reduce consecutive generation of visual effects, visual effects were not generated within 2 s after generating a visual effect.

2.6 Experiments

We conducted experiments with 12 subjects (5 males and 7 females). Each subjects had two sessions. In a session, the subjects sat on the chair with wearing both the simple EEG recorder and the immersive head mounted display, watched a fixation point during 1 min for collecting beta/alpha ratios as a baseline, and watched the virtual reality concert by using the system for utilizing brainwaves. In another session, the subjects sat on the chair with wearing the smart watch and the immersive head mounted display, watched the fixation point during 1 min for measuring heart rate variability as a baseline, and watched the same concert by using the system for utilizing heartbeat. Order of the two sessions was counterbalanced across the subjects.

2.7 Questionnaire

After conducting the experiments, we asked the subjects to complete a questionnaire to answer four questions,

- (Q.1) a question of whether the visual effects appeared when the subjects felt excitation,
- (Q.2) a question of whether the subject like the music used in the virtual reality concert,
- (Q.3) a question of whether the subject like the character used in the concert, and
- (Q.4) a question of whether the subject felt fun,

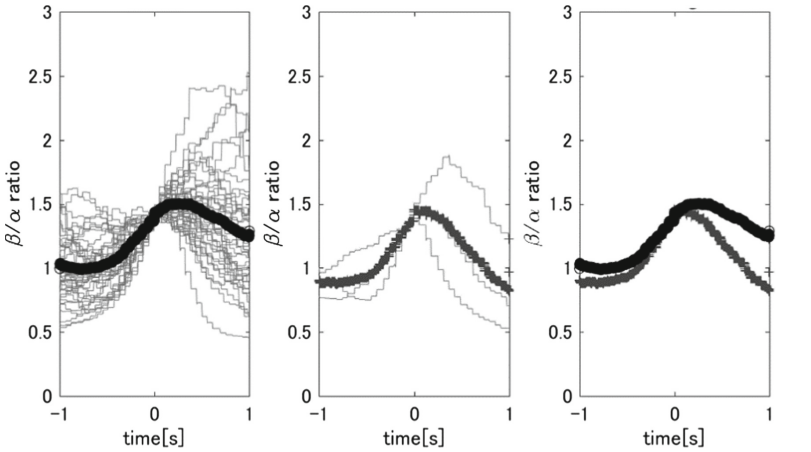
in 7-points Likert scales for both the system utilizing brainwaves and the system utilizing heartbeats. The questionnaire also had a free description field to write how subjects feel in the experiments.

3 Results and Discussion

3.1 Analyses of the System Using Brainwaves

Twelve subjects could watch the virtual reality concert with generating the visual effects successfully with proposed system utilizing brainwaves.

We compared time evolution of beta/alpha ratios between data collected during watching the virtual reality concert and data collected during the baseline. The time series of beta/alpha ratios were divided into epochs beginning at 1 s before the time point when beta/alpha ratio exceeded a particular threshold and ending at 1 s after the time point. Thin gray lines in Fig. 4(a) and ones in Fig. 4(b) show all segmented epochs in watching the concert and all segmented epochs in the baseline respectively in a subject when the threshold was set to the 1.4. In both Fig. 4(a) and (b), the horizontal axis indicates time and the vertical axis indicates beta/alpha ratio. The number of the epochs in watching the concert was more than that of the baseline. Black thick lines, which are sets of circles, in Fig. 4(a) and (c) show averaged beta/alpha ratios across the epochs in Fig. 4(a) and gray thick lines, which are sets of crosses, in Fig. 4(b) and (c) show ones in Fig. 4(b). In Fig. 4(c), the horizontal axis and the vertical axis are same to ones in Fig. 4(a) and (b). In Fig. 4(c), the averaged beta/alpha ratios in watching the concert was higher than that of the baseline in a period 1 s after the time point.



(a) Watching the virtual reality concert (b) Baseline (c) Averaged beta/alpha ratios across the epochs

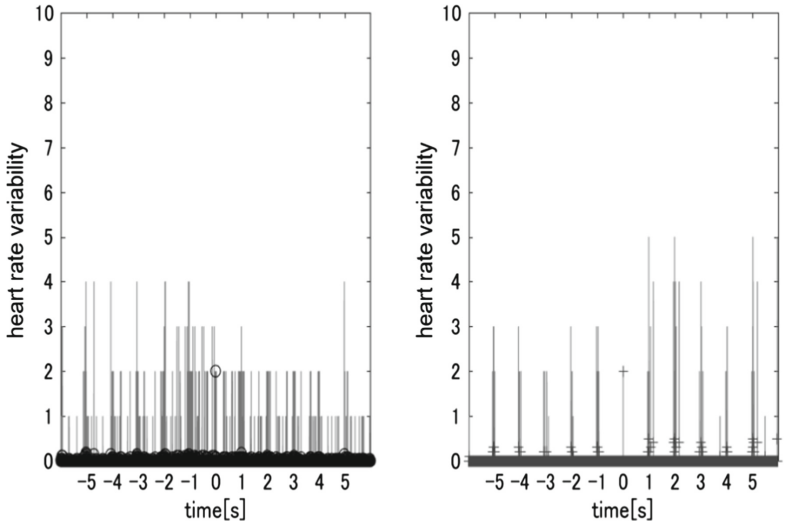
Fig. 4. Time evolution of beta/alpha ratio.

We conducted statistical evaluation by using the mean value of the averaged beta/alpha ratios in the period 1 s after the time point as a statistic. A paired t-test within the 12 subjects showed that the statistic in watching the concert was significantly higher than that of the baseline ($p < 0.05$ on both sides) when the threshold was set to 1.4 and 1.5 while the paired t-test showed no significant difference when the threshold was set to 1.0, 1.1, 1.2, and 1.3. The results suggested that the generation of visual effects of the hearts and the petals of cherry blossoms, which were generated by the threshold of 1.4 and 1.5 respectively, might enhance the beta/alpha ratios. In contrast, the generation of visual effects of the stars, which were generated by the threshold of 1.3, and no visual effects with the threshold less than 1.3 had no effect for enhancing the beta/alpha ratios.

3.2 Analyses of the System Using Heartbeats

Twelve subjects could watch the virtual reality concert with generating the visual effects successfully with proposed system utilizing heartbeats.

We compared time evolution of heart rate variability between data collected during watching the virtual reality concert and data collected during the baseline. The time series of heart rate variability were divided into epochs beginning at 6 s before the time point when the heart rate variability exceeded a particular threshold and ending at 6 s after the time point. Gray lines in Fig. 5(a) and ones in Fig. 5(b) show the heart rate variability in all segmented epochs in watching the concert and ones in all segmented epochs in the baseline respectively in a subject when the threshold was set to the 2.0. Circles in Fig. 5 (a) show averages of the heart rate variability across the epochs in watching the concert and crosses in Fig. 5(b) show ones in the baseline. In both Fig. 5(a) and (b), the horizontal axis indicates time and the vertical axis indicates heart rate variability. The number of the epochs in watching the concert was more than that of the baseline.



(a) Watching the virtual reality concert (b) Baseline

Fig. 5. Time evolution of heart rate variability

We conducted statistical evaluation by using mean value of the number of times that heart rate variability exceeded 2.0, with which the visual effects were generated, in the period 6 s after the time point as a statistic. For the statistical evaluation, one subject who had no heart rate variability during 6 s was excluded. A paired t-test within the 11 subjects showed that the statistic in watching the concert was significantly higher than that of the baseline ($p < 0.05$ on both sides) when the threshold was set to both 2.0 and 1.0. We selected the threshold of 1.0 as the value with which no visual effect appears. The results did not show that the generation of visual effects enhance the heart rate variability.

3.3 Results of Questionnaire

Table 1 shows scores of questionnaires averaged across the 12 subjects for both the system utilizing brainwaves and the system utilizing heartbeats. A paired t-test within the 12 subjects comparing the two systems was conducted for each question. The results show a significant difference only for the Q.1 ($p < 0.05$). The results indicate that the subjects like both the music and the characters used in the virtual reality concert. The results also showed that the subject felt correspondence between their excitation and appearance of the visual effect much in the system utilizing brainwaves as compared with the system utilizing heartrate while the subjects felt fun in watching the concert with the both systems.

Table 1. Scores of questionnaires averaged across the subjects.

	Brainwaves	Heart rate variability
Q.1: correspondence between visual effects and excitation	5.42	4.25
Q.2: feeling of fun	6.08	6.00
Q.3: preference of a music	5.75	5.75
Q.4: preference of a character	5.58	5.58

Some subjects reported in the free description that the visual effects appeared when they did not feel the correspondence in using the system utilizing brainwaves. The reports were consistent with the result mentioned above that the generation of visual effects of the harts, which were generated by the lowest threshold of 1.3, had no effect for enhancing the beta/alpha ratios.

4 Conclusion

In this study, we proposed virtual concert experience systems in which visual effects appears depending on a user's brainwaves or heartbeats. We implemented the proposed systems, conducted experiments, and took a questionnaire on subjects. The results showed that generating visual effects by increase of beta/alpha ratios of brainwaves enhances the subjects' concentration and the subjects felt correspondence between their excitation and appearance of the visual effect when the system utilizes brainwaves. The results also showed that subjects felt fun in watching the concert with both the system utilizing brainwaves and system utilizing heartbeats.

In future work, we developed a system utilizing brainwaves and heartbeats simultaneously to detect when user felt high feeling efficiently. We also investigate mechanism of enhancing concentration and excitation from the view point of biofeedback [5, 6].

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Evaluation of Immersive Feeling in VR System with HMD by fNIRS Measurement

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Abstract. Virtual reality (VR) had a banner year in 2016. VR has attracted a lot of media attention because many companies have launched Head Mounted Displays (HMDs) and other related products. As a result, the term "immersive feeling" has become more widely known. In this study, we evaluate immersive feeling using HMD with fNIRS measurement and describe the results.

Keywords: VR · Immersive feeling · HMD · fNIRS

1 Introduction

Virtual reality (VR) had a banner year in 2016 and has attracted a lot of media attention because many companies have launched Head Mounted Displays (HMDs) and other related products [1]. As a result, the term "immersive feeling" has become more widely known. In previous studies, immersive feeling was evaluated using 3D display by functional Near Infrared Spectroscopy (fNIRS) [2]. However, 3D display can show only a frontal scene. On the other hand, HMD can provide a stereoscopic scene in all directions, and give a more immersive feeling than 3D display. Thus, we set out to evaluate immersive feeling using HMD with fNIRS measurement. We performed an impression survey to find adjectives related to immersive feeling. The results showed that "Thrilling/Not thrilling", "Complex/Simple", and "Stereoscopic/Planar" are greatly related to immersive feeling. Therefore, we created roller-coaster content that has two sections. One section is "thrilling, complex and stereoscopic", and the other is "not thrilling, simple and planar." We used a questionnaire and biosignals (fNIRS) for evaluation. In this paper, we describe the fNIRS measurement results.

2 Experimental Method

2.1 System and Content

We used Oculus Rift as a device to show content. In addition, we used fNIRS to measure the biological signal of cerebral blood flow by attaching a sensing device to the head. Measurement is possible even if the participants move somewhat. For this

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*, Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_31

reason, fNIRS is used as an evaluation method of VR systems. The purpose of this experiment is to evaluate the degree of immersive feeling during content experience and to measure the cerebral blood flow rate.

Figure 1 shows our experimental system.

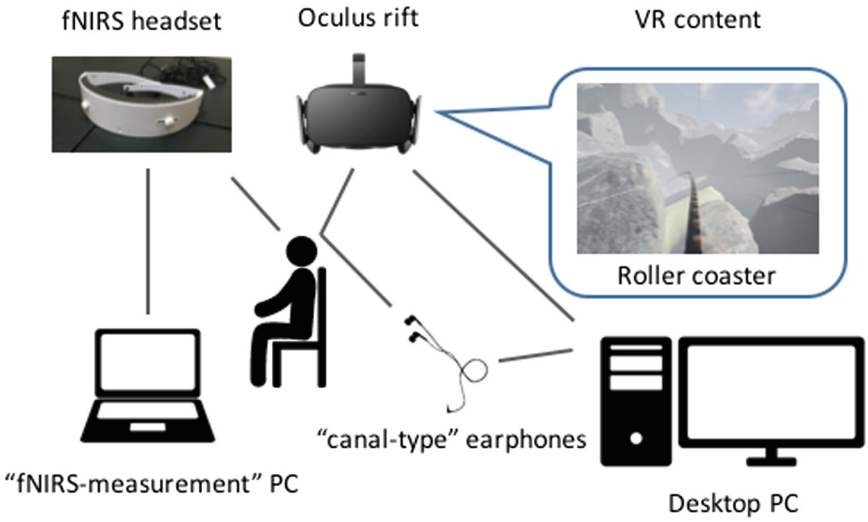

Fig. 1. Experimental system

We created roller-coaster content based on the results of the impression survey of immersive feeling. There are two sections in the content as follows.

A. Straight section (Fig. 2)
This contains only straight, flat, forward motion and lasts 90 s.

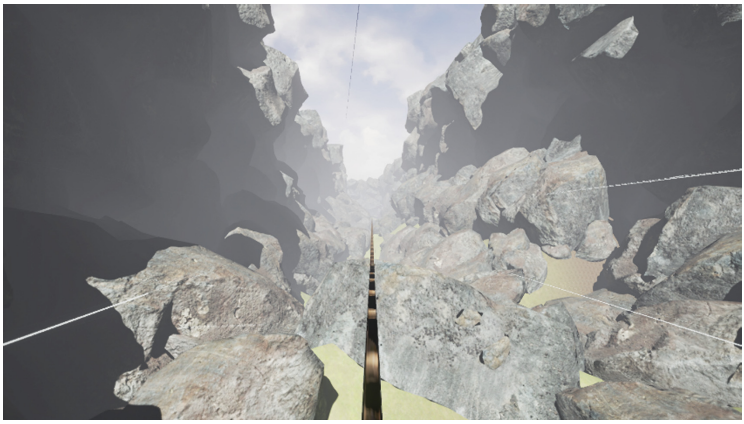

Fig. 2. Straight section

B. Turning and falling section (Fig. 3)
This contains falling and quick-turning motions and lasts 90 s.

Fig. 3. Turning and falling section

Sections A and B are repeated alternately five times each.
Figure 4 shows a timeline of the content.

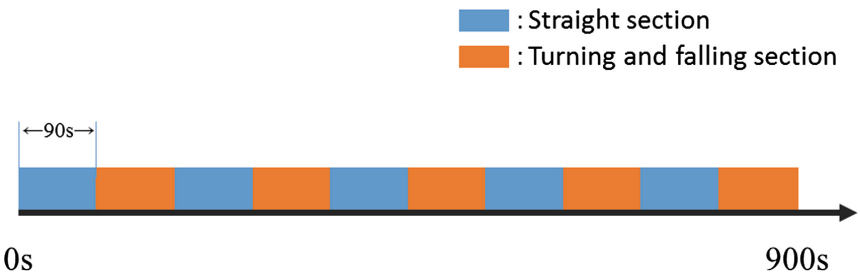

Fig. 4. Roller-coaster content timeline

2.2 Evaluation Method

We created a questionnaire by visual analogue scale (VAS). The items of the questionnaire were based on previous research [3, 4], and it was conducted once for each section after content experience. It consists of questions related to VR content (Q1–Q3), motion sickness (Q4) and immersive feeling (Q5–Q10) as follows.

Q1. Was the content thrilling?
No. [0–100] Yes.
Q2. Did you feel the content to be planar or stereoscopic?
I felt it to be planar. [0–100] I felt it to be stereoscopic.

Q3. Did you feel the content to be simple or complex?
I felt it to be simple. [0–100] I felt it to be complex.
Q4. Did you feel motion sickness from experiencing the content?
No. [0–100] Yes.
Q5. Did you care about the surroundings while experiencing the content?
No. [0–100] Yes.
Q6. Did you feel that you were moving?
No. [0–100] Yes.
Q7. Did you get distracted during the content experience?
No. [0–100] Yes.
Q8. Did you feel as if you were in a virtual space?
No. [0–100] Yes.
Q9. How long was the content time?
It felt short. [0–100] It felt long.
Q10. How was the content?
It was boring. [0–100] It was exciting.

In addition, we conducted an oral questionnaire about the section in which participants felt bored and/or distracted.

3 Experimental Results

3.1 System and Contents

We performed an experiment with seven male participants in their 20 s. The experiment took about 40 min per participant. Each one experienced the roller-coaster content, and we conducted a VAS questionnaire once for each section. During the content experience, changes in cerebral blood flow rate were measured by fNIRS. Figure 5 shows the setting of the experiment.

Fig. 5. Experimental setting

Fig. 6. Simple moving average of fNIRS data obtained at 4th and 5th sections

3.2 Experimental Results and Discussion

From the results of the VAS method and oral questionnaires, six out of seven participants grew bored of the straight sections in the latter half of the content, and did not

Table 1. Variance of cerebral blood flow rate (*100)

Variance[mM mm]^2		
	SectionA	SectionB
No1		
4th time	**0.134**	0.032
5th time	**0.043**	0.028
No2		
4th time	**0.060**	0.018
5th time	**0.054**	0.031
No4		
4th time	**0.230**	0.128
5th time	**0.200**	0.137
No5		
4th time	0.026	0.026
5th time	0.015	0.022
No6		
4th time	**0.213**	0.040
5th time	**0.141**	0.077
No7		
4th time	**0.049**	0.041
5th time	**0.050**	0.042

feel immersed. Therefore, we compared the 4th and 5th straight sections and those of the turning and falling sections as the latter half. Figure 6 shows the simple moving averages of fNIRS data obtained at the 4th and 5th sections.

Many of the participants seem to have larger changes in cerebral blood flow rate in the straight sections than in the turning and falling sections. Therefore, we calculated the variance of cerebral blood flow rate in the 4th and 5th straight sections and those of the turning and falling sections, as shown in Table 1. The values shown in the table are 100 times the obtained variances. Incidentally, participant No. 3 was excluded because he did not get bored in the straight sections in the latter half of the content.

From the result of analysis, in the straight sections where participants do not feel immersed, it is considered that there is a tendency for the variances of the cerebral blood flow rate to become larger. Therefore, we can propose a hypothesis that the variances of cerebral blood flow rate increase when a participant does not feel immersed.

4 Conclusions

We evaluated immersive feeling using HMD with fNIRS measurement. As a result of experiments using content created based on an impression survey, we proposed a hypothesis that the variance of cerebral blood flow rate increases when a participant does not feel immersed in the content. In the future, we will perform additional experiments using fNIRS to confirm the feasibility of the hypothesis.

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Evaluation of "Feelings of Excitement" Caused by a VR Interactive System with Unknown Experience Using ECG

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Abstract. In recent years, virtual reality (VR) technology has made remarkable progress, including the development of many devices and contents for such systems. VR contents that offer unknown experiences are especially entertaining when they incorporate actual feelings, for example, heat and cold. In this report, we describe the development of an interactive system through which players experience fire and ice from their hands using a Peltier device in VR space from a head-mounted display. ECG levels suggest that this new experience is exciting for players who felt excited during the unknown experience of our contents. SDNNs and RRVs of ECGs might be appropriate indexes of feelings of excitement for unknown experiences using VR.

Keywords: Virtual reality · Interactive system · Peltier device · Feelings of excitement · ECG

1 Introduction

In recent years, virtual reality (VR) technology has made remarkable progress. VR had a banner year in 2016 and has attracted substantial media attention because many companies have launched head-mounted displays (HMDs) and related products [1]. We believe that VR contents with unknown experiences are especially entertaining. For example, vibrations and splashes enhance presence in a movie called 4DX [2]. However, no contents use temperature information for unknown experiences. In this manuscript, we describe the development of an interactive system for the experience of emitting fire and ice from hands using a Peltier device in VR space from a head-mounted display (HMD). We confirmed with ECGs that players seem excited by this new experience.

2 System Designs

We created an interactive system that provides the experience of emitting fire and ice from the hands in a VR shooting game to defeat enemy robots. The system consists of the following devices:

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_32

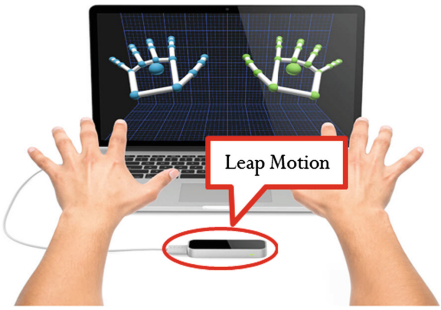

Fig. 1. Leap Motion

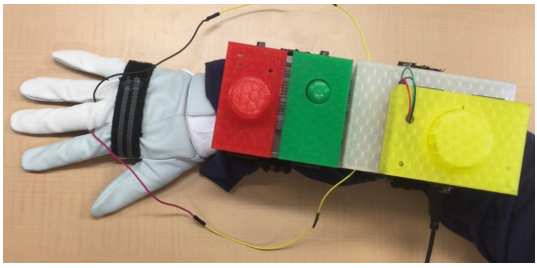

Fig. 2. Prototype of glove-type device

Fig. 3. Peltier device

Oculus Rift CV1: This head-mounted display with a head-tracking function and a wide-viewing angle is used for head tracking and presenting VR game images and sounds.

Leap Motion (Fig. 1): A sensor detects the movements of the player's hands and fingers. We mounted it on the front of the Oculus Rift CV1.

Glove-type device (Fig. 2): We developed this device that presents the temperature information of fire and ice to the player. The glove consists of a Peltier device (Fig. 3) and control switches. The Peltier device cools on one side when a current passes through it and radiates heat on the other side.

The following shows the system's data flow (Fig. 4).

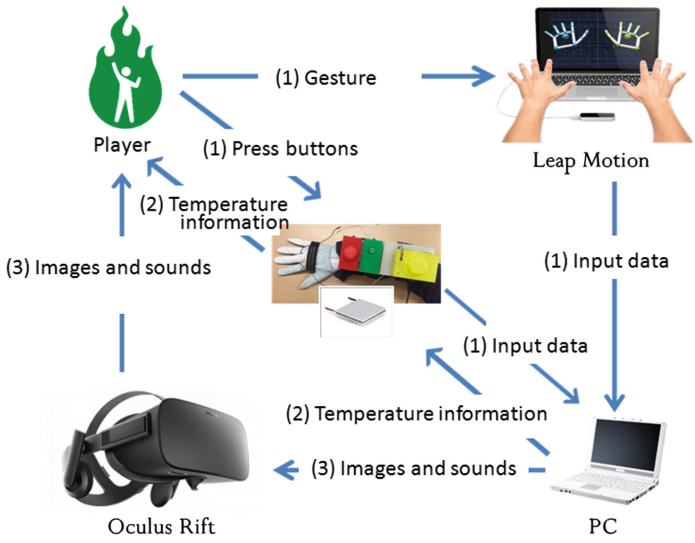

Fig. 4. System diagram

1. Leap Motion detects a player's gesture and sends it to the PC. The glove-type device sends signals to the PC if players press buttons.
2. The Peltier device outputs the temperature information that changes based on the game's situation.
3. Oculus Rift CV1 presents images and sounds.

3 Game Content

The game's flowchart is shown in Fig. 5. Figure 6 shows an example of a game screen.

4 Preliminary Experiment

We made a prototype and experimentally evaluated it with eight participants in the following three steps:

(i) We explained its content to them.
(ii) They experienced its contents.
(iii) They answered questionnaires.

We gave questionnaires to our participants to identify this system's problems and weaknesses. From the questionnaire results, we recognized that it provided unknown experiences and caused feelings of excitement. However, the prototype suffered from the following problems:

– glove-type device is too heavy.
– pushing the buttons of the glove-type device is difficult.
– difficult to feel the ice's coldness.

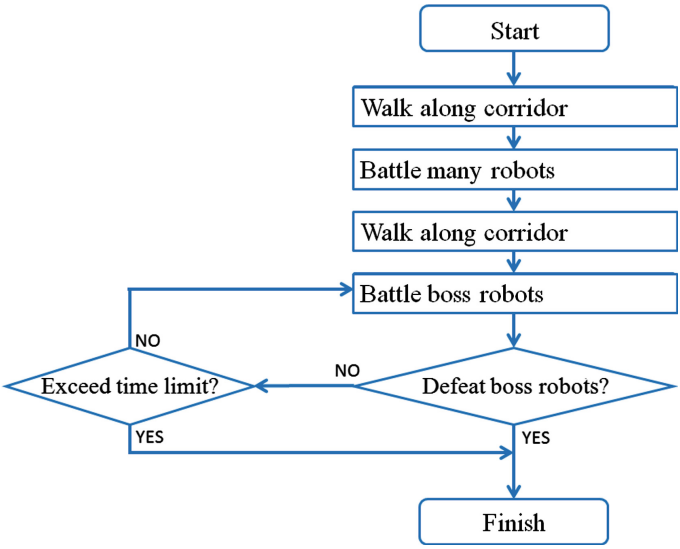

Fig. 5. Game's flowchart

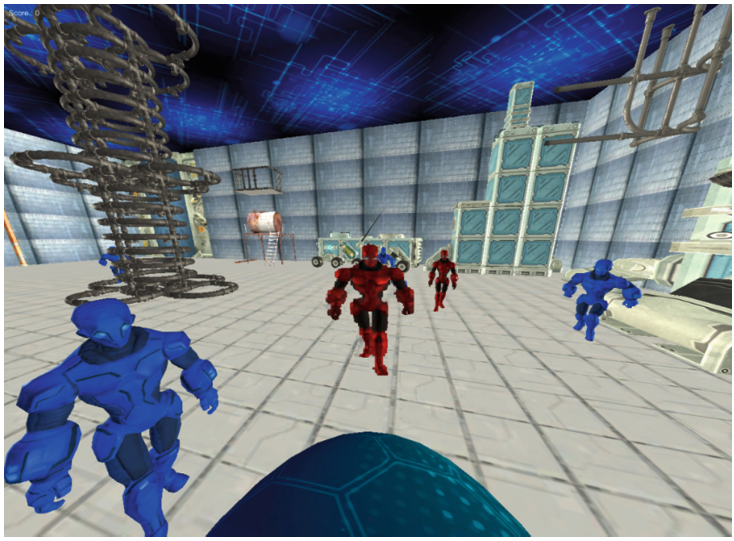

Fig. 6. Example of game screen

5 System Improvements

Based on our preliminary experiment results, we made the following improvements:

- removed the buttons from the glove-type device.
- added a new algorithm to control the game by hand gestures instead of buttons (Table 1).
- made glove-type devices for both hands.

Figure 7 shows our new glove-type devices for both hands. We reduced their weight from 650 to 200 g (100 g for one hand). We also created a tutorial that explained how to play our contents.

Table 1. Hand gestures for control

Hand gestures	Screen images	Temperature of glove-type devices
Closing the right hand once and opening it	Fire comes out from the right palm (Fig. 8)	The palm slowly warms up
	The fire in the right palm disappears	The palm's heat disappears
Turning the right palm to the front	Fireball is emitted (Fig. 8)	The palm becomes hot
Closing the left hand once and opening it	Ice comes out of the right palm	The palm slowly becomes cold
	The ice in the right palm disappears	The palm's cold disappears
Turning the right palm to the front	Ice ball is emitted	The palm becomes cold

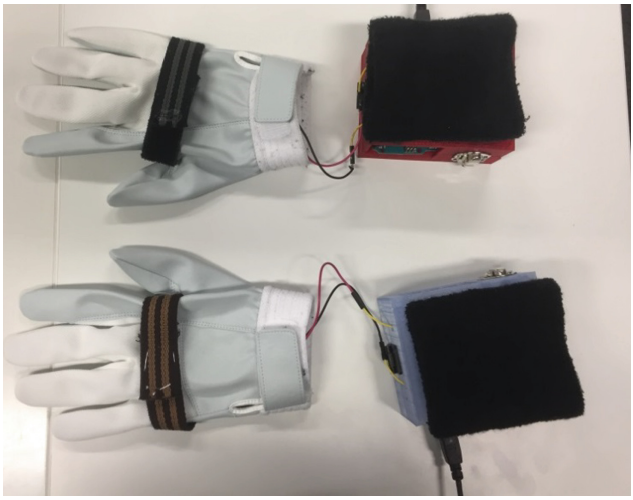

Fig. 7. New glove-type devices for both hands

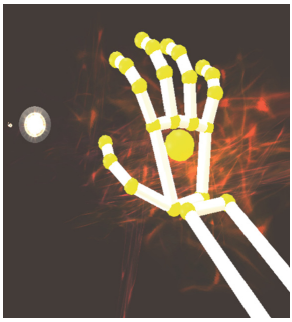

Fig. 8. Fireball is emitted from right palm

6 Evaluation Experiment

We experimentally evaluated whether players were excited by our system's new experience.

6.1 Experimental System

Our experimental system has the following primary components: Oculus Rift CV1, biosignal measuring equipment (Nexus10), and PCs. Previous research evaluated feelings of excitement using such biological signals as EEGs and ECGs [3–5]. In this experiment, we measured electrocardiograms (ECGs) and employed two physiological indices based on ECG signals: SDNN and RRV. SDNN denotes the standard deviation of the intervals between the R-waves (RRIs) of the ECGs, and RRV denotes the ratio of the standard deviation of RRI and its average [6]. According to previous research, physiological indices of ECGs are an index of feelings of excitement [4, 5]. During driving, when participants feel excited, the SDNN and RRV levels are lower than when participants do not feel excited. The physiological indices are given in Table 2.

Table 2. Physiological indices

Biological signals	Physiological indices	Relationship to feelings of excitement
ECG	SDNN	Decreases during feelings of excitement
	RRV	Decreases during feelings of excitement

6.2 Experimental Method

We conducted our experiment in the following eight steps:

(i) We explained its content to the participants.
(ii) We placed the measuring instruments on them.
(iii) We started recording the ECGs and set the resting state section.
(iv) They learned how to play it from a tutorial.

(v) They experienced its contents.
(vi) We stopped recording the ECGs.
(vii) We removed the measuring instruments.
(viii) They answered questionnaires.

7 Experimental Results

7.1 Outline

We performed experiments with ten male students in their twenties. The experiment took about 20 min per participant. Figure 9 shows an experiment scene.

7.2 Questionnaire Results

Figure 10 shows the evaluation results of the questionnaires about whether the players felt heat and whether the experience of emitting fire was exciting. All participants felt

Fig. 9. Experimental scene

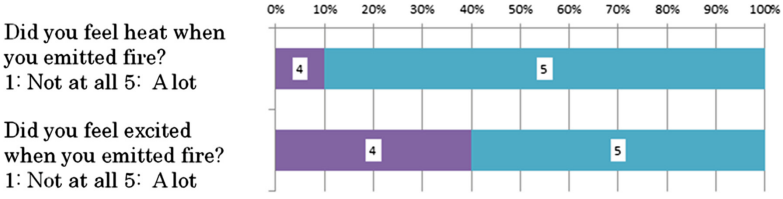

Fig. 10. Evaluation of experience of emitting fire

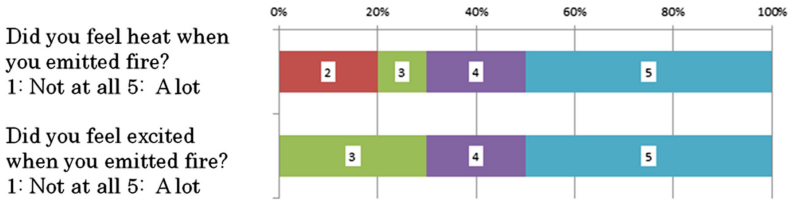

Fig. 11. Evaluation of experience of emitting ice

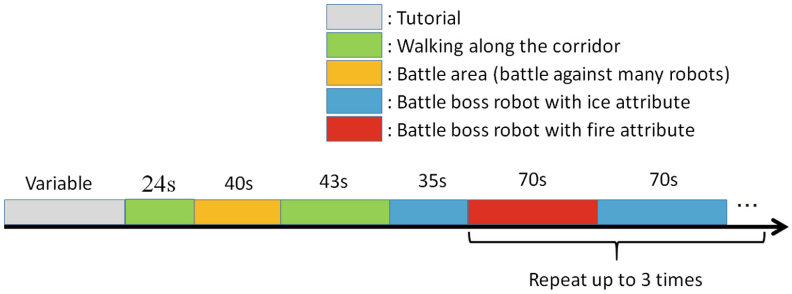

Fig. 12. Evaluation of experience of emitting ice

the fire's heat and were excited when they emitted it. Figure 11 shows the evaluation results about whether they felt cold and whether emitting ice was exciting. Three participants did not feel cold when they emitted ice, and the same three participants did not felt excited. Based on the questionnaire results, we believe that the experience of emitting fire and ice with heat or cold caused feelings of excitement.

7.3 ECG Results

Figure 12 shows a timeline of contents.

We observed the participants in our experiment. Some were irritated about the difficulty level of the boss robot sections. On the other hand, since some defeated the boss robots much quicker than we expected, we used the following sections for analysis:

1. Walking corridor section (Fig. 13):
   Players walk along the corridor before the battle area section.
2. Battle area section (Fig. 14):
   Player battles many enemy robots using fire and ice.

We considered the results during the resting state as the basis and calculated the differences between the resting state section and Sections A or B for analysis.

Figure 15 shows the SDNNs for each participant and their averages. The paired t-test results show significant differences between Sections A and B. Figure 16 shows the RRVs for each participant and their averages. The RRVs show similar results as SDNNs.

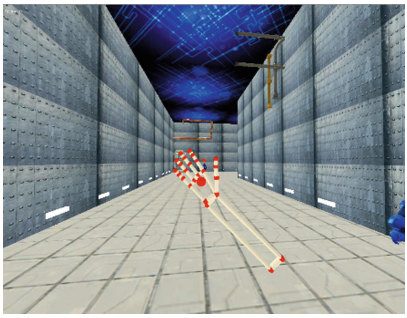

Fig. 13. Walking corridor section

Fig. 14. Battle area section

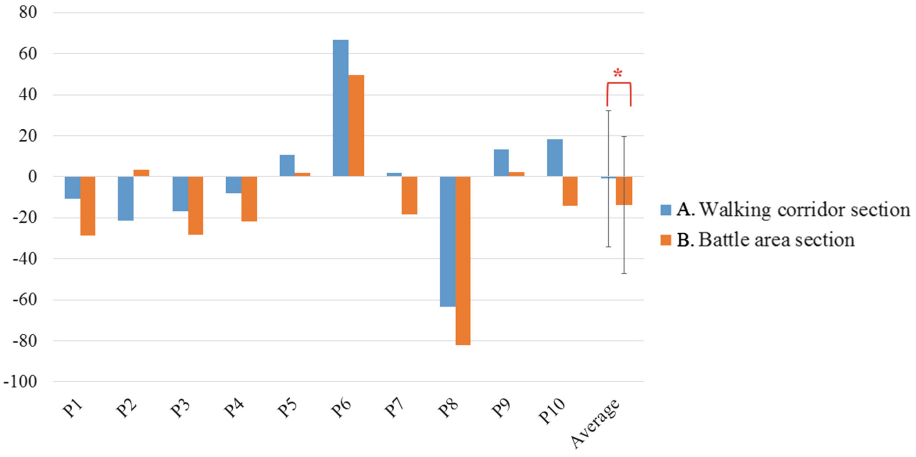

Fig. 15. SDNNs for each participant and their averages

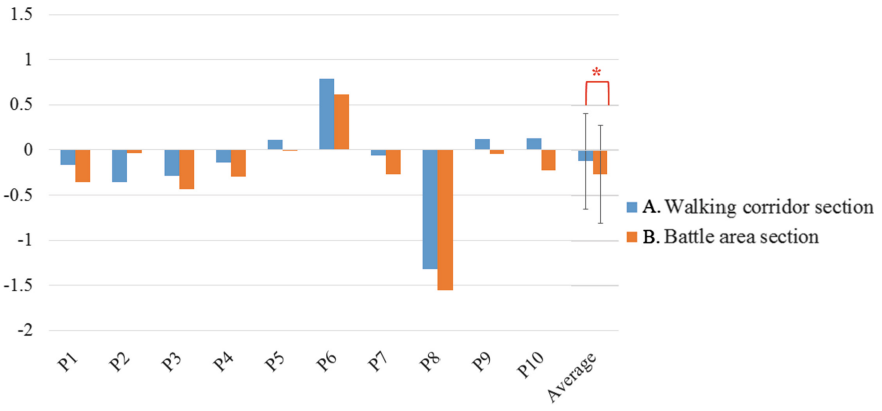

Fig. 16. RRVs for each participant and their averages

8 Discussion

According to previous research, SDNNs and RRVs decrease when a person feels excited [4, 5]. In our results, the SDNNs and RRVs of Section B were lower than those of Section A. Therefore, participants seemed to feel excited when they battled enemy robots using fire and ice, suggesting that such unknown experiences as emitting fire and ice from their hands were exciting. We also clarified that SDNN and RRV indices are useful for feelings of excitement in the evaluation of VR interactive systems.

9 Conclusion

We focused on an unknown experience, which might cause feelings of excitement, and developed an interactive system using a Peltier device. We developed a VR shooting game using glove-type devices that created the experience of emitting fire and ice from hands. We also performed an experiment to clarify the relationship between this system's unknown experience and feelings of excitement using a questionnaire and ECGs and experimentally obtained the following conclusions:

- From the questionnaire results and the analysis results of ECG, we clarified that the participants felt excited by the unknown experiences of emitting fire and ice from their hands.
- SDNNs and RRVs are useful indices of feelings of excitement in the evaluation of VR interactive systems.

Future work will develop and evaluate other interactive systems to more reliably clarify the relationship between feelings of excitement and physiological indices.

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Kansei Engineering

Measurement of Surface and Virtual Prototyping for Kansei Engineering

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Abstract. In Kansei engineering, we have been researching the methods for unveiling relations between physical properties and Kansei. Recent years we have utilized 3D measurements of surface details and making "virtual prototyping using Kansei evaluation". In this research, we have measured the micro-depth and orientation, surface reflectance and transmission of Japanese papers. Measured data were analyzed using directional statistics. As a result, we obtain the statistical model of roughness and its orientation, as well as the surface reflectance and transmission of the light. On the Kansei words "bumpy", "thin", "light", "soft", "pleasant touch", "ambience", "modern", we have found relations between statistical distributions of surface, amount and directions of luminance of both surface reflections and transmissions.

Keywords: Kansei engineering · Computer graphics · Surface finishing · Virtual reality

1 Introduction

Kansei on a product consists of recognition of functions, usability, experience and details of appearance. We have been developing methodologies for analyzing Kansei structure and relation between Kansei and properties of products. Along with developments of computer graphics, especially physically based rendering, there are strong demands to reveal associations between Kansei and physical properties in detail.

New materials, new methods of painting, finishing of surface are continuously introducing to manufacturing. However, because prototyping is expensive and only a few prototypes could used for evaluating a product. Kansei evaluation with virtual

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_33

products, which can show surface appearances without fabricating real prototypes, therefore poses an attractive prospect.

Virtual prototyping involves making 3-dimensional computer model using measured or design data and requires cutting-edge techniques involving 3D Computer Graphics. Since common computer-aided design (CAD) systems do not generally have advanced display functionality, a customized system for rendering the model must be built. As noted above, surface finishing should be faithfully displayed.

In our research that was published in 2010, we have measured and modeled grain patterns of car dashboard panels [1]. In the research, surface pattern of dashboards were measured by laser range finder, then depth data was converted into normal vector map. Using these manipulated real-time 3D CG images, we have measured Kansei and have shown how human is sensitive for surface details both pattern, depth and reflection amount (Fig. 1).

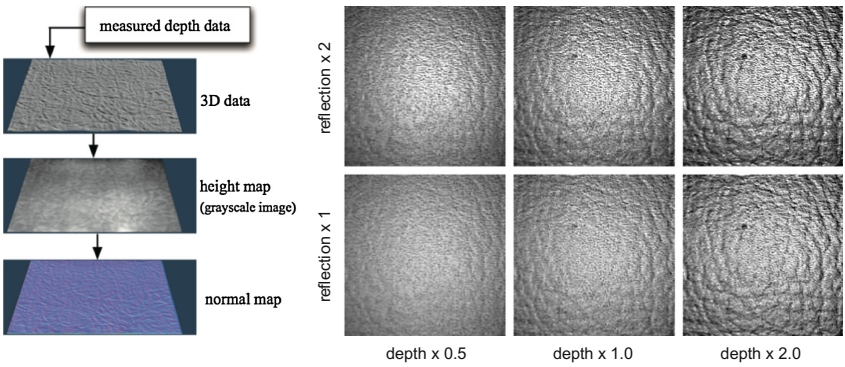

Fig. 1. Measurement and CG reproduction of car dash board pattern [1]

Interior is one of the major applications of Kansei engineering, from the beginning of its research history. Interior has enormous options, and making decisions is difficult for ordinary people. The first KE research paper, which published in 1974, was Kansei on room color [2, 3]. Subsequent papers were also researched on interiors [4] and lightings [5].

In recent years, as the LED lighting becomes popular, setting restriction was unbounded. One of new kinds of lightings is using transmitted light through (half-) opaque materials. For example, lighting that passed through Japanese paper or marble plate. It had been difficult because of danger of fire, deformation and damage due to heat.

These (half-) transparent lightings have difficulties to design. For Japanese paper and other processed paper, object surfaces have irregularity with different material composite and bumpiness. Marble has rather different appearance between surface and transparent lighting, since its composite structure of different density and crystallization.

Utilizing 3D computer graphics is indispensable for designing the interior. Although CG techniques have been developing rapidly, expressing the surface reflection and light transparent function are still difficult.

Fig. 2. Lightings through marble plate (left) and through Japanese paper (right)

The aim of this research is building statistical models for surface reflection and transparent function, based on different measurements. Statistical modeling is based on directional statistics distribution theories.

2 Surface Shape Measurement and Statistical Modeling

2.1 Measurement of Paper Surface Shape

In this measurement, the fine shape of the paper surface was measured using a 3D laser scanner, and the direction of the normal line was calculated from the polygon gradients. Distribution of normal directions is estimated by directional statistics method, and characteristics of distribution were considered.

VIVID 900 laser range finder (Konica Minolta Inc.) - scanner was used for measuring the paper surface shape. Samples were measured with VIVID, then polygon data representing three-dimensional shapes were acquired. Depth resolution was around 100 microns. Acquire data have around 170,000 polygons for each sample of paper, then it was projected onto the plane. 3-dimensional gradients of each polygon are converted to normal vector, as showed in Fig. 3.

2.2 Statistical Modeling of Paper Surface Normal Vectors

Next, we treat the normal vectors as samples and analyze difference of normals for each sample using directional statistics. We use Kent distribution for the distribution model and compare between samples using parameters corresponding to kurtosis and parameters representing variance in two directions.

Parameter Estimation on Kent Distribution. Kent distribution is a variation of Fisher-Bingham distribution, and it could deal with asymmetrical distribution in directional statistics. It is suitable for elliptic distribution and it could be applicable to

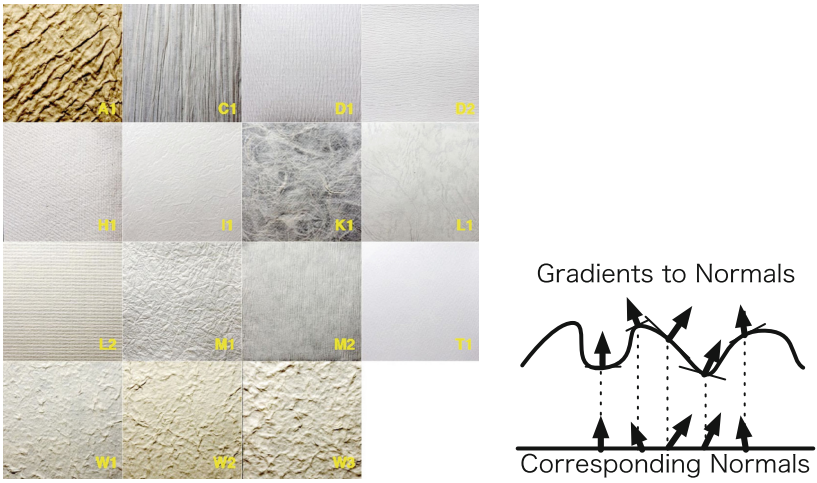

Fig. 3. Evaluation samples (left) and surface depth to normal vectors (right)

both unimodal and bimodal distributions [6, 7]. Density function of Kent distribution is defined as Eq. 1.

$$f(\mathbf{x};\kappa,\beta,\mathbf{G}) = \frac{1}{c(\beta,\kappa)}\exp\left\{\kappa x_1 + \beta\left(x_2^2 - x_3^2\right)\right\}. \\ \mathbf{G}=(\boldsymbol{\xi}_1,\boldsymbol{\xi}_2,\boldsymbol{\xi}_3) \text{ and } (x_1,x_2,x_3) = \left(\boldsymbol{\xi}_1^T\mathbf{x},\boldsymbol{\xi}_2^T\mathbf{x},\boldsymbol{\xi}_3^T\mathbf{x}\right) \tag{1}$$

κ has similar meaning to Kurtosis, determines the concentration or spread of the distribution. β shows the size of variance, determines the ellipticity of the contours of equal probability. $\mathbf{G}$ is a matrix which shows the direction to the center of the distribution. These parameters would be estimated from data samples (Fig. 4).

n-th sample's i-th normal vector is shown as $\bar{\mathrm{x}}_i$. Scatter matrix $\bar{\mathbf{T}}$ is defined as,

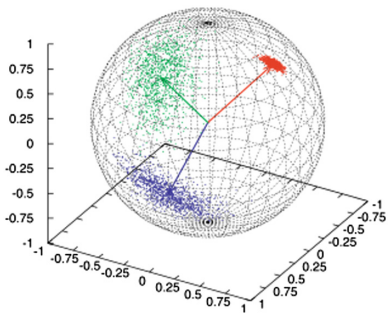

Fig. 4. Kent distribution. Lines from origin correspond to $\mathbf{G}$, which contains the directions to the distribution centers. Red part has smallest κ (from Kent distribution, Wikipedia)

$$\bar{\mathbf{T}} = \frac{1}{n}\sum_{i=1}^{n} \mathbf{x}_i \mathbf{x}_i^T \tag{2}$$

To estimate **G**, matrix **H** is required.

$$\mathbf{H} = \mathbf{H}(\bar{\mathrm{x}}_0, \mathrm{n}) = \frac{(\bar{\mathrm{x}}_0 + \mathrm{n})(\bar{\mathrm{x}}_0 + \mathrm{n})^T}{1 + \bar{\mathrm{x}}_0^T \mathrm{n}} - \mathbf{I}_p. \tag{3}$$

The vector $\bar{\mathbf{x}}_0$ shows the direction of sample mean. The vector $\bar{\mathbf{x}}$ is the diagonal elements of matrix $\bar{\mathbf{T}}$. Then, $\bar{\mathbf{x}}_0 = (1/\|\mathbf{x}\|)\mathbf{x}$ and $\mathbf{n} = (0, 0, 1)^T$.

Then, estimation of parameter matrix $\tilde{\mathbf{G}}$ is given through moment estimation procedure.

$$\begin{aligned}
\mathbf{B} &= \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix} = \mathbf{H}^T \bar{\mathbf{T}} \mathbf{H}, \\
\psi &= \frac{1}{2}\tan^{-1}\left(\frac{2b_{12}}{b_{11} - b_{22}}\right), \\
\mathbf{K} &= \begin{pmatrix} \cos\psi & -\sin\psi & 0 \\ \sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{pmatrix}, \\
\tilde{\mathbf{G}} &= \mathbf{H}\mathbf{K}.
\end{aligned} \tag{4}$$

Next, part of matrix B is used for compute eigenvalue (l_1, l_2) of this matrix, and $Q = l_1 - l_2$.

$$\begin{pmatrix} b_{11} & b_{12} \\ b_{11} & b_{12} \end{pmatrix} \tag{5}$$

When κ is large enough, estimated value $\tilde{\kappa}$ and estimated $\tilde{\beta}$ are obtained by (6). Then, $\bar{R}$ is obtained as a norm of the diagonal element vector ($\bar{R} = \|diag\bar{\mathbf{T}}\|$).

$$\begin{aligned}
\tilde{\kappa} &\simeq \frac{1}{2(1-\bar{R}) - Q} + \frac{1}{2(1-\bar{R}) + Q}, \\
\tilde{\beta} &\simeq \frac{1}{2}\left\{\frac{1}{2(1-\bar{R}) - Q} - \frac{1}{2(1-\bar{R}) + Q}\right\}.
\end{aligned} \tag{6}$$

Compute Elliptical Confidence. In Kent distribution, it could show the feature of elliptical distribution as parameters of confidence interval. When rotate samples with matrix **G**, as ($\mathbf{x}_i^* = \mathbf{G}^T \mathbf{x}_i$), each element of $\mathbf{x}_i^*$ is x_i^*, y_i^*, z_i^*, then the 1st moment (mean), 2nd central moment (variance), the 3rd central moment (skewness) are defined as (7).

$$\tilde{\mu} = \sum z_i^*/n, \tilde{\sigma}_2^2 = \sum x_i^{*2}/n\, \tilde{\sigma}_3^2 = \sum y_i^{*2}/n, \tag{7}$$

When confidence interval is given in the form $100(1-\alpha)\%$, elliptical confidence interval parameter, thus, two radii of an ellipse (s_1, s_2) are given by (8). Graphical presentation of it is called as elliptical confidence cone.

$$\begin{aligned} g &= -2\log(\alpha)/(n\mu^2), \\ s_1 &= \sigma_2\sqrt{g}, \\ s_2 &= \sigma_3\sqrt{g}. \end{aligned} \tag{8}$$

Elliptical Confidence Cones of Normals of Paper Samples. Figure 5 shows the elliptical confidence cones. Normals of polygons of sample data were too large, we re-sampled as 10000 polygons for each paper, and iterated the procedure 20 times. Two arrows show the direction of (s1, s2). As larger the ellipse, the paper has larger unevenness of surface. Round ellipse corresponds random direction of unevenness and narrow ellipse shows the direction of wave-like coherent unevenness.

