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Francisco Rebelo
Marcelo Soares *Editors*

Advances in Ergonomics in Design

Proceedings of the AHFE 2020 Virtual Conference on Ergonomics in Design, July 16–20, 2020, USA

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Proceedings of the AHFE 2020 Virtual Conference on Ergonomics in Design, July 16–20, 2020, USA

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Preface

Successful interaction with products, tools and technologies depends on usable designs and accommodating the needs of potential users without requiring costly training. In this context, this book is concerned with emerging ergonomics in design concepts, theories and applications of human factors' knowledge focusing on the discovery, design and understanding of human interaction and usability issues with products and systems for their improvement.

This book will be of special value to a large variety of professionals, researchers and students in the broad field of human modeling and performance who are interested in feedback of devices' interfaces (visual and haptic), virtual reality, user-centered design, design for special populations, particularly the elderly and assistive technology. We hope this book is informative—but even more—that it is thought provoking. We hope it inspires, leading the reader to contemplate other questions, applications and potential solutions in creating good designs for all.

This book is organized into eight sections focusing on the following subject matters: *Design Methods, User Interfaces and Interaction Design, Information, Design and Visualization Education and Gamification, Tools, Equipment and Space Design*

In the sections that cover Design Methods, User Interfaces and Interaction Design, the focus goes to the limits and capabilities. Generally, the effect of changes in force and kinematics, physiology, cognitive performance, in the design of consumer products, tools and workplaces is discussed. The sections that cover Education and Gamification, Product and Design Evaluation and Sustainable Design employ a variety of research methods and user-centered evaluation approaches, for developing products that can improve safety and human performance and at same time, the efficiency of the system.

Section 1 Design and User Involvement
Section 2 Design Strategies and Innovation
Section 3 Design for Visibility and Comfort
Section 4 Anthropometric Design
Section 5 Editorial and Typographic Studies

Section 6 Design for Behavior Change
Section 7 Education and Gamification
Section 8 Tools, Equipment and Space Design

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We would like to thank the Editorial Board members for their contributions.

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July 2020

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Design and User Involvement

Discussing Research Through Co-design in Policy-Making

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Abstract. The paper describes possible connections between the Research Through Co-design (RTC) model and the contexts of the policy-making through a theoretical framework for envisioning the policy-making as a co-design process and the work of the policy-makers as an autoregulatory research process. The authors use the RTC model with the aim to understand if it describes a valuable process to be introduced in contexts of policy-making. The RTC model is based on the control system theory and the authors discuss how the autoregulation from an RTC perspective is a valuable point to be study in policy-making. In conclusion, key aspects to be adopted in policy-making are suggested (i.e. the autoregulation property, the co-design driven process, the role of the policy maker as a researcher) and crucial aspects to be study further are highlighted (i.e. the effects of positive and negative feedback; the variables that determines the exit from the system).

Keywords: Research Through Co-design · Policy-making · Design research · Control system theory · Co-design

1 Introduction

What in design research is defined as "design thinking" [1, 2] is expanding its practices in complex contexts where intangibility is the order of the day. Design disciplines such as service design are increasingly being introduced in policy making contexts (see [3–7]), also because it "helps policymakers focus their minds on the impact a policy is likely to have on the people who use government services" (Siodmok in [8]). Public and policy-making contexts are often explored as contemporary macro-challenges to be renewed through design practices. Due to its impact on society, this paper considers these challenges as contexts where framing theoretical possibilities for enhancing the quality of the cognitive models that guides the practice and the research of the engaged people. According to this premise, the paper describes possible connections between the Research Through Co-design (RTC) model [9] and the contexts of the policy-making where democracy, plurality, inclusion, and participation should be the main values. Finally, this paper presents a theoretical framework for envisioning the policy-making as a co-design process and the work of the policy-makers as an autoregulatory research process.

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2 Policy-Making and Design (Thinking)

Policies are everywhere and they are not always fully representative of the multitude of the needs of the policy beneficiaries. The authors argue participatory and design-based models need to be discussed in order to understand how these values can be 'naturally' adopted in policy-making.