Paper A1 has large wrinkles to the direction of s_1, to 4 and 11 o'clock direction. Paper C1 has the largest ellipse to the horizontal axis. The sample contains apparent vertical wrinkles those form wave-like repetitive structure. Although D2 and K1 have similar ellipse, but visual pattern of sample photo have rather different. In this case, invisible unevenness of K1 surface has revealed with scanning. Samples W1, W2 and W3 have round ellipse and W2 has larger ellipse than W1, W3 has more larger than W2. Their uneven patterns are similar, but their bumpiness are different.

3 Reflection and Transmitted Light Measurement and Statistical Modeling

3.1 Measurements of Reflection and Transmitted Light

We build an original measurement apparatus to measure both reflection light from surface and transmitted light. Statistical distributions of the light were calculated from the measured results.

Light Measurement Devices and Settings. Figure 6 shows the device and settings. Mejiro PHL-100 halogen lamp unit (Cerma Precision Inc.) was used for light source. Luminance was measured with TOPCON BM-9 luminance meter (TOPCON techno-house corp.), and its measurement angle was 0.2°. Place of the luminance meter was fixed, and sample and light source could be rotated. Angle was set as 0°, where the light source and the luminance meter are aligned in a straight line. Sample and light source were rotated in counterclockwise. Its rotation was 360° in 5° steps. 90 to 270° corresponds to hidden surface, thus it is measurement of transmitted light. Measurement unit is cd/cm2. All measurements were done in a darkroom.

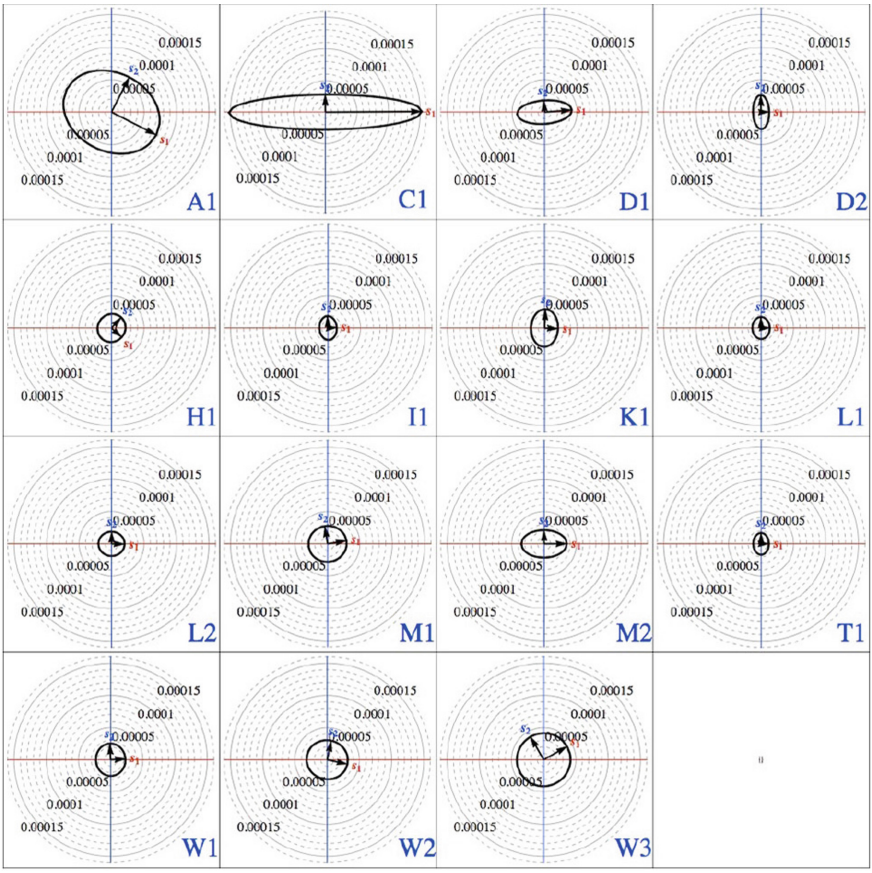

Fig. 5. Elliptical confidence cones of sample normals

Since the measurement area varies depending on the angle between the measuring instrument and the measurement surface, scaling of | 1/cos (θ) | is applied to the measured numerical value in order to obtain the result on the same area. Since light source arm interferes to luminance meter, effective ranges of the angle are 15 to 85°, 95 to 265 and 275 to 345°. From ranges between 15 to 85, and between 275 to 345° are corresponding to surface reflection. 95 to 265° corresponds to transmitted light. Figure 7 shows the measured result.

3.2 Statistical Modeling of Reflection and Transmitted Light

von Mises Distribution of Reflection and Transmitted Light. This analysis we used von Mises distribution [6–8]. von Mises distribution deals with angle data, and it is useful for synthesis and normalizing of data distribution. We fitted the distribution each for surface reflection and for transmitted light. We have used amount of

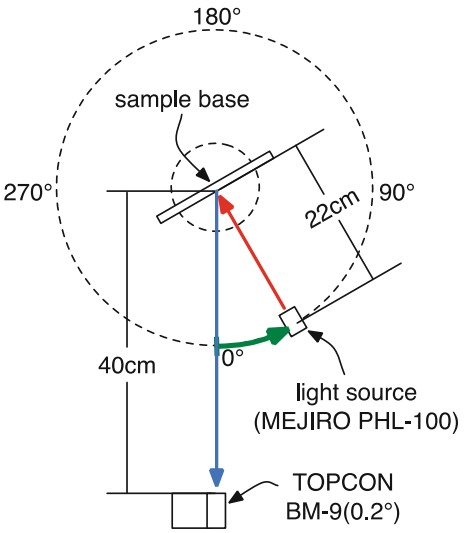

Fig. 6. Reflection and transmitted light measurement device

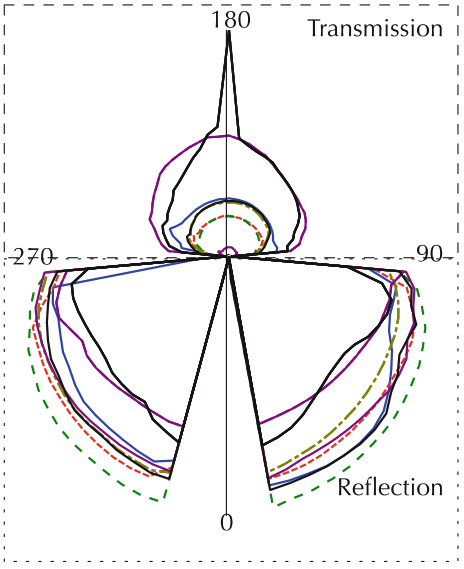

Fig. 7. Measured reflections and transmissions

reflection/transmission luminance per angle from the surface and Kurtosis for analysis of features of the sample.

Equation (9) is a probability density function of von Mises distribution. θ has range of 0 to 2π. μ shows the direction to the mean. κ shows the Kurtosis.

$$f(\theta) = \frac{1}{2\pi I_0(\kappa)} e^{\kappa \cos(\theta - \mu)} \tag{9}$$

I_0 is a zero-order modified Bessel function and is defined as this expression.

$$I_0(\kappa) = \sum_{r=0}^{\infty} \frac{1}{(r!)^2} \left(\frac{\kappa}{2}\right)^{2r} \tag{10}$$

4 Kansei Evaluation

Evaluation Method. In order to obtain the Kansei structure between samples, evaluation experiments were carried out. Fifteen processed papers, mainly Japanese papers and processed papers were used for evaluation. Samples were shown in Fig. 2. The papers are processed to have unevenness, and there are also many variations of surface texture due to processing such as glue, coating and using variation of fibers. Evaluation samples were restricted to papers those were not dyed.

Evaluations were conducted indoors, and the subjects had a 10 × 10 cm sample of processed paper attached to a binder and instructed to evaluate by appearance only so as not to touch the sample directly.

Fifty Kansei words were used for the questionnaire. Five-point SD scale was used. Subjects were 13 males and 7 females. Their average age was 22.

Result of Principal Component Analysis. We have done the principal component analysis on the variance-covariance matrix of 50 Kansei word evaluation. Evaluation value is averaged between subjects. Since first 3 eigenvalues are much larger than others, we consider 3-dimensional structure of Kansei.

Figure 7 shows the principal component loading of Kansei words and principal component score of samples, on the 1st and 2nd principal components. On right hand, large positive of PC1, there are *over decorated, bumpy, volume, weighty* and *coarse*. Corresponding samples are W3 and A1. Both of them have large wrinkles on the surface.

Left hand, *pleasant touch, sharp, soft, young, chill, refreshing, calm, smooth, plain* are located at large negative of PC1. Samples M2 and D2 correspond to these Kansei words. They have relatively coherent waves on the surface.

PC2 has *somber* and *childish* on larger positive. The sample H1 is located near *somber*. It has small bumps to random directions.

Some bipolar relations are discovered. At 8 o'clock direction, there are t*hin, cute, cool, refreshing* and *light*. Samples L1, I1 correspond to it. Opposite to that, at 2 o'clock direction, there are *masculine*, *coarse*, *dark* and *warm*. Samples W2 and A1 take that place (Fig. 8).

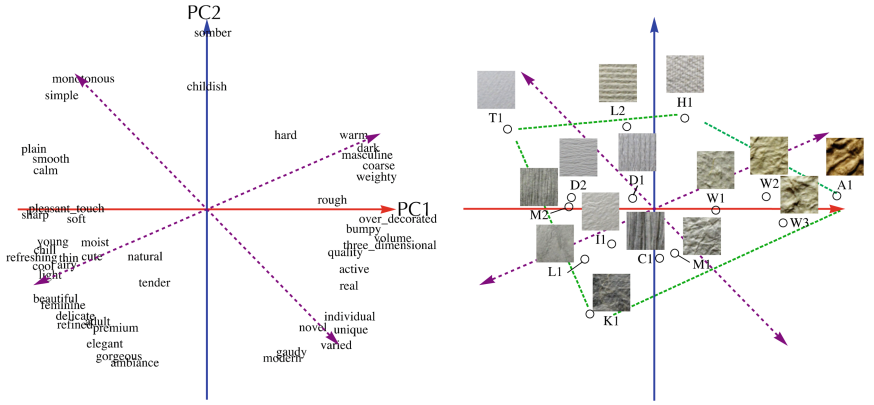

Fig. 8. Principal component loadings of Kansei words (left) and principal component scores of samples (right), on PC1 by PC2 plane

5 Statistical Features and Kansei Evaluation

Reflection - Transmission and Kansei. Figure 9 shows the principal component score and reflection and transmission of several samples. Left plot is PC score and the right plot is shows reflection - transmission amount (cd/cm^2). The X axis of the plot corresponds to measurement steps of angle (each 5°). Thus, its center (36 × 5 = 180°) shows the amount of transmission in a straight line (see Fig. 7). Left and right side of the plot correspond to reflection near right above the sample.

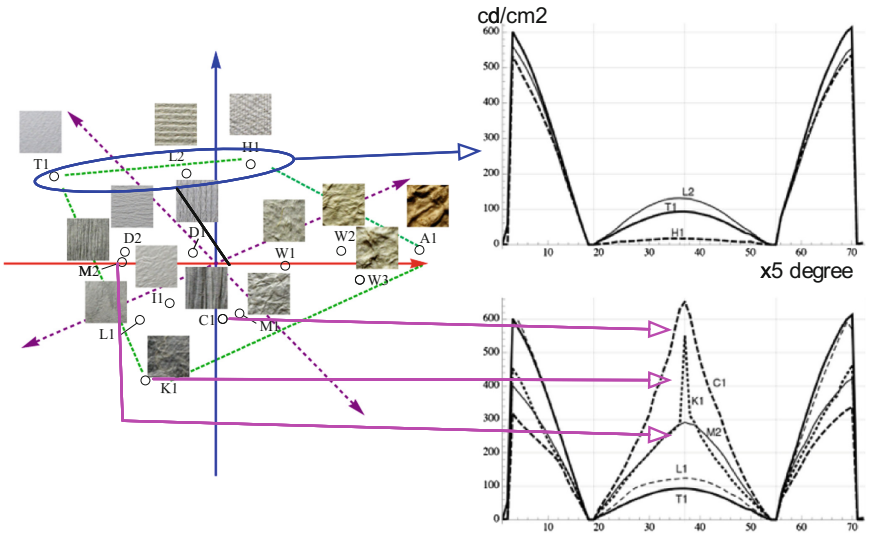

Fig. 9. PC score of samples and reflection/transmission distribution

There are several relations between Kansei structure and reflection – transmission distributions. T1, L2 and H1 are samples correspond to *simple*, *monotonous* and *childish*. Their reflection-transmission distributions are very low at transmission and very high reflection. Reflections reveals less directional specificity. In contrast, samples K1 and M1 have opposite feature on both Kansei and optical distributions. K1 corresponds to *gorgeous*, *ambience* and *elegant*. C1 is slightly *ambience*, *soft* and *modern*. K1 has a sharp peak of transmission. K1 has non-uniform density of combination of thin part and thick fibers. Thin part tends to transmit more light, then this characteristic peak was observed. C1 is also distinguishing, because of its largest transmission amount and lowest reflection among this group. C1 is also thin paper and has a matte surface with one-direction wrinkles. Reflection distribution reveals some of asymmetry.

von Mises Distribution and Kansei. Then we noticed relations between Kansei and features of von Mises distributions, (Kurtosis) and integral of reflection/transmission amount. One sample consists of two one for reflection, another for transmission. Likewise, there is two integral of amount, for reflection and for transmission (Figs. 10 and 11).

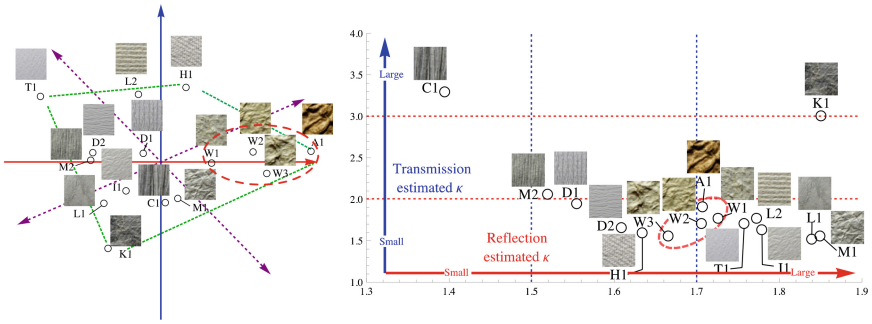

Fig. 10. PC score of samples (left), estimated κ of reflection and transmission distribution (right)

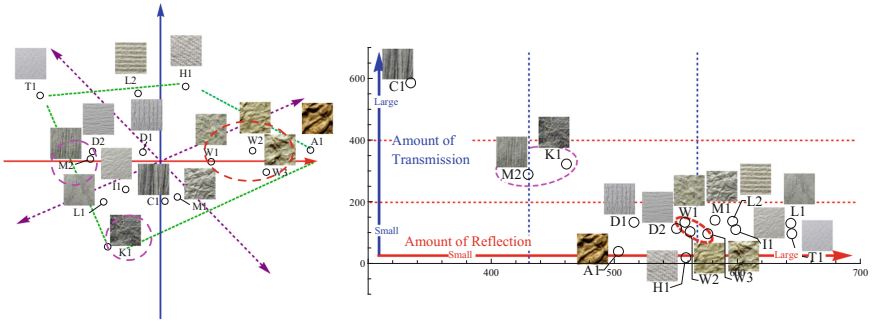

Fig. 11. PC score of samples (left), estimated amount of reflection and transmission distribution (right)

Sample C1 located highest on transmission and lowest on reflection. Since sample C1 has the largest value on both κ and amount of transmission, and it has the lowest value on κ and amount of reflection.

Although K1 has large κ on both transmission and reflection, but, reflection amount is smaller than others.

M2, *soft* and *pleasant_touch* sample is smaller value of both κ and amount of reflection. Transmission amount is slightly larger than others.

Samples A1, W1, W2 and W3 correspond Kansei of *bumpy*, *rough*, *volume* and *heavy*. They have middle reflection κ, small transmission κ, small transmission amount and middle reflection amount.

Relations between Kansei, Surface Shape, Reflection-Transmission Amount and Distribution. Table 1 shows the relations between Kansei and physical measurement results. Some of the consolidated results are recognized. 1. Samples evaluated as *bumpy* (A1, W1, W2, W3) have large and dispersed surface normals. These samples have large amount of reflection and small transmission. 2. Samples evaluated as *thin* and *light* (I1, L1) are small and dispersed surface normals. They have larger reflection and small transmission. 3. *Soft, pleasant touch, ambience, modern* samples have directional surface normal distribution. Transmission κ is large and transmission amount is middle to large.

Table 1. Relations between Kansei words, surface shapes, reflection-transmission amounts and distributions

	Bumpy	Thin, light	Soft, pleasant touch	Ambience, modern
Corresponding samples	A1, W1, W2, W3	I1, L1	C1, M2	K1, M2
Surface normal amount	Mid-Large	Small	Mid-Large	Mid
Surface normal direction	Dispersed	Dispersed	Directional	Directional
Estimated κ of reflection	Mid-Large	Large	Small - Mid	Mid-Large
Estimated κ of transmission	Small	Small	Mid-Large	Mid-Large
Amount of reflection	Mid-Large	Large	Small	Small-Mid
Amount of transmission	Small	Small	Mid-Large	Mid

6 Conclusion

In this research, we have explored relations between Kansei and surface normal distribution, amount and distribution parameters of reflection and transmission, of Japanese papers. Finding physical parameters associated with Kansei has possibilities to make both realistic virtual prototype and real products.

Measurement for surface shape details, we utilized surface normal vectors. With surface normal vectors, surface details could express in statistical distribution parameters. Kent distribution, which can deal with asymmetrical distribution, was used for modeling.

In surface reflection and transmission measurement, von Mises distribution was used for Kurtosis and distribution amount modeling. Physical properties of paper were modeled with statistical values.

Finding relations between Kansei and physical properties were successfully achieved, but not for all of the Kansei. Since human cognitive process for quality feeling has been regarded very complex. Unevenness of luminance, shades are indispensable for such recognition [9]. We would continuously search relations between Kansei and different physical properties.

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Kansei Ergonomic Study of Body Brush Development

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Abstract. We have conducted a series of experiments aimed at improving the design of body brush handles. This study recruited eight female and 13 male university students between the ages of 19 and 21. Three prototype body brushes (A, C, and D), and an existing commercial design (B) were tested. The prototype handles were made from two parallel stainless-steel wires and a plastic base, and each design was uniquely curved. The existing product, B, had a straight wooden handle. Electromyography (EMG) was recorded at the biceps brachii and flexor digitorum profundus while the participants aligned the brush head with the centers of their backs. A significantly lower EMG integral was measured with prototype C, and prototypes A and C both received positive Kansei evaluations. Then, two new designs (samples E and F) based on A were compared with B. Six men between the ages of 30 and 60 years participated in these second experiments. A final design was selected based on the results and the refined model will be marked in July 2017.

Keywords: Body brush · EMG measurement · Kansei evaluation

1 Introduction

Most Japanese wash their bodies with a towel and lathered soap, and they typically clean their backs with the towel by holding its top and bottom in each hand. However, heavily pregnant women, elderly persons with limited flexibility and grip strength, or those with restricted upper body movement may find it difficult to assume this position. Where needed, many people use body brushes as an assistive tool, and it is important for users to be able to reach their backs easily.

We conducted a series of physical and Kansei evaluation experiments using three body brush prototypes, and an existing design. We aimed to design, and bring to market, a new brush model that both reduced the physical load on the user, and received a high Kansei evaluation.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*, Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_34

2 Test of Prototypes

We conducted electromyography (EMG) evaluation experiments.

2.1 Methods

Participants. Eight female and 13 male university students between the ages of 19 and 21 participated in these experiments. None of the participants normally used a body brush to wash their bodies: 16 typically used a towel and four used their hands. All participants were right-handed.

Samples. Three prototype brush (A, C, and D) designs were tested, alongside one existing handle (B). The prototype handles were made from two parallel stainless steel wires and a plastic base that was 310 mm in length, for a total brush length of 440 mm. The curvature of each design was unique, as shown in Fig. 1. Sample A had a brush head at the top of a continuously curved handle; samples C and D also had curved handles, but the heads were angled to extend the grip. They weigh 114 g, 111 g, and 126 g, respectively. The existing design, B, weighs 130 g, and had a straight wooden handle that is 270 mm in length for a total brush length of 390 mm.

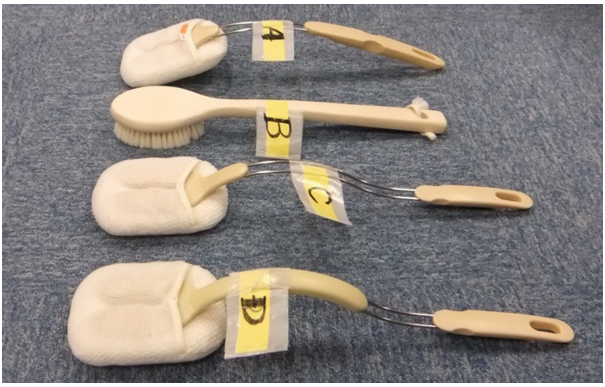

Fig. 1. The four tested body brush designs. Prototypes A, C, and D differed in handle curvature and base design. Sample B was a commercial design with a straight wooden handle.

Measurement. EMG was recorded at the biceps brachii and flexor digitorum profundus while the participants held the brush head against the centers of their backs for 10 s. The participants were required to grip the end of the brush with their dominant hand, lift it over their shoulder, and hold the brush head against their spine, level with the bottom of their shoulder blades. Three Lego blocks were placed on the participant's back to deliver tactile feedback, and the researcher visually verified the position during measurement. The order in which the participants tested the brushes was randomized (Fig. 2).

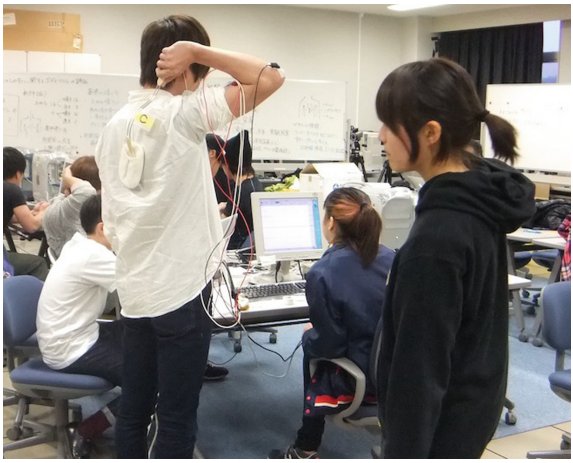

Fig. 2. EMG measurement at the biceps brachii and flexor digitorum profundus while a participant held the brush head against the center of his back for 10 s.

Analysis of EMG. Valid data were obtained from 20 participants (12 males and 8 females). For each participant, the standard deviation and mean integral per second were calculated.

Kansei Evaluation. After the EMG measurements, the participants were asked to evaluate each brush according to Kansei. Participants responded to each of the following questions on a five-point scale. Q1: "How easy was it to reach the center of your back?" Q2: "How much upper limb effort was required?" Q3: "How much shoulder effort was required?" Q4: "Could you quickly reach the areas you expected to reach?" Q5: "Did the brush head fit your body?" The ratings of Q2 and Q3 were reversed, with a high value indicating a negative response. Finally, the participants were asked to identify their preferred design.

Analysis of Kansei. Analysis of variance (ANOVA) was performed.

2.2 Results

Physical Evaluation. Multilevel modeling statistical analysis was performed, for which the brush designs were defined as a fixed effect and participant was the latent variable. The standard deviation of the EMG differed significantly among the brush designs ($df = 3$, $F = 6.0569$, $p = 0.0012$). The EMG mean integral per second also differed significantly when measured at both the biceps brachii ($df = 3$, $F = 3.4778$, $p = 0.0217$) and the flexor digitorum profundus ($df = 3$, $F = 2.6723$, $p = 0.0559$). The standard deviation at the biceps brachii and mean integral at the flexor digitorum profundus measured for prototype C ($p = 0.0197$ and 0.076 respectively) were less than those measured for design B.

Kansei Evaluation. The existing design B received the lowest rating for all questions. ANOVA found a significant difference among the samples for all questions (Q1:

n = 76, df = 3, F = 8.1789, p < 0.0001, Q2: F = 4.4113, p = 0.0076, Q3: F = 3.0810, p = 0.0350, Q4: F = 11.6568, p < 0.0001, Q5: F = 4.7944, p = 0.0049). Prototype A had significantly higher score for Q2 and Q3 (Student's t-test; t = 3.32, p = 0.0016; t = 2.71, p = 0.0090, respectively). Prototype C had significantly higher scores than B for Q1 and Q4 (t = 1.98, p = 0.0049; t = 3.02, p = 0.0039, respectively). Prototype C had slightly higher a score than design A for Q4 and Q5, but the differences were not significant. Of the 16 participants who identified a preferred design, six chose sample A and eight chose sample C.

3 Test of Production Candidates

From these initial results, one candidate prototype was identified: prototype A. We compared two final prototypes, E and F, with existing design B using older participants.

3.1 Methods

Participants. Six male university lecturers and professors in the following age groups participated in these experiments: two of the participants were in their 30 s (one was left-handed), two were in their 40 s, one was in his 50 s, and one was in his 60 s. None of the participants normally used a body brush. They usually used a towel to wash.

Samples. Two new prototype brush designs (E and F) were tested alongside the existing design (B). The prototype handles had curves similar to those of sample A, but were made from elastic plastic. The handle ends were bent into inward and outward opening hooks, as shown in Fig. 3. Both prototype handles were 310 mm long and the total length of the brushes was 440 mm. Prototypes E and F weighed 106 and 116 g, respectively.

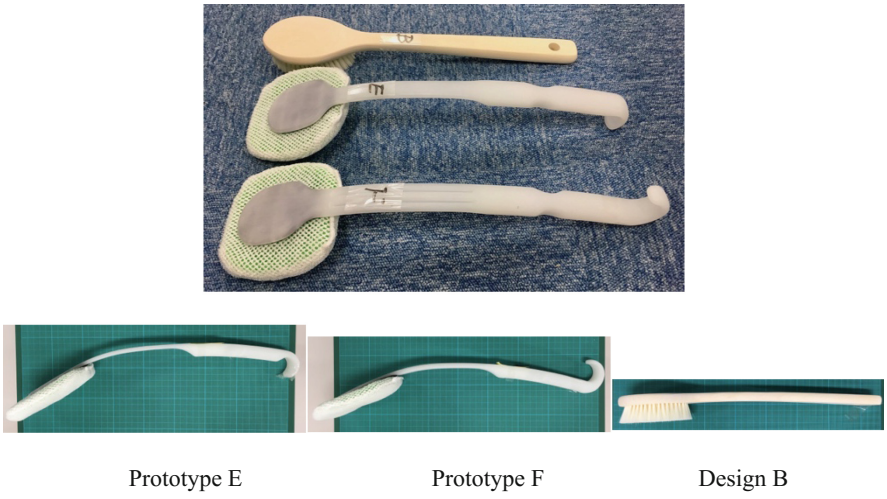

Fig. 3. The three body brush designs tested. The new prototypes, E and F, differed in handle thickness and the hook at the handle end. Design B was the same as the one examined in the previous tests.

Measurement and Kansei Evaluation. EMG was recorded under the same conditions used in the previous experiments. Kansei evaluation using the same questions and an interview were also conducted after the measurements (Fig. 4).

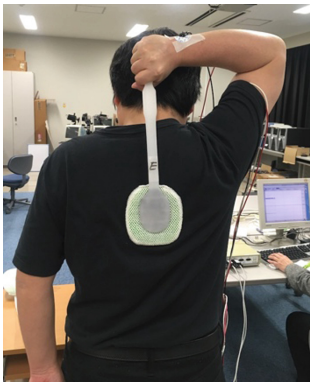

Fig. 4. EMGs were measured in the same manner as described in Sect. 2.

Analysis. For each participant, the standard deviation and mean integral per second of EMGs were calculated separately for the first and last 5 s. Because the participants were older than those who participated in the previous measurement, the effect of fatigue should not be ignored. ANOVA of Kansei evaluation was performed as same manner as the previous evaluation.

3.2 Results

Physical Evaluation. For prototype E, the standard deviation and mean integral per second of the EMG had two peaks. Therefore, the data for sample E were excluded from the subsequent analysis. Multilevel modeling analysis was used to compare designs F and B, in the same manner as in the previous experiment. The brush designs had significantly different standard deviations ($df = 1$, $F = 6.5959$, $p = 0.0199$) and mean integrals per second ($df = 1$, $F = 5.8645$ $p = 0.0269$) when measured at the biceps brachii. Prototype F placed a significantly lower load on the upper limb (Fig. 5).

Kansei Evaluation. Existing design B received the lowest rating for all questions. ANOVA showed a significant difference between the prototypes (E and F) and B for all questions except Q2 (Q1: $n = 18$, $df = 2$, $F = 13.5976$; $p = 0.0004$; Q2: $F = 2.2101$, $p = 0.1441$; Q3: $F = 13.2317$, $p = 0.0005$; Q4: $F = 14.0517$, $p = 0.0004$; Q5: $F = 20.9971$, $p < 0.0001$). Prototype F had slightly better scores, but Student's t-test found no significant differences between prototypes E and F for all questions.

Interview. All participants preferred prototypes E and F because of the effortless reach and effective transmission of force. Three participants found that the outward opening hook at the grip end of prototype F improved the hand grip. Four participants disliked the hook on prototype E because it touched their heads. Four participants chose prototype F and one chose prototype E as the best, the other one rated both as the same (Fig. 6).

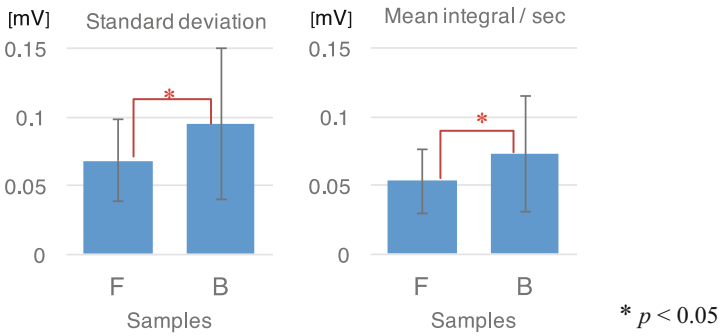

Fig. 5. Comparison of the EMG measured at the biceps brachii of between prototype F and existing design B. Prototype F required a significantly lower load than existing design B.

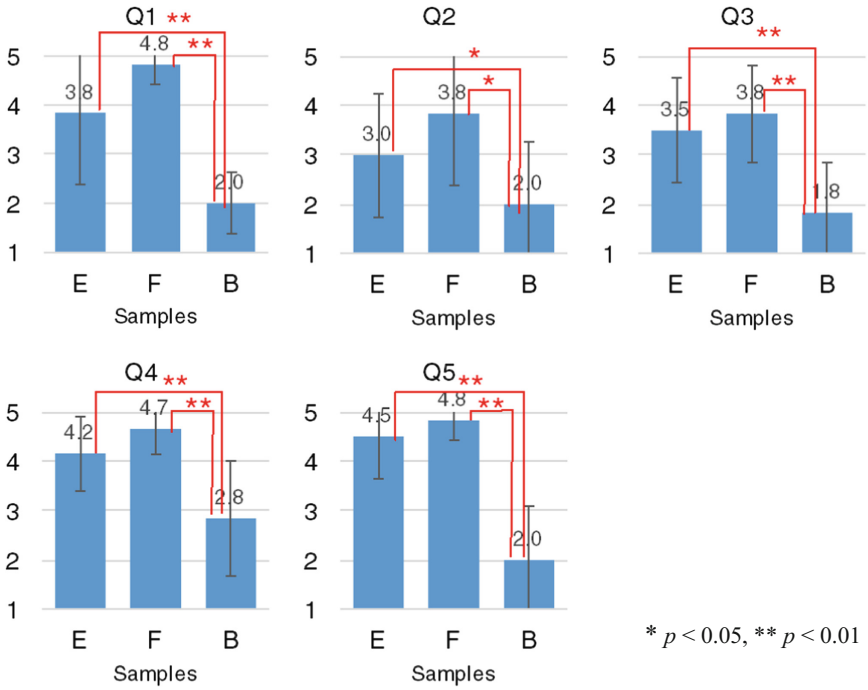

Fig. 6. Comparison of prototypes E and F and existing design B in the Kansei evaluation. Prototypes E and F had significantly better ratings than existing design B.

4 Conclusion

Based on the results described above, the final candidate design for production was prototype F.

The original idea for designing the body brush studied in this project was to make a brush with superfine Trepica® fibers for effective cleaning, and to have a flexible handle for better usability. Therefore, the handles of the first prototypes were made from two parallel stainless-steel wires covered by plastic. However, we found that water entered between the base and wires. In the improved prototypes, the stainless-steel wire was replaced with a solid plastic handle that was as flexible as the parallel wires to keep water out. This also reduced the production costs. A hook-shaped grip end was adopted to prevent the wet handle from slipping out of the hand. Ergonomic and Kansei evaluation experiments helped us choose the best candidate design.

After further refinement, Aisen will market the new body brush in July 2017.

Development and Evaluation of Ankle Mobility VR Rehabilitation Game

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Abstract. VR rehabilitation provides various advantages such as creating a visualization of user's motion and rehabilitation achievements, enhancing motivation for rehabilitation and reducing burdens of human resources for rehabilitation. In this study, a fundamental system configuration of VR rehabilitation support systems is proposed and upper extremity rehabilitation support systems based on the configuration are discussed. In addition, a lower extremity rehabilitation game that we are developing is described. The user sits down and controls an avatar in the VR environment using a VR foot controller. Elder challenged persons tried to use the system, then they excited to explore in the VR environment.

Keywords: VR rehabilitation game · Encouragement · Motor training · Physically challenged

1 Introduction

In Japan, there is increasing ratio of aged population with physical disabilities. [1]. Therefore, rehabilitation trainings are more demanded for both young and aged people. However, the adequate rehabilitation training is not provided because of the shortage of therapists and the lack of motivation of challenged persons.

On the other hand, virtual reality (VR) technologies and sensing technologies for VR are rapidly evolving. For example, VR entertainment systems which provide various feedback to user's motion in the virtual environment are supposed. VR has also a good match with motor rehabilitation. Utilization of VR for rehabilitation is expected to enhance patient's motivation for rehabilitation, visualize the result of rehabilitation and reduce therapist's burden [2]. So, some rehabilitation support systems including the element of enjoying a game have been proposed [3].

In this study, a fundamental configuration of VR rehabilitation systems is proposed through developing two VR-based rehabilitation support systems. In particular, we describe the potential of force feedback function when the user manipulates the device, the support for cognition of body motion by utilizing VR technologies for upper

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_35

extremity rehabilitation and the evaluation for the VR based rehabilitation system by measuring electromyography signal. Furthermore, we are trying to develop another VR rehabilitation support system for lower extremity with above configuration. The system aims to keep ankle mobility. Also, as the user trains in a sitting posture, the system provides an environment for safety training of lower extremities. We reports the overview of the system and trial uses by physically challenged elders.

2 VR-Based Rehabilitation Support System for Upper Extremity with Force Feedback

2.1 Fundamental System Configuration Corresponding to Motor Learning Theory

Body motions can be developed through skill acquisition by motor learning. One of motor learning theory is shown in Fig. 1. This theory is called the feedback control theory [4]. At first, the learner recognizes condition of the environment. Next, the learner considers the motion which is suitable for the condition and plans the motion on the basis of knowledge which the learner has. When the learner starts to move, and the learner also monitors his/her own movement and modifies it if needed.

In motion acquisition, the function of checking own motion is required. VR excels at visualization of motion, so we propose VR-based rehabilitation. Fundamental VR-based rehabilitation system configuration is shown in Fig. 2. This configuration consists of an input and output interface and a virtual training environment.

A force feedback device as an interface was introduced in our previous studies. The device works on the user through force physically and provides high-quality virtual experience. VR-based rehabilitation support system for upper extremity based on the configuration in this section is described in later sections.

2.2 Throwing Ball System

Target motion in throwing ball system [5] is speedy motion of upper extremity shown in Fig. 3. The user throws a ball underhanded like a softball pitcher. Throwing farther requires the acceleration of upper extremity motion. Movements of upper extremity in the training using the system are eight kinds of movement, such as flexion and extension of shoulder joints, adduction and abduction of shoulder joints, inner and external rotation of shoulder joints, flexion and extension of cubital joints, supination and pronation of forearms, dorsiflexion and flexion of wrist joints, flexion and extension of fingers, and grasp motion of fingers. These movements are often generated at the same time and speedily. The user holds a force feedback device by a hand and exercises throwing motion. Therefore, the user can feel the virtual ball weight and the projectile resistance force. If the user moves speedy, the user feels stronger force.

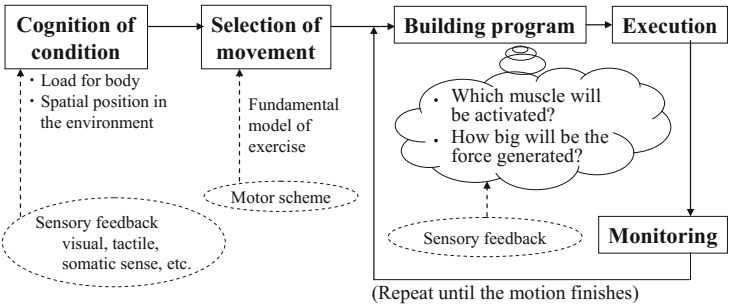


Fig. 1. Feedback control learning model.

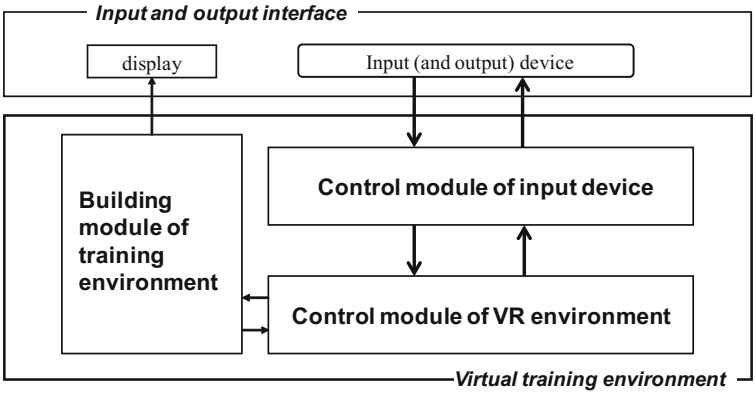


Fig. 2. Fundamental VR-based rehabilitation support system configuration.

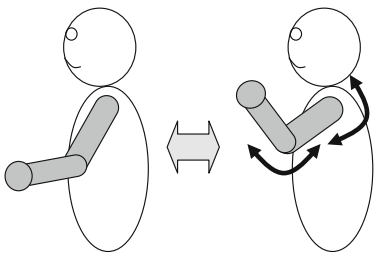
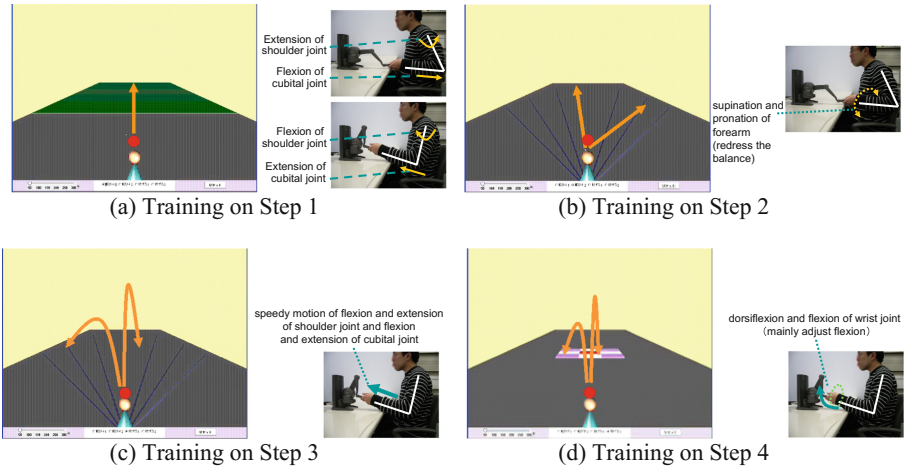


Fig. 3. Training motion of throwing ball system.

A virtual training environment is displayed on the screen. The user throws a ball in the target in the environment. Movement of the stylus of the force feedback device is shown as the of upper extremity direction.

Ball throwing task has four levels according to user's physical ability. Easier levels are suitable for physically challenged people. Figure 4 shows two of training environment in the system as examples. In Step 1 and 2, the user "rolls" a ball simplified throwing motion. In Step 3 and 4, the user acts ordinarily "throwing" underhanded. Additionally, the training tasks are provided for each Step: rolling farther forward in Step 1, rolling/throwing to set direction in Step 2 or 3, throwing to set direction and distance in Step 4. These tasks are based on the common training method, that are (1) alleviation of contracture at joints, (2) increasing muscle strength and (3) formation of transmission pathway in motor center.

Three physically challenged persons were participated to system evaluation. One of participants was a male in his twenties. He had difficulties of the smooth motion of both upper extremities. Furthermore, he also had a moderate intellectual disability, and he could not move a certain part of his body according to instructions. Figure 5 shows trial



(a) Training on Step 1 (b) Training on Step 2

(c) Training on Step 3 (d) Training on Step 4

Fig. 4. Example of the training environment in throwing ball system.

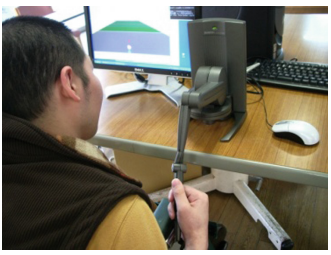


Fig. 5. Trial use by a participant.

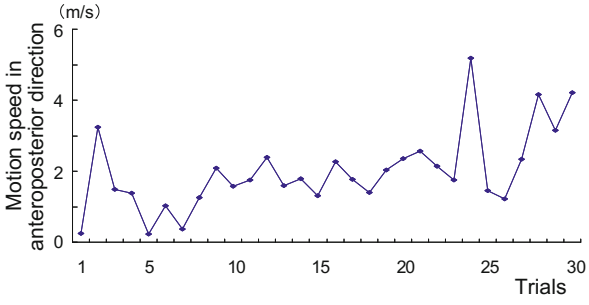


Fig. 6. Transition of throwing motion performance of participant B.

Table 1. Average scores of motion speed of a participant.

Direction	Trial 1–10	Trial 11–20	Trial 21–30
Anteroposterior	1.29	1.86	2.82

(m/s)

uses by him. The training environment corresponds Step 1 and the weight of rolled ball set 50 g because it was difficult for him to manipulate a stylus smoothly. In experiment session, he had thirty throwing trials. Figure 6 shows the transition of throwing motion speed of the sessions. The training task in Step 1 environment consists of the motion to the forward direction only, then the graph of Fig. 6 shows motion data of an anteroposterior direction only. Averages of motion speed are shown in Table 1. Averages are calculated every ten trials. It is found that the participant could not manipulate a stylus well in from the first to the seventh trial, but after the eighth trial, he could almost stably move while the motion speed was not very speedy according to Fig. 6. On twentieth trial, an experimenter have instructed "Roll the ball further," then he could make a smooth motion with upper extremity to the forward direction in some trials after twenty-first trial. Especially he realized to make smooth motions three times in a row in the end of trials. This improvement is also apparent in the average score of after the twenty-first trial in Table 1. It is supposed that the improvement of his performance was appeared but he incompletely-acquired the motion in this trial use. An experimenter instructed the way to operate a ball in the virtual training environment without telling the way to move an upper extremity directly and concretely because he could not understand instructions for the way to make motions of a part of body. The improvement of his performance in the end of trials may mean that the instructional method utilizing events in the virtual environment was effective.

2.3 3D Maze System

Target motion in 3D maze system for rehabilitation [6] is reaching motion by upper extremity. Reaching motion is large motion of upper extremity. One of reaching motion training in clinical practice is ring transfer task which the learner moves a ring right or left widely [7]. In the ring transfer task, motions in horizontal direction are mainly trained. However, shoulder joint has three degrees of freedom of movement and knee joint has one degree of freedom of motion. So human can move his/her upper extremities in three-dimensional space. Therefore it is needed to train motions not only in right-left directions but also up-down and front-back directions [8]. 3D maze system has rehabilitation environment where the user can experience large motions in horizontal, vertical and anteroposterior direction as the motion in real world.

In the 3D maze training environment (Fig. 7), the learner moves along given paths. The learner cannot move to the goal position in direct line. So the learner sets overall paths and intermediate points on the path, and considers a way to exercise for getting to the intermediate point and executes it. For example, in a task showed in Fig. 7, the learner moves a stylus pointer in accordance with arrows. When the learner goes through passages where exist in walls, the learner recognizes where positions of

passages are located on the top/bottom or in the front/back of the wall. In addition, the learner considers the way to activate muscle for moving the stylus. In this training environment, a muscle for motion can be identified shown in Table 2 because the learner moves along pre-arranged passages and a kind of executed motion of the upper extremity corresponds every passage.

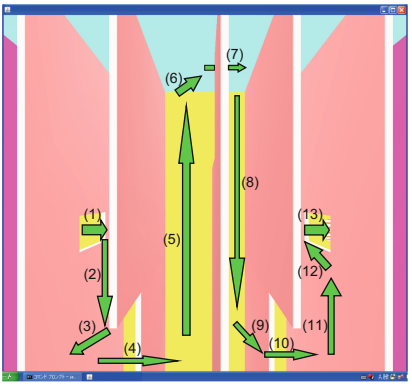


Fig. 7. Example of 3D maze training environment.

Table 2. Correspondence relationship of the motion passing through the passage in a maze to contracting muscle.

Passage No.	Movement	Prime mover muscle
(1), (4), (7), (10), (13)	External rotation of upper arm	Deltoid
(2), (8)	Extention of upper arm	Latissimus dorsi
(3), (9)	Flexion of forearm	Biceps brachii
(5), (11)	Flexion of upper arm	Pectoral major
(6), (12)	Extention of forearm	Triceps brachii

In the evaluation for the system, possibility of motor learning by training using a proposed system was examined. Experimental participants were five university students (age 22 to 28, *SD* = 2.39) with no-disabilities. Figure 8 shows the number of collision with virtual wall every trial by participants. The number of collision with virtual walls by participant A, B and D tended to decrease every trial. On the other hand, the number of collision by participant C and E did not decrease, but the number of collision in all trials was small. Therefore, it is thought that if the number of collision

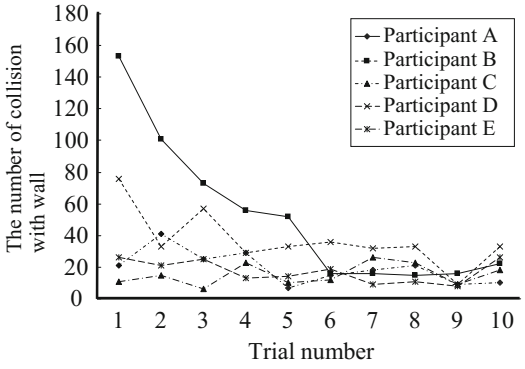
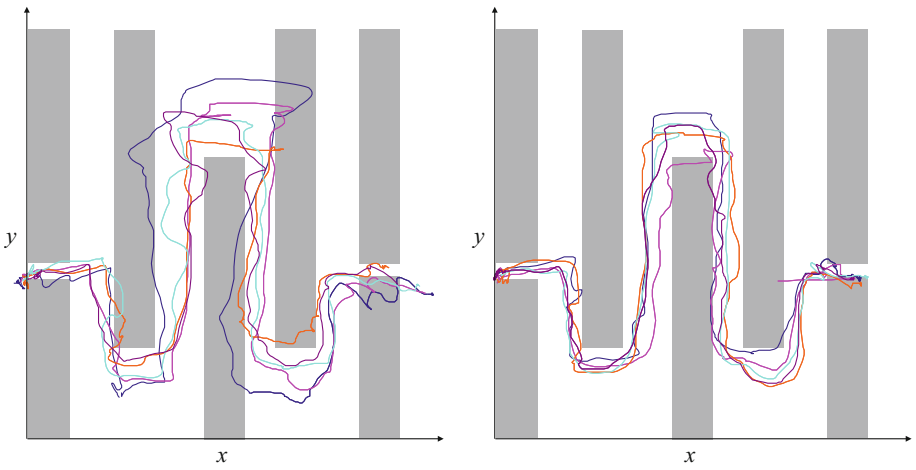


Fig. 8. The number of collision with virtual wall in each trial.



(a) Results of the first to fifth trial (b) Results of the sixth to tenth trial

Fig. 9. The motion by participant A.

is large at the start, then the learner can acquire abilities of the motion, and if he number of collision is small at the start, then the learner can keep ideal motion. And, Fig. 9 shows the motion of the stylus held by participant A. Figure 9(a) is results of the first to fifth trial and Fig. 9(b) is results of the sixth to tenth trial. Gray areas in the figure represent virtual walls in the maze. Meanwhile in the figure, motions are drawn by only horizontal (x-axis) and vertical (y-axis) position data. The learner does not have to concern motions of depth direction in this experimentation environment, so it can think that the figure mostly shows motions of the participant. there are comparisons with performance on first five trials and last five trials. From Fig. 9(a) and (b), it is found that the instability of his trajectories in the last half of trials is smaller than in the first half of trials. Other participants also have the same tendency as the result of participant A. Therefore, if the number of collision does not decrease particularly, the learner may be allowed to exercise the same motion by repeating to train in the maze training environment. For that matter, it is supposed that the learner can acquire motions.