In the public sphere, policy-making is "the process by which governments translate their political vision into programmes and actions to deliver 'outcomes' – desired change in the real world" [10, 11]. Also, policy making can be seen as "an ill-defined professional practice in which civil servants mediate between politics, evidence and delivery to find solutions to public issues" [6]. And policies in design terms are guidelines or frameworks "that delineates the kinds of services and products, the relationships and the manner of the interactions that are possible, encouraged or discouraged within and by a particular human system" [12].

The application of design-led approaches in governments and policy-making contexts is relatively recent and it is grown significantly, even if evidence and research on how it is being implemented in practice are lacking [5]. Policy-making "in its essence, constitutes a design activity" and "a policy is the result of applied design practices that employ certain design concepts and specific design methods" [12]. From a design perspective, a policy can be seen as a product and methods of co-creation and co-design are valuable in early and later stages of policy-making allowing the envision of future policies (see [12]).

3 The RTC Model and Policy-Making: A Speculation

The authors use the RTC model with the aim to understand if it theoretically describes a valuable process to be introduced in contexts of policy-making.

The RTC model is based on the control system theory [13] applied to co-design processes in Research Through Design (RTD) [14–16]. The RTC model is defined as a mathematical model of cognitive control that describes the process of doing research by an RTC process [9]. In this paper, without pretending to exhaust all the aspects of this complex reflection, the authors try to understand if the RTC process can be experimented in policy-making contexts taking advantage from the model properties such as the 'autoregulation'.

3.1 The RTC Model

The RTC model is a 'collaborative model' (co-model) as a modeling of the RTC system. In other words, a co-model is a mathematical model of cognitive control that describes the process in doing research by an RTC [9]. The RTC model was designed with the objective of developing a collaborative model (co-model) based on collaborative design activities in a RTD process; it is theoretically based on the control system theory.

In particular, supposing having a research question R(s) in RTC using a co-design process G(s) and testing H(s), the co-model uses the control theory of closed-loop

system to calculate the error between the research answer obtained and the prefixed research answer.

This model defined by the authors in previous studies, can be explained as a co-model that uses closed-loop feedback controls to generate a control action to bring the controlled process variable to the same value as the set point in input. The controlled action can be positive or negative, as explained in the following figure that shows the block diagram of positive (on the left) and negative (on the right) feedback control system [17–19], (Fig. 1).

Fig. 1. Closed-loop positive (left) and negative (right) feedback systems.

The negative feedback has the ability to autoregulate itself. In fact, considering the effects from a modification it is cable to acting to restabilize a variable around the set point. In nature, negative feedback is closely linked to homeostasis since it contributes significantly to its maintenance [20–22]. While positive feedback amplifies the variables moving the system from an equilibrium state creating as a consequence instability but also exponential growth [23–25]. Both models can be described by a transfer function in Research Through Co-design Theory such as G0(s) = G(s)/1 − H(s)G(s) for the positive feedback and G0(s) = G(s)/1 + H(s)G(s) for the negative one with G(s) a co-design process and testing H(s) that is the gain of feedback path (Fig. 2). G(s) considers at least the presence of two people (co-designers, Co) that collaborate with the facilitation of specific tools (design tools T) according to a design question R1(s). For this reason, G(s) = (Co * T)/R1(s) with Co > 2.

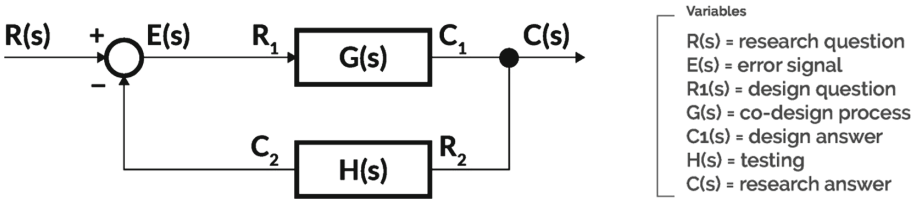

Fig. 2. The RTC co-model.

If we consider the denominator of a transfer function of a negative feedback such as 1 + H(s)G(s) is <1, then the overall gain increases. As consequence the product between H(s)G(s) is negative because the gain of the feedback path is negative.