3 VR-Based Rehabilitation Support Game for Keeping Ankle Mobility

3.1 Purpose of Development

Walking is one of important motions to support keeping the quality of life for elderly. However, there are some elderly at high risk for falling in gait because the muscular strength of they are deteriorating. One of the factors of the fall is for lack of the ankle mobility [9]. This ankle mobility problem is caused by contracture that decreases range of joint motion due to impairment of motor function by disuse syndrome or cerebral infarction. Elderly without sufficient ankle mobility often stumbles on heel contact

phase in walking because dorsal flexion of their ankle is not enough [10]. In addition, it is often difficult to walk smoothly for them because force that pushes off with their toes is not enough on toe off phase [10].

To keep ankle mobility and prevent joint contracture, passive range of motion exercises for dorsal and plantar flexion have been conducted [11]. However, it is difficult to see directly the training achievement in common rehabilitation by therapists, so the patient is easy to lose motivation for rehabilitation. Additionally, there are no rehabilitation systems for ankle mobility.

In this study, VR-based rehabilitation game for ankle mobility is developed. A controller which is manipulated by feet motion is introduced as an user interface and the user controls an avatar in the virtual environment. The design of the game is exploration type, so it is easy to understand the task achievement for the user. We develop two kinds of exploration environment. These environments differ in how to move feet when the user controls the avatar. In what follows, an overview of the system and the evaluation through a trial use by a physically challenged elderly are described.

3.2 System Overview

The user's task is to control an avatar and move from the start to the goal point in the VR exploration game. The user controls the avatar using a VR foot controller, 3DRudder (3drudder.com, France). The device is shown in Fig. 10. 3DRudder is manipulated with user's feet in the sitting position. Figure 11 shows how to manipulate the controller. The user is required plantarflexing ankle joint and tilting the controller forward to move the avatar forward. When the user wants to move the avatar backward, the user is required dorsiflexing ankle joint and tilting the controller backward. When the user would like to move the avatar to lateral direction, the user displaces feet position back and forth to turns the controller, or presses by one foot and tilts the controller to horizontal direction. The user can also move the avatar in an oblique direction by combining controller manipulation.

Fig. 10. VR foot controller.

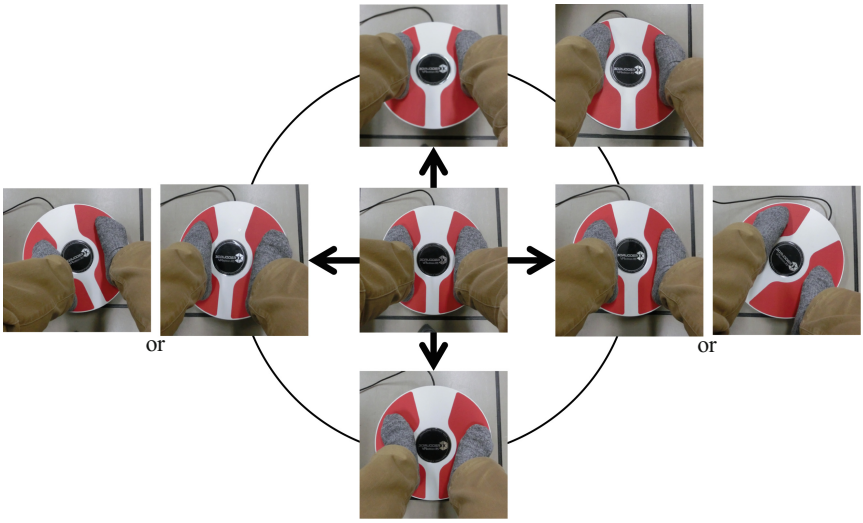


Fig. 11. Feet manipulation of the 3DRudder controller.

Two kind of exploration game environment were developed. Game 1 task is to search the goal point in the map like a maze and Game 2 task is to collect as many items as possible on the way to the goal. Figure 12 shows a display example of Game 1. Game 1 has only straight pathways and angle of corners in the environment consists in increments of 90°. Therefore, when the user changes direction of locomotion, the user changes direction and moves forward after once stops the motion of the avatar. In addition, a cube moves based on sine wave at one place and blocks the route at constant time interval. Figure 13(a) shows a closed pathway by a cube and Fig. 13(b) shows an opened pathway. Therefore, the user is required to go through at the right timing while the route opens. This task requires the user to smoothly exercise feet at the right timing based on visual information. On the other hand, in Game 2, a cobbled road is built on the map. Figure 14 shows a display example of Game 2. The user controls an avatar along the road. In contrast to Game 1 environment, the road has curves irregularly. The road

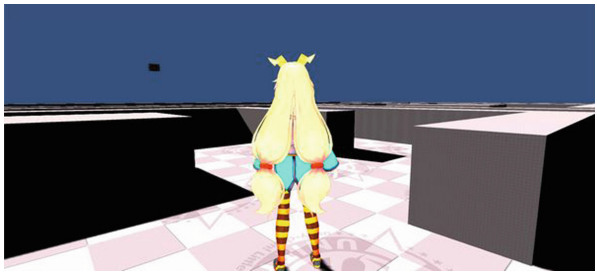
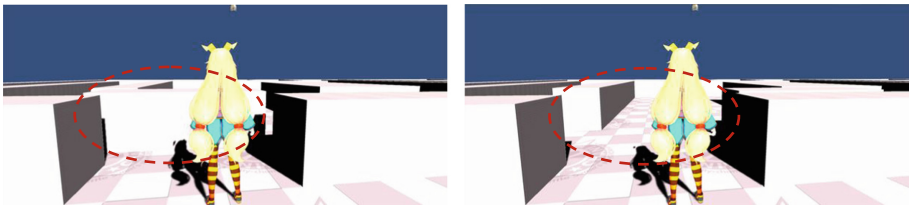


Fig. 12. Game 1 environment.



(a) Closed pathway. (b) Opened pathway.

Fig. 13. Open and close a pathway by a cube.

Fig. 14. Game 2 environment.

promotes moving an avatar to front-back and right-left direction at a time. Additionally, items are placed on the road. The user collects them on the way to the goal point. The user can compete with others for the number of get items.

3.3 Evaluation Through a Trial Use

We evaluated the proposed system through a trial use by a physically challenged elderly in a support facility for challenged. Trial use participant was a physically challenged elderly. Although he was able to walk alone without walking aids, he could not move both under and upper extremities smoothly. He also had articulatory and slight developmental impairment, so he could understand most conversations but without utterance. Figure 15 shows the participant during a trial use. In the trial use, the participant played in Game 2 environment. The participant started a trial use after he heard about game task and how to manipulate a controller.

At early use of the game, the participant could not control the avatar as he wanted because he could not understand appropriate tilt angles of the controller. However, after few minutes, the avatar did not deviate from a road significantly. The participant could also control the avatar to obliquely direct along curved road. In addition, the participant could found and collected items on side edge of the road with only an instruction that an experiment conductor provided once after the trial use started. We think that clarity about his tasks (following a road and collecting items) leads up to control the avatar smoothly.

Fig. 15. Scene of trial use by a physically challenged elderly.

The trial was conducted where other facility users with physically disabled could look. They said, "I cannot manipulate the controller with feet, but I want to play the game with a hand," and "I want to play and compete with everyone on the number of items or elapsed time." These comments suggest the possibility of enhancing motivation for the rehabilitation game by competing with others. Arranging more competitive indices such as new kinds of items is our issue in the future.

4 Conclusion

In this paper, the fundamental design framework of VR-based rehabilitation support environment was shown through three system development experiences. Additionally, VR-based rehabilitation support game for keeping ankle mobility was proposed. Purpose of rehabilitation using the game was to keep ankle mobility needed for appropriate gait. Another purpose was also to safely train for ankle mobility in sitting position. A trial use as evaluation suggested the possibility of enhancing motivation for the rehabilitation training game by competing with others.

Future works are adding interesting things for the VR rehabilitation game and presenting rehabilitation effectiveness of the VR game through measurement of balance abilities for users.

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Persuasive Semantics of Aging Health Products Based on AHP and Kansei Engineering

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Abstract. The hypothesis of this study is that kansei design can improve the user's willingness to use the product, that is the persuasive semantics. In order to improve the health of aging society, the kansei design of healthy products is studied for older adults with Kansei engineering method. The correlation of the elder's kansei needs and semantic of product is established. This method includes morphological decomposition of products' kansei factors, the SD semantic scale test, data analyzed with Spss, and establishing the persuasive semantic space of perceptual evaluation of users. The research finding can be used in the process of product development to persuade users to want to use the product.

Keywords: Aging · Health products · Kansei engineering · Persuasive semantic

1 Introduction

There is a huge demand for intelligent fitness products in the aging society. China is the world's aging population, not only the old population base is huge, but also the growth rate is relatively fast. At the end of 2015, China's population of 60 years old and above is 221 million 820 thousand people, accounting for 16.15%, of which the population of 65 years old and above is 143 million 740 thousand people, accounting for 10.47%. Regardless of the number of aging population or aging rate, China will rank first in the world and become the world's most serious aging country.

Fitness will effectively improve the physical condition of the old adults, but there is a big problem in the physical fitness awareness and fitness condition for them. So there is a big gap in the design of the elderly fitness product. The content of this study is to help the elderly to improve the health status through the Kansei design of health product.

Due to the physiological and psychological changes of the elderly, the weight of the perceptual factors of the product changes, so the design of the product semantic style is different from that of the young people. To design the persuasive factors of health products, product semantic is extracted by AHP method, and various indicators are evaluated with Kansei engineering method.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_36

2 Kansei Engineering

Kansei Engineering is a comprehensive interdisciplinary subject in the field of art design, engineering and other subjects. Research on Kansei engineering is proposed first by the Mazda group president Yamamoto Kenichi in the mid 1980s. This is a technology, theory and method of changing the feeling or image of consumer into design elements. Kansei engineering (Fig. 1) is a technology of product development with the consumer oriented [1]. Its attention is from the consumer's feelings and user's need.

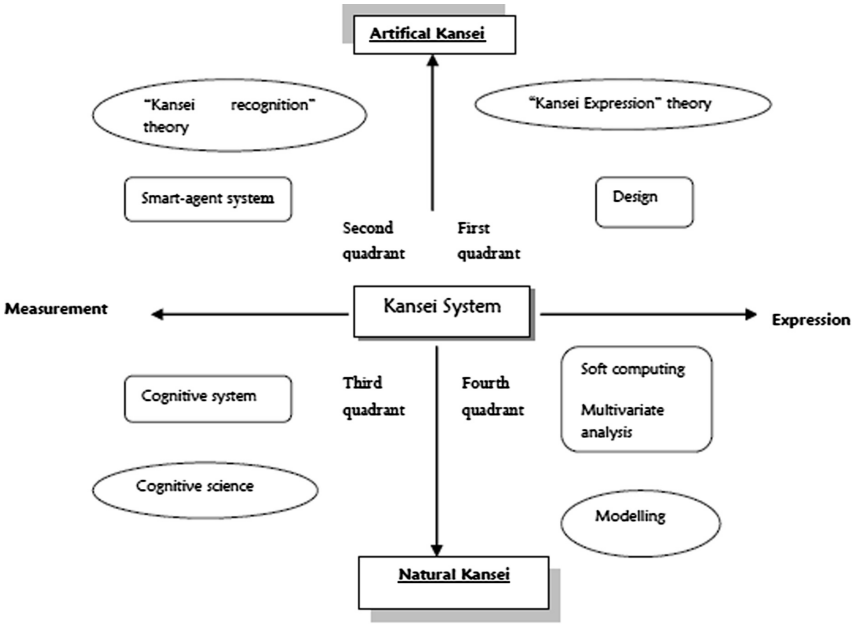

Fig. 1. Kansei system framework (Shiizuka and Watada, 2006)

Studies of the KE method are divided into two parts: (A) the category distinction of Kansei factors: the user's perception of the product is represented in the form of a tree, then the Kansei factors are extracted, and transformed into design factors. (B) Related quantitative research methods.

Research content of KE includes the following four points [2]:

1. Exploring the user's feelings and needs from the perspective of human factors and psychology.
2. Identifying the design characteristics from the perceptual image of the user.
3. Constructing Kansei engineering model and human-machine system.
4. Adjust the system with the change of society and the change of user's preferences [2].

In summary, as a quantitative research tool, Kansei engineering (KE) is widely used in the design and development of user research, and with the concept expansion of design, it is also used to new areas of interface design, service design, etc. Kansei design is essential factor to persuade users to use the product.

3 The Analytic Hierarchy Process

The analytic hierarchy process (AHP) is formally proposed by operational research experts Thomas Wadsworth SETI (T.L.Satty) in the middle of 1970s. It is a systematic and hierarchical analysis method with combination of qualitative and quantitative [3]. Because of its practicability and effectiveness in dealing with complex decision problems, it has been paid more and more attention in the world. It has been widely used in economic planning and management, energy policy and distribution, behavioral science, military command, transportation, agriculture, education, personnel, medical and environmental fields.

The basic procedure of the analytic hierarchy process is as follows:

1. Establish the hierarchical structure model.
2. Construct the pairwise comparison matrix.
3. Calculate the weight vector and does consistency check.
4. Calculate the combined weight vector and does the consistency check.

This method can help to find the important hierarchy of requirements in the design of complex product system, to use the limited resources to solve the key problems. This method will also be used to analysis the design strategy on the persuasive design.

4 Research Process

1. Cluster the products and select the design samples for coding.
2. Collect the data Based on the survey of the old people.
3. Let users do Likert 7 scale test.
4. Obtain the product design elements by using statistical software for data processing.
5. Analyze the weight coefficient level of the product semantics based on the AHP to guide design strategy.

5 Case Studies

5.1 Using KE Method to Evaluate the Healthy Product of the Elderly

KE is necessary to specify the uncertain factors that make users feel happy in the process of implementation. It can be divided into six types, which are the class hierarchy analysis, Kansei engineering support system, Hybrid Kansei engineering system, Kansei engineering mathematical model, Simulate Kansei Engineering and the interaction of Kansei engineering.

Class classification method is the most simple, common analysis method to analyze the Kansei factors of product. The class analysis method is used in the development of new products to reflect the user's perceptual demand.

When using the KE method, the main means of investigation is user interviews, market research, data collection, etc. Secondly, the team members discuss the ideas and express of each person in detail, the results of the discuss will be thought as a product

concept with 0 Kansei degree. Thirdly, it is necessary to convert the 0 degree Kansei concept into a more detailed 1 sense concept. At last, the concept of sub level is decomposed into 1 level by the induction method. Each induction concept is disassembled into a tree structure.

Collecting Descriptive Vocabulary Used by the Elderly. Take fitness product for old people as an example. We made emotion board by searching on magazines and network. Emotion board is intuitive for collecting information of Kansei experience by the older adults. Relevant descriptive vocabularies are refined. KJ method is used by the older adults to exclude synonymy and find the most suitable descriptive vocabularies. These words are as below: Z1 Stable, Z2 Safe, Z3 Affinity, Z4 Light, Z5 Comfortable, Z6 tradition, Z7 simple, Z8 High-grade.

Extraction of Eight Antonyms as the Kansei Words of the Product

- X1 Stable——Dynamic
- X2 safety——Dangerous
- X3 Affinity——Tough
- X4 Light——Thick
- X5 Comfortable——Uncomfortable
- X6 Conventional——Trendy
- X7 Simple——Complex
- X8 High-grade——Low grade

Establish SD questionnaire (Table 1): The questionnaire of the semantic differential method should include three elements: the sample pictures, the adjective pairs and the subjects. The questionnaire adopts Likert7 level measurement method. The perceptual image is divided into different levels, and the 1–7 points are used to represent the different degrees of adjectives. Taking "stable – dynamic" word pairs for example, the evaluation of 7 points means that the shape is very "dynamic" with speed and dynamic impression. 5 points means the sample is close to "dynamic"; the 1 point means that the subjects feel a strong sense of stability. The 4 point is the middle level, more than 4 means the evaluation subjects' impression is close to the right adjective word; on the other hand. If the evaluation level is less than 4, it means the participants' impression is more close to the left adjective vocabulary.

Making and Issuing Questionnaires. Taking into account the subjects continued to test a large number of samples will bring greater psychological pressure and cognitive fuzzy to them, therefore, 15 pictures were extracted as the test samples from 76 samples with the cluster analysis method, by removing some with high similarity on the key features. This test is divided into two parts: the first part is the image evaluation test that was graded according to the likert7 scale by the older adults. The second part is evaluation of the target user's preferences of 15 samples. Finally the users' preference of the product and the evaluation of perceptual factors are counted to get the Kansei factors that elderly like.

Table 1. Design of questionnaire for Likert7 scale of sample

sample 1 	
X1 Stable——Dynamic Grade：1 2 3 4 5 6 7	X2 safety——Dangerous Grade：1 2 3 4 5 6 7
X3 Affinity——Tough Grade：1 2 3 4 5 6 7	X4 Light——Thick Grade：1 2 3 4 5 6 7
X5 Comfortable——Uncomfortable 评分：1 2 3 4 5 6 7	X6 Conventional——Trendy Grade：1 2 3 4 5 6 7
X7 simple——complex Grade：1 2 3 4 5 6 7	X8 High-grade——Low grade Grade：1 2 3 4 5 6 7

5.2 Statistical Analysis of Questionnaire Data

120 questionnaires were issued on the Internet and the reality with the final recovery of effective questionnaires of 89, the recovery rate was 74.2%. 89 questionnaires were input into SPSS software to process the data (Table 2).

Mean Value of the Perceptual Image of the Elderly

Table 2. Mean value of the perceptual image of the elderly

Number	X1 Stable	X2 Safety	X3 Affinity	X4 Light	X5 Comfortable	X6 Conventional	X7 Simple	X8 High-grade	Preference
1	3. 9	3. 65	3.7	3.5	3. 3	3.5	3. 2	3. 5	3.5
2	3. 35	3. 55	3.75	3.2	3. 3	4.1	3. 55	3. 8	3.2
3	3	3. 05	3.6	3.2	3. 4	4	3. 65	3. S	3.2
4	3. 2	2. 95	3. 4	3.6	3.25	4. 05	3.45	3. 4	3.6
5	3. 55	3. 1	3. 65	4.3	3. 6	3. 95	4.1	2. 7	4.3
6	4.35	4. 45	4. 4	3.15	4. 05	3. 95	3. 4	3. 85	3.15
7	3.15	3. 55	3. 7	3.55	3. 85	3.6	3. 4	3. 45	3. 55
8	3. 25	3.5	3.8	4.25	3. 9	4. 25	4.15	2. 75	4. 25
9	3	3. 1	3.5	4.45	3.55	3. 45	3. 85	2. 55	4. 45
10	3.15	3.3	3.85	3.85	3.4	3. 95	3. 65	3.15	3. 85
11	3. 7	3. 75	4	4	4	4.3	4.1	3	4
12	3. 45	3.15	3.7	4.3	3. 8	3.8	4.05	2.7	4.3
13	3.9	3. 55	3. 65	3.1	3.35	3.7	3. 25	3. 9	3. 1
14	4.15	4.3	4.1	2.95	4	4.15	3. 45	4. 05	2. 95
15	4.05	4.5	4. 35	3. 55	3. 7	4. 05	3.55	3. 45	3.55

Line Graph Analysis

According to the line graph (Fig. 2), the most obvious product characteristic is as follows (Table 3):

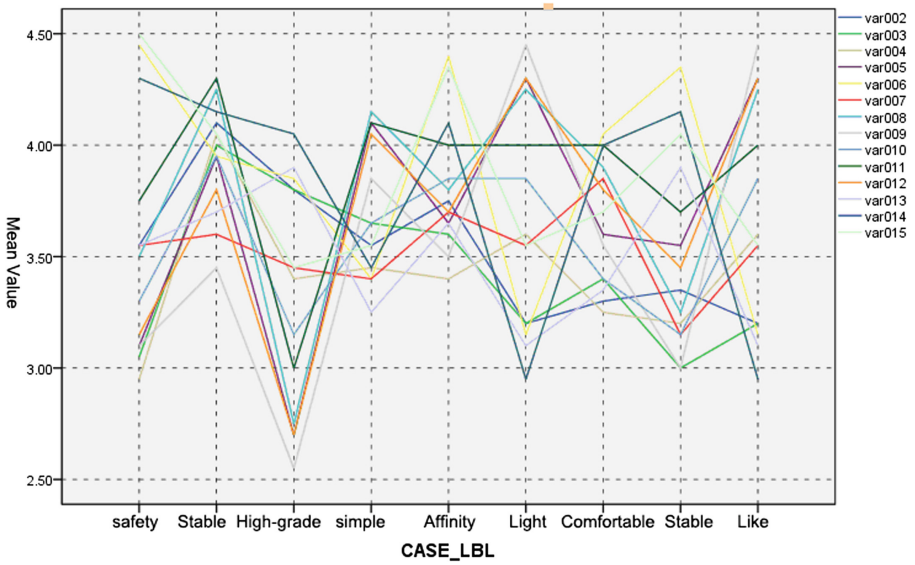

Fig. 2. Line graph

Table 3. Selection results

Safety	Conventional	High grade	Simple	Affinity	Light	Comfortable	Stable	Lite
13	9	9	4	13	2	13	3, 9	14, 13, 6, 2, 3
Dangerous	Trendy	Low grade	Complex	Tough	Thick	Uncomfortable	Dynamic	Unlike
6	11	14	8	6	13	6	6	9,5, 12, 8, 11

It shows that users prefer a relatively cost-effective, simple form, a sense of affinity, security, comfort, tradition and stability of the product semantics. They do not like too trendy and complex shape of the product.

Factor Analysis. Principal component analysis (PCA) was used to analyze the factors. The 12 variables with strong correlation were classified into one category. The meaning of each factor is explained. In order to explain the meaning of common factor better, the rotation of factor loading matrix is realized by orthogonal array.

The general expression of factor analysis:

$$\begin{cases} X_1 = W_{11}f_1 + W_{12}f_2 + \ldots + W_{1m}f_m + \varepsilon_1 \\ X_2 = W_{21}f_1 + W_{22}f_2 + \ldots + W_{2m}f_m + \varepsilon_2 \\ \vdots \\ X_p = W_{p1}f_1 + W_{p2}f_2 + \ldots + W_{pm}f_m + \varepsilon_p \end{cases} \quad (1)$$

In this set of equations, X1, X2,…… Xp indicates the score of the observations of each item by the subject; f1, f2,…… fm represents the score of the subjects on the m common factors; Wij is the coefficient of the i observation variable to the j common factor in the corresponding regression equation, called the factor load (Table 4).

Table 4. Common factor variance

	Initial	Extract
Z1	1.000	.725
Z2	1.000	.912
Z3	1.000	.949
Z4	1.000	.765
Z5	1.000	.949
Z6	1.000	.949

The table shows the common degree of the output variables. In the first column of the table is the original variable name, the second column is 1 calculated according to the initial solution variables, which is actually the common degree that the 6 principal components were calculated as the common factor; the third column is confirmed only two extraction system after the calculation of the common factor degree. In addition to the two items in the table, the other variables are greater than the common degree of 0.80, which is the ideal state (Table 5).

Table 5. Total variance explained

Ingredients	Component initial eigenvalue			Extraction of sum of squares		
	Total	Variance	Accumulate	Total	Variance	Accumilate
1	4.703	52.254	52.254	4.703	52.254	52.254
2	2.643	29.363	81.617	2.643	29.363	81.617
3	0.998	11.088	92.704			
4	.358	3.977	96.681			
5	.202	2.244	98.925			
6	.067	.741	99.666			
7	.030	.334	100.000			
8	2.626E-016	2.918E-015	100.000			
9	1.416E - 017	1.574E-016	100.000			

The characteristic of the first factor solution value is 4.703 that is showed on table. It explains 52.245% information in all 10 variance, and the variance is one of the largest principal components; similarly, the second factors explain 29.363% information in the total amount of variable. The characteristic values from third factor were less than 1. The first two factors explained the 81.617% information of all the variables with a good level, so it is more appropriate to extract two common factors Fig. 3.

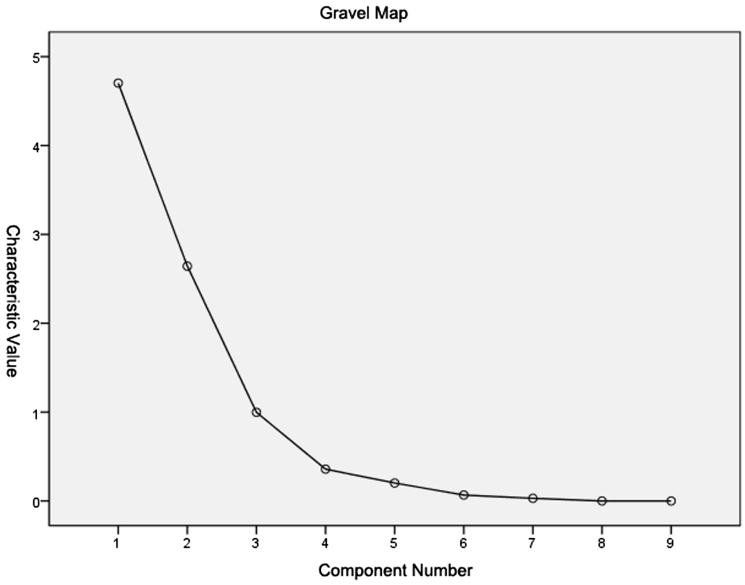

Fig. 3. Gravel map

According to above diagram we can see the third factors is very gentle from the start curve, that means the variance contribution becomes very small after the third factor solution, even can be ignored, so it is appropriate to extract two factors (Table 6).

It is showed in the above figure that there are two variables' loads are more than 0.50 on the same time, so using the method of factor variance maximization rotation is appropriate. Obtained factor rotation matrix above is shown on the right. After the rotation, the size of the load is further differentiated, and the corresponding relationship between the variables and the factor is clearer. The main variable of "simple", "love", which belongs to the "usability" factor, is affected by the first factor. The main variables, "stable" and "security", "light", "comfortable", which belongs to the "perceptual factor" are affected by the second factor.

Table 6. Component matrix & rotated component matrix

Component matrix		
	Component	
	1	2
Z1	.659	.687
Z2	.806	.513
Z3	.171	.525
Z4	.170	.858
Z5	.907	-.355
Z6	-.907	.355

Rotated component matrix		
	Component	
	1	2
Z1	-.236	.922
Z2	-.450	.842
Z3	.109	.541
Z4	.273	.831
Z5	-.965	.137
Z6	.965	-.137

5.3 Analyze the Weight of the Product with AHP Analytic Hierarchy Process

Seven experts score the questionnaires in accordance with the fuzzy AHP, analyzing the product form with each perceptual semantic vocabulary. After the pairwise comparison of the product components, the table of greatest weight of product components that effect on the emotional factors (Table 7) is got. It will provide a reference for the future design with the emotional persuasion intention.

Table 7. Analytic hierarchy process

Target layer	Intermediate layer	The middle sub item	Decision layer
AKansei	AlKansei factor 0.7500	Security 0.3875	Frame 0.3979
Evaluation		Stable 0.1950	Pedal 0.1781
		Comfortable 0.1065	Seat 0.1746
		Light 0.0610	Display device
	A2 Ease of use 0.2500		0.1472
			Handlebar 0.1022

6 Summary

The Kansei engineering methods is used to study persuasion semantic [4, 5] of health smart products in this research. Statistical data was analyzed through the line graph; user preferences and intuitive curve of perceptual characteristics are abstained. The various perceptual samples with Kansei engineering method are evaluated and the perceptual factor with higher contribution by statistical analysis is obtained. Product is decomposed with the morphological analysis and the weight of components in each Kansei factors is get according to the AHP, so as to formulate the strategy and improve the persuasive semantics design.

Acknowledgments. This research was supported by Undergraduate Key Course Construction Project through the Research Foundation of ECUST (No. YZ0126104).

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Development of Remote Control Unit of Domestic Water Heater by Kansei Engineering

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Abstract. This study shows Kansei engineering is applied to a development of a remote control unit of a domestic water heater. Because the control system of a water heater has grown more complicated, the quality of the remote control system becomes increasingly important as means of the utility and the user interface. The remote controller is also required quality of design because it is fixedly installed in a part of interior design. Then, this study has tried to improve the conventional remote controller unit in both usability and design aspects. Two alternatives, which are the conventional physical button device and the touch device shaped by fixed button without display function interfaces, were considered as a potential product of the remote control unit. Kansei engineering is used in several steps iteratively adopted the process of conception, visualization and verification.

Keywords: Control system of water heater · Kansei engineering · Interface design · Usability · Task analysis

1 Introduction

A domestic water heater is a necessity of absolutely every household in Japan. The heating system is diversified in various types because of energy saving. The utility of the system becomes multifunctional according to the mechanical types of energy saving. The main types of the heating system are listed as gas burner, gas combined heat and power, heat recovery gas burner, oil fired, electric and electric heat pump. The system is installed as different functions depending on the feature of the type. A remote control unit of water heater performs an integrated user interface for the functions into defined tasks. The problem to design the controller is complexity of the system. Also, the design of the controller shall be harmonized itself with stylish interior, because the controller unit is often fixed to the newly built house. It is considered that the visual design of the controller is more important rather than the utility of water heater. The quality of the control unit exerts no small influence on it's sales.

The collaboration study meeting including designers of a water heater maker started the research of the development. The meeting conducted the process of the new product development in accordance with kansei engineering methodology. In this project,

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_37

Kansei Engineering was applied into the development process from upper to lower stage. This report shows the adopted kansei engineering methodologies and outcomes from the collaboration.

2 Design Process by Kansei Engineering

Kansei Engineering applies to this product development project all over the stages. There are many issues to be solved at each stage of product development. Generally, kansei engineering uses problem-solving steps including "conception", "visualization" and "verification" which are directed towered the purpose of Human Centered Design [1]. Figure 1 illustrates a conceptual processes adopting Kansei Engineering methodology according with the product development flow. The product development uses kansei engineering to improve through the steps from upper to lower stages [2].

The conception step attempts to propose creative solutions by imaginative way such as brainstorming. In this step, ideas are uncorroborated, but it is important to create approximate solutions or tentative goals in order to avoid loosing direction. A common false is to overemphasize this step which means to progress just to rely the imagination. The key issue in this false is not at the using of conception its self but exception of verification of the given potential solutions. A certain proposition helps to lead successful outcomes and protect from delusion in regard to the project management.

A potential solution given in the conception step must be verified because it is main cause of failure to commercialize unverified ideas. Kansei engineering provides the methods to confirm whether the given ideas are adequate to commercialize or not. Kansei engineering is a relevant approach in order to correlated the complex mechanisms of emotions and behaviors with product specifications. The correlations are primarily revealed by research with emotional experiments and data analyses. The visualization step means to replicate stimuli like potential product utilized for the ergonomic experiment. The purpose of visualization is to observe emotional responses from potential products incorporated some ideas given in the conception steps.

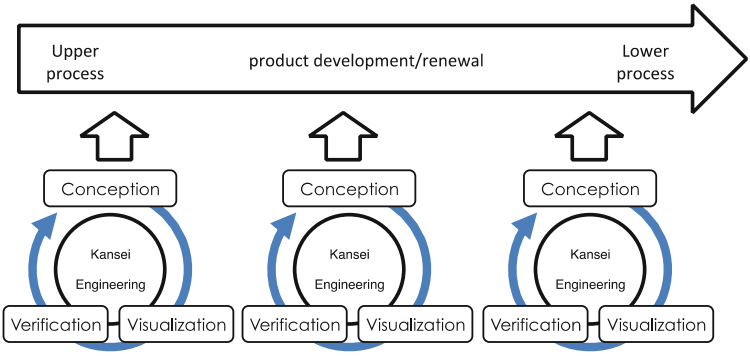

Fig. 1. Product development process by kansei engineering.

Finally, the verification step confirms improved effect of the proposed idea by using data analyses such as multivariate data analyses. Kansei engineering aims to establish cross-disciplinary research platform across multi domains. Therefore, we can also understand that kansei engineering does not mean any specific technique, but the problem-solving steps of "conception", "visualization" and "verification" are repeatedly used to progress the product development from upper to lower stages.

3 Concept Describing on Upper Process

The development process of this collaboration began describing the concept of new water heater controller (Fig. 2). In the first place of the discussion, "attractive controller" was proposed as so called "zero concept". The composition of the zero concept to "attractive" is broken down into "excellent in design" and "user-friendly" at the same discussion. The concept is required to determine the consistency to market demands in accordance with kansei engineering process, so kansei experiment by Semantic Differential method and multivariate analyses are used for verification of the concept.

3.1 Experiment and Concept Mapping

Kansei experiment was conducted in order to confirm validity of the proposed concept. The candidates of kansei experiment were 32 photographs, partly processed by graphic images, from catalogs web sites of the water heater vender. Seventeen participants (male 11, female 6) from within the company evaluated using 37 words drawn by five-points semantic differential scales. Other 6 words concerned with usability of the interface are used for evaluation in addition to the kansei words, and we obtained a total of 43 evaluations.

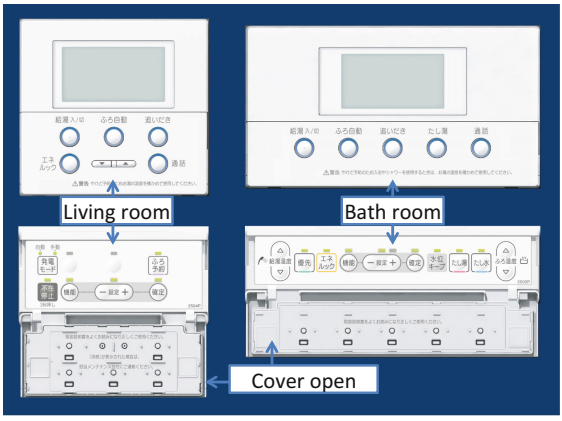

Fig. 2. Distinctive water heater control units for living and bathroom state with cover close and open.

Principal Component Analysis is used for extracting elements as descriptions of the evaluation words in the SD data. Higher five principal components were adopted by a scale of eigenvalue as a threshold rule of greater than 1.0. Table 1 shows resulted five principal components with contribution rates in order to compare themselves with the tentative components from the conception step. From the result, the evaluation word "attractive" was included in the principal component(PC) 1, which is defined as "excellent in design" factor from our discussion. We might say that PC1 was particularly important factor because the contribution rate was 46.6%, which meant to be able to explain almost half of the kansei of the visual designs. The correlation coefficient between "attractive" and PC1 was 0.972, it was the largest value in the evaluation words belonging to PC1. Additionally, the calculated contribution of the "attractive" was 96.2%, it was the second greatest in all evaluation words. The word of the greatest contribution and the second largest correlation coefficient to PC1 was "excellent in design", contribution = 96.4%, correlation = 0.971.

PC2 indicated "soft – hard" axis which also explained "feminine – masculine". PC3 was "usability" which included functionality in the meaning of visual design. The contribution rates of PC2 and PC3 were 16.0% and 11.7% respectively. Then, we concluded that "usability" is also an important factor as to employ the component of the target concept. In order to confirm positions and consistency of the own products to the partial concept mapping defined by PC1 and PC3 (Fig. 3). The circle rounded candidates are in-house designed products for high functional water heaters. We decided to develop a target of the high functional model which was distributed around target area in Fig. 3.

Table 1. Resulted five principal components with factor loadings and eigenvalues by factor analysis.

Principal component	PC1	PC2	PC3	PC4	PC5
	Excellent in design	Softness	Usability	Activeness	Appear larger
PC loading	46.6%	16.0%	11.7%	8.5%	4.9%
Eigenvalue	20.85	7.01	6.04	2.61	1.26

3.2 Quantification Theory Type I

Next, we tried to describe tentative goals of visual design like "prototyping". The water heater company provided actual ranges or values of the design specification. The range was categorized with the help of the designers, and then we obtained 20 items and 66 categories to represent the visual designs of the controllers. On the analysis of Quantification Theory Type I(QT1), total number of the categories should be smaller than the number of candidates/1.5. We reduced the categories exploratory with remaining greater correlation coefficients, which were resulted by QT1, with each evaluation word belonging to PC1 and PC3. The resulted design elements correlated to PC1(Excellent in design) were as follows; edges of rectangular body are acute, display is black background and one-colored text, one-colored display, shape of on/off and auto-fill switch is small circle and inducing color on buttons. The resulted elements for

PC3(user-friendly) were size of display is small, two colored display, Japanese text on switch and many switches installed. Figure 4 shows potential designs drawn by the designers in accordance with the results of QT1, and then all of project members joined to discuss and concluded the properness of the design again.

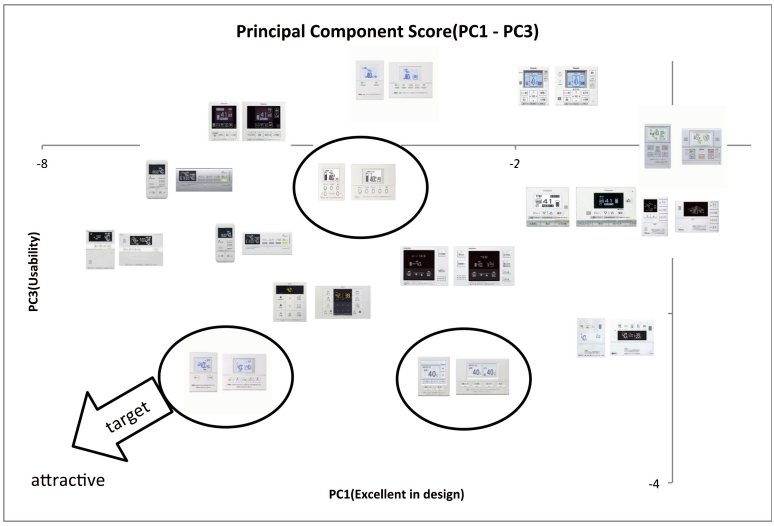

Fig. 3. Partial concept mapping of design candidates defined by PC1 and PC3 of principal component axes direction to “attractive” arrow.

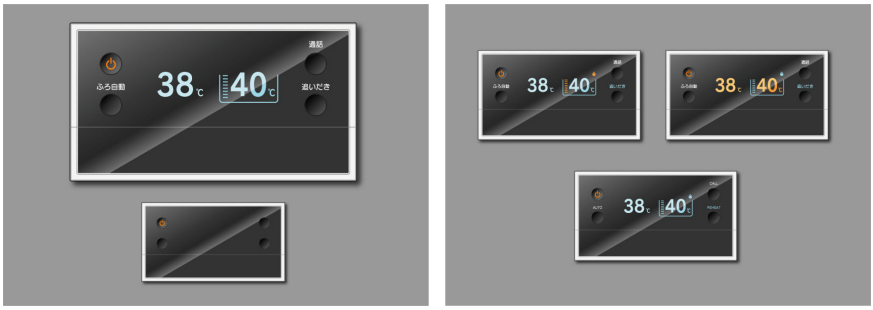

Fig. 4. Potential designs drawn by the designers in accordance with the results of QT1.

4 Experiment for Display Design

At this time, the interface design must be required to change from the push switched interface, because we decided to employ touch-sensitive switches with full-color display. The allocation of the touch-sensors was fixed by a restriction of sensibility because

Fig. 5. Designers provided 5 pairs of candidates of display design used for paired comparison.

Table 2. Analysis of variance(ANOVA) resulted for 5 candidates upon 7 evaluation words (main screen)

Candidate	Elegant	Cool	Eye-friendly	Beautiful	Easy to understand	High grade	Desirable
A	×	×		×	×	×	×
B	●	●		●	×	●	●
C	×	●		×	●		
D	×	×	●		●	×	
E	×		×		×		

Table 3. Analysis of variance(ANOVA) resulted for 5 candidates upon 7 evaluation words (setting screen).

Candidate	Elegant	Cool	Eye-friendly	Beautiful	Easy to understand	High grade	Desirable
A	×	×	×	×	×	×	×
B	●	●		●		●	●
C	×		●		●		●
D		●	●		●		●
E		●	●		●		●

sensors must work well in wet condition. Most of user interface components which had to be designed should be installed in the display to compose “user-friendly” controller. The designers provided candidates of the display design as Fig. 5. The five pairs of design for main and setting screen were evaluated by Paired Comparison method. 20 female participants within the company evaluated 7 kansei words for each pair between 5 candidates, $5 \times 4/2 = 10$ pairs. Analysis of variance(ANOVA) resulted for 5 candidates upon 7 evaluation words are shown in Tables 2 and 3. A black filled circle means that the candidate is significantly high, a x mark means significantly low. In the results, the candidate B is the most dominant design from a comprehensive evaluation in the words and type of screen. The candidate B is however less than the candidates C and D in the meaning of “easy-to-read” and “easy-to-understand”. Then, we decided to create a new design to positively introduce the features of those three candidates.

5 Usability Testing

The most significant advantage of the touch sensor and full-color display from button switch, the interface can be installed by wired logic program. Therefore, the interface of the controller is designed as arbitrary work flows for the convenience of users recognition. In order to confirm this advantage, both types of controller were used to compare by task analyses. Usability testing is a method of user centered design for evaluating a product or service by experiment with representative users [3]. Usually, participants will try to complete given tasks with observers watch, listen and recording. The purpose of experiment is to identify issues of usability, gather subjective and objective data as quantitative and qualitative shape and determine the ideal interface mechanism or style.

Three tasks were prepared for the analysis (Table 4). Task 1 was auto-fill and quit filling task as frequently used one. Task 2 was setting auto or timer start of combined heat and power system as low frequency and lower difficulty. Task 3 was monitor of energy use as low frequency and high difficulty. Each task is composed of several sub tasks, and 3 participants evaluated visibility and usability by subjective appraisals for each sub tasks of the both systems (Table 5). At the same time, the objective measurements were gathered as task completion time, detention time and number of errors.

This task analysis concluded that the traditional button switch interface was more user-friendly than touch sensor. The problem of inconsistency between the screen and the touch sensor was found from data and discussing. It was found that cross-arrow direction key especially made it more difficult to recognize. Then, we made 3 prototypes of potential user interface designs to be verified by task analysis (Fig. 6). In this step, PowerPoint prototyping was employed [4]. PowerPoint prototyping is one of the method of software prototyping which using presentation software, usually Microsoft PowerPoint is used for the analysis, designed the potential interface into the touch display. The potential interfaces were installed as PowerPoint slides. Participants

Table 4. Samples of setup task for controller "A" which has physical buttons analysis using for task analysis to compare usability between physical and touch buttons.

Task name	Operation of task
Task 1	Setting water level to [8], then start filling the tub to the level
Sub task 1–1	Open the cover of the controller
Sub task 1–2	Push the "function button" to show "configuration" screen
Sub task 1–3	Confirm "setting water level" is highlighted, and push "done" button
Sub task 1–4	Set water level "8"
Sub task 1–5	Push "done" button, and fix the water level
Sub task 1–6	Close the cover when the voice of "changed" confirmed
Sub task 1–7	Report the changed water level on the display
Sub task 1–8	Start filling the tub by pushing "Auto filling" button
Sub task 1–9	Confirm auto filling is working
Sub task 1–10	Push "Auto filling" button again to stop auto filling
Sub task 1–11	Confirm "Auto filling" is stopped, and report all tasks are finished

Table 5. Sample of questionnaire to evaluate controller "A" shown in Table 4.

No. of question	Operation of sub task	Evaluation
1–2	"function button" is easily recognizable	1 2 3 4 5 Good < > Bad
1–3	"done" button is easily recognizable	1 2 3 4 5
1–4	Easy to set water level	1 2 3 4 5
1–7–A	Display of water level is easily recognizable	1 2 3 4 5
1–7–B	Easy to change water level	1 2 3 4 5
1–8–A	"Auto filling" button is easily recognizable	1 2 3 4 5
1–8–B	Easy to start auto filling	1 2 3 4 5
1–10	Easy to stop auto filling	1 2 3 4 5
1–11	Display of "Auto filling" for start and stop are easily recognizable	1 2 3 4 5

performed the tasks by touching buttons designed upon the slides. The action by the manipulation is represented by state changing as slide turning. Three prototype interfaces were compared by subjective evaluation. Figure 6 shows three types of interface; 1 is a traditional four directions arrow key, 2 is lowest touch time system and 3 is two restricted directions arrow key. Then, the number 3 was employed from the results of task analyses using paired comparison experiment.

Fig. 6. Potential interface designs installed into PowerPoint pages for prototyping tests.

6 Experiment to Determine Chassis Design

The final plan of the chassis design was determined from the results of Paired Comparison. Figure 7 shows 5 full-size printed models proposed by designers for the experiments. Participants(22 males, 23 females) compared 10 pairs of the candidates by 6 evaluation words as follows; "cool", "advanced", "elegant", "beautiful", "high grade", "desirable". Tables 6, 7 and 8 illustrate summarizes of the results of ANOVA. The results mean that candidate 3 has high ratings comprehensively for every participant group. The second favorite one was candidate 4, which was high rating especially by females. Then, the designers built actual prototypes of candidate 3 and 4 for the final determination. Consequently, candidate 4 was employed as the final decision by management meeting.

Fig. 7. 5 full-size printed models proposed by designers for Kansei experiments by using Paired comparison.

Table 6. The results of ANOVA for chassis design evaluation(23 females).

Candidate	Cool	Advanced	Elegant	Beautiful	High grade	Desirable
1	×	×	◎	◎		
2	×	×				
3	◎	◎		◎	◎	◎
4	×	×	◎	◎		○
5	×		×	×	×	×

* ◎: significantly high. ○: high, × : significantly low.

Table 7. The results of ANOVA for chassis design evaluation(22 males).

Candidate	Cool	Advanced	Elegant	Beautiful	High grade	Desirable
1	×	×			×	
2		×			×	
3	◎	◎	◎	◎	◎	◎
4	×	×	○	○	×	
5	×		×	×	×	×

* ◎: significantly high. ○: high, × : significantly low.

Table 8. The results of ANOVA for chassis design evaluation(45 all participants).

Candidate	Cool	Advanced	Elegant	Beautiful	High grade	Desirable
1	×	×	○	○	×	
2		×			×	
3	◎	◎	○	○	◎	◎
4		×	○	○	×	
5	×		×	×	×	×

* ◎: significantly high. ○: high, × : significantly low.

7 Conclusion

This paper introduced a collaboration study for developing a design of a water heater controller by kansei engineering. Kansei engineering study conducted the process of the new product development which repeatedly used the problem-solving composed of "conception", "visualization" and "verification" steps.

The conception step created tentative concepts, specs, visual designs and technological ideas for visualization step. The ideas from the conception were visualized as key words, images, models and physical or functional prototypes in the visualization step. The visualization step sometimes uses existing products for comparison in experiments. The visualized ideas were verified by kansei experiments and data analyses with the visualized candidates. The final product was concluded through the kansei engineering process.

Future issue to be studied is to confirm whether the kansei value improved by kansei engineering contributes user satisfaction. Objective measurements of the influence are required to validate the results of our study.

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History of Kansei Engineering and Application of Artificial Intelligence

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Abstract. The word "kansei" means human emotion in mind and kansei engineering aims to develop a new product or social system from the customer orientation. It starts an observation of a customer's behavior, grasps his or her emotion using psychological scaling, and analyzes their emotion using several statistical analyses to lead design items. Finally, we create a new model of product with which customers will satisfy. We create AI soft wares as kansei system that realize the customer's needed image. He has developed more than 60 different items of Kansei products including soft wares that utilized artificial intelligence. Types of developed products range from refrigerator, camera, brassiere, house, automobile, aircraft and the like. Relating to AI system, he developed many systems such as passenger car interior design, kitchen design, housing design system, brand name search system using artificial intelligence, and virtual reality system in the 1980s. The list below shows the main new products and AI systems until today.

Keywords: Kansei engineering · Methods · Review of new products · AI · VR

1 Introduction

Nagamachi began the research of Kansei Engineering in the beginning of 1970, and published the first paper in 1974 [1]. He originally learned psychology and he obtained the Ph.D in the field of psychology. He learned medicine and engineering, and worked at the psychiatric hospital as a doctor assistant. After then he moved to the Engineering School of University of Hiroshima and became a professor of Industrial Engineering. As a psychologist, he was originally interested in the Tavistock research [2] and job design [3], he began his research naturally on human-centered ergonomics and participatory management as well, and entered into thought that emphasizes human emotions.

The Japanese "Kansei" has broader meaning than "Emotion" [4] and it means psychological feeling in mind like Want, Need, Aesthetic sensation (beautiful, elegant, etc.), or good taste and so on. Kansei research starts from grasp of customer's kansei and finally creates a good product based on the relation between kansei and design specifications, which aims the customer satisfaction.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
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2 Methods of Kansei Engineering

During kansei engineering research, Nagamachi has developed the methods of kansei engineering [5, 6].

1. *Observation*: Kansei engineers (KE) observe the customer's behavior what subject he or she observes or touches and how long see or touch it. And the KE catches what color, shape and others he or she is interested in. These items are very important ones to make new design.
2. *Category Classification Method*: At first you decide the new product domain: a bus tub, toilet, kitchen, vehicle and so forth. You imagine a new product and write the customers emotion, for instance, imagine what kinds of property the customers need, and then you write down them on a piece of paper. After then, KEs create the tree structure using the cards, like the first category, second category and so on. You can use "Fish-born diagram" in this stage [7].
3. *Psychological Scaling Method:* After collecting kansei (emotional) words, you create Likart-type scale using those kansei words (or SD scale). In this case, the 5- or 7-scale are very popular. In this method, we usually look at the real samples of product and check the feeling on the scale. After then you analyze these records using the multi-variable statistical methods.
4. *Analysis using the multi-variable statistical method:* We usually calculate Factor Analysis to get similar meaning group as a factor structure and delete the meaningless kansei words from the research. Principal Component Analysis, data mining method and others are useful. The JMP (SAS) analysis is most useful to find the design items from customer emotion.
5. *Kansei Rough Set Model*: Rough Set Model is a unique mathematical model developed by Professor Zdzislaw Pawlak in Poland and it is able to make clear the relation between hidden emotion and design items [8, 9].
6. *Artificial Intelligent System and Virtual Reality:* AI and VR is very useful technology to construct a computer system for advising a customer selection of good design. In this computerized system, it consists of emotion database, reference engine and design database. The system first asks the customer about his or her emotion, and then calculates relation of emotion to design speculation and outputs the good design fit to the customer emotion. In VR system, the customer is able to go through the image and control the image following the customer's affection. [10–17].