Conversely, if the denominator 1 + H(s)G(s) is >1 then the gain decreases and the H(s)G(s) is positive. But H(s)G(s) is the loop gain that in the case is larger the transfer

function in Research Through Co-design Theory, G0(s) ≈ 1/H(s) and is independent by the co-design process G(s). But in order to understand how the transfer function is close to G0(s) ≈ 1/H(s), it is necessary to understand the sensitivity [26–28] in RTC explained as the quantification of the research answer variation with respective to a variation of the all RTC system parameters.

The sensitivity defined as S = 1 + G0(s)H(s) increases if the 1 + H(s)G(s) is <1 and decreases in case the 1 + H(s)G(s) is >1. As a consequence, it is necessary to determine the product between the design process G(s) and testing H(s) in order to have less sensitivity in the system's parameter variation. In fact, if an example the product between the design process G(s) and testing H(s) is equal to −1 then the research answer in RTC system will be infinite creating an unstable system.

3.2 Envisioning RTC in Policy Making

Negative feedback is often discussed in public policy studies [29–32], also as a "self-correcting mechanisms that reinforce stability" [33]. Also, the RTC model is based on the negative feedback for modeling the RTD. It is "an embodied/situated/intentional observer inside a design/inquiring system, generating knowledge and change through active participation in the design/inquiring process" [16]. The RTD process can produce communicable knowledge through the practice of design. So, RTC can be defined as the situated observer inside systematic investigation generating knowledge and change through active participation in the co-design process.

The authors argue policy-making can take advantage of the RTC process adopting the idea of the policy-making as a co-design process that guides a systematic investigation on the design/inquiring policy system.

4 RTC for the Policy-Maker

According to the approach investigated in this paper, autoregulation is a valuable point to be studies between RTC and policy-making. Autoregulation can be synonym of self-regulation that can be seen as a "property of complex systems, such as organisms and ecosystems whereby internal adjustments (…) are made to maintain an equilibrium state" [34] or a self-regulatory system among people [35]. However, despite autoregulation and self-regulation seem to be synonymous, 'self' recalls the concept of 'consciousness'; while the meaning of 'auto' recalls the concept of 'automatism' that are not always conscious. What 'self-regulation' and 'autoregulation' have in common is the concept of "value". People find the way to create self-regulatory systems according to common values; and an automatic system can be defined stable or unstable according to a set value.

Therefore, if the co-creation and co-design processes can be considered as 'perturbations' of the system where factors such as ideation, intuition and creativity produce variations and values in the cycle of the system, the RTC system can be an instrument to be adopted by the policy-maker for considering stabilisations (negative feedback) through auto/self-regulation or amplifications and evolutionary developments (positive feedback) of the system. In this case, the policy maker can be

considered as a researcher that facilitates and operates for supporting the application of the RTC co-model. However, the feature needed to the policy-maker as researcher are those that are recognised in the design researcher or designer-researcher [1] able to apply the design thinking in its contexts.

According to this perspective it is possible do delineate some features and attitudes the policy maker should constantly consider and evolve as the system evolves. As a designer-researcher, a human-centred policy makers could (i) recognize if its intervention in the system produces a positive or negative feedback (ii) understand the meaning of interests "in individuals, who, as members of communities, coordinate their understanding by interacting with one another" [36]; (iii) control the sensitivity of the system and takes advantages from the perturbations of the system; (iv) take advantages from the autoregulation/self-regulation property of a system; (v) innovate the system through what she or he learns from the inquiring process of the system through co-design activities. Therefore, a policy-maker that adopts the RTC model as a flexible guide, adopts a systematic approach of inquiring for designing and developing innovative policies paying attention on how managing negative or positive feedback of the system.

5 Conclusions

Despite the model being partially controllable with equations and mathematical rules, not all the variables are actually transformable in quantitative items. This is a resource, an opportunity for enhancing the complexity and the human aspects of this model related to elements such as creativity, intuition and empathy that are more tangible in variables of the model such as the design process (G(s)).