3 Overviews of New Product Development

3.1 A List of New Product Development Based on Kansei Engineering

Nagamachi has developed more than 60 new products based on the customer orientation. In this chapter, we overview only typical kansei products applied kansei engineering. Table 1 shows the list of main Kansei product development based on Kansei engineering since 1970. It describes year, company Name, product type and name. The development systems related to the artificial intelligent and Virtual reality system are described in the lower lines.

Table 1. The list of new kansei products developed using kansei engineering since 1974.

Year, Company name	Product name (Brand name)
1974 Fukuoka Interior	House Living System (House interior)
1979 Sharp	New refrigerator
1980 Sharp	Liquid Crystal Viewcam
1980 Kao	Biore-U (Body shampoo)
1984 Mazda	Persona (passenger car)
1985–87 Mazda	Eunos Roadster (Miata, MX5)
1985 Panasonic EW	Twin lamp (four-folded fluorescent lamp)
1992 Komatsu	Shovel car (digger) Avance 45t: Government Good Design Award
1992 Wacoal	Brassiere (Good-Up Bra)
1993 Komatsu	Avance 200t, Government Good Design Award
1993 Wacoal	Brassiere (2nd Good-Up Bra)
1995 Hyundai (Korea)	Sonata-2 (Compact car)
1996 LG (Korea)	Dish washer machine
1996 Panasonic EW	Roof/Roof gutter/Siding (Wall)/Gate
	Bath tab/Stair case/Washbowl/Closet
	Floor Heating System
	Kitchen design AI-VR system (ViVA)
	New shaver (Smooser)
2000 Panasonic	Sittng shower (The shower)
2003 Milbon	Shampoo & Hair Treatment (Deesse's)
2003 Panasonic EW	Toilet (TRES)
	Bed sore preventing mattress
2008 Boeing (USA)	Boeing 787 interior design
2008 Kounan	Apricot energy jelly (Activo)
2014 Vf Lee	Urban Rider Jeans
AI & VR	WIDAS (Brand system)-1993, ViVA (Kitchen design)
	AI & VR, HKES (Wheel)-1997, VeJEAR (Isuzu) 1996, VeJEAR (Isuzu)-1996, HousMall-1999

We explain some examples selected from the Table 1 and show how these new products were developed using Kansei engineering.

New Refrigerator. Nagamachi had an offer from Sharp in 1979 to develop a new type of refrigerator from the viewpoint of kansei engineering. After teaching 150 designers on kansei engineering, he selected 6 female designers and visited monitors' home with them to investigate how the refrigerator to use. They installed a camcorder in front of the refrigerator and took the wife's cooking behavior using it for two hours. After

visiting 20 homes, they observed videotapes to find some hints to improve the two-door refrigerator design. Nagamachi asked the designers to count how much the upper and lower doors opened for cooking time. They found that wives opened the lower door in 80%. The designer group discussed and tried to find the problem that the lower door opened so many times. As the result, Nagamachi suggested them that the bent posture needed high energy from the viewpoint of ergonomics, and that the wives do not like the bent posture. Thus, we noticed the refrigerator has the ergonomic problem and started what new design is needed to reduce the high energy, in other words, to change the bent postures. Our thinking way was to find a new idea based on customer as "the first principle". As the lower part keeps vegetables, fruits, eggs and others needed to cook. They decided that the lower part should move more comfortable position, namely interchange the upper room with the lower room. In this stage, the engineer group involved with our project to reach a good design for customers from the view point of mechanical technology. Our conclusion was (1) to exchange the upper door to lower one and vice versa, and (2) the lower room has several drawers controlled with different temperature.

As shown in Fig. 1, the lower part of the new refrigerator was divided into three parts and each drawer was controlled by different temperature. The top drawer was kept to be 0–2 °C and this was determined by an ergonomic experiment for good taste for fish and meat (Fig. 2).

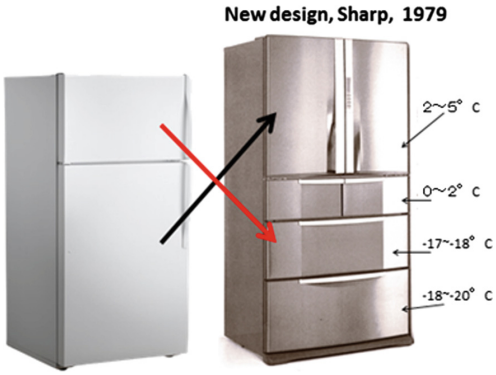

Fig. 1. New refrigerator developed in Sharp in 1979

Thus, we noticed the refrigerator has the ergonomic problem and started what new design is needed to reduce the high energy, in other words, to change the bent posture. Our thinking way was to find a new idea based on customer "the first" principle. As the lower part keeps vegetables, fruits, eggs and others needed to cook. They decided that the lower part should be moved to more comfortable position, namely interchange the upper room with the lower room. In this stage, the engineer group involved with our project to reach a good design for customers from the viewpoint of the mechanical

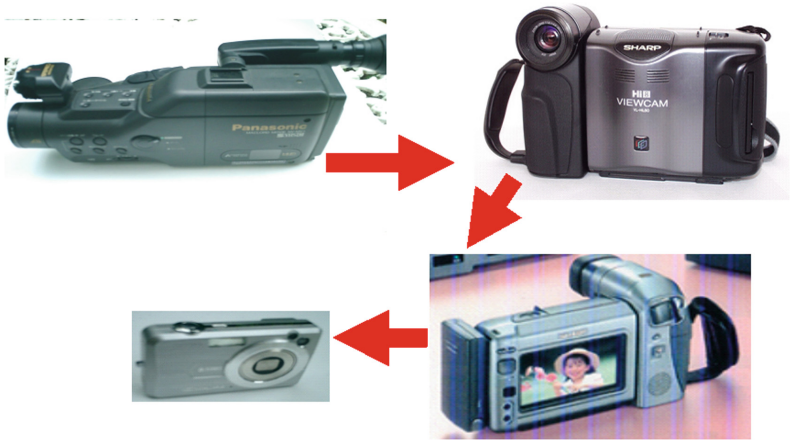

Fig. 2. Liquid Cristal Viewcam and the process from a camcorder to a mini-camera

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As shown in Fig. 1, the lower part of the new refrigerator was divided into three parts and each drawer was controlled by different temperature. The top drawer was kept to be 0–2 °C and this was determined by ergonomic experiment toward good taste for fish and meat.

Mazda MX5. The Mazda CEO, Mr. Kenichi Yamamoto called Nagamachi to support the R&D group to develop the next passenger car using kansei engineering. Nagamachi visited Mazda and taught R&D group on kansei engineering and supported all things on a new car development. Mr. Yamamoto told him that the next car concept would be a sport-type passenger car for young generation.

We decided to use Category Differentiation Method to get the new car concept. To do this work, we started to obtain the young driver evidence. A research takes the seat next to the young driver and takes a movie of his driving operation. Another researcher stands at the intersection and starts a video camera, if the driver looks like a young driver. After these survey, all R&D members gather into a research room (in the hotel), and write the driver emotion or action, each one on a small card looking at video show. This is called as the Card Method. After then, they collected the cards on one group, if they are supposed as the same category. After then, R&D members make a tree structure using the cards like a fish-born diagram. Looking at the tree structure, the designer group linkaged card meaning to design elements. For instance, the word "compact" will be connect with around 4 m in length and two sheet, which does not mean long (Fig. 3).

Recently Mazda decided to redesign the 4th MX5 and researched 1th, 2nd and 3rd ones using kansei scaling method, and confirmed the 1th generation of MX5 as the best kansei product. The R&D people redesigned new MX5 in the last year and obtained "The New Car of the Year 2017" [18].

Fig. 3. Mazda MX5, 1987

Kansei Shovel Car (Digger), the Avance Series. A Japanese Shovel car maker, Komatsu asked Nagamachi to help production of a new designed one. He collaborated with an engineer and a designer. First, he taught them about what the customer orientation philosophy is, and tried to design a cute mini-shovel car with different colors shown in Fig. 4. Komatsu mini-shovel car won popularity in its exhibition and we got the permission from CEO to design a new kansei shovel car.

Fig. 4. The mini-shovel car (left), 45 ton in 1992 (right), Komatsu Co.Ltd.

We survey the shovel car drivers' emotion about a shovel car design. After analysis of their emotion, we obtained their feeling about the car design. They say that we wish such vehicle: when a young girl is passing by the car, she stops and says to the driver, "Hei, can I get in to see inside and what looks like?". We designed a new shovel car using round contour line with purple body color. We received "Japanese Government Good Design Award in 1992" and again "Good Design Award" for the 200 ton shovel car in 1993 [19–21].

Brassiere Design. A top maker of lingerie Wacoal asked Nagamachi to introduce kansei engineering philosophy into its brassiere design. Wacoal ergonomics group surveyed female subjects related to their kansei when they put a bra on. They answered that they want to be "beautiful and elegant". The ergonomists measured the cup design of many bras using the moire shape measurement system and found the principles to feel beautiful and elegant as well. Figure 5 shows the moire measurement results for ordinary bra (left) and kansei bra (right). One of kansei bra principles is that two breasts should be inside two body lines, and the second one is two breasts should be aliened parallel, facing somewhat upward. The new kansei bra was named "Good-Up Bra".

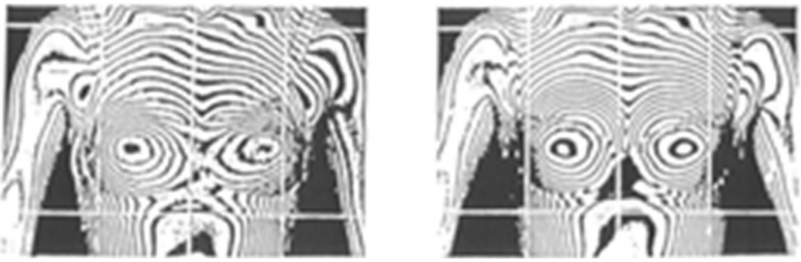

Fig. 5. Comparison of traditional bra (left) and Good-Up Bra (right)

The new bra became very popular in the market and as the result, Wacoal earned a lot of profit by only one new product. Wacoal developed a little reformed the 2nd Good-Up Bra, Good-Up hip as well. Of course, the female customers were very pleased to wear the kansei products.

A Mattress Preventing a Pressure Ulcer Disease (Bed Sore). Japanese is now the most aging society in the world and we have such a big matter that an old people in the care-houses and even in private homes as well have a lot of patients with the pressure-ulcer (bed sore) disease. The bed sore happens on the bed if the patient body weight pushes his back to a bed and blood stops by his or her weight. In the world, the caregivers have to turn the patient body in each 2-hour to prevent the occurrence of bed sore. This work forces hard work for the care givers.

We checked 80 different mattresses to find the good and comfortable ones on the point of preventing blood stop, using pressure test as well as blood stream. We found that a two fold mattress is very comfortable and this model assists to smooth blood stream. In addition to this combination, we noticed the mattresses made of poly-urethane is very comfortable, as shown in Fig. 6 (left). The Fig. 6 (right) shows a developed mattress. In order to get the ergonomic evidence, we measured the body pressure patterns on 5 new models. The Fig. 7 illustrates a good sample of pressure distribution diagram. We can check whether a model is good or not from the inter-pretation of this pattern (Figs. 8 and 9).

We donated 5 mattresses each to 4 national hospitals in order to obtain recovering process data using these mattresses. The Fig. 10 illustrates the recovering process from

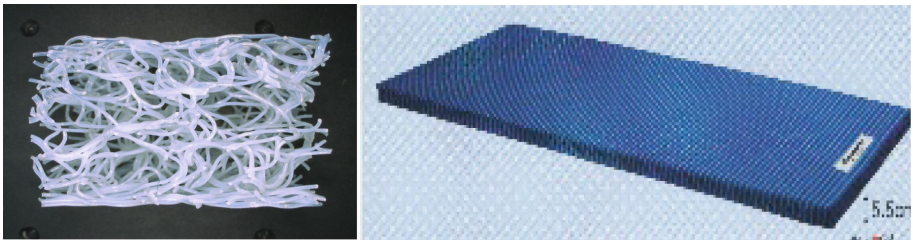

Fig. 6. New material preventing bed sore made of polyurethane (left) and The new two-layer mattress preventing bed sore (right).

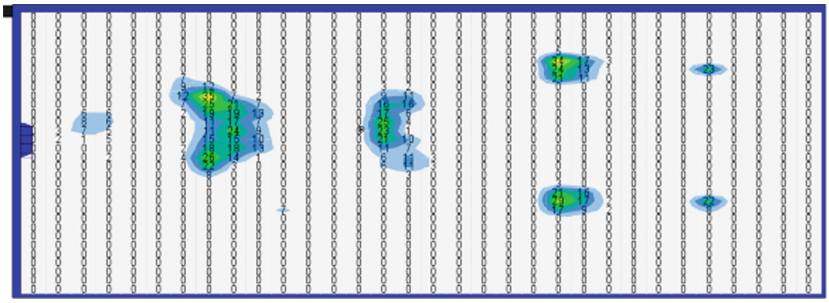

Fig. 7. Body pressure distribution value (head: left)

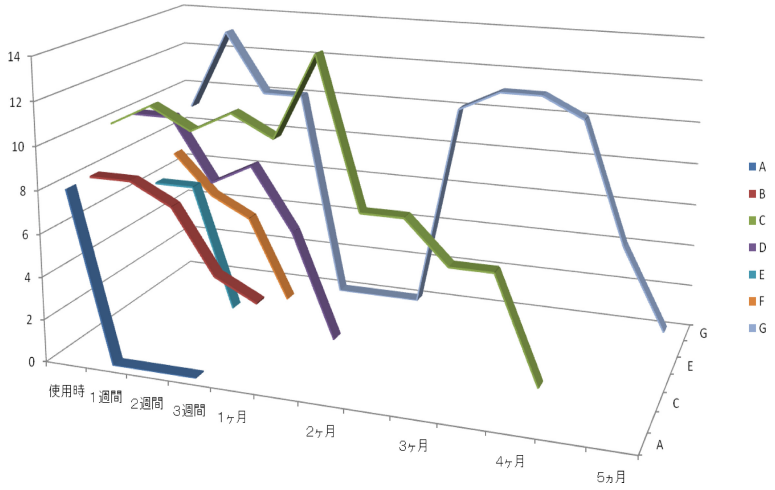

Fig. 8. Recovering dates from bed sore (weeks, months).

Fig. 9. The interior of Boeing 787

Fig. 10. A scene of the AI designing kitchen (ViVA)

bed sore. The bed sore clients recovered in a week, or in several weeks completely and this evidence tells the new mattress is very effective to prevent bedsore [22]

Application of Kansei Engineering into an Aircraft Interior Design. This is an indirect development of kansei engineering application into the aircraft interior design in Boeing. Nagamachi received a call from his friend Glenn Mazur (University of Michigan). He said Boeing sent him to ask Dr. Nagamachi to help an introduction of kansei engineering into the aircraft interior design of Boeing. Nagamachi answered "I am ok". On another day, Glenn said "I will support Boeing. But I am not professional in this field. Can you tell me how to do it?". Nagamachi sent the letter to him, in which he wrote in detail how to do the experiment and analysis. Based on his suggestion, Boeing organized a KE team consisting of engineers, designers, and a psychologist. The psychologist Jeanne Guerin received Nagamachi's letter and Glenn's advice, she started the KE research.

Nagamachi advised as the followings:

- Collect frequent flyers as the subjects.
- Ask them "what kind of feeling do you want inside an aircraft? Nagamachi supposes "relaxed feeling" will be "target" emotion. Then, collect the customers' idea (design items from the emotion) and ask your designers to draw the inside sketch.
- You show the subjects these clear sketches, 7–8 kinds, and calculates the data to find the interior design property.
- Finally, you ask several engineers to draw 7–8 kinds of computer graphics to use a verification experiment.

Jeanne conducted the evaluation experiment for the 80 subjects using 3-D oval screen and she handed all data to the designer group, the Teague Team. Along this story, the Boeing 787 Dreamliner interior was completed [23].

3.2 Development of AI and VR System Based on Kansei Engineering

ViVA: AI-VR Kitchen Design System. We represent an example related to an artificial intelligence & virtual reality application based on kansei engineering, among we have many examples. The AI & VR system is very useful and effective for the customers to select design and redesign according to their own affection. The example of AI & VR system is concerned with a kitchen design.

Nagamachi surveyed 100 kitchen designs using in houses and householder's kansei for kitchen design. On the other hand, he surveyed the relation between kitchen kansei and their life-style, and created the questionnaire to find their life-style consisting of 20 items.

He and his colleagues constructed kitchen design AI and VR system consisting from databases of life-style, kitchen kansei, design and the reference engine. We implemented these databases into AI model connected to VR, in which a customer can walkthrough into the VR system. A wife visits to Panasonic Design room and sits down in front of a computer. First, she asked her family, their ages, and their heights. Secondly the computer invites her to join the life-style test. Finally, it asks her what you do on the day the new kitchen is completed at her home. She answers, for instance, "I will invite some friends and make a French cuisine." After a moment, the computer displays the created design using her data, shown in Fig. 10. All wives say "Wow! yes, this is I wanted". If she wants to change some items, she can walk through into the image (VR). After her decision, the design drawing is sent to an automated factory. All kitchen parts are delivered to her home after a week and a new kitchen is completed in a day. We know all customers are satisfied with it.

WIDIAS: Brand Name Decision System. Wakayama area near to Osaka is very famous for Japanese apricot. Nagamachi collaborated with apricot farmers to product "Apricot jelly". A jelly contains a lot of "acetic acid which is good for health. It especially cheeps up the athletes. Using fish-born diagram and category classification method, we obtained a new apricot jelly idea. After calculation using a statistical method, we constructed the content composition. Finally, we decided the bland name that it cheeps up the athletes and other people. Utilizing the three-fold neural network model, named WIDIAS-III, we found the good name "Activo"(Spanish), shown in Fig. 11.

4 Remarks

We described small number of examples among more than 60 new kansei products. We have never experienced unsuccessful development, Kansei engineering is very powerful technology allied in any field, if human is related to the area (Fig. 12).

The important items are, if you wish to be successful in this project,

1. You keep the customer orientation. You do not take your own or self-assertion. Do not forget, "Customer, the First", or "People, the First". If you are working in factory, "Worker, the First".
2. Statistical method is essential to reach the design solution. If you have knowledge on design, it would be wonderful. Statistical method will help you.

Fig. 11. An Apricot jelly, ACTIVO

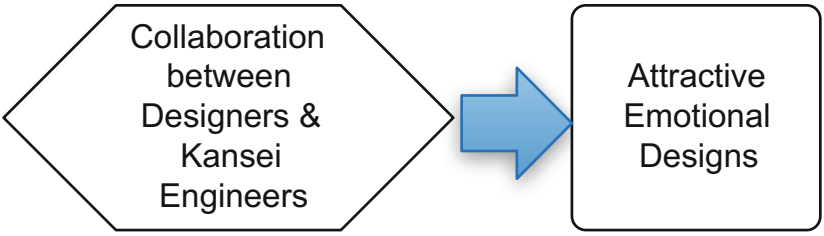

Fig. 12. The final outcome by the collaboration of kansei engineers with designers.

3. AI and VR system is also very powerful. We have utilized AI and VR system since 1990s, which is called the 1st AI generation. They are very useful to create a new design as well as to customer decision-support.

Concerning AI system, we constructed "Driver cockpit design AI system" in Komatsu, "Wheel design AI system" in Nissan, "Passenger car room AI design system" (Genetic Algorithm AI system) in Isuzu, "Whole house design system" (HousMall) [24] in Kansai Power Plant and others.

Finally, we have a very important comment on kansei designing. It is sure that we reach the list of good design property after calculation using statistical analysis of customer kansei (emotion). But it is just data list, not the final design. To complete the final design, we need the excellent designer's cooperation.

It is sure that, we have all succeeded in getting good outcomes. But, it is an outcome through the collaboration of kansei engineers with the excellent designers.

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A Study on the Approach of Redesign Based on Consumer Awareness of Traditional Handicrafts, with Longevity Lock, as an Example

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Abstract. The trend of cultural globalization is gradually taking shape. It makes people's aesthetic experience and aesthetic standards have become increasingly international and modern. However, the design and aesthetic form of traditional crafts in many developing countries still remain in the original rigid stage. With traditional Chinese handicraft longevity lock as an example, this thesis explores the approaches of redesign based on the design with customer involvement. First, the thesis seeks to summarize and analyze the design elements of bestsellers; then, through a survey, the thesis concludes the statistical results on the consumer awareness and product appeal of the Fulushou products. Second, the thesis selects the design elements with greater appeal to consumers; when redesigning the products, these elements should be highlighted. Third, through opportunity trade-off matrix, this thesis allows consumers to evaluate each design plan and the quantized values of selected design elements, so as to figure out the products that are most likely to attract consumers.

Keywords: Tradition and trend · Approach of redesign · Design with customer involvement · Opportunity trade-off matrix evaluation

1 Introduction

The 21st century is considered a new century of cultural convergence and cultural context globalization. Globalization refers to the formation of a "global culture" with increasingly close connections across the entire world [1]. Cultural and economic theorist Caves argues, "Creative industries provide us with products and services which are extensively in connection with cultural, artistic or recreational values [2]. The contemporary world has evolved into a post-industrial society. It has gone beyond the phase of materialistic society [3]. People's demand on products has escalated from basic products to user experience. From the perspective of commercial value, the more cultural properties a product possesses, the better experience it provides, and the greater market value it has (see Fig. 1). The re-design of the crafts is satisfied with the

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_39

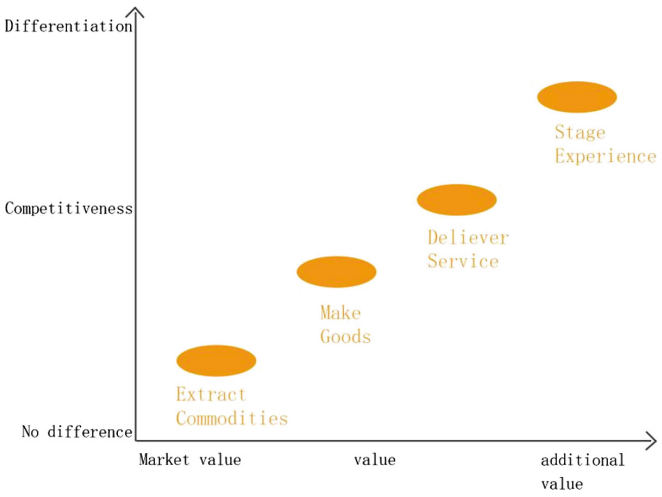

Fig. 1. This picture shows the evolution of business value. Tencent company user research and experience design department. In your side, designed for you [M]. Electronic Industry Press, 2013.

consumer's sense of cultural identity, which reflects the natural heritage of the outstanding traditional culture and the global era of aesthetic ideas bold attempt of the composite cultural emotional needs.

With the changing customer demands and ideas, the consumer market evolves with the progress of the era of experience and aesthetic economy. The uniqueness of local cultural characteristics and the creative knowledge structure will become the core competitiveness for the country [4]. All nations around the world are promoting the development of their cultural and creative industries. Through the combination of commercial events and cultural creativity, industrial value is to increase. For instance, Japanese city Niigata, with its long history of handicrafts, has been active to display the Hyakunen-Monogatari Project to the world since 2005. This handicraft project aims to support and create better styles [5]. In its 13th Five-year Plan, China has placed cultural reform and development in its grand strategy and blueprint for national development. Through multiple forms, such as grass-root investigations, research issue commitments, and seminars, China conducts serious preliminary researches for the planning. With its distinctive features, the industry of traditional handicrafts has received much attention from Chinese local governments [6].

When observing the developmental status quo of the Chinese industry of handicrafts, we have found two extreme phenomena. The first is that the design of handicrafts is incompatible with the aesthetic tastes and awareness of modern consumers; traditional design has become a symbol of obsolescence and cliche. There is a type of alienation particularly among youngsters. The other phenomenon is that some handicrafts on the market are totally unidentifiable as Chinese products. Their Chinese features are completely eclipsed by the modernist design styles. We seek to restore their vitality with the cultural elements, public demands and trends they include through new design approaches.

The literature of previous scholars can be categorized as the following types: 1. Studies and analyses on the development and status quo of traditional handicrafts; 2. Analyses on cultural elements that lead to product popularity; 3. Theories formed through mechanical applications of classic studies. With the longevity lock as an example, this thesis aims to apply the design approach with consumer involvement, explore the awareness of traditional cultural elements from the perspective of customers, and analyze the elements that can gain more recognition from consumers, so as to present a design solution that integrates such elements during the design process. At last, through the approach of opportunity trade-off matrix, we select the products with the best consumer recognition on the market.

2 Method

With the deepening development of market economy in China, market competition becomes increasingly intensive. The market survival rules gradually exert greater effects. The seller's market in favor of sellers no longer exists. It is the buyer's market in favor of consumers that prevails. Consumers are the true dominant forces of the market. The longevity lock mentioned in this thesis is designed with the involvement of consumers. The design procedure consists of three steps:

1. Investigate and research the longevity lock products with better sales on the market, and gather longevity lock designers, experts and sales staff to provide a summary of the elements in such products.
2. Through questionnaires, invite consumers to select the elements of longevity locks that they prefer and deem as necessary.
3. For this design, we apply the most popular design elements with the most votes to the design of our longevity lock, and we provide three design plans, and through the approach of opportunity trade-off matrix, we ask consumers to select the most satisfying product.

2.1 Selection of Experimental Samples and Summary of Design Elements

First, we have selected a total of ten products as samples, including the longevity locks with the best sales in jewelry stores, the ones produced as folk handicrafts, and the products from creative design competitions. Second, we designate designers, experts and sales staff to summarize corresponding design elements based on the three-element theory of product design, namely, functions, styling, and material techniques. For details, see the table below (Table 1):

2.2 Respondents

For the survey on element selection based on the awareness and preferences for the longevity lock, we have invited 300 respondents. Now longevity locks have achieved a breakthrough over the traditional symbolic meaning, i.e., a talisman praying for blessings for newborn babies. Now they exist as an accessory, and their wearers are no

Table 1. Summary of design elements for longevity locks.

Design elements	Explanations on the elements
A01: with practical functions	A practical function is one that can solve practical problems
A02: without practical functions	A product without practical functions cannot solve practical problems
A03: with symbolic meaning	The symbolic meanings include blessing and longevity
A04: without symbolic meaning	There is no need of hidden cultural symbolic meaning
A05: product form 1	The product exterior is simplistic and trendy
A06: product form 2	The product exterior is traditional and relatively complex
A07: product color 1	The exterior color of the product is fashionable and trendy
A08: product color 2	The product exterior color is of a traditional style
A09: product material 1	The materials of the product are of a low price
A10: product material 2	The materials of the product are of mid-range prices
A11: product material 3	The materials of the product are expensive
A12: product exterior 1	The product is of a simplistic and trendy exterior, with a distinctive modernist style
A13: product exterior 2	The product boasts a complex exterior, with a distinctive vintage style
A14: product texture 1	The surface of the product is delicate and beautiful
A15: product texture 2	The surface of the product appears rough and unadorned
A16: decorative pattern 1	The product features a simplistic and abstract pattern
A17: decorative pattern 2	The product features a realist and figurative pattern

longer confined to children. Instead, they can be worn by different groups of people. Therefore, buyers and wearers become more diversified. The object is no longer a gift bought by grandparents for their newborn grandchildren. Therefore, it is not necessary for us to differentiate buyers and wearers when selecting the questionnaire respondents.

2.3 Summary of the Questionnaire on Design Elements of the Longevity Locks

Based on the design elements summarized by designers, experts, and sales staff, we have prepared a questionnaire including such elements, and provided an explanation for each of them. Before the questionnaires are filled, we have explained to the respondents about the filling process. The first part of the questionnaire is personal information, and the second is the degree of importance for the design elements of longevity locks. The respondents may choose the elements based on their own experience and understanding of design elements. The following is a table of the preference degrees concluded by us of these 300 respondents (Table 2).

Table 2. Summary of design elements for longevity locks.

Design element	A01	A02	A03	A04	A05	A06	A07	A08	A09
Number of respondents	120	180	267	33	161	139	126	174	18
Percentage	40%	60%	89%	11%	53.6%	46.4%	42%	58%	6%
Design element	A10	A11	A12	A13	A14	A15	A16	A17	
Number of respondents	236	46	175	125	275	25	183	117	
Percentage	78.6%	15.4%	58.3%	41.7%	91.6%	8.4%	61%	39%	

2.4 Process of Analysis and Design

Through analyzing the data in the table of preference degrees of consumers for different design elements, we can figure out that consumers desire more than just cultural meanings and ornamental functions of the longevity locks. About 60% of the consumers hope that the longevity locks may provide practical functions. Around 89% of the respondents show a considerable degree of attention on the symbolic meaning of the products. Concerning the exterior design, 53.6% of the consumers prefer trendy and minimalist longevity locks. Concerning colors, 58% of the surveyed consumers prefer traditional colors. Concerning materials and prices, 78.6% of the consumers prefer products with mid-range materials, and those who prefer cheap longevity locks account for 6%. Concerning product exterior, 58.3% of the consumers also prefer modernist and minimalist exteriors. Concerning the product texture, 91.6% of the consumers prefer delicate and exquisite longevity locks. Concerning product pattern, 61% of the consumers prefer abstract patterns.

Through an analysis of the data above, it can be concluded that the preference degrees of consumers for longevity locks are influenced by a number of elements listed above. Among them, practical functions (A01), symbolic meaning (A03), product form 1 (A05), product color 2 (A08), product material 2 (A10), product exterior 1 (A12), product texture (A14), and product pattern 1 (A16) exert greater influence on the preference degrees of consumers. As a result, when we design the longevity locks, we tend to highlight these elements (see Fig. 2). In the following plans for three products, Proposal 1 has added a practical function of positioning, and the other two products have no practical functions.

2.5 Product Selection by Consumers

When the design proposals are available, through the approach of opportunity trade-off matrix, we select the design proposal with the best conformity to the results of survey analysis. First, based on the results of survey analysis, we verify the appeal degrees of the following design elements to consumers, including practical functions (A01), symbolic meaning (A03), product form 1 (A05), product color (A08), product material 2 (A10), product exterior 1 (A12), product texture (A14), and product pattern 1 (A16). We set the appeal degrees of each design element as a meter with five levels, among which 1 means very unattractive, 2 not attractive, 3 average, 4 relatively attractive and 5 very attractive. After that, we have invited 15 surveyed consumers, and asked the

Fig. 2. Plan images of three design proposals. Product 1 (with a practical function) and product 2 (without practical functions). Product 3 (without practical functions).

15 participants to wear and observe the three items. The 15 participants evaluate the corresponding design elements of each product based on their own experience and perception, and we can calculate the total evaluation scores given by the 15 participants on these elements, so that we can figure out the compatibility between these proposals and the results of the survey and analysis, as shown in the table. Eventually, we can decide on which product to be launched in the market for the greatest consumer satisfaction.

2.6 Formulas

When the evaluation score on the element of practical function of P1 is calculated, C represents the number of respondents in each degree, and each element is evaluated by 15 people. The calculation formula:

$$\mathrm{P1}\ (\mathrm{C1}) * 1 + \mathrm{P1}\ (\mathrm{C2}) * 2 + \mathrm{P1}\ (\mathrm{C3}) * 3 + \mathrm{P1}\ (\mathrm{C4}) * 4 + \mathrm{P1}\ (\mathrm{C5}) * 5 = \mathrm{z}. \quad (1)$$

2.7 Results and Analysis

We have collected the longevity locks with the best sales on the market, and invited designers, experts and sales staff to summarize the design elements of these bestsellers. Then we have invited 300 people as respondents for our survey. Consumers make choices of the design elements which are appealing to them when they make their purchases of the longevity locks. The design elements selected by such an approach are accurate. When we provide proposals for redesign, we can make more our design purposes clearer based on these elements. At last, we apply the approach of opportunity trade-off matrix for the design proposals, and let consumers evaluate the three design proposals and provide scores for the designs with greater appeal. Eventually, we can conclude the most attractive product for the consumers.

Through analyzing the data in Table 3, the final results suggest that P1 has the highest score in the quantitative analysis. When we observe the data in the table, we can notice that the scores for the three product proposals for the practical function are 44, 38 and 43, and the results are consistent with the previous survey results. In the meantime, this also indicates that traditional designs with practical functions indeed would be popular with most consumers. In the elements of symbolic meaning and product form, P1 features a combination of deer antlers and a circle, with a style of both modernist simplicity and trendiness, as well as a symbolic meaning of affluence. P1 shows only a circular shape that boasts modernist minimalist style, without traditional symbolic meaning. P3 has an exterior shape of a heart. The corresponding scores for the three products are 121, 105 and 110. It can be concluded that consumers prefer the forms that are minimalist and trendy, but sheer minimalism without meaning does not gain popularity with consumers. Concerning colors, the scores of P1, P2 and P3 are 57, 51 and 51. Nowadays, consumers prefer vintage colors, and they do not favor bright and refreshing colors. Concerning product materials, the relevant scores for P1, P2 and P3 are 60, 50 and 44. The material of P1 is a clearer indicator for its status as a mid-range product. Concerning product exteriors, the relevant scores of the three products are 47, 55 and 46. The exterior of P2 appear more fashionable and minimalist. Concerning the exquisiteness of product textures, the scores of P1, P2 and P3 are 62, 50 and 48. P1 appears more exquisite and refined. Concerning the abstract patterns, the scores are 50, 51 and 53, and there are no distinctive differences. Based on the analytic results related to the three products, it can be concluded that P1 should be selected for manufacture, since it is more likely to gain popularity with consumers.

Table 3. Opportunity trade-off matrix for the design proposals

Design elements	Degree of appeal	Product proposal P1	Product proposal P2	Product proposal P3
A01	1, 2, 3, 4, 5	3, 3, 3, 2, 4	3, 4, 5, 3, 0	5, 1, 3, 3, 3
A03	1, 2, 3, 4, 5	1, 0, 2, 6, 7	1, 2, 5, 5, 2	0, 2, 1, 6, 6
A05	1, 2, 3, 4, 5	1, 1, 2, 9, 2	0, 1, 6, 5, 3	1, 3, 6, 1, 4
A08	1, 2, 3, 4, 5	0, 3, 1, 7, 4	0, 4, 5, 2, 4	2, 2, 3, 4, 4
A10	1, 2, 3, 4, 5	0, 1, 4, 4, 6	0, 3, 5, 6, 1	1, 2, 9, 3, 0
A12	1, 2, 3, 4, 5	0, 3, 8, 3, 1	1, 1, 3, 7, 3	1, 6, 2, 3, 3
A14	1, 2, 3, 4, 5	0, 1, 3, 4, 7	1, 2, 5, 5, 2	0, 4, 6, 3, 2
A16	1, 2, 3, 4, 5	0, 3, 3, 6, 3	0, 2, 6, 6, 1	0, 5, 1, 5, 4
Total		441	400	395

3 Conclusion and Significance

Recently, all parts of China are in the transformation of the development mode, the supply side of the structural reform background, innovation and lead, cultural win to become mainstream. The Chinese Government and many cities are promoting the redesign of traditional handicrafts. However, most handicrafts still remain at a stage of imitation and relocation of the original forms. The sector has not combined the

demands and aesthetic tastes of the contemporary consumers. This thesis seeks to explore the approaches of redesign for traditional handicrafts to remove the obsolete elements and embrace the new ones. It employs the design approach with customer (users) involvement, and strives to achieve the combination of traditions and contemporary trends, so as to cater to the demands by the present-day consumers and the current trends. Additionally, through the concluded data of the design case, traditional handicrafts can gain greater popularity with consumers with the addition of practical functions. Given the transformation of traditional culture for innovations, it is a mission for modern design to renew traditional products from their original statuses. Meanwhile, this thesis also provides reference of methodology for the redesign of traditional handicrafts.

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Integrated Design

Modeling the Relationship Between Stress and Appetite to Create a Dish Recommendation System Based on Desired Nutrients

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Abstract. Using decision trees, we investigated the relationship between stress condition and the nutrients contained in the consumed foods during the stress condition. The objective of this study is to develop a prospective dish recommendation system. Some explicit analyses of the nutrients preferred by people with high stress condition were performed. Thus, we were able to find the possibility of a dish recommending system based on nutrients and stress level.

Keywords: Dish recommendation system · Food preference analysis · SPSS · MBP · Nutrients

1 Introduction: General Concept of Dish Recommendation System

Policies regarding lifestyle disease preventions have recently been introduced in many countries, and dish recommendation systems of them have been proposed to facilitate dietary modification [1, 2]. These recommendation systems can help ordinary users without specialized knowledge to easily choose daily meals with well-balanced nutritional contents. However, people often desire specific dishes related to their current stress condition, and additional stress can be created if these desires are not addressed [3].

Therefore, the present study aimed to evaluate the relationship between stress and the nutrients in the desired dishes, in order to facilitate the development of a dish recommendation system that takes stress levels into account.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_40

2 Future Work: Dish Recommendation System Using Wearable Device

We are currently developing a dish recommendation system using wearable devices [4]. This research is a basic research for the developing system.

The system is for recommending the most satisfying food of eaters. Thus, we adopt the algorithm to estimate user's food preference of the moment. In the algorithm calculation, user's nutrient adequacy will be used for score calculation model as usual studies [5]. However, because the mental status of the user is not taken into consideration in the conventional method, it is impossible to accurately estimate user's food preference of the moment. Therefore, we are considering using the wearable device to estimate user's real-time mental status, in particular the stress condition in which has been revealed the influence on food preference [6, 7], and use it for weighting in score calculation model. In this study, we investigated the relationship between stress condition and nutrients in the desired dish in order to examine the nutrients weighing according to stress condition.

3 Experiment: Stress Measurement and Desired Dish Survey

The experimental time was set between 15:00 and 17:00 which minimize the effect of hunger and satiety, and 14 experiment participants were selected in this study. In order to control conditions other than stress, the experiment participants unified to healthy male college students.

First, in order to measure the degree of stress, we measured the following two factors:

- Subjective Psychological Stress Score (SPSS; scores of 0–172 points), based on the "Ministry of Health, Labor and Welfare Version Stress Check Implementation Program (Fig. 1)"
- Mean Blood Pressure (MBP).

Generally, stress is classified as two: chronic stress and acute stress. Although two stresses are not in independence relation, each has a different influence on food preference [6, 7].

In the context of this experiment, the SPSS reflects the participant's subjective inner feelings, although different subjects can have varying SPSS scores, which can also reflect their long-term mood. In contrast, MBP is an objective variable as following equation (A) and reflects the patient's immediate physiological stress during the experiment [8].

$$\text{Mean Blood Pressure} = \text{Diastolic Pressure} + \left(\frac{1}{3} \times \text{Pulse Pressure}\right). \quad (1)$$

$$\text{Pulse Pressure} = \text{Systolic Pressure} - \text{Diastolic Pressure}. \quad (2)$$

Therefore, we included both variables as indicators of stress.

Please answer the following questions concerning your health during the past month by circling the number that best fits your situation.

	Almost never	Sometimes	Often	Almost always
18. I have been very active	1	2	3	4
19. I have been full of energy	1	2	3	4
20. I have been lively	1	2	3	4
21. I have felt angry	1	2	3	4
22. I have been inwardly annoyed or aggravated	1	2	3	4
23. I have felt irritable	1	2	3	4
24. I have felt extremely tired	1	2	3	4
25. I have felt exhausted	1	2	3	4
26. I have felt weary or listless	1	2	3	4
27. I have felt tense	1	2	3	4
28. I have felt worried or insecure	1	2	3	4
29. I have felt restless	1	2	3	4
30. I have been depressed	1	2	3	4
31. I have thought that doing anything was a hassle	1	2	3	4
32. I have been unable to concentrate	1	2	3	4

Fig. 1. The questionnaire of "Ministry of Health, Labor and Welfare Version Stress Check Implementation Program [9]" (Excerpt)

Second, in order to investigate the food preference during a stress period, we administered another questionnaire survey.

The participants' desired dishes were evaluated based on their responses to a questionnaire survey that asked them to select five dish menus that "I want to eat right now" from a list of 62 staple dish menus (Fig. 2) that are listed in the "AJINOMOTO PARK (Recipe Encyclopedia) [10]" released by Ajinomoto Co., Inc. and "Rakuten Recipe [11]" released by Rakuten, Inc. Because "AJINOMOTO PARK (Recipe Encyclopedia)" and "Rakuten Recipe" are Japanese major WEB services used for searching a staple dish, and have already classified representative staple dishes, we used the staple dish menus.

4 Results and Analysis

We categorized the questionnaire results based on total 70 nutrients from the "Dish Nutritional Value Database [12]" provided by Eat Smart Inc., and created decision trees with the explanatory variables indicating specific nutrients. The decision tree was generated by default command of "rpart" package and "partkit" package of statistical analysis software "R" [13, 14]. The decision trees included the objective variables (SPSS and MBP), and were structured according to nutrients and degrees of stress.

Fig. 2. Questionnaire for desired dishes (Excerpt)

4.1 Relationship Between SPSS and MBP

We examined the correlation between SPSS and MBP, and found that the correlation coefficient was 0.67. This result may indicate that a subjective feeling of fatigue is moderately correlated with increased blood pressure.

4.2 Relationship Between SPSS and Desired Nutrients

The main categories of the SPSS decision tree (Fig. 3) were as follows:

(1) Dishes with <0.9 g of salt and <0.75 g of ash were associated with the highest SPSS (median: 81 points). Dishes with <0.9 g of salt and >0.75 g of ash were associated with the second highest SPSS (median: 73 points).
(2) Dishes with >0.9 g of salt and >173.45 g of water were associated with the third to fifth highest SSPS, according to their proline and potassium content (median scores: 66 points, 57 points, and 48 points, respectively).
(3) Dishes with >0.9 g of salt and <173.45 g of water were associated with the lowest SPSS (median: 48 points).

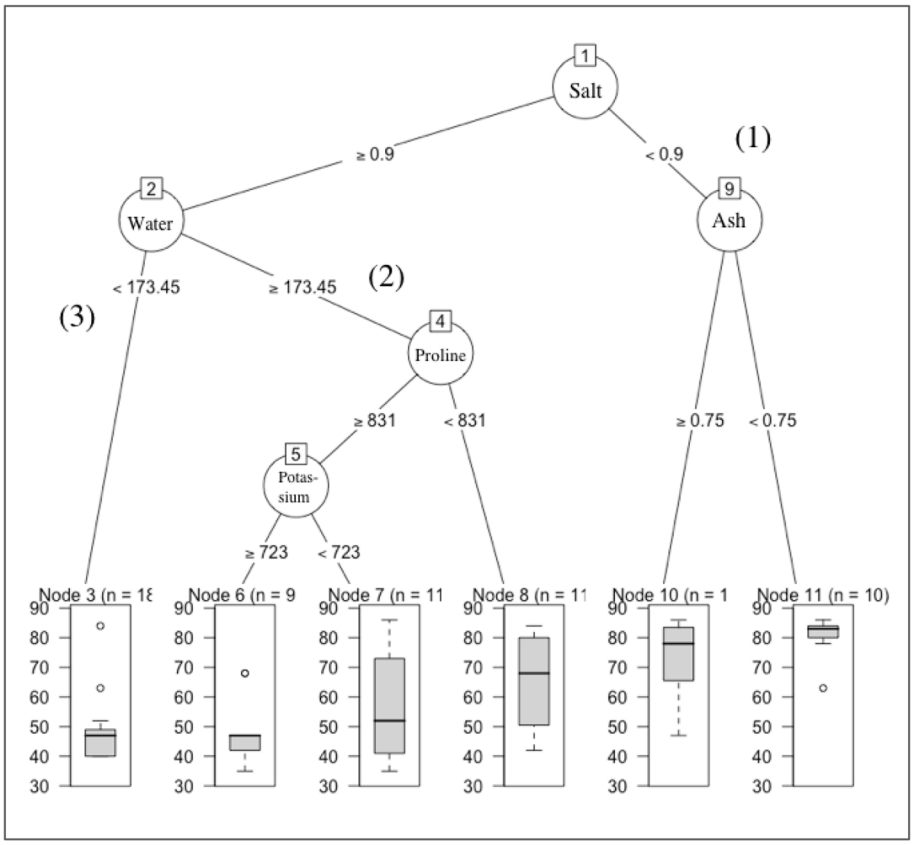

Fig. 3. Pruned Subjective Psychological Stress Score (SPSS) decision tree

Because it has been reported that humans tend to overdose salt when mental stress accumulates, Branch (1) appears to be irrational [15]. However, the content of the questionnaire response included in the first right branched category of (1) was desserts such as pudding and ice cream. Generally, it is well known that snacking increases when mental stress accumulates [7]. It appears that this branch reflects this snacking trend. At the second branch of (1), the branching ash is the main component of wheat flour, such as, cakes and donuts. Considering the branch, it is assumed that further detailed branching corresponding to stress levels is necessary for snacking classification.

The dishes in Branches (2) and (3) were most likely to be soups and pots. Further-more, it has been reported that soup dish, with low relation with proline and potassium in the investigation, produces a feeling of relief and has the effect of relieving stress [16]. The subjective expectation for that effect appears to have influenced Branch (2).

4.3 Relationship Between MBP and Desired Nutrients

The main categories of the MBP decision tree (Fig. 4) were the following:

(1) Dishes with >7.2 g of sucrose were associated with the highest BMP (median: 93 mmHg).
(2) Dishes with <7.2 g of sucrose were associated with the second to sixth highest MBP, according to the arginine, glycine, phosphorus, and alanine contents (median: 93 mmHg, 89 mmHg, 84 mmHg, 81 mmHg, and 78 mmHg, respectively).

As sucrose is the main ingredient of sugar, as with (1), the branch of (4) or (5) may be related to differences in eating behaviors such as snacking or having a meal.

The findings from the branch of (5) are more difficult to interpret, although high stress levels may be associated with dishes that contains glycine (antioxidant activity), alanine (highly correlated with vitamin B1), and niacin (antioxidant activity). Therefore, participants high MBP may have sensibly selected dishes that contain nutrients that are suited to their stress levels, although this point remains debatable.

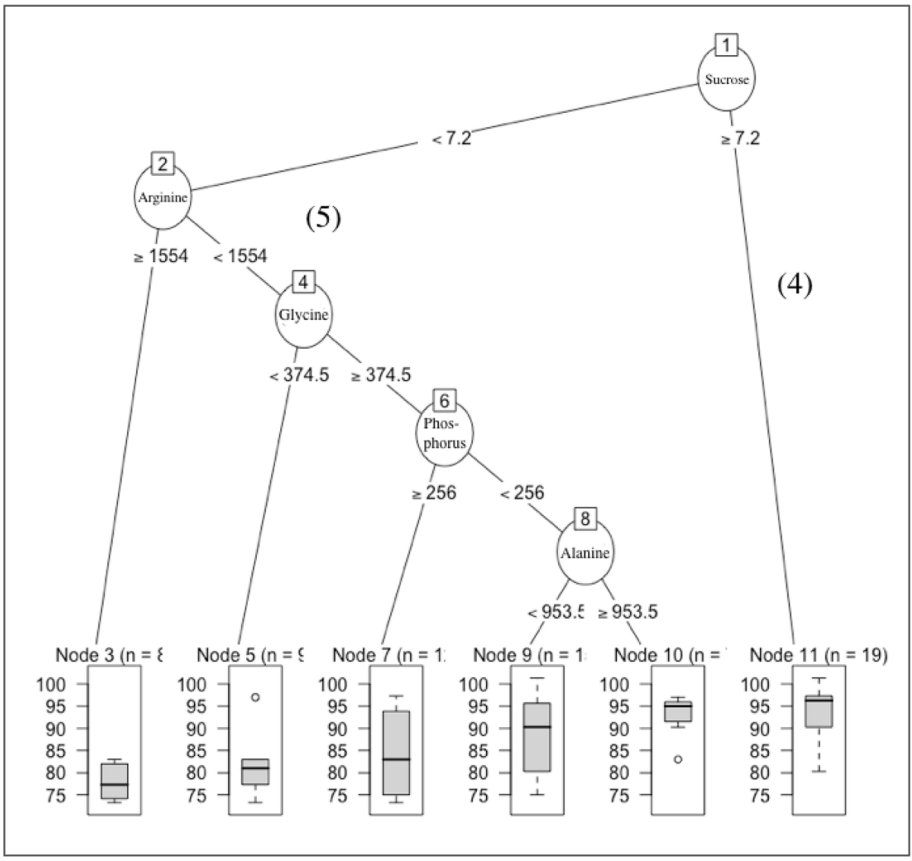

Fig. 4. Pruned Mean Blood Pressure (MBP) decision tree

5 Discussion

The investigation using decision trees showed that food preferences change according to stress conditions. In view of the result and analysis of the decision tree, it seems that several factors are intertwined in a complex manner in the food preference model that changes according to stress conditions. However, assuming that food preference is a combination of several simple factors for convenience, we can extract the representative features from decision trees and arrange the factors as follows:

- A person with high stress levels is likely to eat snacks, and there is a possibility that the tendency of picked snacking changes according to the stress condition [7, 15].
- A person with high stress levels is likely to choose a food containing nutrition with reward effect, such as sucrose [7].
- A person with high stress levels is likely to choose a hot-watery dish such as a soup and pot [16].

Several other trends were noted, but analyzing all of them falls outside the scope of this study.

In the mouse experiment, many of its food preference has been elucidated. However, regardless of the characteristics of the food, human experience often determines the likes and dislikes of food [17]. Therefore, in addition to a common analysis of food tendency, individual analysis is necessary as well.

6 Conclusions

The present study examined the preferences of people with high stress for specific dishes, as well as the nutritional components of those dishes. These analyses may facilitate the development of dish recommendation systems based on nutrients and subjective/objective stress levels. This type of system would be further improved by acquiring detailed nutritional data through the use of food logs, as well as stress-related data using wearable monitoring devices.

Acknowledgements. This work was partially supported by JSPS KAKENHI grants (No. 25240043) and TISE Research Grant of Chuo University.

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Assessing Symptoms of Excessive SNS Usage Based on User Behavior and Emotion: Analysis of Log Data

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Abstract. The use of social networking sites (SNSs) continues to dramatically increase. People are spending unexpected and unprecedented amounts of time online. Such excessive and compulsive use has been categorized as a behavioral addiction. We assessed the symptoms of excessive SNS usage by studying user behavior and emotion in SNSs. In previous studies, we developed a data collection application as a tool for collecting data from questionnaires and SNSs by APIs. We experimentally collected data from undergraduate students at the Thai-Nichi Institute of Technology (TNI), Thailand. To improve our data analysis, we employed web log data and analyzed, including the combination with questionnaires data to clarify SNS usage behaviors and the factors associated with SNS addiction. Our analytical results identified the variables that distinguish excessive users from normal users.

Keywords: Social networking sites · SNS · Social network addiction · User behavior

1 Introduction

Digital technology plays an important role in the daily lives of most of the world's people. Social Networking Sites (SNSs) have exploded as a popular form of communication where groups virtually meet and interact with others who share similar interests [1].

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*, Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_41

A summary of SNS usage by We Are Social [2] reported that in January 2017 about 2.7 billion of the world's 7.4 billion people are active SNS users, which is almost 40% of the world's population. Over 50% of Thailand's population are active SNS users and 96% of her Internet users use SNSs [3]. Thailand's three most popular SNSs are YouTube, Facebook, and Line [3]. The average daily SNS use is almost three hours [3]. Unfortunately, some people spend too much time on SNSs and use them in potentially deleterious ways. Many studies [1] have warned about the negative consequences of excessive SNS usage, including the risk of addictive behavior.

This research studied user behavior and emotion related to SNS usage to assess the symptoms of excessive usage. We divided our research into the following four main stages:

1. Collect SNS user behavior data
2. Clarify the characteristic of SNS usage and their relationships
3. Estimate user emotions of SNS usage using biological signals
4. Detect symptoms of excessive SNS usage.

In the first stage, we previously designed and developed a data collection application as a tool for collecting SNS user behavior data from questionnaires and SNSs by APIs [4, 5]. The questionnaires gathered user experiences with SNSs. Modified IAT and BFAS were employed as part of a questionnaire to measure SNS addiction. APIs directly retrieved data from SNSs. The data were collected from 177 student volunteers at the Thai-Nichi Institute of Technology (TNI), Thailand. Figure 1 illustrates the procedures for collecting the SNS data.

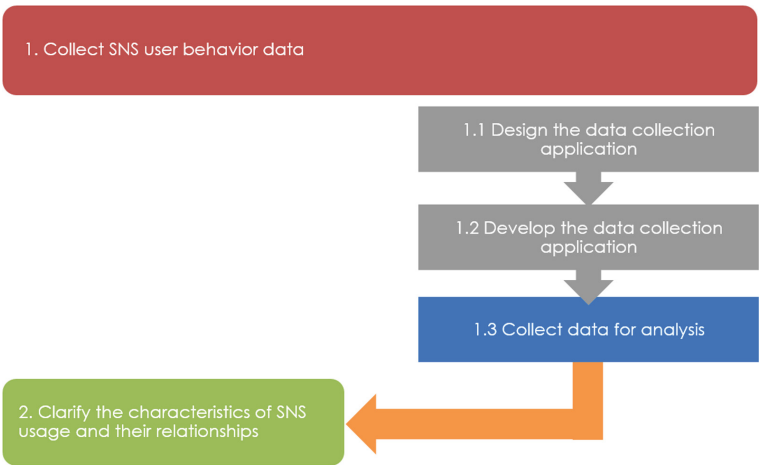


Fig. 1. Procedures for collecting SNS data

In the second stage, we analyzed the data obtained by the application to clarify the characteristics of SNS usage and their relationships. The analysis results identified the potential candidates of the key components of SNS addiction [6, 7]. To improve our

data analysis, we employed web log data that reflect the usage behaviors of accessing websites by multiple users. In this article, we introduce our analysis of web log data, including a combination with questionnaire data for identifying the factors associated with SNS addiction.

We will apply our analysis results for detecting the symptoms of excessive SNS usage and developing prevention strategies for increasing the awareness of excessive SNS usage.

2 Literature Review

2.1 SNS Addiction

Many studies have argued that excessive SNS usage can cause such negative consequences as relational, performance, health-related, and emotional problems, including the risk of addiction. Excessive and compulsive SNS use has also been linked to behavioral addictions [8].

Internet addiction is one type of behavioral addiction. Young [9, 10] identified five types of internet addiction: computer addiction, information overload, net compulsion, cyber-sexual addiction, and cyber-relationship addiction. SNS addiction falls in the last category [1]. Since Facebook has become one of the world's most commonly used Internet sites, addiction to it might be a specific form of Internet addiction [11].

SNS addiction shares similarities with other behavioral addictions [1, 8]. Kuss and Griffiths [1] argued that the symptoms of SNS addiction resemble the symptoms of other addictions. The following are the addiction components from a biopsychosocial perspective [11]:

1. Salience: behavioral, cognitive, and emotion preoccupation
2. Mood modification: engagement that modifies/changes emotional states
3. Tolerance: increased amount of time spent on it
4. Withdrawal: unpleasantness when the use is restricted
5. Conflict: relationship problems with family and friends because of usage
6. Relapse: failure to avoid use.

2.2 Data Collection Application

In previous studies [4, 5], we designed a data collection application and developed a tool for collecting SNS data from questionnaires and SNSs by APIs.

Questionnaire. Questionnaires are a part of our data collection application with which we gather user SNS experiences [4]. We employed the Internet addiction test (IAT) [12] and the Bergen Facebook addiction scale (BFAS) [11] to reflect addictive behaviors.

IAT is a 20-item questionnaire [12] that measures the characteristics and the behaviors associated with compulsive Internet use. IAT is scored on a 6-point Likert scale and results in four levels: none, mild, moderate, and severe.

BFAS, which is a six-item questionnaire [11] that assesses Facebook addiction in epidemiology studies and clinical trials, is scored on a 5-point Likert scale and broken down into normal and excessive users.

SNS APIs. We directly retrieved Facebook, and Twitter data through Graph APIs and REST APIs, respectively. We implemented Facebook and Twitter quizzes that asked such questions as "How often do you tweet?" as part of our data collection application. When users completed the quizzes, the data are retrieved by APIs [13].

In previous studies [6, 7], we experimentally collected data from undergraduate students in Thailand to determine their SNS usage variables and clarify the relationships between them and the factors associated with SNS addiction. Our analytic results identified potential candidates of the key components of SNS addiction.

In this study, we combined the data obtained by questionnaires with web log data and analyzed them to identify the factors associated with SNS addiction.

3 Methodology

3.1 Dataset

We collected a dataset of web log files from the Thai-Nichi Institute of Technology over a 38-day period (January 4 to February 10, 2017). Web log file records access to websites including SNSs by multiple users and reflects usage behaviors.

Data Description. There are two types of data: web usage and detailed usage of users. Web usage summarizes the access of websites by all the users in such different dimensions as browsing time, internet bandwidth usage, and top visited websites. User detailed usage includes the activities of individual users across multiple websites. The data contain information of the host IP addresses/user IDs, hostnames of accessed websites, and timestamps.

Data Limitation. The data available from the detailed usage of users do not provide information of page views. These data only contain the hostnames of the accessed websites, which are insufficient for describing the types of usage behaviors in detail. Moreover, such detailed usage data are from LAN connections, which do not represent all user activities.

3.2 Defining Session Characteristics

We defined session characteristics in the dataset by examining the number of sessions and their duration for each user.

Session Identification. Session identification categorizes the different activities performed by each user and segments them into individual access sessions. If the activities are not connected to previous activities or if there is more than a 30-minute delay (based on previous empirical findings [14]) between activities, then it is defined as a different session.

Session Characteristics. We segmented the detailed usage data of users as sessions for each user and calculated the number of sessions and their durations between the first and last activities within a session.

Table 1 shows an example of defining the session characteristics from the dataset. User AAAA has two sessions. The first and second activities are defined as the same session (A) with a 14-minute-time difference, and four activities (from three to seven) are defined as the same session (B) with a 9-minute-time difference.

Table 1. Example of defining session characteristics

#	User ID	Action times	Time differences (minutes)	Session IDs
1	AAAA	2017-01-26 10:21:51	N/A	A
2	AAAA	2017-01-26 10:36:38	14	A
3	AAAA	2017-02-01 10:17:04	N/A	B
4	AAAA	2017-02-01 10:18:13	1	B
5	AAAA	2017-02-01 10:19:17	1	B
6	AAAA	2017-02-01 10:23:50	4	B
7	AAAA	2017-02-01 10:27:18	3	B

4 Results

4.1 Overall SNS Usage

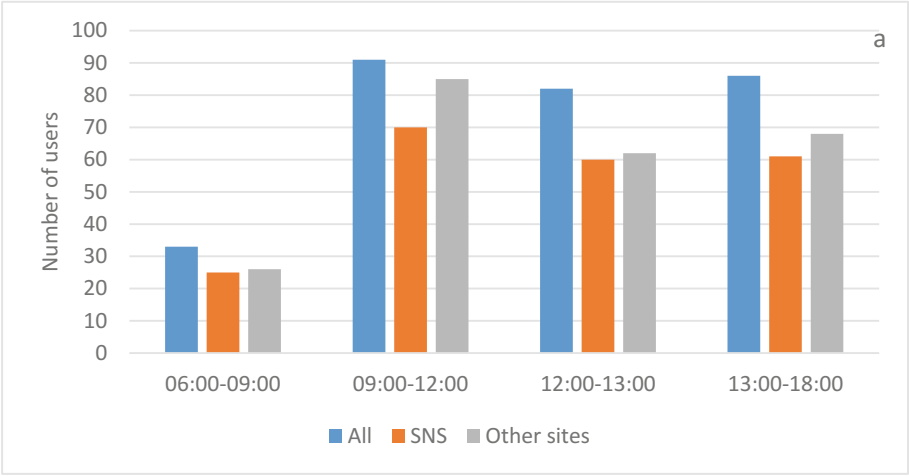
We summarized the usages of 4,191 users over a 38-day period as web usage data. The total browsing time from the top 50 sites was 25,864 h, 26 min, and 32 s or about six hours per user. 40% of the browsing time used SNSs. The top SNSs were Facebook, Twitter, Line, Google Plus, and LinkedIn. For Facebook, users spent 9,537 h, 12 min, and 44 s or about two hours per user.

4.2 User Activities

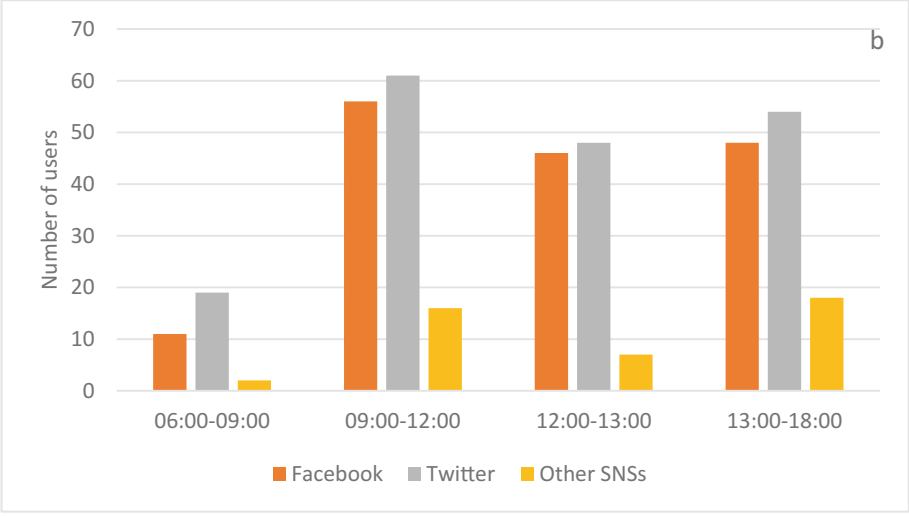
The dataset of the detailed usage of the users we analyzed came from 96 participants of previous experiments [6, 7]. The session characteristics were defined to represent the activities of each user.

SNS Usage. An overwhelming majority of the users (96.88%) visited SNSs. They also visited Twitter (89.58%), Facebook (82.29%), and other SNSs (35.42%). In terms of time spent, 29% of their browsing time was on SNSs: Twitter (65%), Facebook (35%), and others (2%).

Usage Period. Figure 2 shows that the top usage period was between 9:00–12:00 for all sites and SNSs, and there was no usage after 18:00. Fewer users visited SNSs than other sites in all periods. There were also more Twitter than Facebook users in all periods.



(a) Comparison among all sites, SNSs, and other sites



(b) Comparison among Facebook, Twitter, and other SNSs.

Fig. 2. Number of users in each usage period

To compare the usage in each period, we calculated the number of sessions per hour as normalized values due to the different length of each period. Figure 3 shows the normalization of the number of sessions in each usage period. The highest number of sessions was during the 12:00–13:00 period, and the lowest number was during the 6:00–9:00 period for all sites, SNS sites, Facebook, and Twitter.

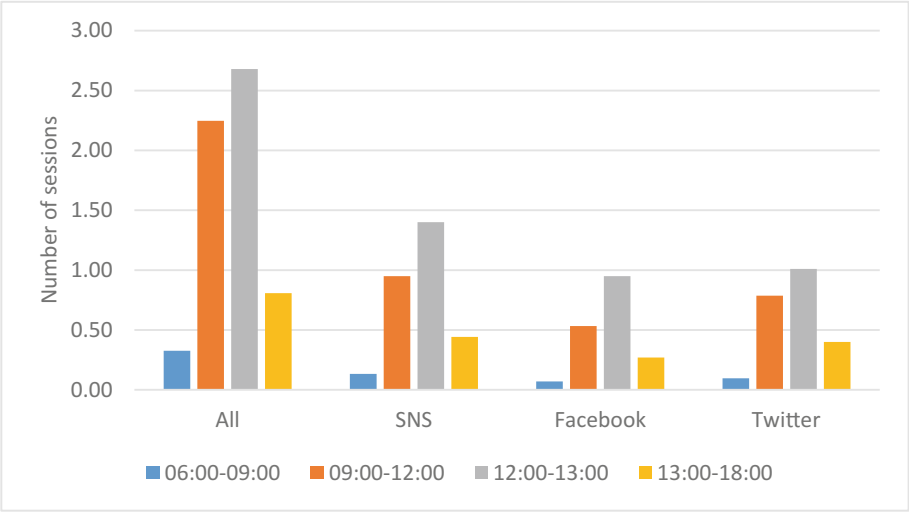


Fig. 3. Normalization of number of sessions in each usage period

4.3 Relationships Among Variables

By defining the session characteristics, we obtained the following variables from the web log data: number of sessions, time spent, and number of sessions in each usage period.

We performed a Spearman's correlation analysis to measures the strength and the direction of the monotonic relationships between two variables. The Spearman's correlation coefficient (r_s) ranged from −1 to +1, where −1 indicates a perfect negative association of variables, +1 indicates a perfect positive association, and 0 indicates no association. The r_s values between the variables are shown in Table 2.

For the relationships between the number of sessions and time spent, the correlation analysis indicated a strong correlation for Facebook ($r_s = 0.718$, $p < 0.01$) and Twitter ($r_s = 0.746$, $p < 0.01$), and moderate correlation for all other sites ($r_s = 0.463$, $p < 0.01$).

For the relationships between time spent and usage period, we found a strong correlation in the 13:00–18:00 period ($r_s = 0.557$, $p < 0.01$) and moderate correlation in the 06:00–09:00 period ($r_s = 0.353$, $p < 0.01$) for all sites. For Facebook, we found a strong correlation in the 13:00–18:00 period ($r_s = 0.531$, $p < 0.01$) and moderate correlation in the 09:00–12:00 ($r_s = 0.486$, $p < 0.01$) and 12:00–13:00 periods ($r_s = 0.358$, $p < 0.01$). For Twitter, we also found strong correlation in the 13:00–18:00 period ($r_s = 0.541$, $p < 0.01$) and moderate correlation in the 09:00–12:00 ($r_s = 0.391$, $p < 0.01$) and 12:00–13:00 periods ($r_s = 0.385$, $p < 0.01$).

For the relationship between using Facebook and Twitter in each period, the correlation analysis indicated strong correlation in the 13:00–18:00 period ($r_s = 0.757$, $p < 0.01$) and moderate correlation in the 09:00–12:00 ($r_s = 0.453$, $p < 0.01$) and 12:00–13:00 periods ($r_s = 0.468$, $p < 0.01$).

Table 2. Relationship among variables by Spearman's correlation analysis

Comparison pairs	Correlation coefficient (r_s)
Number of sessions and time spent	
All sites	0.463**
Facebook	0.718**
Twitter	0.746**
Time spent and usage period	
All sites	
06:00–09:00	0.353**
09:00–12:00	0.237**
12:00–13:00	0.291**
13:00–18:00	0.557**
Facebook	
06:00–09:00	0.122
09:00–12:00	0.486**
12:00–13:00	0.358**
13:00–18:00	0.531**
Twitter	
06:00–09:00	0.217
09:00–12:00	0.391**
12:00–13:00	0.385**
13:00–18:00	0.541**
Use of Facebook and Twitter in each period	
06:00–09:00	0.251*
09:00–12:00	0.453**
12:00–13:00	0.468**
13:00–18:00	0.757**

**Correlation is significant at 0.01 level (2-tailed)

* Correlation is significant at 0.05 level (2-tailed)

4.4 SNS Usage and Addiction

We also analyzed the web log data, including a combination with the data obtained from questionnaires, to identify the factors associated with SNS addiction. We used the IAT and BFAS results from the questionnaires for measuring SNS addiction based on the results from a previous study [6].

According to the definition of the original IAT level, we labeled participants as *excessive* users if their scores appeared in each level of the Internet addiction (mild, moderate, and severe) and the others as *normal* users. The original BFAS also classified users this way.

Normal and Excessive Users. According to the IAT results, 52.63% were excessive users and the others were normal users. For the BFAS results, 54.74% were excessive user and the others were normal users.

Location and Device for Accessing SNSs. 84.21% of the users accessed SNSs from their university (TNI). The number of excessive users who accessed SNSs from TNI exceeded the number of normal users. The number of excessive users who accessed SNSs by computer also exceeded the number of normal users. Chi-square analysis results indicated that accessing SNSs from their university was significantly different between normal and excessive users classified by IAT ($p < 0.05$) with a medium effect (contingency coefficient = 0.310). On the contrary, our analysis results indicated that accessing SNSs by computer had no significant difference between normal and excessive users for both IAT and BFAS.

Usage Period and SNS Addiction. To examine the relationships of SNS addiction with usage periods, we employed the Mann-Whitney U Test. As shown in Table 3, the number of sessions that accessed SNSs during the 09:00–12:00 period was significantly different for both the IAT ($z = -2.038$, $p < 0.05$) and BFAS levels ($z = -3.105$, $p < 0.05$). The number of sessions that accessed Twitter during the 09:00–12:00 period was also significantly different for both the IAT ($z = -2.123$, $p < 0.05$) and BFAS levels ($z = -3.341$, $p < 0.05$). These results indicated significant differences between the 09:00–12:00 period and the number of sessions that accessed Facebook for the BFAS level ($z = -2.526$, $p < 0.05$).

Table 3. Mann-Whitney U Test for number of sessions in each usage period

Variables	Z-value	
	IAT	BFAS
Number of sessions in each usage period		
All SNSs		
06:00–09:00	−0.057	−1.707
09:00–12:00	−2.038*	−3.105*
12:00–13:00	−0.009	−1.723
13:00–18:00	−0.194	−0.076
Facebook		
06:00–09:00	−0.697	−0.634
09:00–12:00	−0.782	−2.526*
12:00–13:00	−1.483	−1.577
13:00–18:00	−0.564	−0.430
Twitter		
06:00–09:00	−0.181	−1.412
09:00–12:00	−2.123*	−3.341*
12:00–13:00	−0.367	−1.255
13:00–18:00	−0.080	−0.43

*Significant at 0.05 level (2-tailed)

5 Discussion

Our descriptive analysis results indicated that SNS usage by all users as well as specific users was different. For all users, 40% of their browsing time accessed SNSs, and Facebook was the top SNS. For specific users, 29% of their browsing time accessed SNSs, and Twitter was the top SNS. The differences in our findings might reflect the limitations of the detailed usages of users that can only capture the activities by LAN connection, which does not represent all user activities.

In terms of the relationships among variables, we found a correlation between the number of sessions and the time spent. There were also correlations between time spent and each usage period.

As for the combination of the variables from the web log data and the questionnaire data, the Mann-Whitney U test indicated that the usage in the 09:00–12:00 period distinguished excessive from normal users. Unfortunately, due to data limitations, we cannot identify the candidates of the key components for SNS addiction.

6 Conclusion

This research assessed the symptoms of excessive SNS usage by studying user behavior and emotions in SNSs. We analyzed a dataset of web log files collected from a university in Thailand that included a combination of data from questionnaires to clarify SNS usage behaviors and factors associated with SNS addiction. This study's analytical results identified the variables that distinguish excessive users from normal users. Even though the web log data were insufficient to capture all of the user activities due to data limitations, our results identified the differences between excessive and normal users.

Using these results, including the analysis of the data obtained by questionnaires and SNS APIs from previous studies, we will clarify the characteristics of SNS usage associated with SNS addiction. Finally, we will apply our analytic results for detecting the symptoms of excessive SNS usage and use our research's outcome for developing prevention strategies to increase the awareness of the risks of excessive SNS usage.

Acknowledgements. We thank Dr. Thongchai Kaewkiriya, the Head of Information and Communication Center, Thai-Nichi Institute of Technology (TNI) for the web log data dataset. We also thank the TNI students who volunteered their web log data.

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Transformable Camping Cart Design for a Jack Company

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Abstract. For fuel efficiency and long-distance driving, it is important to reduce vehicle weight. This pushes car manufacturers to replace extra weighted components, such as spare tires and jacks, with light and disposable ones. However, this trend is a crisis for companies manufacturing extra components for cars. It is crucial for car manufacturing companies to find new business opportunities based on their existing technologies. This paper shows how design can contribute to new business development for a company facing such a crisis. To this end, we developed a new item for a jack manufacturer, focusing on applying the manufacturer's proprietary technology. In the design research stage, we analyzed social trends and the strengths, weaknesses, opportunities and threats of the manufacturer and its technologies. As such, we designed a deformable camping cart using the jack's mechanism to minimize the obstacles and discomfort that campers faced during use of the camping cart. Our study suggests that design offers the capability to produce new products and the potential to create new markets for B2B suppliers with their own production technology. In addition, there is a higher possibility of design concept realization when a design project starts with existing technology than when it relies mainly on market and user research. We hope this study provides insights into new product development through a design process for B2B suppliers.

Keywords: New business opportunity · Deformable camping cart · Ergonomic design

1 Introduction

The present manufacturing industry of Korea is in crisis. According to recent report by Goldman Sachs, the profitability of the manufacturing industry of Korea has declined, and a phenomenon of decreased exports has occurred [1]. Therefore, it is highly expected that the small and medium companies that have difficulty with new product R&D will collapse along with the large companies. Due to this situation, we intended to find possibilities to provide new business opportunities for production-based companies that were suppliers of large companies and had not before used a design-oriented approach. In this paper, we present a case design project in which we applied a design approach to find a new business opportunity for a jack manufacturer. In this project, we

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_42

cooperated with SAMKI IND CO. LTD., a manufacturing company of automobile jacks. A jack is a device used to lift up a vehicle from the ground. Recently, automobile manufacturing companies have reduced orders for production of automobile jacks because they want to produce lighter cars to fulfill social and global environmental requirements. The regulations for automobiles have become strict and stringent, and low energy consumption has become crucial in order to save energy and reduce CO2 emissions due to the global warming crisis [2]. Light automobiles would have a direct influence on the volume of CO2 gas discharged by cars [3]. Since automobile jacks are made of steel, they are a very heavy accessory. Due to this attribute, the automobile manufacturing industry has begun to replace spare tires and jacks with tire puncture repair kits (see Fig. 1). The second reason for automobile companies to remove jacks is that car drivers do not always know that there is a jack in their trunk. When there is a problem with a tire, most drivers call their insurance company. Due to this situation, automobile companies no longer have a reason to continuously include jacks. This change has a critical impact on companies such as SAMKI.

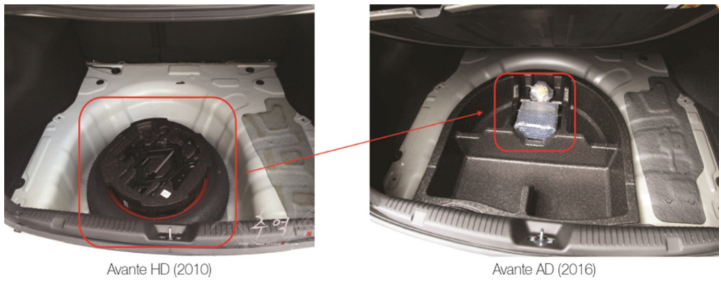

Fig. 1. Example of changes in recent trends of Hyundai Avante Car model 2010 with jack and spare tire, and Hyundai Avante model 2016 comes with puncture repair kit only.

SAMKI IND has made an effort to break down the product line into several product categories. It has begun to produce components for hydrogen fuel tanks. However, the fact that the very existence of SAMKI IND is greatly dependent on changes in the automobile industry has not changed. Due to this situation, SAMKI IND has requested to find and present a new business opportunity to facilitate its accumulated technology and facilities through a design approach.

When this project commenced, we had two inquiries. First, in order to identify a new business opportunity for the automobile jack manufacturing company that belongs to a declining industry, how should the design process be applied? Second, through this new business opportunity, what would the influence of a product be on the company? The first question is important because answering this will give production-based suppliers, such as jack manufacturers, a clue as to how to overcome the current economic crisis. If a company identifies new product or product service opportunities through the design process, it will be able to develop a new business strategy. When you uncover new business opportunities, it is important not to view them as possibilities, but to see if they can actually be commercialized and sold. This is why we have the second question. With these two perspectives, this paper presents the process and the results of the design project.

2 Design Approach

We first visited the company to investigate the company's technologies, facilities and business status. We interviewed employees and the company's CEO in order to understand the company's business situation and direction. We performed a strengths, weaknesses, opportunities and threats (SWOT) analysis of the company and used the seed-need method to identify new business opportunities based on the collected data. The following sub-chapters will introduce the details.

2.1 SWOT Analysis

We conducted a SWOT analysis to identify an appropriate business strategy for the company. Based on the data collected, we analyzed the strengths, weaknesses, opportunities and threats of the company. This was helpful to find out the company's present status and opportunities for the future in a balanced way. This analysis showed that the company's advanced production technology is an important asset (see Table 1). Weaknesses and threats that we discovered are related to the narrow product line-up and limited customers.

Table 1. SWOT analysis of SAMKI industry

Strengths	Weaknesses
- Advanced production technology (patented) - Lots of partner companies - Stable buyers (Hyundai, Kia) - Solid capital	- Small number of products in the line-up - Decreasing profitability - Stable buyers (Hyundai, Kia) - Solid capital
Opportunities	**Threats**
- Few competitors - Emergence of new marketing channels (B to C, online marketing, etc.) - Emergence of new market (Electric/hybrid vehicles, etc.) - Emergence of personal mobility products (Segway, Ninebot, etc.) - DIY trend	- Chinese competitors with cost competitiveness - Decreasing trend of engine-type car manufacturing - Emergence of substitutes for jacks - Decrease of global manufacturing scale

Based on the SWOT analysis, we established new business strategies by integrating the four SWOT categories (see Table 2). Among them, we evaluated that the SO strategy (strengths-opportunities strategy) would have potential for the company because we, along with the client, agreed that the company's advanced production technology should be considered the first factor for developing future business opportunities.

Table 2. Business strategies through SWOT analysis

	Strengths	Weaknesses
Opportunities	- A strategy targeting DIY interior markets with new product development utilizing the advanced production technology - A strategy targeting B-C markets through developing new consumer products	- A strategy targeting a whole new market aside from the current B-B market in the auto industry - A strategy developing goods that are competitive against jacks
Threats	- A strategy developing new items for personal mobility with partner companies	- A strategy developing new items against existing competitive goods

2.2 Seeds and Needs Matrix Method

We used the "seeds and needs matrix" method to identify product opportunities. It is a design method to generate potential design opportunities by matching every element from the "seeds" category with every element from "needs." "Seeds" means technologies or know-how that the company possesses, while "needs" refers to problems that should be solved. In this method, we used a table where the elements of "seeds" were placed in the first column and the "needs" were placed in the top row. In the seeds part, we summarized the company's current production-related technologies and know-how. These include various basic production technologies such as bending, shearing, punching, machining, etc. Jacks and most other SAMKI products are made with sheet metal technology. We saw many gigantic press machines when we visited the company. Furthermore, technology sets or know-how were also included. For example, the company is specialized in producing a light and stable product that can lift up heavy objects. Under the analysis of the seeds, we expected the final outcome of the project to be a form of a product utilizing the company's current technologies and know-how.

Next, we sought "needs" to match the seeds. Since SAMKI considered opening a new B-C market, we searched for people's needs in various everyday activities. These included sports, DIY work, office work, home activities, etc. Among them, we focused on camping because camping has been becoming popular in Korea and the market is growing. In addition, we realized many camping products were produced through sheet metal processing such as pressing, bending, punching and so forth, which are SAMKI's main production technologies. Under this context, we drew the conclusion that SAMKI could use its technology and know-how in the camping goods market.

2.3 Concept Generation

To identify a design opportunity in camping, we needed to understand campers' behaviors and problems. First, we analyzed camping activities through related literature. Then, we experienced camping activities ourselves. Based on this, we generated a

camping journey map to understand actual design problems in camping activities (see Fig. 2). This gave us insightful information about design problems related to camping. In all of the camping activities, we found that a camping cart was an essential piece of equipment that helped campers carry various goods in many situations. In the preparation stage of camping, campers used it to carry foods and camping items at the grocery store. At the camping site, campers used a camping cart to move various items here and there. Based on our analysis, we found characteristics of existing camping carts. Most existing camping carts have a low center of mass to prevent them from tipping over when being pulled over rough surfaces. Because of this, the height is low. This low height causes users to assume an inconvenient posture, lowering their waists each time goods are loaded into or unloaded from the cart. This results in an undesirable experience for users and is one of the reasons users consider camping to be a cumbersome event.

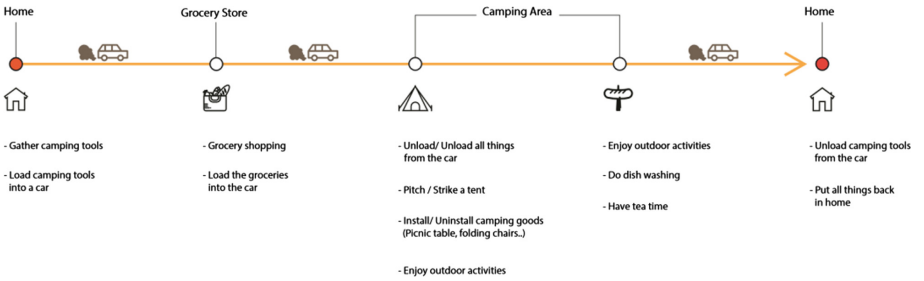

Fig. 2. A typical journey map of campers starts from home to the camping area and return home.

In addition, in some extreme cases, use of a camping cart can cause fatigue and contribute to the development of pain and disorders in the lower back, such as musculoskeletal disorders [4]. This was a good and proper design problem to tackle for the company considering the market and the company's competence. Therefore, we decided to design a camping cart with an adjustable height using the mechanism of the automobile jack. The aim of the design was to minimize the inconvenient posture during the use of the cart.

2.4 Implementation

Based on our analysis of campers' behaviors and competing products, we formulated a design requirement before designing the cart, as follows.

1. It should not be heavier than the existing camping carts in the market (maximum of 20 kg).
2. It should be able to carry as much weight as or more than existing camping carts do (100 kg or heavier).

3. The height should be adjustable to prevent inconvenience to users while loading and unloading camping items.
4. It should be completely foldable to easily set in the car.
5. It should be able to be produced using the technology held by SAMKI.

Based on the design requirements, we began to design the camping cart. First, the size of the camping cart was determined through analyzing different types of camping carts available in the market. Considering the need for users to carry many items at once, a bigger one is better than a smaller one. However, applying the fourth design requirement, the maximum size is constrained by the size of the car trunk. In Fig. 3, the carts that are smaller than 100 kg on the left are the ones that can fit into sedans.

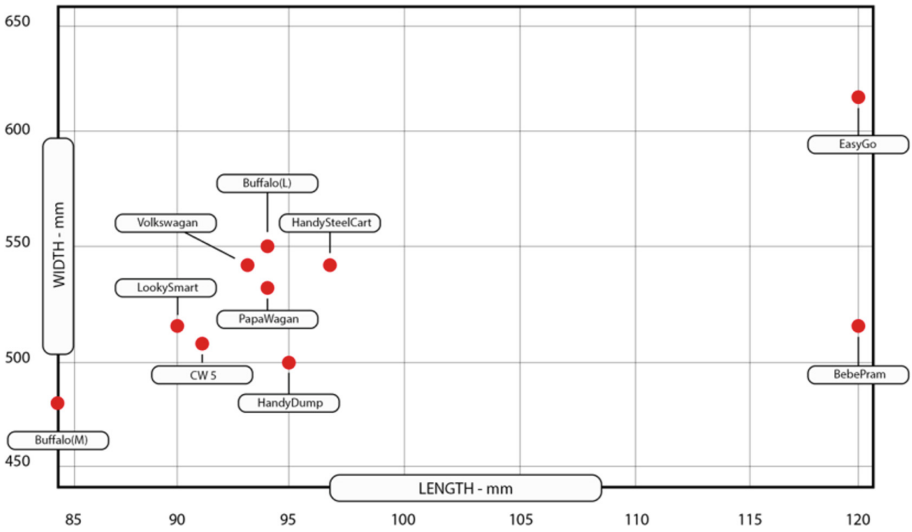

Fig. 3. Survey on the existing camping carts

Based on the determination of the size, we determined the detailed structure and shape by using a CAD program (see Fig. 4). All components of the camping cart were designed to be produced using the company's production technology so that there would be no need to invest in additional manufacturing facilities.

To fulfill requirement 3, we designed a manual adjustable height mechanism. Users can control the height by turning the knob of the cart (see Fig. 5). The cart structure should be simplified to lower the manufacturing cost as well as maintain a light weight. In addition, the basket was designed to be completely foldable. This is advantageous for campers when taking goods out because they do not need to lift the items from the basket.

After defining each part's geometric details, we developed prototypes for the next verification stage (see Fig. 6).

Fig. 4. Rendering images of height adjustable camping cart

Fig. 5. Camping cart with a manual height adjustment

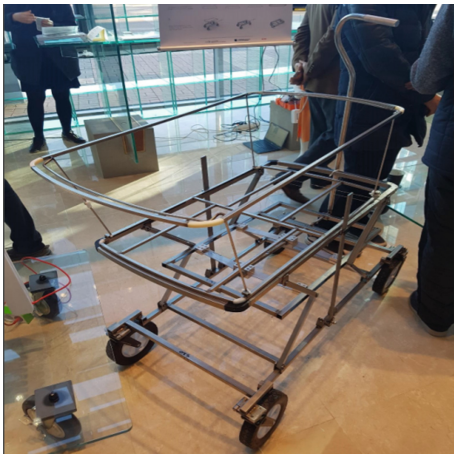

Fig. 6. A working prototype of the camping cart

3 Evaluation of the Prototype

The prototype we manufactured has special functions aside from the common features of existing camping carts. These are the height adjustment function and folding function of the basket. Due to the characteristics of such a design, inconvenience and negative experience for users are reduced, and bodily damage due to inconvenient posture in loading and unloading goods is prevented. In addition, the cart can be manufactured using SAMKI's production facility.

In the final stage, eight external experts assessed the prototype. Two of them were from SAMKI. They commented that the prototype has the potential to pioneer a new market. This could reduce the risk of business expansion because the camping cart can be produced within the current manufacturing facility and using existing know-how. SAMKI managers expressed significant interest in the fact that design had a role in the identification of a new business opportunity based on the company's existing production technology and know-how. The prototype was presented and demonstrated in the executive meeting of the company. After that, the company reviewed business feasibility.

4 Conclusions and Future Development

As we carried out this project, we considered answers to the two inquiries that we had in the early stage of the project.

Q1. In order to identify a new business opportunity for the automobile jack manufacturing company that belongs to a declining industry, how should the design process be applied?

We think it is important to understand the current status of the company first and find out the strengths and weaknesses of the company. Through interviews with managers and employees, we understood the situation and potential of the company. We also determined business strategies based on a SWOT analysis. The "seeds-needs matrix" method provided us with specific design opportunities. We can conclude that appropriate design methods should be used at first to understand a company's status, production facility and technologies.

Q2. Through the new business opportunity, what would the influence of a product be on the company?

The external experts and the company managers agreed that the product has the potential to open a new market. They commented that demonstrating the working prototype helped them better understand the design concept and technology feasibility.

This project is currently in progress. The company is reviewing further development of the product. Some incomplete designs should be revised. The designs had hardly been completed before testing the working prototype. In addition, the user evaluation was not included in the current phase of the project. For further study, a usability test should be conducted. Furthermore, ergonomic analysis is needed to test the influence of the adjustable height function on actual usage.

Acknowledgments. This study is supported by the Ministry of Education and National Research Foundation of the Republic of Korea (NRF-2015S1A5A8010614). The work is also supported by the Promotion of Special Design-Technology Convergence Graduate School of Korea Institute of Design Promotion with a grant from the Ministry of Trade, Industry & Energy of the Republic of Korea (N0001436).

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Integrated Design Process: A Case of Recliner Design

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Abstract. This paper presents a design approach that uses internal functional elements as external form elements through the development of a recliner. This approach has to take more into consideration than conventional methods in the integrated design process, which allows for designing something that offers unique and distinguished implications as the principle of primary function that should be expressed in the form. This integrated approach is expected to serve as a guideline in making a new attempt to design something that removes the boundary between internal design and external design. This should be done by actively integrating the internal function component design and the external design in a product.

Keywords: Integrated design · Product design · Design engineering

1 Introduction

Generally, there are two main approaches in product design: the inside-out approach to create an internal structure with product-working functionality (layout and functional structure), and implement a human using functionality (form, user experience) on working functionality; and the outside-in approach that considers a human using functionality first, and implements the product working functionality elements [1]. Thus, the existing product development approach typically goes through the process of developing and completing the internal and external designs alone. However, using the internal structure as an external element typically increases the overlapping area between the internal and external designs, which makes it difficult to implement alone. In some cases, original design can be achieved by implementing the design process in an integrated approach [2]. That is, a new design principle or form can be achieved when developing internal functional elements and external forms developed in a simultaneous and integrated approach. This study explores the case of a design process in which engineers typically complete the internal design, while the external design is performed by industrial designers, which is naturally done via an integrated approach. To this end, we developed the design of a recliner driven by mechanical configuration.

Unlike other chairs, a recliner allows users to adjust the angles of the backrest and the leg rest. The mechanical functional parts that enable such positions to occur are

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_43

normally hidden on the inside, which is usually wrapped by an exterior cover. Therefore, it is typical to design the internal functioning parts to work as intended, followed by wrapping the exterior with such materials as leather or fabric. This is a typical example of the inside-out design process mentioned by Kim and Lee [1]. On the other hand, you may also design the external use or form before having functional elements arranged on the inside, which is known as the outside-in design approach.

To explore the different processes described above, we have developed a new type of functional chair, using the reclining technology provided by a local company. This paper will describe the processes and results of the inside-out design approach applied to a recliner's design and the integrated design approach featuring the integration of internal design and external design, as well as the experiential lessons and insights gained from carrying out these two processes.

2 Design Progress

Most product designs are completed by cooperation and collaboration between the industrial design and the engineering design [1, 3]. These two design fields engage in different domains [4, 5] and take different approaches [6, 7]. Hubka and Eder [8] defined the product as a technical system. They described the internal properties—such as an operating structure—belong to the engineering designer's domain and the external properties—such as visual elements or user experiences—are the industrial designer's tasks. Describing the inside-out/outside-in approaches by Kim and Lee [1] and based on the definition made by Hubka and Eder, the inside-out approach is to develop the internal properties first and then the external properties, while the outside-in approach is to develop the external properties first and then the internal properties. This paper describes an actual recliner design development case that attempted to integrate these two processes.

For this study, the design project used a case study aimed to develop a functional recliner with market competitiveness and the use of the patents and technologies provided by the local company, which involves not just simple styling or conceptual design but design engineering; that is, the analysis and reinterpretation of the operating mechanism and the redesign of the entire structure.

2.1 Analysis of Testing Prototyping and Working Mechanism

In the initial stage of the project, we were provided with a real model and its design drawing for the purpose of verifying the operating mechanism (see Figs. 1 and 2). The two key technical mechanisms have been adopted to implement this product: The one that reclines the chair backward or unlocks the chair by the motion and force exerted by a user, and the other that transforms the chair to help a user stand up from his or her body weight being exerted on it (see Fig. 2).

The structure of the real model is designed to be slightly transformed by the spring tension while it is fixed by the latch. In addition, if a user exerts force on the footrest and stands with the side lock released, the structure is transformed to rise, which makes it easier for the older adults with weak legs to stand out of the chair (see Figs. 1 and 2).

Fig. 1. Real model of the recliner used for verification of mechanism

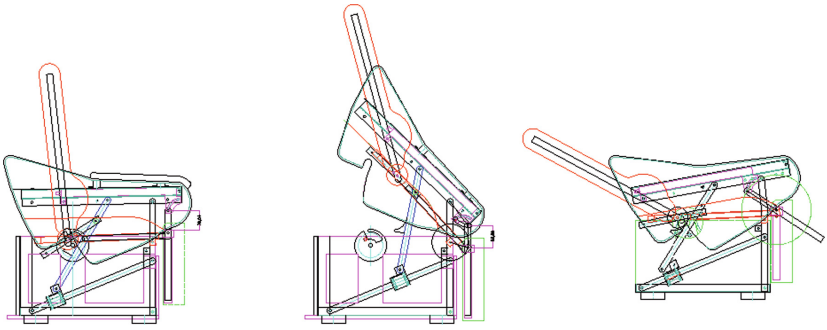

Fig. 2. Basic mechanism of the recliner

The real model for verification (see Fig. 1) has a back function that allows one to sit and stand, but is also a structure built by welding metal parts and tightening bolts; so, we had to work on the internal design and exterior design processes. First, we analyzed and measured the given structure to generate 3D CAD data (see Fig. 3). This digitized data can be easily modified and improved, as opposed to the actual product or drawing. Another advantage is it allows one to perform simulated verification prior to adapting a complete design to the real product.

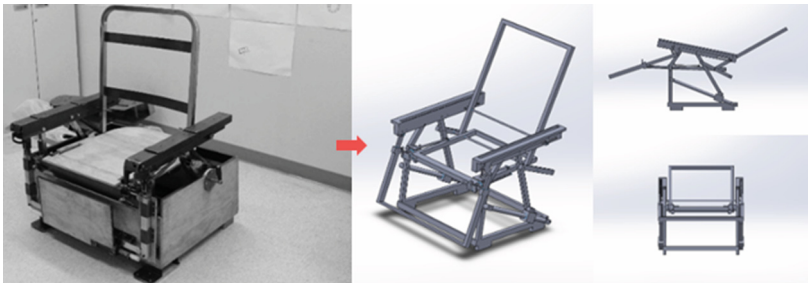

Fig. 3. 3D CAD modeling data of the recliner

We developed a design based on the 3D CAD modeling data. First, we came up with the basic form related to the chair based on the given frame, and then we developed more specific ideas for the external appearance and the internal mechanism of the chair (see Fig. 4). We attempted the inside-out approach, which wraps the exterior of the internal structure, and the integrated approach, which involves the internal and external designs.

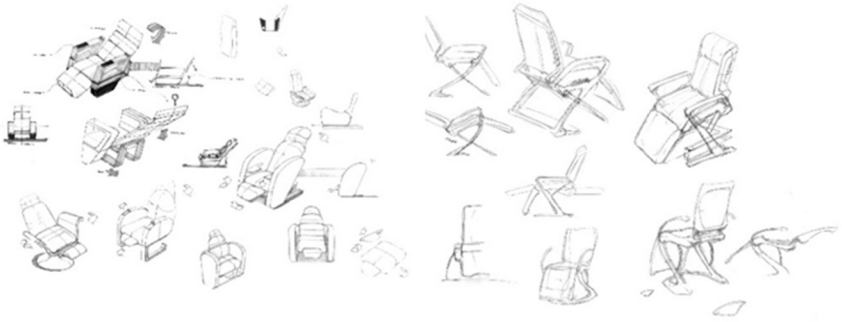

Fig. 4. Stages of developing the recliner ideas

To determine the initial direction of design development, we developed three different types of designs—A, B, and C, as shown in Fig. 5—based on our sketches. Type A and type B have taken the inside-out approach of first defining the internal frame structure and then covering it with exterior material. On the other hand, type C has the internal structure itself reorganized and rearranged with external elements. We decided to proceed with the detail design development for type A and type C upon completion of evaluating the overall design quality with the client.

Type A has taken the inside-out approach that starts with the internal design, followed by the external design based on it, while type C has adopted the integrated design method that performs internal and external designs at the same time. The following is a detailed description of these two design approaches.

Fig. 5. 3D CAD modeling (Type A/B/C)

1. *Type A – Inside-out design process*. Based on the internal structure that is previously been developed, type A had determined the size of the exterior designed to cover the internal structure with the exterior appearance sketched on it. Upon determination of the exterior sketch, a 3D shape has been implemented on the 3D CAD modeling of the internal structure. This is a typical example of the inside-out approach, characterized by designing the internal functional elements followed by the exterior appearance. Figure 6 shows the detailed designing and operating simulation of type A. As illustrated in Fig. 6, type A shows a structure in which the external material wraps around the internal structure.

Fig. 6. Type A detail design and simulation of the recliner

2. *Type C – integrated design.* Figure 7 shows the final result of type C's design. Unlike type A featuring a closed internal structure with the entire internal structure covered by the exterior, this type has attempted to create a visible internal structure, which is also used as an aesthetic element (see Fig. 8). Since this process does not allow external and internal designs to be carried out separately, we had to proceed with an integrated design approach to design both simultaneously.

First, we fixed the original structure components' axes on the drawing of the 3D CAD space and designed the shape of the frame based on it. The original structure has a straight-line frame, as shown in Figs. 2 and 3. Type C's model has been redesigned to have the frame shaped as a curve and to implement movement the same as the original structure by adapting the axes and the motion trajectory to those of the original, though the frame shapes are different from each other.

Type C's development process can be regarded as an integrated design process that simultaneously designs internal and external elements by taking the inside-out/outside-in approach of Kim and Lee [1]. Since the frame of the internal element serves as an external element as well, both elements must be taken into consideration. The structure of

Fig. 7. Completion and drive of Type C design

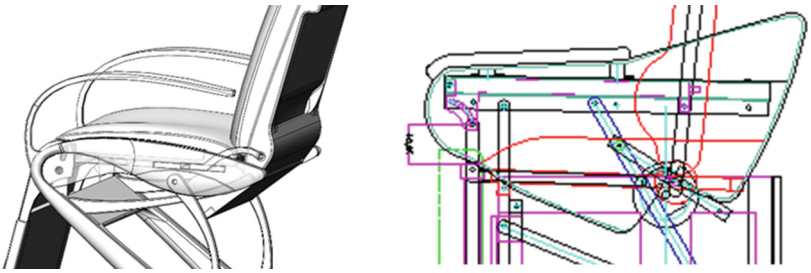

Fig. 8. Comparison of Type C structure and original drawing

type C (left) and the initial structural drawing (right) are presented in Fig. 7. Both have the same mechanism with identical structural movements. Noticeably, however, the forms of structural elements that comprise the mechanism are different.

We sought to implement the functional structure responsible for the movement, while maintaining the structure and movement in the design process. However, a variety of errors caused by changes in operating the structure—including unexpected jams due to distorted form of frame and discrepancies in component size—had to be constantly corrected. These difficulties were inevitably caused by having to consider the operating structure and the exterior at the same time. However, we had relatively fewer difficulties in type A, as the order of defining the internal structure and exterior as part of the inside-out process applied to type A was linear, with elements to be defined and clearly identified.

3 Findings

In general, a product design must take into account the engineering design and the industrial design. This is all the more so for mobile products, such as a recliner, as a variety of impacting factors—including operational orbit, spatial interference by operation, friction, and power transmission, in addition to the arrangement of internal parts—must be considered in a comprehensive manner during the design process.

This study has carried out two different design approaches: (1) the inside-out approach, characterized by designing an internal structure followed by covering it; and (2) the integrated approach that simultaneously designed the internal and the external structures to have the internal structure exposed and used as an external element. Most product developments take the first approach, or the outside-in method, but some products, such as a recliner and other furniture, take the integrated design approach with a positive possibility of implementing new challenging external elements that cannot be easily accomplished by the inside-out or the outside-in approach. This requires designers and design teams to be equipped with a capacity to fully understand and apply the structure while meeting market needs in terms of external appearance.