Therefore, this opens a wide reflection related to the risk of simplifying through numbers and formulas the complexity of a context with mechanistic approaches that are widely outdated in design research. In studying the RTC model, the authors want to support values such as collaboration, participation and democracy in research processes that can be applied in complex contexts. Therefore, the use of a model based on the systems thinking has the aim to orient a transition toward more satisfying approaches that can be the core of future research. Indeed, the RTC model cannot cover all the aspects of the complexity related to contexts such as the policy-making space and thus it can serve only as a guide for supporting creative, structured and collaborative processes in complex systems. It can facilitate the transition from impulsive and autocratic approaches to intuitive, reflective and democratic approaches also through the help of the negative feedback. It simplifies the comprehension of some complex variables that can be easily transformed in numbers saving efforts and resources. This gain can be spent in shifting the saved resources and efforts in more complex aspects related to human aspects taking advantage of collaborative, creative and intuitive processes of the model.

In conclusion, the RTC model presents some aspects that are possible to adopt in policy-making such as (i) the self/autoregulation property; (ii) the co-design driven process; (iii) the role of the policy maker as a situated designer-researcher. Also, the RTC model presents aspects to study more in depth for its experimentation on the

policy-making context such as (i) the effects of positive and negative feedback; (ii) the variables that determines the exit from the system. As limits of this study, cases and empirical data are needed to support the assumptions and the evolution of the research on the RTC model.

Finally, this paper highlights a question that could be the subject of future research in the fields of design research and applied ergonomics, as well as in the field of study of ergonomics in design. Can the RTC model be considered an ergonomic method for doing research in policy-making contexts? This could underline the need to better define a policy ergonomics field of study. Starting from this research request policy ergonomics can be defined as the science of studying ergonomics in policy-making for enhancing participative, democratic, and emancipatory models to spread design-driven innovation for the society.

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The Washing Machine and the Freed Time: The Modernization of a Social Rite and the Aesthetic Conquest of a Model Made in Italy

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Abstract. The history of the washing machine as an object, in its varied connotations of meaning, accompanies the evolution of a female social model in an Italy that passes all the phases of a real economic miracle. After the Second World War, it began to be introduced in response to a lack: the inability of foreign brands to meet the needs and tastes of typically Italian social classes. The organization of the mechanical workshops shifted from a family-run model to structurally complex models. This reorganization contributes to transforming Italy into an industrial reference capable of placing its products all over the world, distinguishing itself for design and innovation. But the story of the Italian washing machine is linked to the history of two brands: Candy and Zanussi. This contribution aims to tell the story of the washing machine object in the Italian post-war society in its many connotations: starting from the need to perpetuate an all-female ritual and arriving at the will to create and define an object of desire that would represent the Italian female taste.

Keywords: Washing machine · Social rite · Candy · Design · Time released

1 Introduction

The normalization of spaces was a process that the modern architecture of the 20th century considered as a priority. The search for normative accuracy and controlled fluidity of space inevitably extended to the standardisation of the body of those who were to inhabit the spaces. This fruition had to be regulated, through predictions of movements and rituals that transformed the use of space into a series of programmed, controllable and verifiable sequences. As Maurizio Vitta states, the design of the spaces was preceded by the design of the body, which was social rather than architectural, and this project had to be inserted in a cultural system that included home, but also work, collective rituals, the territory [1]. The study of the body in its formal manifestations and movements was for example part of Frank B's research. Gilbreth, which tended to classify the basic movements of the worker independent of his assigned tasks [2]. The shape of the body and its movements formed the basis of Oskar Schlemmer's "anthropological design", which led man to a revisited Renaissance centrism.

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It was around man that the spaces were shaped and that the functions began to lose the fluidity of improvisation to be entrusted to the hands of those who managed their control [3]. This mathematical science related to the body also applied to living space, which thus became the result of relationships between objects and spaces. The living space diagram was controlled by specific functions and the distribution of rooms and compartments definitively fixed the anthropological roles associated with the family nucleus. Living was thus transformed into a universe of mathematical and geometric functions and the body, as Vitta says, is understood as a pure ergonomic parameter for the definition of the space "system" [1, p. 71]. In reality, the commitment with which modern architecture has confronted itself in the project of living around the "body" of the inhabitant is the testimony of a will and an objective with a utopian flavour: that of restoring dignity to the inhabitant, guaranteeing him the rights of hygiene and comfort and, why not, also of decorum. Modernity in this field has been possible because it has been accompanied by an evolution in technology, which has transformed living into a more and more evident artificialization, accelerating the operations that the body carried out, and bringing objects towards greater simplification, technical rationalization, and an increasingly dematerialized design. The history of household appliances and in particular that of washing machines should be included in this procedural context.