As in the development of type C, the integrated design approach is suitable to design a product with an external element used as part of the internal structure. Designing the internal structure and the detailed elements of parts with the exterior requires more effort than the inside-out or outside-in approach, where the design process is linearly conducted on a step-by-step basis. Via the step-by-step basis, working on elements one after another opposes carrying out design implementation in an integrated manner. This is because the existing inside-out or outside-in design approach is a method of having the external element match the completed internal structure—or vice versa—while the integrated approach must take all elements of the design process, including internal and external ones, into simultaneous consideration. Therefore, the latter significantly increases the number of elements taken into account by a designer at a given time. On the flip side, it allows the designer to come up with new possibilities when creating something not easily achievable from conventional design approaches. This especially arises from attempts to harmonize the internal structure and the exterior.

4 Discussion and Conclusions

The design approach applied to type C and the like requires not only exterior design competences but a thorough understanding and application of internal functional parts and their structures. Ulrich [9] describes the product development process in six different steps, as illustrated in Fig. 9.

Fig. 9. Ulrich's product development model

In the design of type A, we secured the space for the internal structure, whose dimension is determined in the concept development stage, and then we came up with the external concept that meets the dimensional requirement. Next, we arranged several required parts based on the previously determined concept in the system level design stage. Last, the exterior parts match the internal structures in the detail design stage, followed by defining all parts comprising the chair in a detailed manner. This is a typical example of the linear design process.

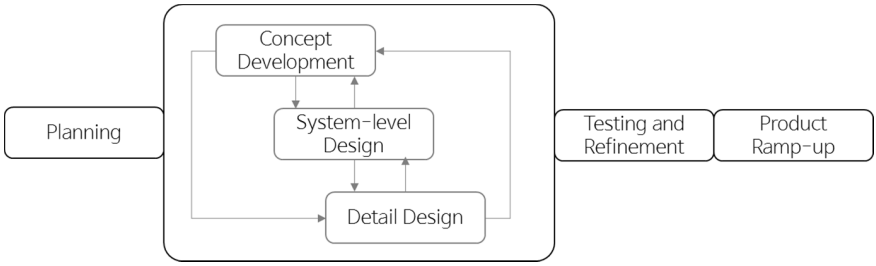

Fig. 10. Integrated design process

On the other hand, the integrated design process applied to type C's design has arranged parts and components to achieve the mobile mechanism, while designing the frame on top of it with the frame serving as a visual exterior element. That is, external design for the appearance of recliner and the system level design that involves arranging parts and components in the concept development stage, determining mutual positions among parts, and determining the interaction design as part of the detail design have been conducted all at the same time. This approach is not certainly understandable with the existing linear processes. The diagram in Fig. 10 illustrates this process.

The integrated design process we attempted incurs difficulties that differ from those of other design methods, as it requires the consideration of various factors—including detailed structure, layout, and external shape—from the initial stage of the design. This can be explained as the interdependency among elements that comprise the product becomes significantly higher [10]. The linear design development applied to type A heads toward reducing the level of interdependency among individual parts and components, as it is conducted in a linear or sequential manner from the concept development to the detail design. Since the integrated design process requires simultaneous consideration of all affecting factors, the interdependency greatly increases, as there is more for designers to consider. Therefore, more designers' competencies are required. Despite these difficulties, however, it is worthwhile to adopt this method in developing unique designs from those currently designed by conventional design approaches. This is especially the case if you compare type A's design with type C's.

The existing linear design process models appear not only in Ulrich's models but in design process models by Pahl and Beitz [11] and in product design process models by Ullman [12]. Though these processes explain the design process takes place in an iterative process, it also notes the external and internal functions, as well as structures, are developed in a sequential manner, and this sequential development is repeated in a linear pattern. In this respect, the integrated design process we have attempted provides numerous implications as methods for developing new innovative designs.

Many design schools tend to focus on designing the exterior as a key part of product design education. Since the external appearance of a product is closely interrelated with the internal structure, separating these into two different design sections is problematic. However, many industrial design departments do not pay as much attention as they should in teaching internal structural design and functional

prototyping [13]. As demonstrated in this paper, the advantage of the integrated design approach involves external and internal designs and raises a need for an integrated approach to design education with a balanced focus on aesthetic and engineering properties.

Acknowledgments. This study is supported by the Ministry of Education and National Research Foundation of the Republic of Korea (NRF-2015S1A5A8010614). The work is also supported by the Promotion of Special Design-Technology Convergence Graduate School of Korea Institute of Design Promotion with a grant from the Ministry of Trade, Industry & Energy of the Republic of Korea (N0001436).

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The Design of Personal Protective Garments for Workplace: An Ergonomic Radiation Protection Design Practice

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Abstract. Personal protective garments are commonly used to protect workers from direct and secondary radiation in radiological workplaces. Traditionally, these garments are manufactured using heavy shielding chemical materials, such as lead or lead composite mixed with binders and additives to make lead loaded vinyl sheets. The materials used in such garments are toxic, subject to rapid decline, and cause lead poisoning and heat gain that create moisture inside the garments. These garments are heavy in weight, causing a higher risk of musculoskeletal injuries and workers' fatigue and discomfort, which results in low productivity due to ergonomic detriment. We designed an ergonomic personal protective garment with a lightweight flexible structure and optimal shielding performance after a thorough examination of the existing safety in the workplace, worker's tasks and exposure to radiation, and weight and type of the materials used in the existing garments. Our study suggests that a lightweight and flexible design factor that could improve workers physical activities and body movement by considering ergonomic design could increase productivity in radiological workplaces.

Keywords: Personal protective garment · Ergonomic design · Radiological workplace

1 Introduction

Nuclear power plants have both positive and negative effects on workers and local populations. The release of gases, radiation, and soil and water pollution are negative effects that cannot be ignored. However, workers are highly exposed to radiation and experience severe health problems related to radiation doses. Personal protective garments are commonly used to protect workers from direct and secondary radiation in radiological sectors, such as nuclear reactors and power industries. Traditionally, these garments are manufactured using heavy shielding chemical materials, such as lead shielding or lead composite shielding mixed with binders and additives to make lead loaded vinyl sheets [1]. However, the materials used in such garments are toxic and subject to rapid decline, which requires a special disposal procedure [2]. In addition,

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_44

these garments are heavy in weight, causing a higher risk of musculoskeletal injuries and workers' fatigue and discomfort, which results in low productivity due to ergonomic detriment caused by the garments [3]. Moreover, a lead-based garment can cause lead poisoning and heat gain that creates moisture inside of the garment.

Based on a thorough investigation of the workplace and its workers, we designed an ergonomic personal protective garment with a lightweight flexible structure and optimal radiation-shielding performance. The existing safety and workers' productivity are subject to the amount of radiation-shielding abilities and weight of the garments, and different levels of shielding are required depending on the radiation dose. Thus, the garments should be flexible with a weight that does not affect workers' productivity. The main components of radiation-shielding garments are a lead vest and lead genital protectors with disposable gloves and a dosimeter to measure the radiation dose. Most garments are made of vinyl or waterproof fabric, which are easy to clean and reuse. However, the type of material used in the garments are typically lead vinyl, which is made by mixing lead powder with vinyl liquid to form a smooth plate enclosed in a lighter fabric. Some garments are lightweight, nontoxic, and lead free, but their shielding performance is low. In our proposed design, we used a nano-tungsten powder-filled polymer, which is a nontoxic and lead-free radiation-shielding material. The nano-tungsten powder in the polymer provides high protective characteristics against ionizing radiations, such as X-rays, gamma rays and thermal neutrons [4].

Our design is based on three layers with special consideration of specific postural adjustment and ergonomic conditions. In layer 1, we designed the inner part with a protective vest for the thorax and abdomen, the size of which is adjustable through the rear belt. In layer 2, we designed a front plate with a buckle to provide additional protection. In layer 3, we designed a back plate with a buckle to provide protection to the back. In this layer, helmet, goggles, an oxygen respirator, and a gas mask can also be added.

This study suggests three important design factors that can be considered in the de-sign of a lead garment for radiological workplaces: a lightweight and flexible design to enhance work efficiency, a design with shielding capability to increase shielding performance, and improvement of workers' specific postural adjustment considering ergonomic design.

2 Design Requirements and Approach

First, we observed a local nuclear power plant and its workers. We observed the existing safety measures in the workplace, workers' exposure to radiation, the proportion of radiation-shielding abilities, and the weight of the personal protective garments. Second, we observed the basic components of the existing protective garments. Third, we studied the current protective garments for weight, ergonomic structure, materials and shielding performance. Finally, we set design requirements considering the weight and type of material and its shielding performance, ergonomic and aesthetic structure; human body parts that are more vulnerable to radiation doses and specific postural adjustment of the upper and lower parts of the human body. The aforementioned phases are illustrated in the following sections:

2.1 Workplace Observation

Due to safety and health-related risks in real-time observation in radiological workplaces, we observed the workplace through a video-recorded clip obtained from a local nuclear power plant. We observed the current safety measures and the workers' exposure to radiation (snapshots from the video clip are presented in Fig. 1). First, workers in the plant change their clothes in a separate room before entering the radioactive zone. Second, they wear anti-vibration suits with disposable work tools, and a lead- based shielding vest corresponding to the radiation dose of each radioactive zone. To this end, the operator accompanying the workers carries a dosimeter to measure the radiation dose, and if the dose value becomes too high during the inspection, the operator immediately informs the workers to replace their protective garments. Finally, we looked at the current environment around the radiation source for thermal energy and heat absorption. We noted that workers wear a heavy vest with a lead-wrapped protective garment that may absorb heat, considering that the garment can be contaminated by moisture. Thus, the workers are required to replace and clean the garment at certain working-hour intervals, which may hinder work efficiency.

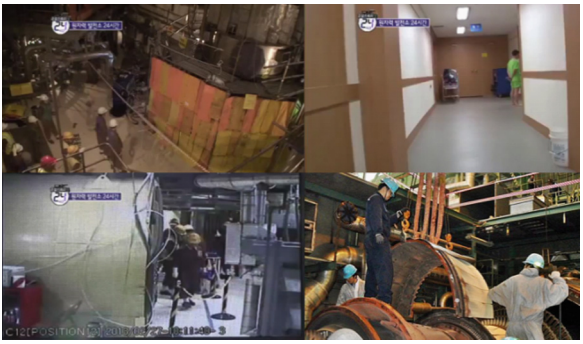

Fig. 1. These snapshots are captured from the video-recorded clips that were observed to understand the current safety practices in the nuclear power plant.

2.2 Expert Interviews

To understand safety measures in the workplace, we conducted in-depth inter-views with three researchers from a well-renowned research institute for nuclear safety in South Korea. In view of risks and accidents, most domestic nuclear power plants in Korea are not safe for either their workers or the workplace where they work. As participant A notes,

'Nuclear power plants currently built in South Korea were bought in the United States after liberation. This is the first generation of nuclear power plants, such as the Kori and Wolsong power plants. These plants are old and should rebuild and repair the old parts and recertify them. The reason that they are still in operation after having been in use for a long time seems to be because most domestic regulations comply with Japanese law even though the domestic nuclear power plants are American facilities.

Safety issues, radiation exposure to nuclear workers, and the disposal of radioactive waste are much more dangerous. Japan's Atomic Energy Act is also inevitable in view of Fukushima's case, and Korea has not changed much for nearly 50 years without revision. Workers' safety is not addressed in the manual and should be secured.'

In light of safety measures for workers, it seems that workers are more likely to be exposed to radiation when carrying out emissions and nuclear waste from the plants. Participant B notes.

'Generators in nuclear power plants are carefully equipped with tens of layers of shielding materials. Most nuclear power plants in Korea use a pressurized water reactor system. Pressurized light water reactors are like saunas. After the primary cooling water cools the reactor, it moves the heat energy from the reactor towards the steam generator. This is called boiling water in a pot. Although the thermal efficiency is somewhat lower than that of the boiling light water reactor in Japan, it is much better in terms of safety, and the reactor coolant contaminated with radioactivity is mixed in the seawater that cools the steam after turning the turbine. Therefore, the problematic are-as are radioactive waste and the exposure of workers. Disposable gloves or clothes are used in nuclear power plants for waste. Construction of the reprocessing facility is good because pure uranium can be obtained after the half-life of radioactive materials. However, if an accident occurs while the waste is moving, it can be as daunting as the accident in Fukushima, so it is urgent to prepare measures against it.'

It is also important to understand the circumstances in which workers are highly exposed to radiation. Participant C notes,

'This is not fair to disclose because of internal security, but I know that I wear a protective vest made of lead due to the possibility of inspection. Diesel generators such as one in the Fukushima accident carry the waste later or operate a cooling water turbine because the power drive devices were messed up due to the tsunami; thus, the cooling water was not supplied. When the power supply fails, it is necessary to operate the manual energy assisting de-vice created by a third power source. Unless you are near a nuclear reactor, it is unlikely that you will have to wear a completely thick protective suit.'

After in-depth interviews with experts, we agreed that radiation shielding requires both proper instruction and drills for the workers in radiological workplaces and accessibility of suitable shielding tools and garments. The garments that the workers used in the workplace are made of heavy shielding materials such as lead or lead composite materials.

The following sections briefly discuss the current safety practices and use of radiation shielding aprons in the workplace and present a proposed design for a personal protective garment.

2.3 Radiation Shielding Garments and Materials

In general, personal protective garments are made of vinyl or waterproof fabric that is easy to keep clean and available to a wide variety of people. The type of material used in such garments can be divided into lead vinyl, which is made by mixing lead powder into vinyl liquid and making it into a flat plate, and covering fabric, which is lighter

than lead vinyl. They are expensive because they are subject to expensive compression molding processes. Recently, the use of nano-tungsten powder in polymer resins has become popular [4], which is advantageous in terms of price competitiveness and mass production due to its elimination of harmful effects and ability to apply the extrusion process instead of the expensive compression molding process. Moreover, this material has less of a chemical fragrance, superior elasticity, and flexibility compared to ordinary rubber plates (see Fig. 2 as an example).

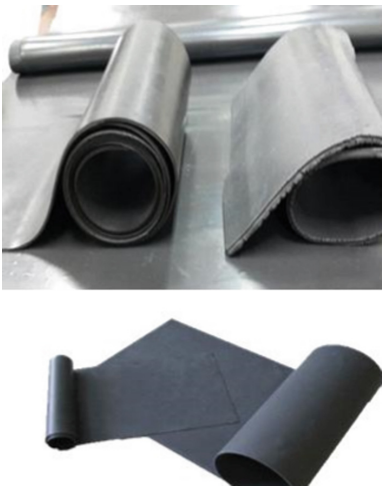

Fig. 2. The material is the combination of nano-Tungsten powder and polymer resins. The material is lightweight and has optimum shielding performance.

We thoroughly examined this material and its processes and principles of radiation. Based on the Nuclear Safety Standards Act and the Enforcement Decree of the Nuclear Safety Research Institute, the safety and facility standards for the actual radioactive works were also examined. The radioactive disaster response facilities and reference facilities for the equipment were also considered.

2.4 Radiation Dose Assessment

We investigated the current safety-assessment techniques to understand the parts of the human body that are more vulnerable to radiation doses. International organizations, such as the World Nuclear Association and International Commission on Radiological Protection, endorse the quantities and units that should be used in radiological workplaces for safety measures. Using occupational dosimetry, dose limits for workers are shown in terms of equal dose in an organ or tissue (HT) for individual body parts and exposure and effective dose (E) for whole-body exposure, with SI units in Sievert [5, 6]. The sensitivity of the various organs of the human body is associated with the relative sensitivity of the cells from which they are collected because blood-forming

cells are one of the most sensitive cells due to their rapid regeneration rate. These organs are some of the most sensitive to radiation [7]. The biological effects of radiation doses on the human body are shown in Fig. 3. In our proposed design, we considered the parts of body that are more sensitive to radiation doses.

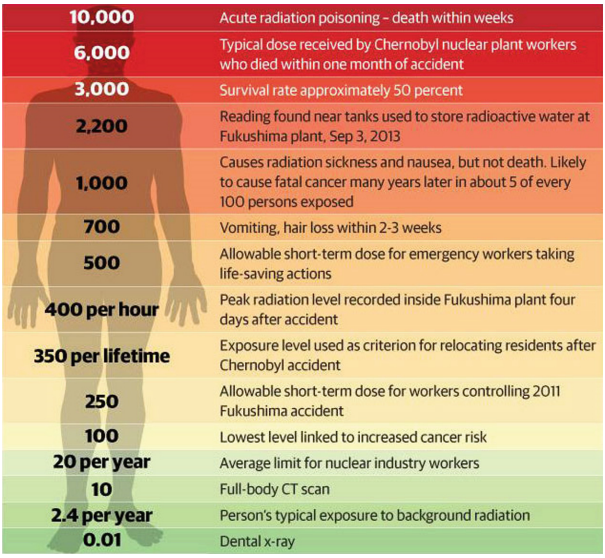

Fig. 3. Human body parts that are exposed to radiation doses are presented in Millisieverts (mSv) – Sieverts is the SI unit. The source is IAEA - World Nuclear Association.

2.5 Ergonomic and Postural Adjustment Assessment

After a thorough investigation of the use of radiation-shielding garments in the workplace, we found that the most important aspect in using garments is to increase work efficiency. With the existing garments, workers found obstacles that adversely affected their work efficiency due to inflexibility in the garments and their heavy weight. Therefore, we conducted ergonomic assessment by conducting a further investigation into weight, flexibility, and postural adjustments with the existing shielding garments. The aim was to produce a design factor to the proposed design that adjusts body postures using ergonomic design. Table 1 shows the weight, material type, and shielding performance of the garments currently used in the workplace.

We considered design factors for the vest structure in areas such as neck, shoulder joint and waist movement and a combination of front-back and vertical rotation (See Fig. 4).

The structure of shoulders joint movements was studied in detail to understand the joint movements of the parts where the vest is worn. The detail structure is presented in Fig. 5.

Table 1. Garments with weight, material and shielding performance

	Material	Weight	Shielding performance
Biorubber Rsm E-400	TX (Textile-based)	9–11.5 kg	Γ-ray: 4.4% (mix 50%) X-ray: 92.2%
Demron® Class 2	Liquefied Metal	4 kg	Γ-ray: 50%, X-ray: 75%
Composite Blend Apron	Vinylon, Coated Cloth (0.3 mm)	12 kg (with storage bag)	X-ray: 97% at 100 KVP

BIORUBBER RSM: https://inis.iaea.org/
DEMRON: http://www.radshield.com/product/demron-class-2-full-body-suit/
Composite Blend apron: http://www.evolvetechcorp.com/files/apron_weight_comparison.pdf

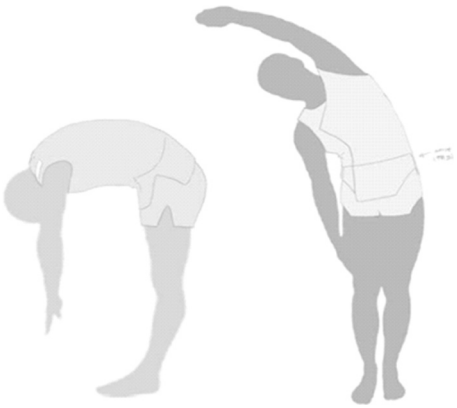

Fig. 4. The proposed design of vest is shown to explore ergonomic and postural adjustment. The aim is to design a vest fixed and tight with the body in order for open body movement.

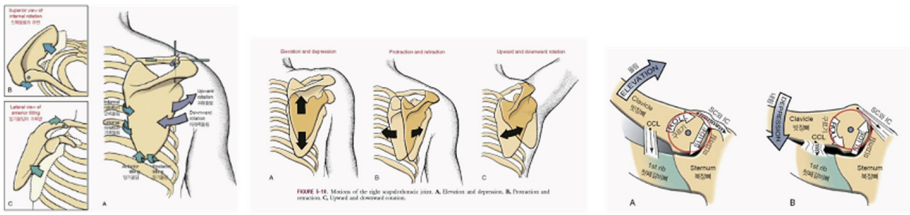

Fig. 5. The structure of shoulders and its joint movements is presented. The joint movement is thoroughly studied for both the shoulders and neck and arms movement.

For the lower body parts, we considered the movement of the lower body when a wearer is walking or running. We analyzed the anatomy of the body parts involved in body movement. We aimed that the design should be fixed to the body so that the wearer would not feel discomfort with the garment when sitting or standing. The structure of the lower body is shown in Fig. 6.

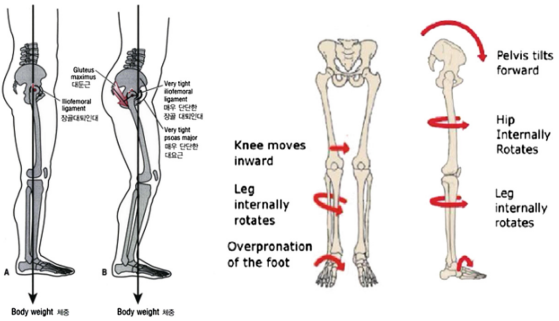

Fig. 6. The structure of the lower body parts with joint movements of the legs, hips and its rotation with respect to pelvis bones are presented.

2.6 Proposed Design

As shown in Fig. 7, our proposed design consists of three levels. In level 1, the suspended belt is fixed on the garment's lower part so that it can safeguard the lower parts of the body. In addition, this design holds the protective vest for the thorax and

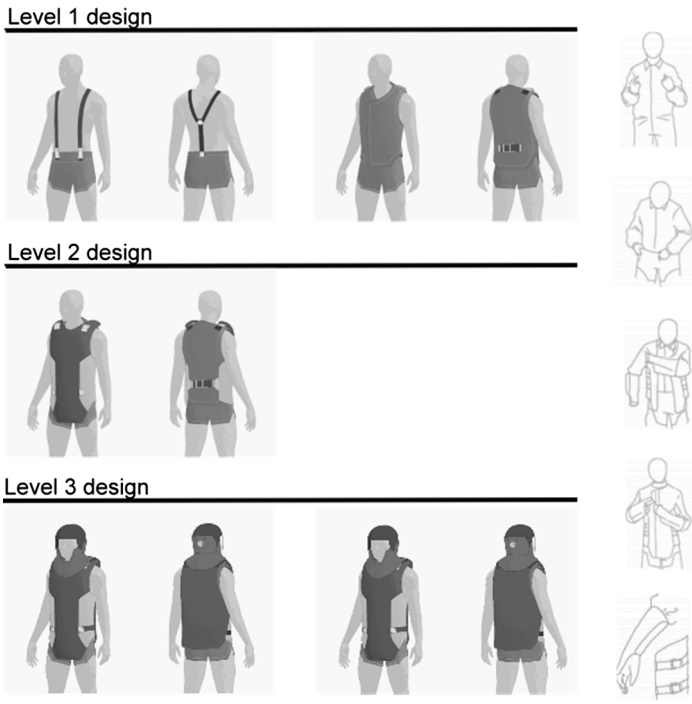

Fig. 7. The proposed design is based on three layers where each layer comes with protection of respective parts of the body. Layer 3 is the overall protection of the body where masks and other accessories are optional.

Fig. 8. Final design with the prototype is presented. The proposed design shows the protection of the upper and lower body parts.

abdomen, the size of which is adjustable through the rear belt. In level 2, the wearer can fasten the front plate for additional protection in front. The level 3 design pro-vides additional protection on the back where the back plate is fixed. This level also includes oxygen respirators and a gas mask with a helmet.

With the overall sketch of the proposed design, we improved the final product with additional protection (See Fig. 8). For example, we fixed the lack of protection of the neck and thyroid by adding a collar to each side of the vest. In addition, we fixed the difficulty in adjusting the size of the toe, as previously, this made it difficult to work. Moreover, we added a zipper line to the top that should be padded on the upper side to cover the inside to minimize its interference with work because in most cases, workers attempt to adjust and fix the garment during work.

3 Conclusions

Personal protective garments with a vest or skirt configuration are opted for by many operators and workers to minimize risks associated with radiation. Due to the ergonomic risks of garments with leaded aprons that increase fatigue and discomfort associated with wearing heavy protective garments, we present an ergonomic radiation-protection design practice. As such, we mainly focused on three important design factors for a personal protective garment: a lightweight flexible design, a design for enhanced shielding performance, and an ergonomic design to improve workers' specific postural adjustment. We believe that our proposed design holds promise for improved ergonomics and safety. We demonstrated the final product to experts in the radiation-protection field, and they positively rated the product and the proposed design. In future work, we will evaluate the current product with operators and workers in radiological workplaces to understand its usability to further improve the design.

This study suggests that garments with a lightweight flexible design and enhanced shielding performance can increase workers' productivity in radiological workplaces. However, radiation safety measures should comply with local and domestic regulation authorities to consider ergonomic importance and postural adjustment associated with current personal shielding garments. Moreover, management and authorities of radiological workplaces should also examine the current radiation-shielding practices for ergonomic hazards and improved safety by adopting standardized lead-free protective aprons to increase work efficiency in the workplace.

Acknowledgments. This study is supported by the Ministry of Education and National Research Foundation of the Republic of Korea (NRF-2015S1A5A8010614). The work is also supported by the Promotion of Special Design-Technology Convergence Graduate School of Korea Institute of Design Promotion with a grant from the Ministry of Trade, Industry & Energy of the Republic of Korea (N0001436).

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Implication of User Behavior in Design Process

Memory Recall of Nouns and Adjectives Expressing Two-Color Combinations

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Abstract. We investigated impressions of a color scheme can be expressed with nouns or adjectives, and whether nouns (associated with colors) or adjectives (expressing the impression of colors) are recalled first. We used two-color arrangements comprising red, yellow, orange, green, blue, purple, black and white, from which we prepared 64 pattern combinations. Participants were 20 Japanese college students with normal visual acuity and color vision. Each two-color scheme was presented, and participants were asked to orally respond. Analysis of variance revealed that the total number of nouns produced in this task was significantly larger than the total number of adjectives ($p < .05$). Additionally, significantly more nouns were answered first ($p < .05$). Analyses of whether adjectives or nouns were recalled or recalled earlier revealed that nouns are more likely to be recalled than adjectives. There were no significant differences based on the different colors, except in the case of purple.

Keywords: Noun · Adjective · Two-color scheme · Impression · Association

1 Introduction

Many studies have been conducted on color scheme impressions. Specifically, there are many studies that have reported on the use of adjectives in describing color schemes in the field of sensibility (KANSEI, or impressions that are emotional, intuitive, etc.). However, color scheme impressions can also be expressed using nouns. For example, red and green color schemes can be reminiscent of "Christmas." Therefore, the conventional research approach should be modified to take either adjectives or nouns into account.

In past research on describing colors with nouns, Palmer and Schloss found that color preferences are correlated with color associations [1]. Kunugida et al. also conducted research in the same area; they used Putian's research method and examined the color association process, focusing on the effects of ambient lighting design on psychological associations with color [2] (Table 1).

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_45

Table 1. Nouns and adjectives

Word class	Nouns	Adjectives
Expression	Words associated with colors	Words expressing the impression of colors
Examples	Ribbon, Piglet, Christmas, summer, etc.	Happy, energetic, cool, dull, strange, etc.

2 Impression Formation

Ito and Oyama classified the functional relationship between the Munsell color system and color emotions using the SD method and proposed a monochromatic emotional expression and an emotional expression of two color schemes [3]. In addition, Makino and Takahashi created a three-color scheme and examined the difference in impressions using onomatopoeia with colored images [4]. However, it is believed that not only adjectives, but also nouns are included in the answers from subjects regarding color schemes. Since Ito and Oyama used the SD method in the experiment using nouns, nouns were not given due consideration [3]. As regards research on nouns, Kunugida et al. paid attention to the associative process, examined the design process of ambient lighting and its effects on psychological associations, and developed a design based on human impression evaluation [2]. Based on the research method used by Kunugida et al. (2008), we carried out our experiment.

3 Experiment

We used two-color arrangements to investigate whether adjectives expressing impressions of colors, or nouns associated with colors, are recalled first. The materials used included a total of 8 objects in 6 colors (red, yellow, orange, green, blue, and purple), and black and white, with which we created 64 combinations. The participants were 20 Japanese college students with normal visual acuity and color vision. Each two-color scheme was presented to the participants, who were asked to respond (verbally, in an open-response format) within 8 s. The participants rested for 8 s between each set. The experimenter classified their responses into adjectives expressing impressions of colors and nouns associated with colors (Fig. 1 and Table 2).

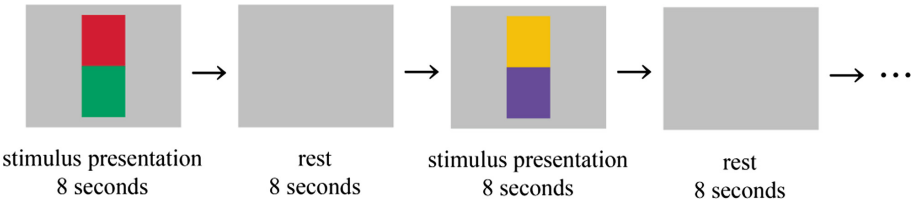

Fig. 1. Experimental procedure

Table 2. Eight presented colors

No.	Color name	Munsell color notation			sRGB digital values		
		Hue	Value	Chroma	R	G	B
1	Red	4R	4.5	14	211	30	48
2	Orange	4YR	6	13.5	233	112	20
3	Yellow	5Y	8	13	247	193	0
4	Green	3G	5.5	11	0	157	94
5	Blue	10B	3.5	10.5	0	92	152
6	Purple	9PB	3.5	11.5	92	70	144
7	White	N10	–	–	255	255	255
8	Black	N0	–	–	0	0	0

4 Results

An example of experiment results is shown below (Table 3).

Table 3. An example of recalled words. + indicates a noun, and # indicates an adjective.

Participant	1st word	2st word	3st word	•••
Female-1	Park +	Boy +	Junior high school student +	
Female-2	Friendly #			
Female-3	Refreshing #	Summer +		
Female-4	Nature +	Horizon +		
Male-1	Calm down #			
Male-2	Mediocre #	Normal #		
Male-3	Ocean +	Sky +	Grassland and sea +	
Male-4				
Male-5	Sober #			
•••				

4.1 Significant Difference

Analysis of variance revealed that the total number of nouns used in the participants' responses was significantly larger than the total number of adjectives used ($p < .05$). Moreover, a significantly larger number of nouns were used first ($p < .05$). Analyses of whether adjectives or nouns were recalled and which were recalled first revealed that nouns are more likely to be recalled than adjectives (Fig. 2).

4.2 Personality

There were no significant differences based on the different colors. It is our opinion that the big differences in the responses that were influenced by personality were also the cause for the ways in which the different color combinations were perceived.

Purple has long been a nobleman's color; however, these results suggest that it is negatively perceived (Fig. 3).

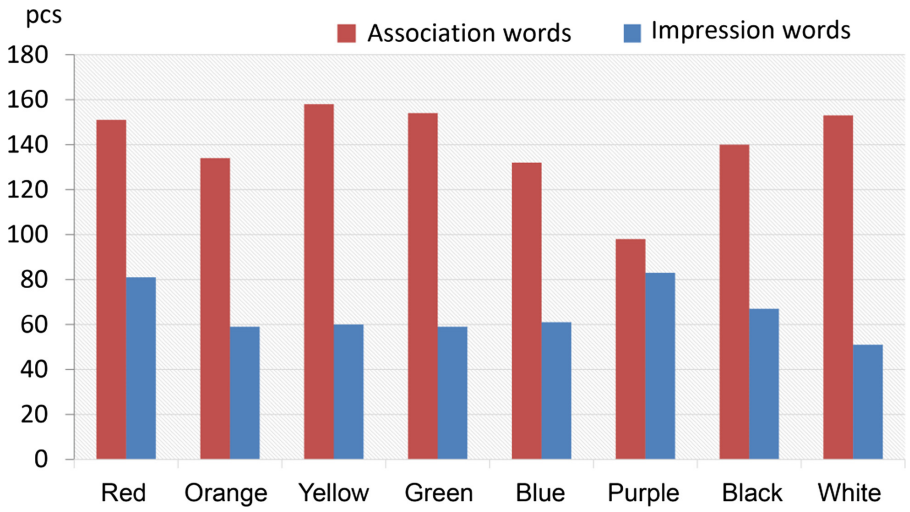

Fig. 2. The number of recalled association words is larger than that of impression words.

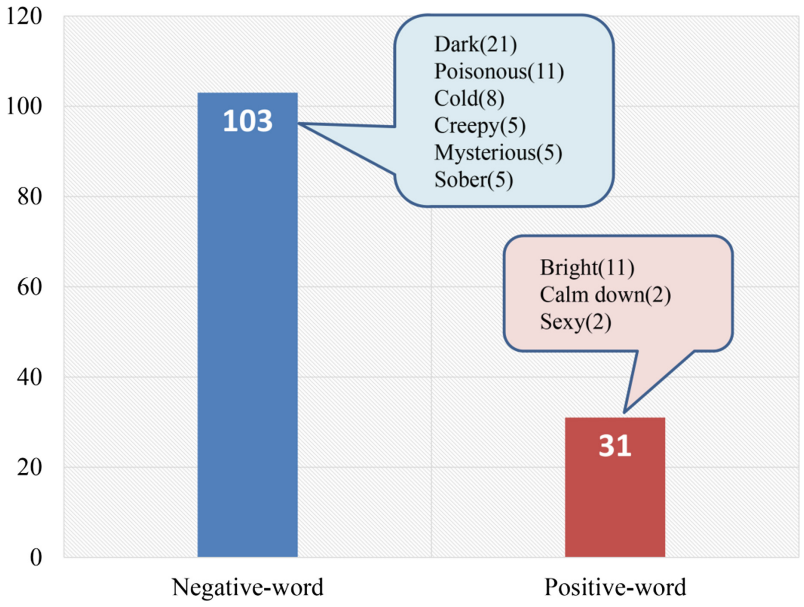

Fig. 3. Purple reminds participants of negative feelings rather than positive feelings.

5 Summary and Future Work

There were no significant differences based on the different colors, except in the case of purple. In color schemes that included purple, differences between nouns and adjectives were not significant. Moreover, adjectives describing purple were found to be

associated with negative feelings such as “dark” and “bad” feelings, unlike the adjectives used to describe other colors. Although purple has long been a nobleman’s color in Japan, the results of the study indicate that people do not, in fact, associate the color with nobility.

Acknowledgments. I am deeply grateful to the members of Human Media Engineering Laboratory of the Faculty of Science and Technology, Chuo University, and the Kansei Robotics Research Center, who are enthusiastic about research discussions and cooperation for experiments.

This work was partially supported by JSPS KAKENHI grants, “Research on Sensitivity Symbiosis Mechanism within Groups in Real Space/Information Space” (No. 25240043) and TISE Research Grant of Chuo University, “KANSEI Robotics Environment.”

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Determination of the Optimal Timing for a Relaxing Stimulus

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Abstract. In this study, we investigated the relationship between the timing of a relaxation stimulus and its effect on a participant performing intellectual work. Experiments using light and sound stimuli showed that the relaxation effect is weakened or becomes stressful when the stimulus is provided during the work period, as opposed to the beginning. In addition, we found a possible synergistic effect could be achieved by combining a light and sound stimulus.

Keywords: Heart rate power spectrum · Light · Sound

1 Introduction

Long-term intellectual tasks such as deskwork can be stressful. Stress can be broadly categorized as good or bad. Good stress is encouraging, while bad stress is discouraging [1]. Most stress is bad, and thus is discouraging. The mitigation of stress therefore has a great significance.

The relaxing effects of light and sound have been studied insofar as what kinds of light and sound are effective, but the role of the time at which these stimuli are delivered is not well understood. Nagano et al. showed that relaxing stimuli may be particularly effective when given in an uncomfortable condition [2].

We hypothesized that the result reported by Nagano et al. could be generalized to light and sound relaxation stimuli. Moreover, we hypothesized that a relaxation stimulus provided after a participant has begun to feel stressed would be more effective than one provided at the beginning of the task. In this study, we compared the efficacy of relaxing stimuli when provided at the beginning of a task vs. in the middle.

2 Stress Definition and Index

We defined "stress" as the activity of a sympathetic nerve. The autonomic nervous system is the result of the conjoined activity of the sympathetic and parasympathetic branches, and its activity can be assessed by measuring the power spectrum from the

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_46

time series data of the heartbeat. Signals between 0.04 and 0.15 Hz are called the Low Frequency component (LF), and between 0.15 and 0.40 Hz are called the High Frequency component (HF). If the sympathetic branch is active, LF and HF both increase. However, if the parasympathetic branch is predominant, only the HF component will increase [3]. We used the LF/HF ratio as a stress index, and treated the effect of lowering this value as a relaxing effect. We used the MEG-6108 cardiograph (NIHON KOHDEN), the Vital Recorder (KISSEI COMTEC) for data acquisition, and the BIMUTAS2 (KISSEI COMTEC) for data analysis.

3 Approach

We measured the LF/HF ratio while providing a relaxing stimulus at the beginning of the intellectual task, and while providing the stimulus after the participant began feeling stressed, and compared the difference.

We used light and sound as relaxing stimuli. In the previous studies, light or sound was examined. However, a specific combination of light and sound may recall a specific scene. And it may yield a synergistic relaxing effect. We selected "Green Light" and "Babbling of River" from those that have recognized physiological effects from previous studies and combined them [4, 5]. "Green Light" was given at 300 lumens and "Babbling of River" was given at 45 dB. We used the PLAYBULB color (MiPow) for the lighting equipment and a digital audio system (SONY) for the loudspeaker.

We used the calculation task shown in Fig. 1 for the intellectual task. This task was conducted such that the subject would have to subtract B from the original number A, subtract C from the former answer, and so on. Participants performed 10 calculations per question and repeated this for experiment time. In order to record the participants' progress, the participants were asked to state the outcome of every calculation.

A	
B	G
C	H
D	I
E	J
F	K

1427	
17	26
25	19
16	27
28	18
15	29

Fig. 1. Calculation task form and example

4 Experiment

The following experiments were conducted on 8 participants aged 21–22 years (6 males, 2 females).

4.1 Measurement of Stress Load Effect

After resting for 1 min, we let participants perform the calculation task for 10 min while recording every heartbeat. By comparing the LF/HF ratio before and during the task, we investigated the task's perceived stressfulness (Fig. 2).

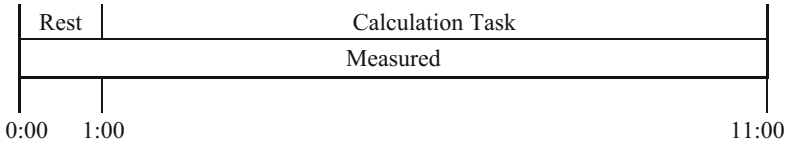

Fig. 2. Flow of experiment (4.1)

4.2 Measurement of the Relaxation Effect

We gave stimuli of "Green Light/Bubbling of River", "Green Light/None", "White Light/Babbling of River" and "White Light/None" for 3 min to the participants in a rest state in the order shown in Table 1, and measured heartbeat. Two participants were assigned to each condition. In order to prevent subjects' thinking from influencing the result, we taught participants to count their own heartbeat. After each measurement, participants took a 2-minute break while being exposed to "White light + None" (Fig. 3).

Table 1. Stimulation pattern

Pattern	1st stimulus	2nd stimulus	3rd stimulus	4th stimulus
1	Green/River	Green/None	White/River	White/None
2	Green/River	White/River	Green/None	White/None
3	White/None	Green/None	White/River	Green/River
4	White/None	White/River	Green/None	Green/River

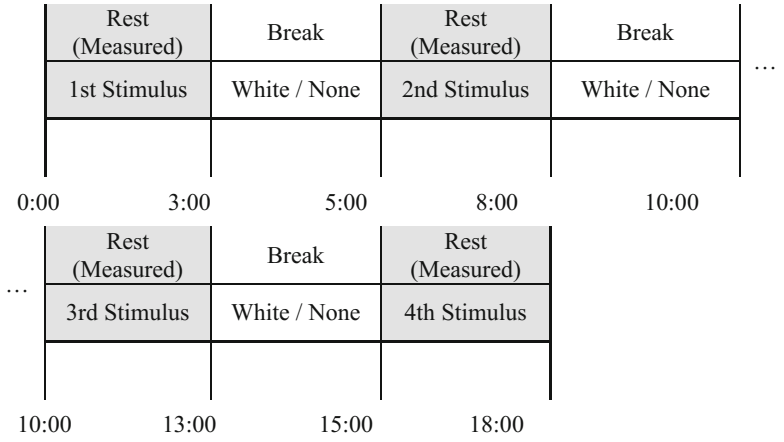

Fig. 3. Flow of experiment (4.2)

4.3 Control of Stimulus Timing

Participants performed the calculation task twice for 15 min each. The stimulus was provided at the start and middle of the task and heartbeat was measured. The stimulus sequence was counterbalanced. Participants took a break for 5 min after the first measurement. For the case of giving the stimulus from the middle, the least relaxing stimulus in 4.2 was given from the start to 7 min, and after 7 min elapsed, the best one was given. The stimulus changeover was carried out gradually between 7 min and 7 min 30 s (Fig. 4).

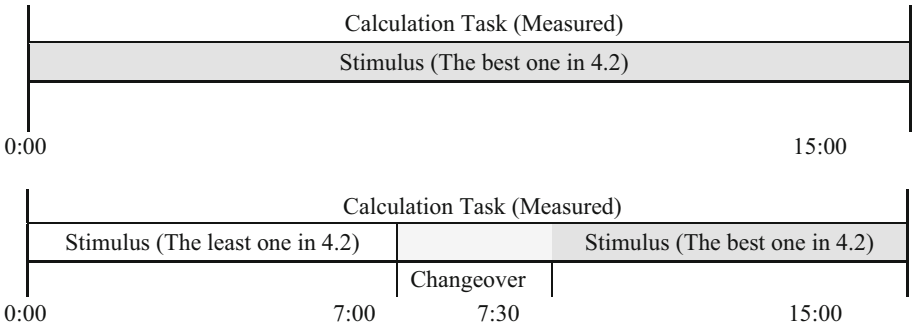

Fig. 4. Flow of experiment (4.3)

5 Results and Discussion

Unless otherwise noted, t-tests were used for test.

5.1 Stress Load Effect of Calculation Task

Table 2 and Fig. 5 shows that the LF/HF was greater than "Rest" in almost all periods. For "240–300", "300–360", "360–420", p-value < 0.10. For other periods and "Task Average", p-value < 0.05. These findings suggest that this task is a stressor.

5.2 Relaxation Effect of a Stimulus

For each stimulus, the LF/HF ratio of 3 periods was obtained every 60 s. Because the variation was large for each period, we adopted the lowest value instead of the average value.

Table 3 shows that "Green/River" was the best for relaxation and "Green/None" was the least effective, $p < 0.05$. Therefore, we used "Green/River" as an effective stimulus, and "Green/None" as an ineffective stimulus for experiment 4.3.

"Green/None" and "White/River" have higher average values than "White + None". As to why our results and those of previous studies disagree, one possibility is

Table 2. LF/HF ratios during calculation task

		Subject							
		A	B	C	D	E	F	G	H
	Rest	0.93	0.44	0.18	0.57	0.24	0.34	0.90	0.62
Periods (sec.)	0–60	1.85	2.36	1.38	1.12	0.43	1.69	0.27	0.23
	60–120	0.19	5.41	3.89	1.70	1.82	3.49	1.45	1.26
	120–180	4.29	0.52	0.35	0367	3.54	0.32	0.35	0.86
	180–240	7.07	5.66	0.59	3.27	3.70	1.76	1.94	−0.01
	240–300	2.36	10.65	2.11	0.52	0.47	1.44	1.58	−0.03
	300–360	3.82	19.14	2.10	0.25	6.15	1.07	1.79	0.35
	360–420	1.34	0.73	2.48	0.32	5.00	1.04	0.03	−0.22
	420–480	0.61	2.37	1.92	0.83	3.57	1.61	0.97	3.75
	480–540	2.36	1.77	1.42	0.68	1.50	0.15	0.21	3.70
	540–600	4.44	4.22	0.70	0.81	3.30	0.09	0.19	0.56
	Task average	2.83	5.28	1.70	1.58	2.95	1.26	0.88	1.05

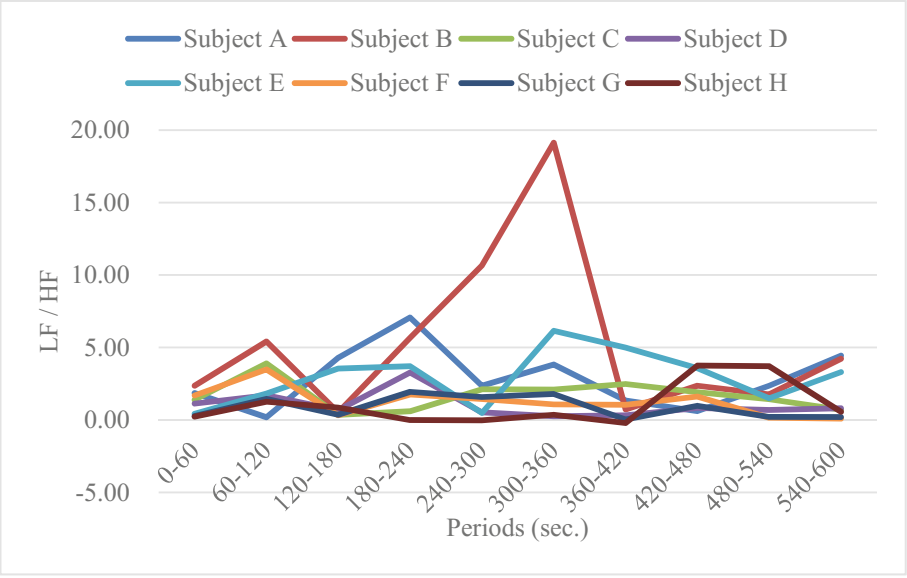

Fig. 5. Difference in LF/HF ratio from "Rest"

that previous studies did not use the LF/HF ratio. In spite of this result, "Green/River" was relaxing. Although the two-way analysis of the variance yielded an insignificant p-value (0.12), this may be a clue that a synergistic effect as described above may have occurred.

Table 3. Comparison of LF/HF when giving each stimulus

	Subject								
	A	B	C	D	E	F	G	H	Average
Green/River	0.573	0.157	0.112	0.0653	1.33	0.365	0.789	0.0923	0.435
Green/None	1.66	0.555	0.231	0.0822	2.79	2.83	1.25	0.155	1.19
White/River	4.84	0.160	0.155	0.133	0.507	0.498	0.967	0.874	1.02
White/None	0.911	0.148	0.439	0.229	0.846	1.45	0.837	0.100	0.620

5.3 Effect for Each Use Timing

Figure 6 shows that for all participants, the LF/HF ratios measured at the Middle were significantly greater than those obtained at the Beginning ($p < 0.05$). Nonetheless, Table 4 shows no noticeable trend between the two conditions, and there was no statistically significant difference between them.

Figure 7 shows that while there were many participants with high "480–900" values, the differences were not statistically significant. Figure 8 shows that except for subject E, the value of "Middle" was high. Once again, no statistically significant difference between stimuli provided in the Middle vs. Beginning was observed.

From Fig. 6, it is clear that participants felt greater stress during the "Middle" rather than the "Beginning." Anecdotally, many participants said that when the sound began, they were distracted. Thus, applying the stimulus at the middle might itself be a stressor for participants, as suggested by Figs. 7 and 8.

The presentation of "Babbling of River" could have been a factor. The final volume of this stimulus was informed by previous research [6]. However, because the time

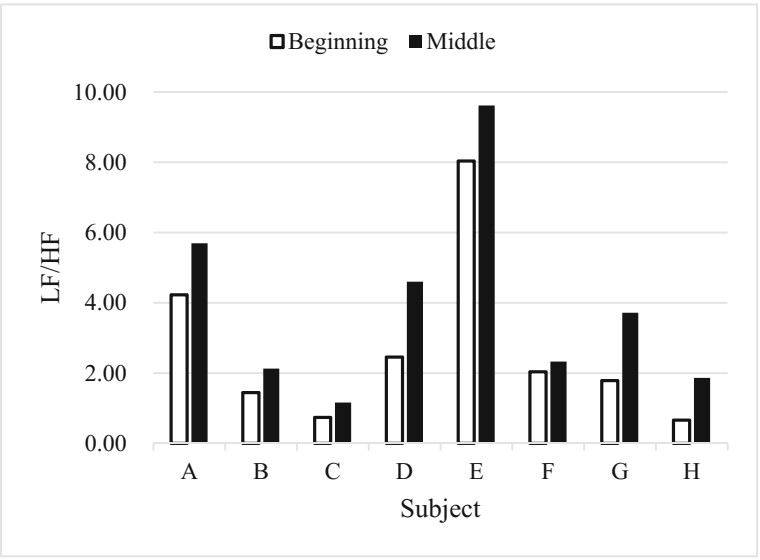

Fig. 6. Comparison of LF/HF by stimulation timing

Table 4. Comparison of LF/HF when giving each stimulus

		Subject							
		A	B	C	D	E	F	G	H
Beginning	Number of answer	68	74	444	172	110	84	220	147
	Average time (sec.)	13.2	12.2	2.03	5.23	8.18	10.7	4.09	6.12
	Number of correct	53	66	424	160	109	82	214	145
	Correct rate (%)	77.9	89.2	95.5	93.0	99.1	97.6	97.3	98.6
Middle	Number of answer	57	80	420	190	124	90	230	152
	Average time (sec.)	15.8	11.3	2.14	4.74	7.26	10.0	3.91	5.92
	Number of correct	44	77	390	187	122	88	223	148
	Correct rate (%)	77.2	96.3	92.9	98.4	98.4	97.8	97.0	97.4

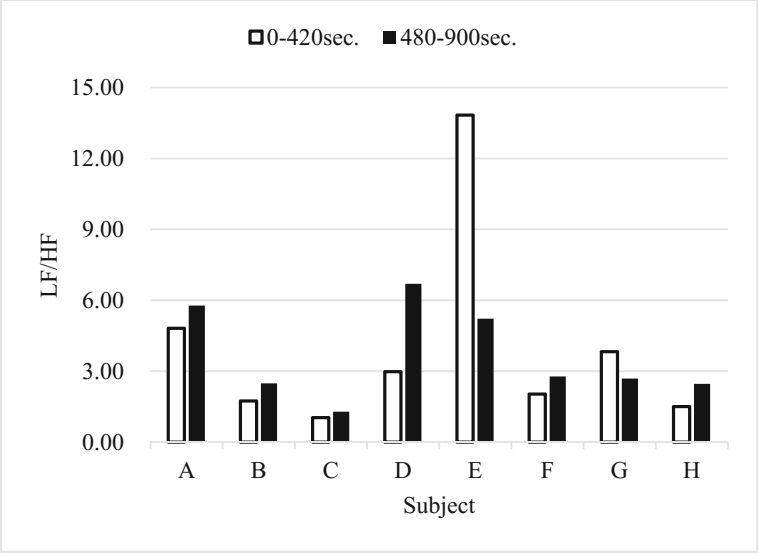

Fig. 7. Comparison of LF/HF before and after stimulation

required to change to this volume was brief, participants might have perceived a disruption. In addition, although the previous research presented many sounds intermittently, the "From the middle" condition gave a single stimulus in the midst of silence. Because of this, the ideal volume for participants might be different from previous research.

Table 4 shows that there is no correlation between the stress and the performance of the calculation task. The task is significantly stressful but since it did not require special attention, it is thought that such result was obtained.

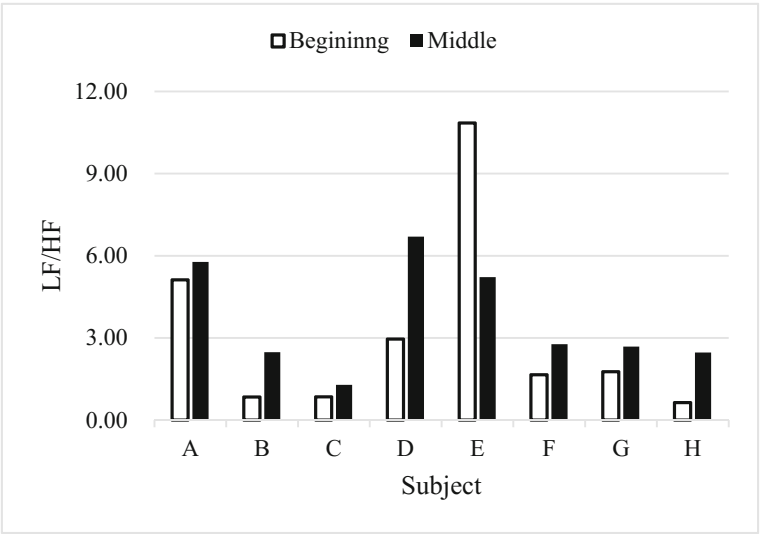

Fig. 8. LF/HF comparison for 480–900 s

6 Conclusion and Future Work

In intellectual work requiring a stress load, when giving a relaxing stimulus to an operator, it is most effective to give it from the start of the work. When the stimulus is provided in the middle of the task, the effect diminishes or may increase the stress level. However, since various conditions concerning stimulus and work in this study were generally simple, careful judgment is required in generalizing the conclusion.

A synergistic effect may have been generated by the combination of light and sound. The crucial question here is what kind of stimuli should be combined with each other to achieve the greatest effect.

Acknowledgements. This work was partially supported by JSPS KAKENHI grants (No. 25240043) and TISE Research Grant of Chuo University.

We would like to thank Editage (www.editage.jp) for English language editing.

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Research on Attitude Accessibility in Product Design Evaluation: Cognitive Features and Memory Network

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Abstract. As a crucial index in product design evaluation, users' attitude, together with cognitive features, constitutes the memory network, which would further influence on users' decisions and behaviors. In the features cognition of products, the central traits, formed based on the different speeds of various kinds of cognitions extracted from memories, are of higher attitude accessibility and have more effects upon attitude due to shorter structural distance. In the existing evaluation systems, there are relatively fewer research on the users' attitude and its accessibility. Adopted different perceptual evaluation features, this research combines the reaction time of cognition and evaluation strength to build the cognition-attitude structure (memory network), and further analysis the attitude accessibility of various cognitive features and their influences on users. Meanwhile, semantic selections in product modeling design are supported through the assessments of design elements in diverse shapes and comparisons among attitude accessibility differences caused by distinct cognitive features.

Keywords: Design evaluation · Attitude accessibility · Memory network · Reaction time

1 Introduction

With the development of science and technology, our society has stepped into the Industry 4.0 gradually. Facing the increasing new needs of users, design has been changed from mass-production-oriented to user-satisfaction-oriented. Accordingly, product design has been transformed from manufacture-centered to consumption-and-usage-centered. Afterwards, user-centered design (UCD) formed as the dominant design philosophy. Therefore, designers turned their focus from product functions to the perceptual evaluations and Kansei Engineering emerged.

Kansei Engineering first comes from the speech of the art of automotive development, addressed by a Japanese scholar in University of Michigan, 1986 [1]. The theory and method of relationship between emotions from human beings and features

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_47

from objects were explored in an engineering way [2]. In the process of product design, the core part of perceptual design lies in the transformation from emotional elements into physical design, which would help the designers control the product characteristics, understand the relationship between customers' feelings and products, define if the evaluation is in line with users' needs and expectations, and eventually offer more useful reference for designers. Currently, research on Kansei Engineering mainly includes semantic difference (SD), Factors Analysis (FA) and so on [3]. Product design elements were deeply analyzed via evaluation strength of perceptual cognition, however, the attitude accessibility of users in the evaluation stage were rarely mentioned.

From the perspectives of attitude strength and accessibility in the evaluation process of users, the perceptual semantic scales and reaction time were examined. In this way, the time scale of perceptual words evaluation was integrated in the evaluation system, which further enriched the research methodology of Kansei Engineering, and provided more reference for multidimensional structure of product evaluation systems.

2 Theory

2.1 Implicit Cognition

Human factors are always playing a significant role in user-centered design [4]. And user-centered design hardly isolates from the research on the human activities that generate from the information processing in human brains [5]. Modern Cognitive Dual-Process Theory illustrates that human behaviors are decided by two separated and different processing channels: the first one is implicit cognition that is an intuitive, perceptual and unconscious process, in which the thinking consequences could be influenced, yet hardly being distinguished; the other one is explicit cognition that is a rational, expressive and controllable process, in which both the courses and consequences could be tracked [6]. A series research results demonstrate that unconscious-implicit-cognitive process control human behaviors in most cases, namely, our life is mainly dominated by unconscious and intuitive implicit cognition [7].

2.2 Attitude Accessibility

Attitude, the overall evaluation of product defined by individuals, is the assembly for a series of features cognition and assessments. The research related to the implicit attitude shows that the processing of evaluative semantic content is an automatic approach based on the visual experience. When any object or concept is concerned, such as the electric scooter, the brain would search for information related to those features in the memory and provide it to the cognition for judgement and evaluation afterwards. When presented in the cognition, information is organized in some structures with the defined concept as the center and some relevant information as the nodes, which constitute the semantic network or schema [8]. Taking reaction time of information extraction as an index, the structure distance between extracted information and the certain object is

illustrated by the distance from the node to the center. Social psychologists extended this structural concept into "memory network" or "cognition-attitude structure" [9]. For the various features of the same object, cognition has different effect on the attitude, among which the most influential features cognition is named as "central traits". Central traits or basic features cognition have evident links with the overall judgement. For the purchasing behaviors of customers, attitude somehow dominants their decisions. At the same time, the speed and complexity to extract attitude from the memories shows its accessibility.

2.3 Reaction Time

Reaction time is one of the most frequently-used normal forms in cognitive psychology. Firstly, something to stimulate the participants need to be prepared and participants shall react quickly and accurately after being stimulated. During this period, the time is recorded from the stimulation presented to the reaction conducted and the latency time in between is named as reaction time [10]. Reaction time is a key criterion for the measurement of attitude accessibility, which reflects the speed of attitude extracted from the memory and indirectly indicates the complexity of this process as well.

3 Method

Adopted the measurement of reaction time, this research takes the electric scooters as a case study and analyses the influence of users' evaluation attitude and its accessibility on perceptual design evaluation of the product. As an environmental-friendly transportation mode, electric scooters use the electricity to provide energy and attract increasing attentions from the consumers gradually. In recent years, both the annual output and inventory are growing step by step. Since the environmental problems are more valued and emphasized than ever before all over the world, pollution-free electric scooters achieve a great improvement accordingly and customers show the extremely high consuming desires on them. Thus, they are not simply used as a trip mode any more, but also serve for the exercises and entertainments. The electric scooters reflect not only the further optimization of product function in the Information Age, but reveal the perceptual aesthetic needs of users as well. Therefore, designers should fully take consumers' using habits and perceptual experiences into consideration and further improve the design in accordance with users' needs and preference.

3.1 Experiment 1: Selection of Perceptual Words and Memory Network

The shape of scooters' body is a crucial factor influencing the customers' purchasing decisions. Proper perceptual words could better support the designers to make analysis on the exterior design, as well as reflecting the decision-making mechanism and the implicit attitude of customers towards scooters. Lots of perceptual features cognition

would be generated by customers and later they would be expressed through perceptual connotations. When the electric scooters attract the attention from people, various perceptual connotations could form memory network because of the differences on the structure distances, among which perceptual words with relatively higher accessibility become the "central traits" of "electric scooter". Precisely, this part has more impacts on customers purchasing decisions. Experiment one aims to collect, analysis and filter the words in line with cognitive features of human beings and central traits in memory network, and bring more proof to support the experiment afterwards.

Through the collection from manufacturers' websites, magazines, newspaper, interviews with consumers and brainstorms, more than 100 perceptual words related to the electric scooters were selected. Among of them, some words irrelevant to the perceptual analysis or product shape were filtered. Finally, 20 words in line with our research were organized. As cognitive feature words, those selected parts were edited with conceptual word – "electric scooter" in E–prime, and then participants were invited to conduct the measurement. To ensure the accuracy of this experiment, 16 participants from universities who basically knew about the scooters and had experiences on using or purchasing them were chosen. After seeing the words, participants were required to mark the influential significance of those cognitive feature words on the perceptual exterior design as soon as possible. (1 – quite insignificant; 2 – not significant; 3 – do not know; 4 – significant; 5 – quite significant).

Based on the regression analysis given by Sternburg, it takes at least 379 ms for our brain to code information and make judgement [11]. Hence, reaction time less than 379 ms should be filtered as invalid data so that the research result would not be influenced by faulty answers. Taking the average reaction time of all valid data (2156 ms) and standard deviation (407 ms) as segmented nodes, memory network based on the reaction time and evaluation strength are listed as Table 1 below:

Table 1. Memory network of electric scooter shape.

Reaction time (ms)/ evaluation strength	5.00–4.50	4.49–4.00	3.99–3.50	3.49–3.00	2.99–2.50	2.49–2.00
379-2156	**Comfortable** (4.63, 1494) **Angular** (4.56, 1685)	**Fashion** (4.19, 1722) **Fluent** (4.31, 1767)	Technological (3.81, 1554) Characteristic (3.75, 1611) Simple (3.63, 1988)	Cool (3.31, 1892) Interesting (3.43, 2073)		
2156-2563	**Delicate** (4.50, 2189)	**Smart** (4.38, 2397)	Compact (3.57, 2225) Speedy (3.94, 2162)	Qualified (3.43, 2157)	Elegant (2.69, 2256)	Smooth (2.44, 2469)
2563-2970	Durable (4.56, 2578)	Young (4.19, 2756)		Soft (3.06, 2675)		Lovely (2.31, 2803)

From memory network, the cognitive feature words in line with "central traits" of scooters were selected. Six perceptual words were picked out whose evaluation strength were higher than 4 (significant) and their reaction time were less than the sum of average time and a standard deviation. Those six words were coded as in Table 2 below:

Table 2. Words list of perceptual evaluations for electric scooter.

Code	Y1	Y2	Y3	Y4	Y5	Y6
Perceptual Words	Comfortable	Angular	Fashion	Fluent	Delicate	Smart

3.2 Experiment 2: Perceptual Evaluation and Attitude Accessibility

This experiment mainly tested the relationship between design semantics in different components of the scooters and semantics of perceptual words. Through checking on relevant magazines, manufacturers' catalogs, product websites, forums and so on, we selected the samples for the scooters' evaluation. Filtered over-similar and inappropriate ones, 17 samples were kept finally and discolored afterwards as Fig. 1 to avoid the impact of color on the shape evaluation accuracy.

In previous experiment, participants were required to score the selected perceptual words. Constrained by the space, we only chose evaluation index of "angular" for the evaluation attitude experiment here. (1–7, 1: very gentle; 7: very angular) The average score for those 17 samples were listed in Table 3 below:

Table 3. Evaluation average score of "angular" in 17 samples

Sample	1	2	3	4	5	6	7	8	9
Score	1.88	1.79	2.02	2.35	4.73	6.65	6.34	5.22	2.13
Sample	10	11	12	13	14	15	16	17	
Score	5.54	3.74	4.83	3.13	1.84	5.78	5.35	2.45	

Here selected we samples with score higher than 5 for the attitude accessibility analysis, namely, sample 6/7/8/10/15/16. Through the eye-tracking, it is demonstrated that the focus of participants mainly on the "lamp", "face" and "trail", when they were evaluating the "angular" features. Therefore, we could conclude that "angular" features on those three components play an effective role in product "angular" evaluation. Furthermore, to know the influence of evaluation attitude accessibility towards different parts of the product on overall evaluation of samples, we extracted the lamps, faces and trails from previous six samples and code them as Table 4 below. Supported by E-Prime, those parts were randomly presented for 18 participants who were required to assess for the "angular" feature in each part. Combined with reaction time and evaluation strength data, the cognition-attitude structure of "angular" features were illustrated in Table 5 below. The more the component close to the upper left, the more evident effects on participants' "angular" cognition, and vice versa.

Fig. 1. 17 Samples of electric scooters

Table 4. Components code list

Sample	6	7	8	10	15	16
Lamp	A6	A7	A8	A10	A15	A16
Face	B6	B7	B8	B10	B15	B16
Trail	C6	C7	C8	C10	C15	C16

Table 5. Cognition-attitude structure of "angular" features in components

Reaction time (ms)/ evaluation strength	5.00–4.50	4.49–4.00	3.99–3.50	3.49–3.00	2.99–2.50
379-2058	**B6** (4.72, 1762) **C7** (4.56, 1645)	**B8** (4.33, 1874) **A7** (4.44, 1920) **B15** (4.17, 1908) **C6** (4.39, 1754)	B10 (3.61, 1899) C10 (3.89, 1673)	C8 (3.33, 1902)	
2058-2340	**A6** (4.56, 2191) **B7** (4.61, 2062)	**A16** (4.28, 2227)	B16 (3.72, 2315) A15 (3.61, 2283)	C16 (3.33, 2175)	
2340-2622	A8 (4.50, 2398)	A10 (4.44, 2424)			C15 (2.94, 2607)

4 Analysis and Result

Among the words selected in the first experiment, the "durable" feature was filtered by the adding of reaction time, compared with original evaluation system purely depending on the evaluation strength. Meanwhile, "fashion" features were included in the evaluation system as a perceptual word, because its reaction time was relatively short and its attitude accessibility in memory network of electric scooters was higher.

In the second experiment of perceptual evaluation, it was evident that the design elements in sample 6 and 7 were closer to "angular" features, which was in line with the overall evaluation result. At the same time, the evaluation for "angular" features of "face" were greatly stronger than of "lamp" and "trail". Short as the reaction time of "trail", the evaluation strength was less than "lamp". Thus, if the overall shape of electric scooters need to match with "angular" cognitive features in future, it is essential to pay more attention on the "face" elements, followed by "lamp" and "trail". Summarized the analysis of design elements, we found that the most effective way to design an "angular" scooter was to emphasis the "angular-and-sharp liner shape" on "face". For the other components, "V-shape" lamp and "angular trail with up warp" more tend

to match with "angular" design semantics. This result is basically in accordance with the result from factor analysis. However, it is manifested that the "lamp" design shared more importance than "trail" for the "angular" features cognition.

5 Conclusion

The memory network integrated reaction time and evaluation strength is a crucial research method in cognitive psychology. Meanwhile, it could also provide more reference materials for the evaluation methodology of product design. Through the analysis of features cognition and attitude accessibility when users making evaluation, their reaction time is included into the evaluation system as an index, which could support the building of product evaluation system in a multidimensional structure. Research in future should more focus on how to define the proper weight and proportion of evaluation attitude accessibility and design elements involved inside, so that the product evaluation methodology could be further improved.

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Affective and Emotional Aspects of Design

Research on the Information Transmission Design of OTC Medicine Packaging Graphic for the Elderly

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Abstract. This research chooses medicine packaging, which the elderly are familiar with, as the object. From the perspective of graphic design, it classifies graphic designs on packaging into different types and forms, explores graphic design which meets the elderly' demand physically and psychologically, introduces and improves theories of barrier-free graphic design in China.

Keywords: The elderly · Medicine packaging · Graphic design · Accessible design · Information transmission

1 Introduction

With the aging population worldwide and the rapid development of medical undertakings, it has become a heated concern to enhance the health of the elderly and medication safety. The elderly are vulnerable to diseases, and the main consumers of medicines as well. According to some researches, there is a distinct increase of self-care awareness and self-treatment willingness among the elderly, 60% of patients resort to self-care in the early stages of diseases, and 60% of elderly people use medicines for self-care every day [1]. When getting old, the ability of elderly's vision, cognitive, memory and other aspects decline, which lead to their difference when receiving information on medicine packaging from ordinary people. Graphic, scripts and color are the important components of visual information transmission of medicine packaging design; graphic design is the most direct, effective and intuitive for the elderly with insufficient education, and relatively weak in mastery and understanding ability. There is a growing demand for OTC medicines among the elderly, but there is also a lack of research on medicine packaging design for the elderly currently. Therefore, it will help fill the gap of market with great realistic significance to study on the information transmission design of the OTC medicine packaging graphic for the elderly combining the physiological characteristics of the elderly.

2 Research Objects and Survey

2.1 Research Object

100 elderly people who need to constantly purchase OTC medicines at pharmacies between the ages of 60 and 80 were selected as the target research object for the study

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_48

as Table 1 shows. OTC (Over the Counter) medicine is explained as "Medicines published by State Council Medicine Administration Department that can be judged, purchased and used by consumers without the prescription from practicing physicians or practicing physician assistants prescription" [2]. The elderly's visual ability decreases and they fail to read the instruction on the package whose texts are too small when they get old, resulting in wrong medication, insufficient dose or casual medication situations. A good medicine graphic design can not only accurately express the characteristics of medicines, transmit the medicine information and its efficacy, but also can bring a sense of security of medication for the elderly to convey them the humanized care and warmth as well as to enhance their confidence of recovery when they are taking the medicine. Combining the characteristics of the elderly's vision and cognitive ability, this research will study on the graphic recognition among the elderly. Inducing and summarizing, in detail, from on the classification and expression form of packaging graphic on the level of user experience, this study tries to find out the graphic designs in line with the physical and psychological needs of the elderly to enhance the pleasure of vision and trust when the elderly take medicine.

Table 1. Gender and age ratio (n) of the research targets

Gender	Age group				
	60–65	66–70	71–75	76–80	Total
Male	5	10	9	2	26
Female	11	31	28	4	74

2.2 Visual Characteristics and Psychological Characteristics of the Elderly

Aristotle divided the human senses into five parts: vision, hearing, touch, smell and taste, among which the visual dominates the sensory system. About 90% of the external information is acquired via the visual sensory system. According to the research and survey, people's visual starts to get degradation in their 40s or 50s and function that controls the pupil's muscle gradually decreases as well. When they get to the age of 65, their eye cornea becomes thicker, their ciliary muscle regulation ability gets weaker, and their lens elasticity decreases and turns yellow gradually, making their senile sensitivity to blue light declines [3]. The visual deterioration of the elderly renders them susceptible to presbyopia, cataracts, floaters and other eye diseases.

2.3 Presbyopia

With the progressive hardening and thickening of the lens of the elderly's eyes, the retina fail to be fully focused. This makes the elderly have a blurred vision when looking at the close things and feel eye fatigue and acid; they have to pull the distance to see clearly. OTC medicine packaging text design should take full account of the visual needs of the elderly. The name of the medicine, usage, dosage, production date, contraindication and other important content should be of large bold font.

2.4 Cataracts

The crystalline lens in the eyeball becomes turbid and opaque, blocking light from getting into the eye, which affects the elderly's vision. For elderly between the age of 60 to 70, their crystalline lens get yellow gradually and their color vision ability declines. Therefore, when designing medicine packaging color, the designer should enhance appropriate amount of color brightness and contrast and avoid using the color matching of blue, purple or green.

2.5 Float Disease

Floater is mainly caused by the deterioration of crystalline lens and vitreous. The "liquefaction" of vitreous leads to turbid matter in the eye. Due to the high density of the crystalline lens, the turbid point rotates against the direction of eye rotation and so the point-like dark shadows appear in the vision of the elderly. These dark points are like flying insects with the shapes of round, oval, point-like, linear and so on.

Based on the above analysis of the elderly' s eye physiological function, the visual characteristics of the elderly and visual disorders will be as design reference and theoretical basis to guide medicine packaging graphic design for the elderly OTC medicine. With the increase of age, the elderly not only change physically, but also change psychologically. There are three main aspects of the elderly's psychological characteristics:

(1) the elderly cannot quickly read the package instruction with too small font size or differentiate medicines, and thus they might be frustrated and helpless
(2) the elderly live separately from their children and lack of care, and hence they are prone to loneliness
(3) the elderly are nostalgic to the past [4].

To sum up, the elderly OTC medicine packaging graphic design should take full consideration of the visual characteristics of the elderly and their psychological characteristics. As an important carrier to convey the design of packaging information, graphic symbols can effectively disseminate the efficacy and features of the medicine. Simple and clear graphical design is conducive to reduce the elderly reading difficult and help them to identify and remember the medicine.

3 OTC Medicine Packaging Graphic Design

3.1 The Principles of OTC Medicine Packaging Graphic Design for the Elderly

Graphic design takes up most part of the medicine packaging, and when the elderly patients read the text, they would notice the pattern in between first [5]. Combined with the visual characteristics of the elderly and psychological characteristics analyzed previously, the following design principles should be met for the elderly's OTC medicine packaging graphic design. (1) Principle of information transmission accuracy:

the graphic on the medicine packaging must be strictly in accordance with the relevant provisions of the national OTC medicine packaging design and faithfully convey the information of medicines; (2) Principle of caring: graphic symbols on the medicine packaging should be user-friendly to comfort and reduce the metal stress of the senior patients. (3) Principle of visualization: the characteristics of the medicine, its function, efficacy and other aspects should be the main contents of graphic design which intuitively reflects medicine information and help the elderly to identify and remember the medicine. Realistic and descriptive approach should be adopted to refresh the reader.

3.2 Survey and Analysis of OTC Medicine Packaging

Elderly people are vulnerable to chronic diseases. Table is the result based on the survey on the frequency of elderly people buying OTC medicine. The ranking of medicines frequently purchased by the elderly: (1) rheumatic pain medicine (2) cold remedies (3) cardiovascular medicine (4) gastrointestinal medicine (5) vitamins (6) health care products (7) antipyretic analgesics (8) ENT medicine. Female elderly often buy rheumatoid pain medicine, while male elderly buy cardiovascular medicines more often. For the elderly with poor visual ability and weak text comprehension capability, the graphic is a simple and easy to understand language which directly and vividly convey the efficacy of medicine information and our care for them so that they can get emotional empathy and thus increase their trust of the medicines (Table 2).

Table 2. Analysis tables of the frequency of the elderly purchasing OTC medicines

Medicine type	Frequency of male	Frequency of female	Total frequency
Cold remedies	3	18	21
Health care products	2	3	5
Vitamins	2	8	10
Gastrointestinal medicine	4	7	11
Cardiovascular medicines	10	4	14
Antipyretic analgesics	1	2	3
Rheumatic pain medicines	2	29	31
Others	2	3	5
Total	26	74	100

After sorted collection of medicines that frequently bought by the elderly, three types of the OTC medicines packaging graphic in current market can be concluded: figurative graphic, abstract graphic and decorative graphic [6]. (1) The figurative graphic is expressed in a way of realistic depiction and exaggerated induction. Realistic depiction is a form of using photographic pictures and realistic hand-painting to convey medicine information including features, efficacy and other aspects [7]. The purpose of it is to enable the patients to intuitively picture the scene of recover from the diseases and to bring purchasers a safe and effective psychological feelings. Exaggerated induction: exaggeration is to exaggerate the figurative graphic and add simple handling

to concisely and clearly highlight the theme from color or graphic with novelty and rationality, and thus to comfort the patients psychologically and to win the trust of the elderly and their recognition of the medicine efficacy. (2) Abstract graphic adopts point, line and surface changes to compose graphic with indirect appeal through the conceptual and associative performance characteristics [8]; graphic language is more concise with more prominent personality. There are regular geometric type and irregular freehand type. Regular geometric graphic is with implied and metaphorical nature, which brings buyers a rational and prudent sense of order and passes on certain medicine efficacy information; irregular freehand graphic focuses on the patient's psychological feelings, and guide consumers to picture and think. (3) Decorative graphic, designed in accordance with the rules with a strong sense of rhythm, are the subjective and recapitulative description of human about nature. The elderly tend to be strongly nostalgic and more inclined to choose the traditional decorative graphic. Traditional decorative graphics are with rich cultural connotation, representing the Chinese nation's national spirit and auspicious meaning, but they are mostly used in traditional Chinese medicine or proprietary Chinese medicine packaging, not directly or specifically conveying medicine information and expressing significance. Hence, we will choose the figurative and abstract graphic for the elderly to identify in this research. Since there are too many changes within each style, we simply separate the figurative graphic into two styles: "realistic depiction" and "exaggerated induction"; the abstract image: "regular geometry" and "irregular freehand ". Therefore, we have a total of two groups with four graphic style see Fig. 1. Form questionnaire are made from the sorted medicine packaging graphic, and test the research objects about their visual recognition these graphics. The aim of this is to know what type of graphic design is easier for the elderly to get the efficacy of the medicines and more accurate in conveying information about their functions.

3.3 Analysis and Discussion

Table 3 identifies the ranking result of different medicine packaging graphic, and a conclusion can be drawn that the figurative graphic style excels in recognition results and exaggerated induction of figurative graphic has the best identification results for 75.8% the elderly. The second to best is realistic depiction of figurative graphic, 65.78% elderly people cannot recognize irregular freehand graphics. abstract graphics are not suitable for OTC medicines packaging for the elderly. There is no clear indicative information and significant medicine features between regular geometric graphic and irregular freehand graphic.

There are three important tasks for the graphic design of the medicine packaging: attracting consumers' attention, guiding patients to safe medication and transmitting information about the efficacy of medicines. Graphic is the best way to keep the message communicated after the interruption of the text message. The elder patients notice the graphic in between when reading text on the packaging. Graphic design can intuitively convey medicine information, and guide patients to understand their efficacy. The unique visuality, vividness, effectiveness and richness of the figurative graphic are capable of capturing patient's attention and lead them to the medicine, meanwhile, figurative graphic can express humanized care to patients and enhance their

Fig. 1. Classification of sample medicine graphics

Table 3. Ranking of different types of medicines packages graphic for the elderly to identify

Medicines	Graphic			
	Identification results ranked from top to bottom			
Rheumatic pain medicine	Exaggerated induction	Irregular freehand	Realistic depiction	Regular geometry
Cold remedy	Realistic depiction	Exaggerated induction	Irregular freehand	Regular geometry
Cardiovascular medicine	Exaggerated induction	Irregular freehand	Realistic depiction	Regular geometry
Gastrointestinal medicine	Realistic depiction	Regular geometry	Exaggerated induction	Irregular freehand
Vitamins	Realistic depiction	Exaggerated induction	Regular geometry	Irregular freehand
Heath care medicine	Realistic depiction	Exaggerated induction	Regular geometry	Irregular freehand
Antipyretic analgesics	Exaggerated induction	Realistic depiction	Regular geometry	Irregular freehand
ENT medicine	Exaggerated induction	Regular geometry	Realistic depiction	Irregular freehand

sense of trust in the medicine [9]. Therefore, proper use of graphic with clear theme and consistency between form and contents can help directly and appropriately convey the medicine brand and medicine characteristics [10].

At present, graphic design of medicine packaging in China is relatively ordinary, and simple, lacking distinctive brand characteristics. Graphic design as the language of medicine information transmission, is the integration between art and technology, and culture and science. To make the graphic in the medicine packaging design more aesthetically pleasing, comfortable, reasonable, and get consumer's recognition, the following methods can be adopted: (1) Design graphic from the image of the efficacy, such as Fig. 2 the package of "Tylenol" cold remedy. It uses realistic depiction supplemented by coloring the treatment human parts. The color turns from dark to light symbolizes the efficacy of medicines, soothing the analgesic psychological feelings of elder patients. Combining figurative graphic and instruction in black bold font, it vividly and accurately conveys the medicine attributes and brand appeal. (2) Design graphic from brand image, for example, Fig. 3 "KEKE cough capsule" expands and designs from its brand logo to select the basic elements including trade names, common name, trade name, business name and so on. For brand name "KEKE" and "cough", the designer smartly adopted subtraction design and summed up a homonym and a small yellow triangle, which makes a visual and auditory combination of successful design example. Using brand Graphic image helps enhance consumers' cognition and impression on the brand, making up the limitations of brand identity in the practical application. Scientific packaging of medicines, on the one hand, induces the patient's to buy with a strong psychological purchase willingness; the visually simple and clear graphic design helps the elder patients identify more easily and motivates them to buy; on the other hand, excellent graphic design of medicines packaging increases corporate

identity among the elderly psychologically, and helps establish a reputable corporate image and brand culture, build trust with patients, so as to obtain the market share. Combining with two methods and the physiological and psychological characteristics of aging patients, the medicine packaging will move from a unitary design to humanized design.

Fig. 2. The package of "Tylenol" cold remedy

Fig. 3. The package "KEKE cough capsule"

4 Conclusion

China has entered an aging society, and the elderly have become the main consumer group of OTC medicines. The traditional medicine packaging design fails to meet the needs of this huge consumer group. The future graphic design of medicine packaging should not only meet the safety and effectiveness of medicine, guiding the basic functions of medication [11], but also should study psychological, physical and

emotional needs of the elderly with an elderly-design-orientation to reduce their reading difficulty and stress physiologically and psychologically. Meanwhile, the graphic design of medicine packaging should bring the elderly sense of security and convenience during medication, arousing their confidence of life, improving their quality of life, and promoting the healthy development of China's medical industry.

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Musical Preferences Are Influenced by Changes in Heart Rate: A Trial Study Using Step Aerobics

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Abstract. This study aims to investigate whether the exercise induced changes in the heart rate influences the musical preference of an individual. We believe that an individual's musical preference while exercising is different from that while resting. If this idea is correct, it is necessary to reproduce the music according to the situation and state of the user, not random. It is not clear what influences the change in the musical preference. It is also unclear which musical features are preferred during exercise. Moreover, the heart rate changes due to stress, exercise, and excitement. Several studies have explored the relationship between heart rate and music. In this research, we report (1) how exercise-induced change in the heart rate influences the musical preference, and (2) which musical features influence an individual's preference of music under specific heart rates.

Keywords: Musical preference · Heart rate

1 Introduction

The use of portable music players has become prevalent in recent years. A 2011 survey showed that the possession rate of portable music players was 70.6% [1]. Devices such as portable music players allow us to listen to music while resting and while exercising.

We know empirically that the musical preference of an individual while exercising is different from that while resting. Therefore, it is necessary to reproduce the music according to user's situations and states, not random. In order to reproduce, in addition to musical features, we need a mechanism to combine user's preferences and situations of the user.

In current study, by using annotation concerning the situations of appreciation and musical scenes which are information of user's musical interpretation in addition to lyric information, a method has been proposed in which similarities of users are found in accordance with the user's preferences and circumstances and the play list is

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_49

automatically generated [2]. On the other hand, researches are also being conducted to estimate the user's situation with using various sensor information and provide services according to the situation. As a method of selecting music considering user's situations, method based on reaction and surrounding brightness when listening to music is proposed and developed [3]. However, it is not clear what influences such changes in the musical preferences. It is also unclear which musical features are preferred while exercising.

2 Related Work

The heart rate changes due to stress, exercise, and excitement. Several studies have explored the relationship between heart rate and music. When people were allowed to freely adjust the tempo of pure tone from 10 bpm to 300 bpm, it was found that there were three peaks of preferences correlating with the tempo ratios, which is a value obtained by dividing the desired tempo by the heart rate. The values of the tempo ratio were 1.0, 1.5, and 2.0 [3]. In addition, nearly twice as many individuals reported that a music search system based on the measured heart rate identifies the desired music better than random music searches [4]. However, music search using heart rate is thought to be divided into those who feel it is very effective and people who feel ineffective and it is inappropriate for those who listen to only the songs of your favorite artists.

Therefore, in this research, we report (1) how exercise-induced changes in the heart rate influences our musical preferences and (2) which musical features influence the musical preferences under specific heart rates.

3 Experiment: Musical Preferences Focused on Genre

First, we investigated the change in musical preference with regard to the genre of music. Music consists of three major elements of melody—rhythm, harmony, and the sub-elements of tempo, dynamics, and tone color [5]. The genre of music is determined by the combinations of these elements. Therefore, we focused on the genre of music.

3.1 Exercise Load

We used step aerobics as the exercise load in our study. Further, experiments based on exercise load intensity were conducted by using a combination of three loads of step height, weight (1 kg $\times$ 2), and mask based on which we selected aerobics as the form of exercise. With aerobics, we could adjust the exercise load and control the heart rate at a specific value while maintaining a constant motion rhythm. Because we aimed to investigate the relationship between heart rate and musical preference, it was necessary to eliminate the influence of movement rhythm on the musical preference. We could control the movement rhythm by using the above exercise system.

Three university students participated in this experiment. Five types of exercises were performed for 1 min (Table 1). Each type was performed three times. We used a sample statistical image because the step aerobics were done while listening to music. The rhythm of the step aerobics was 110 bpm, which is the average value of the tempo of music used.

Table 1. Five exercise patterns

No.	Exercise pattern (Step · Weight · Mask)
1	(Low · Without · Without)
2	(Low · With · Without)
3	(Low · With · With)
4	High · Without · Without
5	High · With · With

We used a wearable instrument, Mio LINK, to measure the heart rate during exercise.

We used ANOVA and multiple comparisons to analyze the observations.

Based on this experiment and with consideration to safety, we selected two exercise patterns: (Low · Without · Without) and (Low · With · With) (Table 2). We defined the pattern (Low · Without · Without) as "light load" and (Low · With · With) as "heavy load."

Table 2. Average of the heart rate of the subjects and the total value

	1	2	3	4	5
A	15.0	17.3	28.3	15.7	21.0
B	15.7	21.0	21.7	29.0	37.0
C	31.3	21.7	40.0	38.0	32.0
Total	62.0	60.0	90.0	82.7	90.0

3.2 Select Music

We used four genres of music that are often listened to—"J-POP", "Anime Song," "Hip-Hop," and "Rock/Punk." Five songs with different tempi were prepared for each genre. As a result, we prepared twenty songs in total (Table 3). Using the quartile for each genre, we used five songs with the tempi "minimum value," "first quartile number," "median," "tertiary quartile," and "maximum value."

3.3 Procedure

Figure 1 shows the flow of the experiment. Two university students participated in our experiment. At first, the heart rate at rest was measured. Next, they listened to 20 songs played for 30 s per song. By doing this, we mitigated their possible dislike of the songs

Table 3. Titles and artists of the five selected songs of each genre

Genre	Title	Artist
Hip-Hop	KRAZIE KLUB	JOYSTICKK feat. AK–69
	日本語ラップ is DEAD? (Nihongorappu is DEAD?))	Den, D.O, JBM, VIKN, SIMON, MUNARI, DJ MISSIE
	FUKUROU (YAKANSIKOU)	YOU THE ROCK
	SHOCK TO THE FUTURE '04	FUTURE SHOCK ALLSTARS
	GROWTH	ANARCHY
Anime Song	Sister's noise	fripSide
	Hacking to the Gate	いとうかなこ(Ito Kanako)
	DreamRiser	ChouCho
	DREAM SOLISTER	唐沢美帆(Karasawa Miho)
	僕らは今のなかで (Bokurawaimanonakade)	μ's(myuzu)
Rock/Punk	ネコ飼いたい (Nekokaitai)	ヤバイTシャツ屋さん (YabaiTshatsuyasan)
	Shampoo	Waybee
	ヒーローが死んだ夜 (Hirogasindayoru)	フィッシュライフ (Fisshuraifu)
	ライブオアライブ (Raibuoaraibu)	HOWL BE QUIET
	動物ディスコフィーバー (Doubutsudhisukofiba)	THE BOY MEETS GIRLS
J-POP	I Believe	絢香(Ayaka)
	ホストに声を投げ入れて (Hosutonikoewonageirete)	YUKI
	僕の名前を (Bokunonamaewo)	Back number
	やさしさで溢れるように (Yasashisadeafureruyouni)	Flower
	What you want	JUJU

they have not listened to previously. Two exercises with "light load" and "heavy load" were performed for 1 min. The heart rate measurement at this time was taken using Mio LINK.

In addition, after each minute of exercise, we evaluated three items in five stages as shown in Fig. 2.

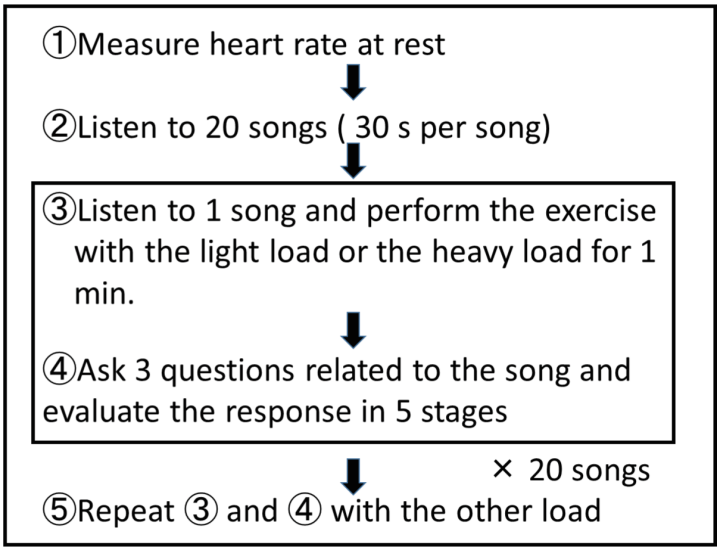

Fig. 1. Flow of the experiment

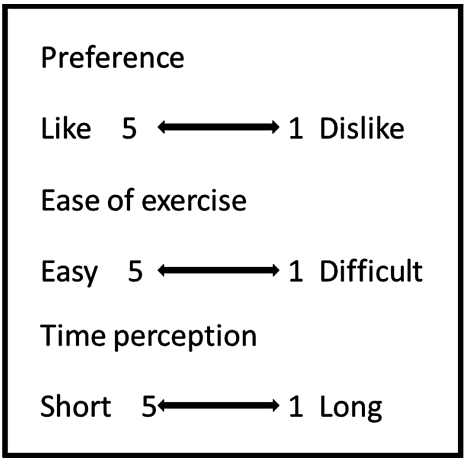

Fig. 2. Three questions that were asked to the participants

4 Results and Discussion

4.1 Heart Rate

Table 4 shows that the heart rate is higher for "heavy load" in subject A ($p < 0.1$). This result suggested that there is a possibility that the exercise load may need to be properly adjusted.

Table 4. t-test (heart rate)

Subject A		
	Light load	Heavy load
Average	12.6	15.8
Variance	52.7	30.5
Observed frequency	20	20
Degree of freedom	19	
t value	−1.827	
P(T <= t) 2–sides	**0.083	
t critical value 2–sides	2.093	
Subject B		
	Light load	Heavy load
Average	16.2	14.6
Variance	44.1	9.8
Observed Frequency	20	20
Degree of freedom	19	
t value	0.976	
P(T <= t) 2–sides	0.341	
t critical value 2–sides	2.093	

4.2 Preference

We used ANOVA, multiple comparisons using Sidak's method, and t-test for analyzing the observations made in our study.

Both subjects indicated that their musical preferences differed depending on the genre ($p < 0.05$). However, it cannot be said that their preferences differed depending on the exercise load.

Table 5 shows that they liked "Hip-Hop" the least and their preferences for "Rock/Punk" were divided. We believe this was because they usually did not listen to "Hip-Hop," and subject B frequently listened to "Rock/Punk."

Table 6 shows that the subject A liked "Hip-Hop" and "Anime Song" with "heavy load" ($p < 0.1$). A related work reported that the tempo of music influences the heart rate. Therefore, we believe that music features such as tempo may have influenced the preference of this subject.

4.3 Ease of Exercise

Table 5 shows that music played in the order of "J-POP < Hip-Hop < Rock/Punk < Anime Song" made it easier to exercise in subject A whereas in subject B, listening to "Rock/Punk" made it easier to exercise than "Hip-Hop" ($p < 0.05$). Table 5 also shows that listening to "J-POP" made it easier to exercise than "Hip-Hop" in subject B ($p < 0.1$). We believe that listening to "Hip-Hop" makes it difficult to exercise.

Table 5. Multiple comparisons by Sidak's method

Subject A						
	Preference		Ease of exercise		Time perception	
Genre	P value	Sidak method	P value	Sidak method	P value	Sidak method
Hip-Hop·Anime Song	0.090	*−0.476	0.058	*−0.642	0.033	*−0.782
Hip-Hop·Rock/Punk	0.070	*−0.575	1.000	*−1.000	0.058	*−0.642
Hip-Hop·J–POP	0.030	*−0.801	1.000	*−1.000	0.156	*−0.206
Anime Song·Rock/Punk	0.126	*−0.321	0.105	*−0.408	0.156	*−0.206
Anime Song·J–POP	0.258	0.091	0.053	*−0.669	0.058	*−0.642
Rock/Punk·J–POP	0.205	*−0.048	1.000	*−1.000	0.500	0.484
Subject B						
	Preference		Ease of exercise		Time perception	
Genre	P value	Sidak method	P value	Sidak method	P value	Sidak method
Hip-Hop·Anime Song	1.000	*−1.000	0.500	0.484	0.070	*−0.575
Hip-Hop·Rock/Punk	1.000	*−1.000	0.105	*−0.408	0.126	*−0.321
Hip-Hop·J–POP	0.063	*−0.611	0.242	**0.053	0.049	*−0.691
Anime Song·Rock/Punk	1.000	*−1.000	0.830	0.830	0.500	0.484
Anime Song·J–POP	0.500	0.484	0.874	0.874	0.295	0.173
Rock/Punk·J–POP	1.000	1.000	0.795	0.795	0.500	0.484

Table 6. Comparison of "light load" and "heavy load" due to genre differences

Subject A			
	Preference	Ease of exercise	Time perception
Genre	P value	P value	P value
Hip-Hop	**0.089	0.500	0.352
Anime Song	**0.089	**0.089	**0.089
Rock/Punk	Null	0.500	0.500
J–POP	0.187	0.500	0.152
Subject B			
	Preference	Ease of exercise	Time perception
Genre	P value	P value	P value
Hip-Hop	0.187	0.187	0.352
Anime Song	0.374	*0.016	0.500
Rock/Punk	0.374	0.115	0.399
J–POP	0.311	0.500	0.311

Table 6 shows that exercising with "Anime song" was easier under "heavy load" than "light load" in both the subjects ($p < 0.1$). We believe this was because both liked the "Anime Song" genre.

4.4 Time Perception

Table 5 shows that the subject A had the longest perception of time when he listened to "Hip-Hop" and the shortest when he listened to "Anime Song" ($p < 0.05$). Table 5 also shows that the subject B reported the longest perception of time when he listened to "Hip-Hop" ($p < 0.05$). We believe this was because of their dislike for "Hip-Hop."

Table 6 shows that in subject A, the same amount of time felt shorter for "heavier load" than for "light load" when listening to "Anime Song" ($p < 0.1$). We believe this was because "Anime Song" is easier to exercise with under "heavy load." The same was not observed in a significant manner in subject B and for other genres. This could be because the time perception is affected by the context of the song. Additionally, one minute is not enough time to influence the time perception.

5 Conclusion and Future Work

The results of the above experiments suggest that the genre we usually do not listen to has low effects on the ease of exercise and time perception whereas the genre we often listen to has a high effect on the same.

However, we also found that music features such as tempo might influence the above.

In our future work, we plan to investigate the effect of music features. We believe that we should consider the order of the songs played while evaluating the perception of time. Moreover, using the above results, we plan to build a music reproduction system that is suitable for the individual situation and state of each user.

Acknowledgements. This work was partially supported by JSPS KAKENHI grants (No. 25240043) and TISE Research Grant of Chuo University.

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Fitting School Buildings to the Requirements of Physically Disabled Students in Algeria: An Ergonomic Study

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Abstract. Achieving development in any country is a joint responsibility and needs intensive efforts from all citizens; the able-bodied and the disabled. But how can people with disabilities contribute to this development if their work and environment are not fitted to them? In Algeria, according to the Algerian National Office of Statistics, it is estimated that the total number of disabled people is around two million. Algeria has adopted the policy of inclusion in all levels of education, with a large number of those with physical challenges attending educational institutions with main-stream students. Hence, it is necessary to assess to what extent educational facilities are designed to fit the requirements of the disabled students, including their emotional needs.

Keywords: Emotional response · Physically challenged students · School buildings · Algeria

1 Introduction

Theories of development such as modernization theory [1], dependency theory [2], and globalization theory [3], have been advanced to develop third world countries. They stress the fact that development requires the efforts of all citizens including the physically challenged individuals. Everybody should perceive he/she is valuable in society.

But to what extent, do people with disabilities contribute to the national development if the work and environment are not fitted to them?

The environmental factor is becoming a necessary component to understanding disability. As early as 1997, the International Classification of Impairments, Activities, and Participation subsidiary of World Health Organization (WHO) has considered this factor as very important when talking about disability [4]. In addition, other authors consider environmental factors very important in the inclusion of disabled people [5–7].

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_50

Ergonomics as a science of fitting the work to man, can make the participation of the disabled in the development process very effective. Ergonomists have already stressed that environment should be designed to improve access for people with physical disabilities [8–10]. The result has been enormous, and if applied, will be of great benefit not only for the disabled but for all members of society. In the 1980s, ergonomists were demanding a barrier- free environment, but in the 21st century, the emphasis has shifted from such design [11], to design-for-all environment [12].

According to Snider and Takeda [12], design for all is "the design of products and environments to be usable by all people, to the greatest extent possible, without need for adaptation or specialized design". It is a design which takes into consideration the needs of all members of society (able-bodied, and disabled; young and old people; men and women) [13, 14].

The need of having the physically disabled individuals in educational and work institutions was the major cause of having numerous criteria that aimed to ease their life. In this context, the American Council for Exceptional Children published standards on how to use different services for people with special needs, including several private educational environments such as using libraries, playgrounds and laboratories [15]. In addition, international initiatives encourage integration strategy such as the World Conference on Education for All [16].

With the call for the right of all children to learn together, regardless of their physical, intellectual, or emotional disability, the last decades of the twentieth century witnessed an increase in the number of disabled students attending classes in regular education [17].

In Algeria, the Algerian National Office of Statistics [18], estimates that the total number of disabled people is around two million, 44% of them are physically disabled, and 50% are children and adolescents (Table 1).

Table 1. Number of disabled in Algeria according to disability

Type of disability	Number	%
Physical	880000	44
Hearing	73437	03.67
Vision	173031	08.65
Intellectual	167000	08.35
Various	85511	04.27
Chronic	620000	31.06
Total	2000000	100

Since Algeria has adopted the policy of inclusion in all levels of education (primary, intermediary, secondary, tertiary, etc.), a large number of students with physical disabilities attend educational institutions with main stream students. It is estimated that the number of disabled students who learn in different public and special schools exceeds (24000) learners [18]. Hence, it is necessary to assess to what extent educational facilities are designed to fit the requirements of the disabled students. Therefore, this study aims to answer the following question:

What are the emotional responses of the study sample towards the following topics:

- The entrances to buildings, classrooms, laboratories, elevators, bathrooms and stairs?
- The ability to reach the fire-fighting devices, lighting switches, door and windows handles?
- The Movement inside corridors, classrooms, laboratories, libraries, and amphitheaters?

2 Methodology

2.1 Method

To achieve the objectives of this study, the researchers used the descriptive method especially the sample survey.

2.2 Sample

In this study, researchers used the snowball sample. Initially, one of the researchers (H.K.) had a contact with one of her students who is a wheelchair user, who in turn enabled her to have a contact with other disabled students in the different colleges at the University of Setif. At the end, researchers were able to collect information from a number of disabled students (n = 51 students). Table (2) shows some characteristics of the study sample.

Table 2. Sample demographic characteristics

Males		Females	
Total participants	33	Total participants	18
Average age (years)	13.51	Average age (years)	13.66
Standard deviation (years)	2.34	Standard deviation (years)	3.01

2.3 Data Collection Tool

In the last thirty years, there have been multiple attempts to measure emotional responses. The result was the development of several tools. For detailed information, see [19]. In this study, researchers used the Geneva emotional wheel to assess the emotional responses of disabled students. It is a self-report tool on which 20 positive and negative emotions are depicted with five circles for each. The largest circle indicates a strong emotional response. To know the validity and reliability, the researchers relied on the fact that the tool was used in a lot of previous scientific research, [20–23].

2.4 **Procedures:** Data Analysis Was Carried Out in Four Phases

Phase I (Survey Distribution) and Phase II (Responses Cleansing) were executed in parallel such that papers were handed out to each participant and when the participant finishes, the paper would be checked for miss-entries or vague responses on the spot. The latter served as a cleansing stage.