2 Social – Domestic

The history of the washing machine is complex for several reasons. From a technical and technological point of view, it carries with it a sequence of mechanical conquests that make it one of the revolutionary elements in social everyday life. Not to mention the aesthetic effort that has set it in motion to transform it into a real object of desire. But probably the most difficult implications to interpret are those that have been reflected on a social and cultural level, to which must be added a complete transformation of the perception of everyday time and a redefinition of familiar roles. First of all, as Enrica Asquer observes, this complexity should be analyzed by distinguishing a plan of representation and a plan from reality to which the complexity of experiences is generally entrusted. That of representation, instead, is the plan, borrowed from the bourgeois culture of the Orrocento, in which the house was identified as the expression par excellence of the feminine, entrusting the public sphere to the masculine [4]. This system of interpretation, as the author continues, makes us forget that the term "domestic" does not always mean "homely", since the boundaries of domesticity have not always coincided with the limited and physical space of the home [5].

In the past, the home-woman association was only valid for certain social classes, generally of the upper-middle classes, which had the privilege of matching the experience of space and time and the place of family intimacy. This was because being in the home did not result in an uncomfortable experience [6]. In the less well-off classes the perception of the limits between the private and the community is much more fluid. The demands of everyday life were projected towards a need for sharing in order to be able to carry out certain domestic chores, such as washing laundry, which generally took place in public washers. Hence the difficulty of associating the term "domestic" with the space "home", because domestic meant doing laundry away from home.

Time must also be related to the social class that employed it in daily chores. The time of the lower classes was not "free" but entirely occupied by work, and the rhythm with which this work was carried out was not syncopated but slow, repetitive and fluid. Cadence and rhythm transformed the perception of this time into a ritual, and the gestures of those who washed, always the same, guaranteed the respect of an inherited protocol and the perpetuation of an example to be handed down [7]. Beyond the symbolic aspects, washing clothes therefore required spaces that could not necessarily coincide with living space. There were thus district wash houses, and then later municipal wash houses. And these places were transformed into the occasion of a shared sociality that the advent of the washing machine has necessarily altered, not without consequences.

3 The Automation of the Ritual

The arrival of the electric washing machine therefore changes two factors: the manifestation of time, and the space of action. Its appearance in the lives of women after the Second World War in Italy is a promise of quality hitherto unknown to the female universe: speed, simplicity and automation. In reality, the inclusion of this household appliance in Italian families has not been so linear mainly because of the social and relationship consequences it has caused. First of all, at an early stage, those who benefited from this "miracle" were the domestic workers of the wealthiest families; the rest of society continued in the same daily routine as always. This object should have represented a democratizing element, both transversally to the social classes and horizontally in the family context, redefining for example the male and female roles in domestic management. In reality, this promise had to clash against the resistant wall of the difficulty of changing certain principles such as family collaboration by men, who were always recognized as the link with the outside world of work and public society [4, p. 51].

But the nature of the time of the washing gesture changed radically: the cyclical, ritual, symbolic periodicity was replaced by the possibility of washing at any time, thanks to the simple push of a button. Slowness was replaced by rapidity, fatigue was replaced by efficiency, and aleatory by rationality. From that moment on, women's hands, free of weight and water, could do something else.

Another aspect that had to adapt and change was the space where the washing process took place. The boundaries of the domestic walls were fortified by closing this gesture in an increasingly circumscribed and solitary space. These changes would not have taken root in Italian society if, in the meantime, an operation of valorization and professionalization of the figure of the Italian housewife had not taken place during the fifties and sixties. A female model based on domesticity and on a management of power that saw the home as the main kingdom.[1] Certainly it is undeniable the influence that the American model had on the imagination and aspirations of Italian women in

[1] The role of women in these years, conveyed by the national press, is analyzed in public in a critical way such as: M. Buonanno, Naturale come sei. Indagini sulla stampa femminile in Italia, Firenze, Guaraldi, 1975; S. Cassamagnaghi, Immagini dall'America. Massmedia e modelli femminili nell'Italia del secondo dopoguerra 1945–60, Milano, Angeli, 2007.

this period. In the American debate, however, the domestic role of women must be analyzed at the same time as a process of constant definition of the idea of female freedom.[2]