Phase III (Data Entry), each survey obtained from each participant was entered as a new row in an excel sheet. Each excel sheet represented a survey category.

Phase IV (Data Analysis), data was handled using Microsoft Excel and all blank emotions not answered by participants were converted to zeros. Each emotion of the Geneva Emotional Wheel was put in a column of its own to ease calculations for each emotion.

For each emotion the sum, mean and sample standard deviation were calculated, the process was repeated for each a of the surveys' categories (Fig. 1).

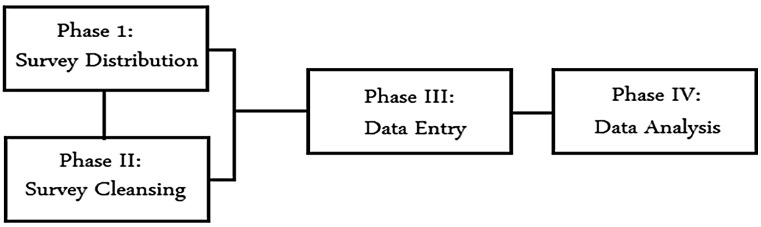

Fig. 1. Data analysis procedures

3 Results Analysis and Discussion

This study aimed to answer the following question: What are the emotional responses of the study sample towards the following topics?

- The entrances to buildings, classrooms, laboratories, elevators, bathrooms and stairs.
- The ability to reach fire-fighting devices, lighting switches, door and windows handles.
- The Movement inside corridors, classrooms, laboratories, libraries, and amphitheaters.

Results are shown in Tables (3, 4 and 5).

As to the entrances, it is shown that larger results belong to negative emotions especially anger, hate and sadness. For the reach, anger, hate, disgust and disappointment are the emotions which got the highest results. Finally for movement in buildings, anger, fear and contempt had the highest results.

Based on the above results, there is no doubt that the image that we got indicates that emotional responses of individuals are negative. We believe that these responses are very natural. Students have been at the university campus for at least three years. During this period, they had negative experiences that could be one of the reasons for the negative trends outlined by the results.

Table 3. Results of the entrances to buildings

Type of emotion	Entrances to											
	Buildings		Teaching rooms		Laboratories		Elevators		Stairs		Bathrooms	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anger	0.4	1.3	0.6	1.6	0.5	1.4	0.7	1.4	0.6	1.5	0.4	1.3
Interest	0.2	0.9	0.3	1.0	0.1	0.7	0.0	0.4	0.0	0.4	0.3	1.1
Hate	0.4	1.3	0.5	1.5	0.4	1.2	0.6	1.4	0.7	1.5	0.5	1.3
Amusement	0.0	0.0	0.1	0.5	0.1	0.5	0.0	0.3	0.2	0.9	0.1	0.6
Pride	0.1	0.8	0.2	0.9	0.1	0.5	0.1	0.6	0.0	0.0	0.1	0.5
Joy	0.2	0.9	0.3	0.9	0.2	0.9	0.2	0.8	0.2	0.8	0.2	0.8
Pleasure	0.1	0.5	0.1	0.5	0.1	0.8	0.1	0.8	0.1	0.5	0.1	0.5
Contentment	0.2	0.8	0.2	1.0	0.2	0.9	0.1	0.8	0.1	0.6	0.1	0.6
Love	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.0	0.4	0.1	0.5
Admiration	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.7	0.1	0.7	0.1	0.5
Relief	0.3	1.1	0.3	1.1	0.2	1.0	0.2	1.0	0.2	0.9	0.2	1.0
Sadness	0.4	1.3	0.2	0.8	0.2	0.9	0.1	0.6	0.2	0.7	0.5	1.3
Guilt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fear	0.2	0.9	0.3	1.0	0.1	0.8	0.8	1.6	0.6	1.5	0.3	1.1
Disgust	0.3	1.0	0.1	0.7	0.1	0.6	0.1	0.6	0.1	0.7	0.2	0.8
Contempt	0.2	0.9	0.3	1.1	0.3	1.1	0.1	0.6	0.1	0.5	0.3	1.1
Shame	0.2	0.9	0.1	0.6	0.1	0.5	0.0	0.4	0.0	0.0	0.2	0.9
Regret	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Compassion	0.3	1.1	0.1	0.5	0.1	0.6	0.0	0.2	0.1	0.7	0.1	0.5
Disappointment	0.3	1.1	0.3	1.0	0.1	0.8	0.2	1.0	0.4	1.3	0.7	1.7

Table 4. Results of the reach

Type of emotion	Reaching							
	Fire extinguishers		Light switches		Door handles		Windows handles	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anger	0.47	1.43	0.99	1.89	0.83	1.77	1.18	2.04
Interest	0	0	0	0	0	0	0	0
Hate	0.36	1.19	0.26	1.02	0.28	1.01	0.22	0.82
Amusement	0.06	0.53	0.06	0.53	0.06	0.53	0.06	0.53
Pride	0	0	0	0	0	0	0	0
Joy	0.06	0.53	0.06	0.53	0.06	0.53	0.06	0.53
Pleasure	0	0	0	0	0	0	0	0
Contentment	0.12	0.75	0.11	0.75	0.22	1.04	0.11	0.75
Love	0	0	0	0	0	0	0	0
Admiration	0	0	0	0	0	0	0	0
Relief	0.11	0.75	0.13	0.77	0.43	1.31	0.11	0.75
Sadness	0.24	0.94	0.28	0.94	0.27	1.04	0.39	1.27
Guilt	0	0	0	0	0	0	0	0
Fear	0.08	0.57	0.12	0.64	0.08	0.57	0.11	0.65
Disgust	0.37	1.19	0.3	1.11	0.3	1.11	0.43	1.28
Contempt	0.06	0.53	0.08	0.57	0.03	0.32	0.04	0.42
Shame	0	0	0	0	0	0	0	0
Regret	0	0	0	0	0	0	0	0
Compassion	0	0	0	0	0	0	1.18	2.04
Disappointment	0.76	1.64	1.1	1.85	0.62	1.47	0	0

Table 5. Results of the movement in buildings

Type of emotion	Movement in									
	Corridors		Classrooms		Laboratories		Libraries		Amphitheaters	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anger	0.49	1.38	0.45	1.37	0.4	1.29	0.44	1.31	0.36	1.19
Interest	0	0	0	0	0	0	0	0	0	0
Hate	0.13	0.74	0.28	1.07	0.33	1.14	0.26	1.01	0.31	1.1
Amusement	0.15	0.81	0.11	0.75	0.11	0.75	0.11	0.75	0.11	0.75
Pride	0.11	0.75	0.11	0.75	0.06	0.53	0.06	0.53	0	0
Joy	0.03	1.19	0.03	1.19	0.13	1.19	0.13	1.19	0.14	1.19
Pleasure	0.27	1.12	0.3	1.15	0.27	1.12	0.31	1.18	0.3	1.15
Contentment	0.11	0.75	0.11	0.75	0.11	0.75	0.11	0.75	0.06	0.53
Love	0.02	0.21	0.02	0.21	0.02	0.21	0.02	0.21	0.02	0.21
Admiration	0.1	0.67	0.1	0.67	0.1	0.67	0.06	0.53	0.1	0.67
Relief	0.26	1.08	0.22	0.97	0.15	0.81	0.15	0.81	0.11	0.65
Sadness	0.22	0.88	0.09	0.49	0.08	0.53	0.07	0.39	0.1	0.56
Guilt	0	0	0	0	0	0	0	0	0	0
Fear	0.45	1.24	0.35	1.14	0.28	0.98	0.33	1.13	0.3	1.05
Disgust	0.2	0.88	0.12	0.69	0.27	1.02	0.26	0.99	0.16	0.75
Contempt	0.36	1.08	0.28	1.02	0.28	1.09	0.28	1.04	0.28	1.02
Shame	0.26	1.07	0.29	1.11	0.18	0.85	0.13	0.74	0.18	0.85
Regret	0	0	0	0	0	0	0	0	0	0
Compassion	0.16	0.85	0.11	0.53	0.08	0.53	0.02	0.21	0.13	0.74
Disappointment	0.21	0.99	0.27	1.04	0.27	1.12	0.22	0.97	0.43	1.3

Why responses are negative? No one doubts that the students showed negative responses because they are suffering a lot every day they spend at the university.

These negative responses indicate that the design of these buildings is not suitable for the disabled. Despite the fact that the university buildings are new, they are not well-conditioned for the disabled. They do not allow students to enter and exit from buildings without difficulty, they do not allow them to reach what they need easily, and they limit their freedom of movement. In addition, they lack elevators. There is no need to wonder if you see a wheelchair student carried by colleagues to the upper floor. Further, when the wheelchair student arrives at the hall, he/she will find not enough space for his/ her legs. Also, many of the floors in the buildings are sliding. In addition, the buildings are spaced from each other to the extent that the disabled find it very difficult to move from one building to another. Furthermore, most of the buildings rise from the Earth's surface with a number of grades (3–4) and there are no ramps to the extent that some parents have made these slopes themselves to facilitate the entry of their children into classrooms.

Similar results are found elsewhere. Kalia et al [24] found that all the students they interviewed, had difficulty in accessing higher educational buildings (class rooms, seminar halls, auditoriums, laboratories, library & internet facilities, toilet and wash areas, eating outlets, & parking areas).

Aljowair [25] showed the invalidity of the hypothesis that were widespread among architects and architectural students, which stipulates that newly-opened buildings that

were designed by Saudi and non-Saudi architects at the University of King Saud, don't respond to the requirements of disabled students.

Further, Walid [26] concluded that students with motor disabilities face within the school some of the problems arising from the design of the school building, such as: lack of private parking, the difficulty of entering the wheelchair from the main door and the difficulty of opening different school doors, (the main door of the school, the doors of the classroom and the gates of science and computer labs). Furthermore, the bookshelves of the school library are often beyond the reach of the students.

Fassoli [27] concluded that the overall level of services provided to disabled students, does not exceed 10% of the needs, and requirements, except for ease of entry to the school from the outer door, which is designed for the car to enter, while the rest of the other requirements such as toilets, chairs and a blackboard and other facilities are not suitable for them.

Finally, Pinto et al. [28] found that if the physical environment is not designed to fit the disabled, it will not help inclusion policies to succeed.

4 Conclusion

Ergonomics has for a long time called for the application of ergonomic principles to the design of workplaces, tools and apparatus the disabled use in their daily life [29–32]. Results from different studies including this one, indicate that physically challenged are not satisfied with their workplaces, and the tools they use. Ergonomists have to take this issue into consideration and think carefully about the effective application of ergonomics applied to disability matters, so that their subjective well-being will improve.

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Categorization of Aesthetic Pleasure Derived Attributes: A Cultural Perspective

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Abstract. Current design researches on product appearance have increased, exploring the fact that products not only have practical value, but the way they are designed have the ability to evoke aesthetic pleasure. The configuration of the appearance of objects has contributed to the development of economies, societies and cultures around the world. Due to the growing interest in this topic, a more detailed analysis is necessary to evaluate the relationship between aesthetic pleasure and culture through the development of projects that focus on the characteristics and preferences of the context itself. This study analyzes and compares preferences for globally and locally recognized, consumed and used objects in a specific context. The information obtained by this research generated a hierarchical categorization of aesthetic preference of two samples, one located in the city of Cali (Colombia) and another in Dublin (Ireland).

Keywords: Aesthetic pleasure · Aesthetic attributes · Culture · Appearance

1 Introduction

The word aesthetic comes from the Greek "aisthētiké" that refers to the sensation, perception and understanding of all that is perceptible. The study of aesthetic pleasure begins as a profound exploration of arts and has been the subject of philosophical discussion since ancient Greek philosophers such as Plato, who argued that beautiful objects embody proportion and unity in their composition [1]. Likewise, Aristotle, in his work Metaphysics, affirmed that the universal elements of beauty are order, symmetry and proportion [2]. However, it is not until Baugarden, in the eighteenth century, that aesthetics is established as a discipline, based on the conjunction of art and beauty. For Hekkert, art is precisely the field that seeks to gratify the senses applying judgments of aesthetic experience as: aesthetic attitude, aesthetic understanding, aesthetic emotion and aesthetic value [3]. For its part, Umberto Eco, in The History of Beauty, makes a compilation of documents of art, handicraft, literature and entertainment, where he poses that the consideration of beauty depends mainly on time and culture and highlights the different conceptions of what manifests itself as beautiful through time and context [4].

This paper takes over the thought of Eco and focuses on the study of aesthetics from beauty.

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_51

Despite all of the time and information invested in the study of aesthetics about art, only during the last decade the attention for aesthetic pleasure has increased in design research, which has allowed further relevance to a field that is not only limited to the practical value (function and use of objects), but emphasizes its formal value in regards the capacity to generate pleasure. Studies carried out by different design theorists have allowed to see the relation between aesthetic pleasure and other aspects of a product such as functionality, usage and buying interest. In one of the most relevant studies in this field two functionally identical mobile phones were contrasted respect to their appearance to determine the relationship and influence of aesthetic pleasure and ease of use, concluding that the most attractive objects for the users are the ones that they qualify as more useful [5], this is mainly because the interaction with objects is not limited only to use but also to the emotional relationship that is established with them [6]. In another study, the appearance of a product was analyzed in relation to categorization, use value, functional value, symbolic value and aesthetic value, concluding that the last two (symbolic and aesthetic) were determined by users as more relevant in choosing to purchase a product [7].

In the design field the term "aesthetic appreciation" has been approached in two ways: by objective characteristics of a stimulus (shape, tone, color, texture, size), that is, located in the object, or by subjective reactions to the qualities of a product, in this case, located in the individual, customer or user [5].

In objects design and products development is important to take into account that aesthetic appreciation not only comes from specific factors of the products but also is determined or can be modified by user characteristics such as age, personality, culture, gender [8], fashion trends or Zeitgeist effects [9] and even by adaptive conditions in evolutionary processes [3]. The present study focuses on the analysis of the relationship between aesthetic pleasure and culture. Culture is an essential factor in the interpretations and relationships that the users have with the appearance of a product. An example of this are the associations of color, which vary considerably according to the context and symbolic charge: in the United States, white represents purity while in Japan it represents mourning [6]. Globalization has not only contributed to the acceleration and integration among nations, but has also greatly influenced the unification of various areas of art. Unfortunately, this unification seems to generate a gradual loss in cultural identity [10].

Based on this view, the analysis of the relationship between aesthetic pleasure and culture dealt with in this study allowed to generate a categorization and hierarchy of aesthetic preference of visual, tactile and audible attributes, from two groups of individuals, one located in the city of Cali (Colombia) and another in Dublin (Ireland). This categorization revealed differences in the attributes that each group considered more important when evaluating a product, suggesting also that each group has a particular taste and preference for their local products.

2 Hypothesis

Each social group appreciate more their local objects than global objects. This is evidenced by the importance and difference that is granted to formal attributes of local and global products.

3 Methodology

The test was set out by analyzing and comparing preferences over global and local objects of two user samples in two different cities. The subjects surveyed evaluated six physical products on which visual, tactile and audible attributes were analyzed. The global objects studied were: a Colgate toothpaste (Maximum Protection Caries, 150 cm^3), a bottle of Coca-Cola (Original Flavor 350 cm^3) and an iPhone 6s; Among the local objects evaluated in the city of Cali were: a bottle of Aguardiente Blanco del Valle (No Sugar, 750 cm^3), a pack of Rosquillas Caleñas (30 g) and a handmade necklace (made of Totumo and resin, 16 cm × 9 cm). On the other hand, a Guinness beer (Extra strong, 500 cm^3), a bar of Kerrygold butter (Salted Butter, 250 g) and a Claddagah ring (Classic Sterling Silver Ring, size 7) were evaluated in the city of Dublin.

The appearance attributes that were assessed are listed below, in visual terms: size, harmony, symmetry [11], proportion, familiarity [12], delicacy [13], complexity, quality, and innovation [9].

The evaluated tactile attributes were properties derived from the contact with the material or the surface of the products as: texture, hardness, elasticity, temperature, weight and balance [14, 15].

As for the audible attributes, it is necessary to clarify that there are not many studies on these product properties. Among the few that are found, there is one piece of research on the basic semantic components of product's sounds that suggest a hierarchical structure in the associations of sounds of the products [16]. For the development of the present study, the attributes used were those that conform that hierarchical structure: attention (high tone, slow, fast, and low tone; sharp or silent), roughness (rough, mechanical or noisy), familiarity (familiar, unfamiliar), time constancy (constant, repetitive or electric) and softness (soft sound).

Because the perceptions about the shape of the objects and the definitions provided by a design professional could be different from those of a normal user [17, 18], a list with brief descriptions of each of the attributes was given to the participants (see definitions in Table 1) to avoid that the meaning of each concept be misunderstood and the accuracy of categorization affected.

3.1 Participants

The groups of surveyed were men and women in an age range of 20 to 35 years. The group in Cali (Colombia) had nine participants and the group in Dublin (Ireland) had six participants.

Table 1. Definitions of evaluated attributes

Visual attributes	Definitions
Size	Set of physical dimensions of an object for which it has smaller or larger volume
Harmony	Unity, order and coherence between the elements of the object and its shapes, colors and parts
Symmetry	Object's equilibrium, it can be divided in equal parts
Proportion	Harmonic relationship of one part with the others and with everything
Familiarity	It is a known product, seems common
Innovation	Different, advanced/new
Fragility	Sophistication, fragility
Complexity	Ease/Difficulty to understand its shape, how it works, what it is
Quality	The object satisfies your needs
Tactile attributes	
Texture	Relief, repetitive movements
Hardness	Material property which prevents deformation to the touch
Elasticity	Material elongation capacity
Temperature	Cold - warm ratio
Familiarity	It is a known product, seems common
Weight	Light/Heavy ratio
Balance	Refers to the stability of the elements of an object
Audible attributes	
Attention	The way it responds to stimulus, compare it with the sound of an alarm, or a bell
Roughness	Refers to mechanical object sounds, harsh or noisy tones
Familiarity	It is common, sounds that can be related to other objects, places or circumstances
Time constancy	If it is an electric sound, i.e. repetitive and constant, or if it is produced manually, i.e. irregular or by impact
Softness	Refers to passive and less hectic sounds, their opposite are the active sounds

3.2 Testing

- For the development of the test, two studies on categorization of aesthetic attributes were taken as reference. Firstly, aesthetic attributes were evaluated and categorized to show differences between professionals and users [18]; secondly the importance of twelve (12) aesthetic attributes was measured to obtain design data from customer emotions [19].
- In the present study, participants were invited to an interview room. Instructions to carry out the test were given and the visual, tactile and audible attributes to be evaluated were explained. Later, the three global and the three local objects were

placed in the room and the participants were asked to first evaluate how they liked the appearance of the objects in the room on a 5-point Likert scale ('1': "I love it", to '5': "I don't like it"). They then freely categorized each of the visual attributes by placing them in order of importance in terms of appearance and the same procedure was performed with the tactile and audible attributes. The experiment leader was present in the room and the task was performed with no time constraints.

4 Results

The information obtained from the surveys was processed in the statistical software SPSS. Upon comparison, there were significant differences and similarities between the two groups of surveyed users about the products and attributes that represented more interest to them. This first phase lasted approximately 30 min. The data obtained during the tests are presented below: as shown in Fig. 1, the results of this study show that 61% of the participants in the sample from Dublin responded I love it or I like it to the appearance of their local products. Among the group from Cali, 59% were indifferent to their local products and only 30% love or like it, which represents less than half of the sample in Dublin (Figs. 2 and 4).

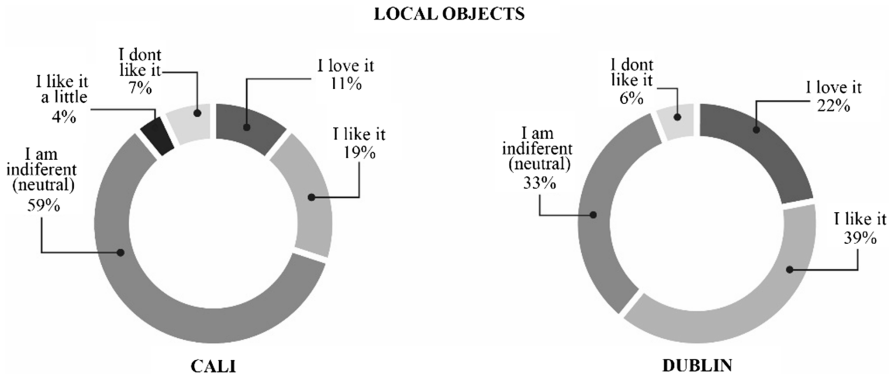

Fig. 1. Preference by local object appearance, Cali and Dublin

It should be considered that using products such as alcoholic beverages and other symbolic aspects may constitute a possible factor of alteration in the responses from the participants.

As to global objects, 59% of the sample in the city of Cali responded I love it or I like it, and 50% of the sample in Dublin were indifferent or don't like the products (see Fig. 3).

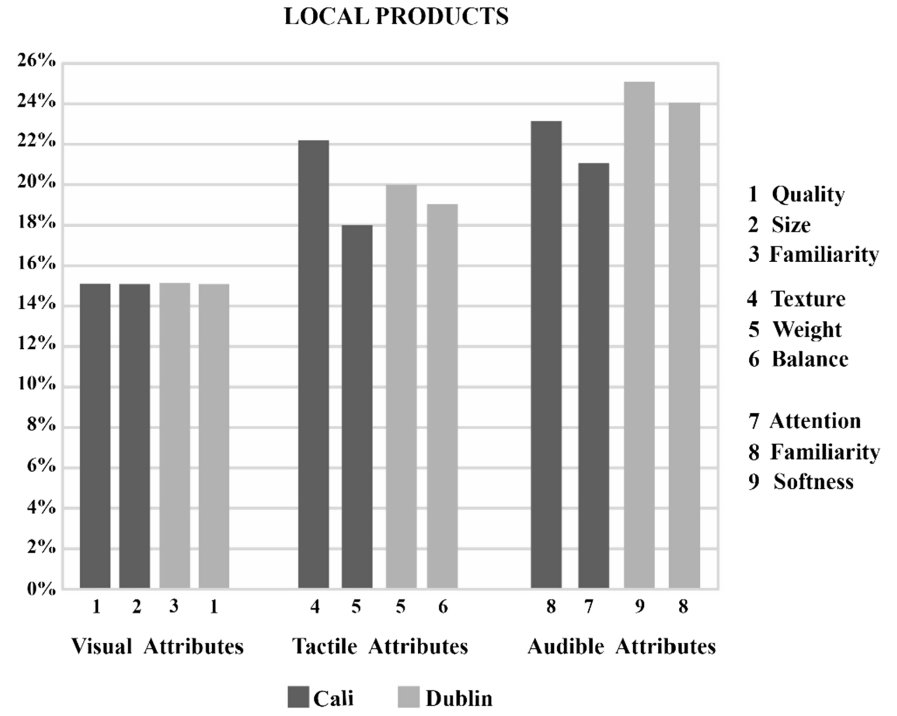

Fig. 2. Most important attributes in local products, Cali and Dublin

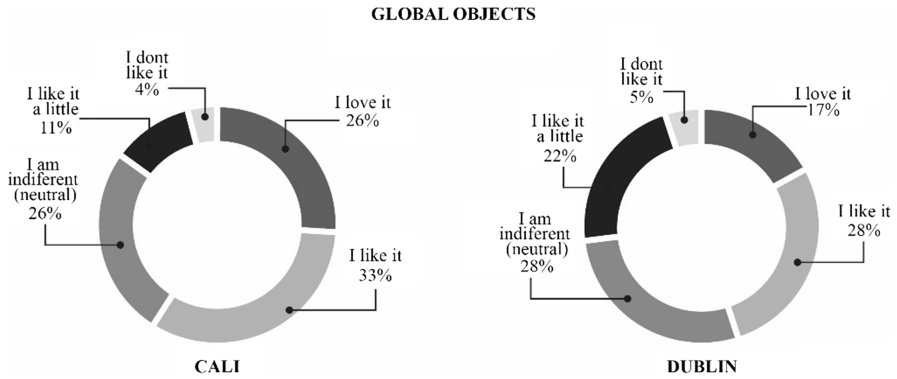

Fig. 3. Preference by global object appearance, Cali and Dublin

4.1 Local Objects

Visual Attributes. In terms of the categorization of aesthetic attributes, in the city of Cali the sample identified the size (15%) and quality (15%) as the most important visual attributes among the local objects, while the least important were harmony (7%)

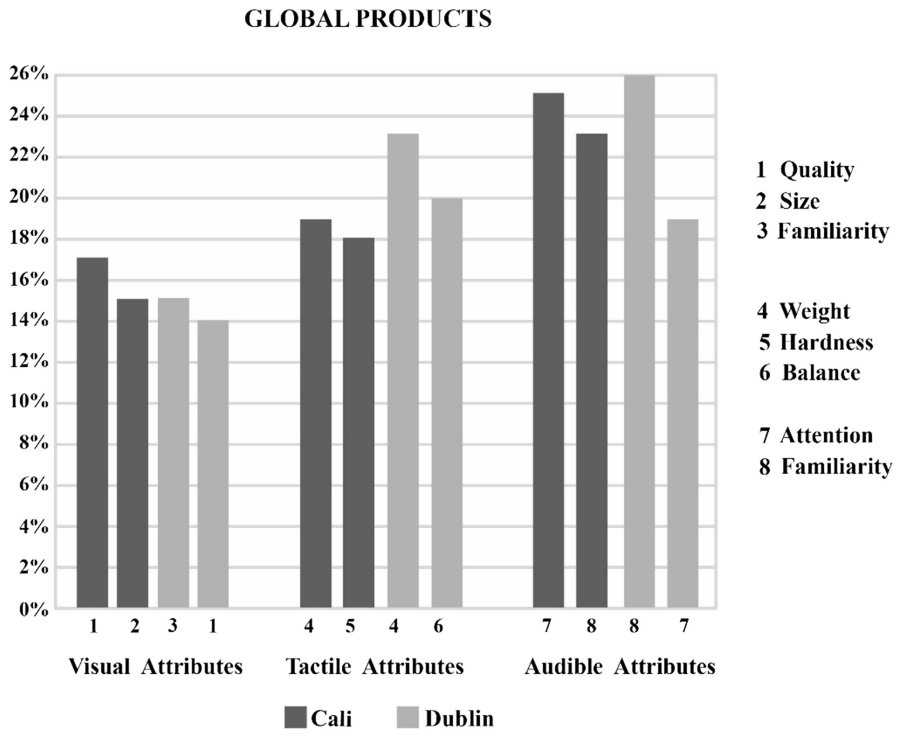

Fig. 4. Most important attributes in global products, Cali and Dublin

and delicacy (22%). This means that for this group, it is more important that the products are sophisticated or present unity, order and coherence between the elements that comprise it, while the adequate volume of the objects and that they satisfy the needs for which they were designed is less important. In Dublin, the most important attributes were familiarity (15%) and quality (15%), and the least important were complexity (6%) and innovation (7%). In this case, a familiar product that satisfies their needs is more relevant to them than understanding what the product is, how it is used or how it works.

Tactile Attributes. The most important tactile attributes evaluated in local objects in Cali were texture (22%) and weight (18%), and the least important were balance (13%) and elasticity (15%). This means that for this group, reliefs, surface finish and an adequate weight are more important than the elongation capacity or the stability in the object's elements. In Dublin, the most important attributes were weight (20%) and balance (19%), and the least important were elasticity (9%) and hardness (16%). In this case, the stability in the object's elements and an adequate weight are a more relevant criterion than the elongation or deformation capacity of their materials.

Audible Attributes. The sample in Cali identified familiarity (23%) and attention (21%) as the most important audible attributes among the local objects, and the least important were time constancy (17%) and roughness (19%). In Dublin, the most

important were softness (25%) and familiarity (24%), and the least important were roughness (14%) and attention (17%). It can be observed that the two samples gave more value to the familiarity attribute and less value to roughness, that is to say, it is more important for them that the objects emit familiar sounds that they can relate to other objects, places or circumstances, and is less important that the emitted sounds correspond to functional or mechanical aspects of the object.

4.2 Global Objects

Visual Attributes. As for global objects, in the city of Cali, the sample identified visual attributes quality (17%) and size (15%) as being most important, and complexity (8%) and delicacy (8%) as least important. In Dublin, the most important attributes were familiarity (15%) and size (14%), and delicacy (7%) and complexity (9%) were least important.

In this case, the two samples determined size as the most significant attribute, and complexity as the less important, that is to say. An adequate volume is more important for them than understanding what the product is, how it is used or how it works.

Tactile Attributes. In Cali, the sample identified the weight (19%) and the hardness (18%) as the most important tactile attributes among the global objects and elasticity (12%) and equilibrium (30%) the least important. were In Dublin the most important were weight (23%) and balance (20%), and the least important were elasticity (12%) and temperature (12%). The tactile attributes in this case, resemble the results obtained among the local objects.

Audible Attributes. Attention (25%) and familiarity (23%) were the most important audible attributes among global objects, and roughness (16%) and softness (17%) were the least important. In Dublin the most important were familiarity (26%) and attention (19%), and the least important were roughness (16%) and softness (18%). Again, the two samples gave a high value to the familiarity attribute and less value to roughness, as presented in the local objects evaluation.

5 Conclusions

According to the results and their respective analysis, it is found that in the surveyed group in the city of Cali, people did not like their local products, contrary to what happened in Dublin. This fact makes it possible to emphasize the importance of focusing on design projects that highlight the aesthetic attributes of local products that could generate more attraction in users.

The aim of this research was to provide knowledge about users' preference for appearance attributes of products by selecting from a list of attributes with definitions from different design theorists. In the data collected, it can be observed that the same groups of participants determined the same criteria for the two types of products (global and local), but some differences between the prioritizations by each group were evident.

By relating the hierarchy of the products' attributes with the taste of them, it can be inferred that, although the subjects in the city of Cali evaluated the same attributes in accordance with the order of importance given, the taste for the local products were less. This shows that local products did not respond to the aesthetic requirements that users expect in this city.

It is necessary to consider a later phase in this exploratory study which would allow validation of the obtained data, highlighting the attributes that the samples considered to be the most important and evaluating them later to determine if the taste for the product appearance of local objects increases.

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Research on User Experience Design Applications in Detail Designs of Elders' Garment Products

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Abstract. Elderly people are often left out by the information era, they should be receiving more care physiologically. Fashion designer should design product truly suitable for them based on their unique needs, and following user experience concepts. Clothing, as an inseparable part of people's daily life, requires fashion designers not only emphasizing the aesthetic feeling in the design, but should also gradually realizing the importance of the wearing experience, body functionality and behavior habits. Especially in details of the elderly clothing design, user experience is a bridge connecting relationships between users and clothing products. Such apparel product of the humanities concern ought to be brought to the attention of the designers. This article mainly from the user experience, design idea, the design of the human body engineering and psychology point of view, to explore the clothing products for the elderly in detail design.

Keywords: User experience design · Detail designs of elders' garment products · Button

1 Background

Due to some arthrosis disease, there will be joint activity and coordination problems occur to the elderly's body as the growth of the age, such as shoulders, arm joints, finger joints and other special structures and locations. The patient suffers from different degrees of chronic pain cause by the declined body function.

1.1 Elderly People Susceptible to Degenerative Joint Disease

Related studies show that elderly people have (2.09 + 1.028) pain sites on average and 5 at most. Patient who have 2 pain site is the most widely spread, accounting for 40.00%. Low back (48.20%), neck (30.00%) and lower limbs (29.10%) were the pain sites often, and the pain nature of various. For many subjects, the most common causes of chronic pain were osteoarthritis, osteoporosis, neurodynia operative wound or

W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4_52

trauma. The average pain intensity and pain intensity right now ranged from mild (VAS<4) to moderate (VAS4-6). Worst pain intensity fell in moderate (VAS4-6) [1].

However, common elderly clothing products are basically in accordance with average people style designs. For instance, extra effort is often required for the elderly in certain clothing that buttons are small and widely added. Many round collar of dress design requires substantial joint movements to put on, which may cause joint sprain and muscle strain. In those designs, users' experience and their physical conditions were not taken into account, which ignored the concept that clothing products also need to be designed from the perspective of the user experience.

But round collar dress warmth retention property was stronger than cardigan, and the pattern is hard to avoid. The elderly as the change of the age, most associated with osteoporosis. Years of work to retirement age, many elderly people joints have different symptoms of degenerative diseases. There are some old people suffering from cancer, cancer bone metastases, the basic skeletal pain cannot provide for oneself. Even so, the dress is still an indispensable part of their lives. These elderly clothing detail design doesn't take into account the elderly in experience and physical condition, clothing products detail design is not from the perspective of user experience design concept, the temperature of the loss of good product design should have.

1.2 Elderly's Clothing Product Details Not Pertinent

In the 21st century, world-wide consecutive attentions are putting on two major problems, negative population growth and aged tendency of population. In Asia, the proportion of elderly people in the country's population distribution is continuous growing bigger. For China's special social characteristics of population and age structure, the aging population trend has emerged. In that case, designers -no matter in what area of expertise- need to notice the fact that the elderly people's need cannot be ignored. Thus, products that conform to their character, that solve their problem, that improve their live qualities are highly demanded. Given priority to comfort, the elderly clothing design usually tends to be conservative, while no big change and break-through on the style. Clothing design especially for the elderly characteristic are much rarer.

Because the clothing styles of old people is normal, the elderly tend to wear simple and loose version, so can only start from clothing details. The intimate details of the design, in view of the characteristics of older adults details of improvement, the production cost can be ensured can to a certain extent, reduce the difficulty of developing products. User-centered is needed to design a product by the designer, study the physiological characteristics of old people. Investigation of the user experience and requirements of the elderly in the clothing products, based on the user experience design concepts to develop and design suitable for the elderly and convenient old people wear clothing products, to fully consider various factors especially the cost factor, understand the facilitation of demand for clothing products in the elderly,

prompted the details of the clothing products design more joint the physiological needs for old people.

2 Research Methodology Based on the Core of Design Concept for the Elderly's Experience

User Experience design mainly refers to a design measure aiming at the user, which means designing for the target of users' demand. The procedure of User Experience design also focuses on the users with the integration of the concept of user's experience from the very beginning stage of the whole design procedure. During the process of improving the product details for designing the elderly's garments, the paper analyzes the real demand and expectation of the elderly with three steps of early research. Finally, the data is modeled and simulated in practical scenarios, and the function and reasonability of such design for garment details have been demonstrated.

2.1 Survey and Analysis

Interviews. The interview is conducted with elderly in the community for the topic of the inflexibility of elderly's arthrosis and their demand for garments.

- Interviewee A, male, 63. A retired teacher suffering from rheumatic arthritis, cervical spondylosis and inflexible lumbar joints pains, who cannot burden strenuous exercise. He is used to wear cardigan and casual pants. He told that the buttons of T-shirt and trousers are too complicated for him.
- Interviewee B, male, 61. A worker, who previously worked for physical labor, has ever got wounded in the arms so that it cannot put in energy. He is used to wear loose casual wears with zipper. He told that it is quite hard for him to wear round collar garments in winter.
- Interviewee C, female, 70. A housewife, who has been engaged in housework for long time, suffers rheumatic arthritis, bulky joints and paralysis in palm nerve that makes her unable to stretch. She is used to wear free style cardigan. She told that it costs her much time to deal with the tiny and smooth buttons on some garments.
- Interviewee D, male, 83. A retired civil servant suffers from prostatic cancer of the middle and later periods, osseous metastasis of cancer cells ache all over the body. He can wear the garment by himself and is used to wear cardigan. He told that he needs someone to help him to wear the clothes as he is unable to accomplish major movements.
- Interviewee E, female, 61. A retired nurse with wellbeing just occasionally suffers from waist ache. She is used to wear regular woman's wear. She told that she expects to see more younger elements in garment styles.

- Interviewee F, female, 74. A housewife suffers from diabetes II and waist-leg weakness, who can wear the clothes by herself by sometimes fails to button due to Joint swelling in the fingers. She is used to wear cardigan with press buttons and pullover T-shirts with only one button. When the blood pressure rises, she suffers spasm in the arms. She told she hope the light materials can be used for garment and a more loose design on arms, oxter and waist.
- Interviewee G, male, 65. A security guard suffers from prostatitis. He is used to wear uniforms and trousers. He told that the design of trousers seems too complicated, which should be improved.

The above is the result of interviewing the elderly in the community. There are totally 20 elderly people are interviewed and ten elderly people with wide representativeness have been extracted for the summary. It can be initially concluded that most of the elderly may suffer from arthropathy as they become older and are used to wear cardigan. Meanwhile, it should be addressed that some special garments positioned for the elderly should be developed.

Observation

Location of Observation. Hospital.
Target Group. The elderly inpatients of diabetes.
Method of Observation. Naturalistic observation method.
Contents of Observation. The dressing habits of the elderly patients.

The Conclusion of Observation. Diabetes occurs frequently among middle aged and elderly people. That's why the elderly inpatients of diabetes are chosen as the target of observation. With the daily observation for the elderly inpatients of diabetes, it can be found that the many inpatients suffer diabetic complication and a decreasing immunity, the most widely among which is nephropathy. It leads to the fact that the elderly tend to wear cardigan due to the dropsy and spasm in hands, which make it difficult for the elderly to button. The problem is also mentioned during the interviews with other elderly. Thus button is a crucial detail to improve the wearing experience of the elderly.

Questionnaire. With the interview and observation on the elderly, the author has conducted a questionnaire survey with the topic of the user's experience on the details design of elderly's garments. Totally 100 questionnaires are given out and 52 questionnaires are returned with availability.

Among the question of the main positions of degenerative change caused by the inflexibility of the elderly, shoulder joints account for 21%, finger joints account for 20%, lumbar vertebra joint accounts for 38%, knee joints account for 36%, and arms account for 14%. lumbar vertebra joint is the most common position for illness and knee joints come secondly. Meanwhile, there are also a large number on shoulder joints and finger joints. It can be concluded that the elderly is the group with high possibility for degenerative change on joints (Fig. 1).

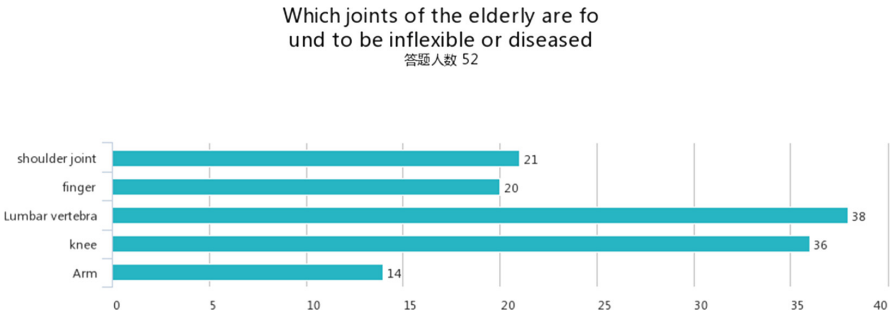

Fig. 1. Which joints of the elderly are found to be inflexible or diseased?

At the same time, for the question of whether to find it difficult for the elderly to dress themselves, 90.38% of the respondents mentioned that they have noticed that the elderly is hard to dress themselves (shown in Fig. 2). It proves the fact that there is no customization for the elderly's garments and the details design for elderly's garments are often ignored. The problem exists for long time. We should widely notice that the elderly's body status is quite different from normal human being. Without the customized garments, the wearing experience will be bad for the elderly, which may also trouble the elderly and their families.

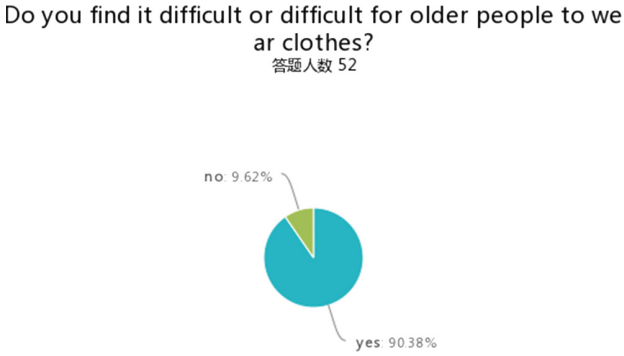

Fig. 2. Survey of elderly people with difficulty in dressing

Finally, for the question of the cause of making it difficult for the elderly to dress themselves, 63.46% of the respondents have chosen degenerative change in joints. 21.15% of the respondents thought that it is the too tiny buttons that make the elderly hard to accomplish buttoning. 13.46% of the respondents thought that the reasons should be the garment styles that are not easy to be worn. Another 1.92% of the respondents thought the details design is too complicated (Fig. 3).

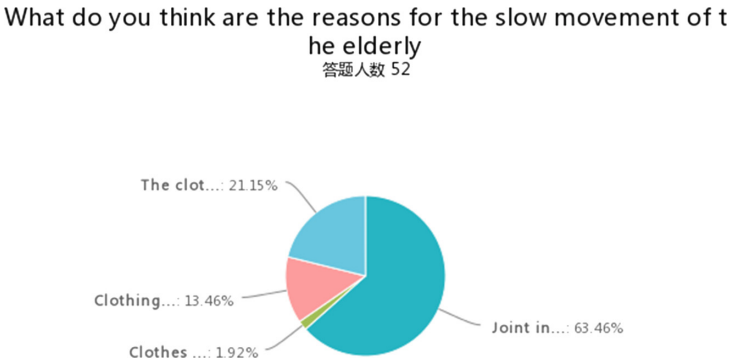

Fig. 3. People think that the cause of the elderly dressing difficulties

We can draw the conclusion from the data of questionnaire that most of the elderly are suffering from the difficulties of dressing themselves. The main reasons lie in the problematic joints and the unsatisfying experience caused by the lack of customization. Considering the solution of improvement with low cost, replacing the materials for buttons of clothes and changing the round collar structure can be the effective ways.

2.2 Simulation of Scenarios

The clear data situation can be derived from the above research. With the data analysis, we can summarize the three problems for the deficiency in details design for the elderly's garments, which cause the unsatisfying user experience. The three problems are as follows:

- The round collar design makes it hard for elderly to dress themselves and easy to twist the joints.
- It takes the elderly with inflexible fingers long time to dress themselves due to the tiny buttons on cardigans.
- The round collar garments have better heat retention property than the cardigans, which makes it hard to be replaced.

Also it can be much change in the pattern as well. We will conduct a simple simulation with the data related to these three problems to obtain the solution to improve the user experience of details design for the elderly garments.

Scenario for Simulation. The elderly with inflexible joints is left alone at home in winter. When he gets up in the morning, it is hard for him to dress himself due to stiff joints. But he still needs to wear one round collar sweater and one cardigan all by himself. As he is trying to wear the round collar sweater, it takes him a few minutes to stretch the joints. Then as wearing the cardigan, it is hard for him to button due to the dim light in the morning and inflexible fingers, which takes more than ten minutes.

During the whole process of wearing, he has to complete the major movement of stretching the arms twice, which makes him easy to twist if there is no one around to help.

Solution 1. Change the round collar structure to the flexible one. Keep the round collar pattern but change it to side open structure with side belt. It guarantee the round collar to be easy to wear alone just like cardigan and also maintains the heat retention property of the round collar structure.

Solution 2. Replace the buttons of cardigan to magnet materials or Velcro, which can be completed without using the fingers. Velcro is the suitable materials as the cost is low and the elderly can just press slightly to accomplish the wearing.

3 Programme Design

3.1 Plan 1 (as in Fig. 4)

A common cardigan style which contain buttons on the front, including shirts, sweaters, casual jackets. We abandon the regular buttons structure and embrace the Velcro materials to simplify the design. The Velcro type are both easy to tope on, better in keeping warms and gives the cloths a simplicity which may also be welcomed by the elderly. This kind of design are mainly to consider those people who have suffered from rheumatoid arthritis and finger stiffness and feel difficult to button up themselves. At the same time, this product's detail won't affect the overall style and have a low cost so it can be use everywhere on the cloth products. However this function have a malpractice that it might stick some fiber of other wool fabric on it so it should be use more in the woven style clothes instead of wool, felt and woolen clothes.

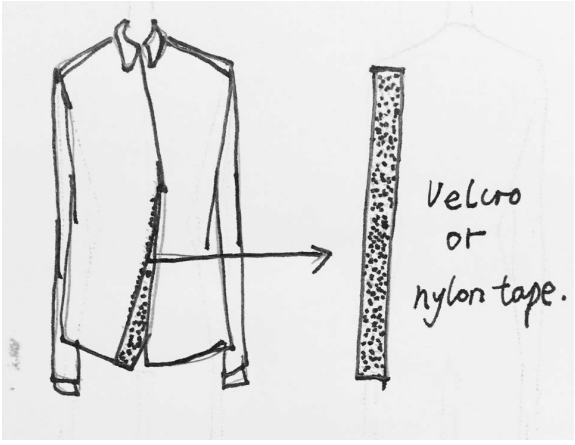

Fig. 4. Shirt detail improvement

3.2 Plan B (as in Fig. 5)

Improved round-neck cloth design for elderly (Fig. 5). Mainly designed to avoid sprain and strain injury when putting on round-neck sweater. By split off the front piece the traditional round-neck shirt from one side as illustrated on figure, to act as hinge type of structure, elderly people can wear it just like cardigan. After putting hands in first and then tight up the front piece on the side. This kind of design not only preserve the heat keeping feature of round-neck shirt, but also prevent elderly from sprain injury. Meanwhile, this kind of structure looks as elegant as traditional Chinese dress. Moreover, this type of tightening method can also be hidden underneath. The way to do this is to replace the tightening lace by Velcro strap, which makes it more hidden and more suitable for other styles of round-neck clothing. This type of design mainly originate from elderly user experience, preserve its original heat keeping feature meanwhile adding elegancy and user friendly feature to design.

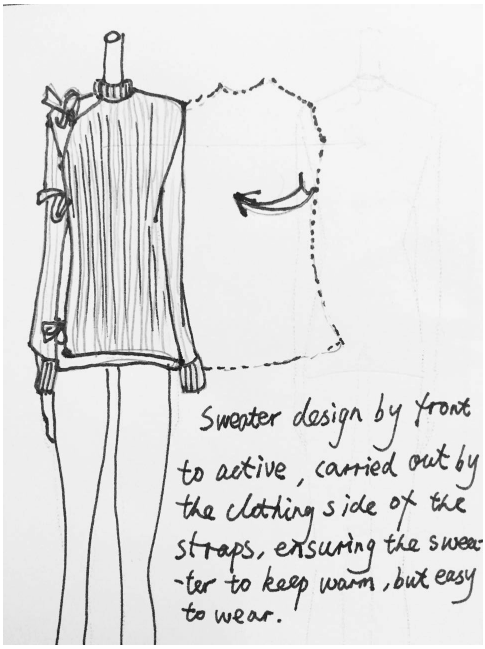

Fig. 5. The details of the modified sweater

3.3 Plan C (as in Fig. 6)

Some occasions the elderly still need some formal dress, inevitably requires some shirt type clothing. Shirt that made with thin clothing material and is close to the skin must use the buttons. In scheme 3, traditional buttons are replaced with high precision magnetic component of the magnet buttons. This design avoids that the tiny buttons is not easy to use and need to put on one by one. The buttons will be absorbed on the

fixed position. The improvement summary in clothing design is based on the user survey data and scene deduction. Without increasing production cost too much, a tiny detail change will bring considerable design to the old. In the design process, especially the costume designer, should put the user in the core position. Blindly pursuing the beauty on the vision is lack of humanistic care for the old.

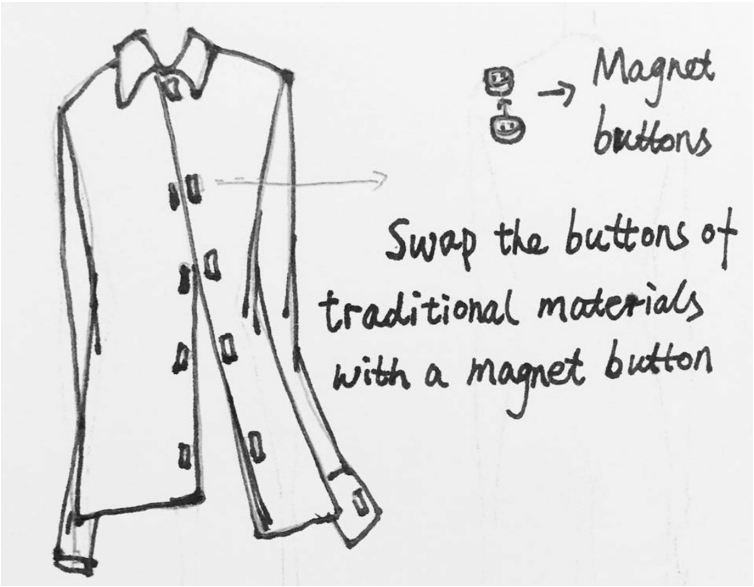

Fig. 6. Button material replacement

Figure shown above is improved design based on customer survey, without increase manufacturing cost, small design alteration can improve elderly people's user friendly experience. A successful designer, especially fashion designer, must putting user experience in a core position, only pursuing visual beauty is lack of care especially for elderly people.

4 Conclusion

According to the elderly people's physiological characteristics, many of them find it difficult to buy suitable clothes on the market. The main reason is that the design of clothing products for the elderly are lack of pertinence. Clothing is an essential part of people's lives, the design especially in details often determines the quality of the user experience of their products. Therefore to design and make perfect products for the elderly, we should make more deep contact to the elder people and feel what this group really needs. That's how we can grasp the core concept of user experience design accurately and design good clothing products with considerable details.

Acknowledgements. The project supported by the South China University of Technology under the Degree and Postgraduate Education Reform Research Project, Grant No.: yjjg2016005.

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W. Chung and C.S. Shin (eds.), *Advances in Affective and Pleasurable Design*,
Advances in Intelligent Systems and Computing 585, DOI 10.1007/978-3-319-60495-4