4 "Everything in Its Place, a Place for Everything"[3]

The American model of the perfect rationalization of spaces and time dedicated to domestic functions is initially borrowed from the European culture that welcomes the *rational household* in its reflections on the modernity of spaces. Starting from Germany and Holland, the concept is considered fundamental in the architectural and urban studies of social housing. In Germany, the principles of home economics of Beecher and Frederick were revisited and adapted by the architect Erna Meyer in her handbook[4]. The kitchen became the witness of the perfect rules of space rationalization, the heart that activated all the other rooms of the house. One example was the "Frankfurt kitchen", designed by the architect Grete Schütte - Lihotzky, on the occasion of Ernst May's 1926 project for the Frauheim opera house. It was designed to be mass-produced and with a few variations for adaptability to the ten thousand social housing units that made up the floor [8, pp. 239–300]. This model of kitchen represented a real parameter of modernity, with its U-shaped floor plan, it was arranged in such a way as to be a self-sufficient element but also a space of connection and filter with the other spaces of the house, such as the living-dining area [9, pp. 213−214].

In Italy, the modernization and rationalization of living space is presented in the form of a model home that celebrated the arrival of electrification in the home as a triumph. The "Electric House" by architects Figini, Pollini, Frette and Libera was presented at the IV Exhibition of Decorative and Industrial Arts in 1930, sponsored by the Edison Company [10]. Everything was designed to achieve maximum efficiency with minimum effort. Once again everything was measured on the relationship between a space of production (the kitchen) and the space of relationship and consumption, and once again the undisputed protagonist continued to be the new female model, the perfect housewife [4, p. 61].

In the aftermath of the Second World War, the American myth continues to represent a model to be adopted, although in Italy it is assumed not without some

[2] Just to mention some firm points of this process, it is enough to remember Florence Kelley with the National Consumers' League movement in the early twenties of the twentieth century, which was open to a sort of "consumer ethic". See in this regard: L.R. Storrs, Civilizing Capitalism: The National Consumers League, Women's Activism, and Labor Standards in the New Deal Era, University of North Carolina Press, Chapel Hill, 2000.

[3] This is the motto invented by Catherine H. Beecher in her famous manual The American Women's Home: or Principles of Domestic Science, New York 1869. Another fundamental manual in home economics studies is *The New Housekeeping: Efficiency Studies in Home Management* di Christine Frederick (1913).

[4] E. Meyer, Der neue Haushalt, ein Wegweiser zu Wirtschaftlicher Hausshaltfürung (the new housekeeping manual that teaches the scientific conduct of the house), Franchk, Stuttgart, 1926.

contradictions.[5] First of all, the rate of female employment in Italy is in these years the lowest in Europe, and the figure of the full-time housewife is a model across all social classes. The novelty was not in the working role of the woman, but in the ways in which the tasks could be carried out: everything was easier and faster. How the American model was implemented is to be found, for example, in the housing policies that were adopted in the immediate post-war period throughout Italy. Questioning these strategies, we can also go back to the idea of space that was beginning to be associated with washing clothes. From the analysis of these policies emerges the important tendency on the part of the institutions that promote housing for office workers and workers, to reserve less and less space in projects for collective services such as wash houses. They began to prefer less and less communal and more and more private spaces, especially for washing functions. This was probably due to an increase of distrust towards the neighborhood, considered no longer as an ally of a shared community dynamic, but more as the "unknown". So the idea of the "private" begins to change, and washing clothes goes from a culmination of a social ritual to a necessary moment of solitude, since "dirty clothes are washed in the family". See to this propósito the urban policies developed in the fourteen years of the INA-Home Plan, by the Minister of Labour, Fanfani.[6]

5 Candy, an Italian Story

Italian companies began to find their own consolidated segment in the market for the production of household appliances after the Second World War, when technologies and applied research had already reached a certain maturity in the United States [11]. In the period between the two World Wars in Europe the big German (Bosch, Siemens, AEG) and British groups had already established themselves, such as Hoover, which had differentiated its vacuum cleaner production with the introduction of the washing machine, overtaking the competition from Hotpoint, Wilkins and Mirchell.[7] The big Italian companies, towards the middle of the fifties, considered the production of household appliances as a second-storey production. It should be noted, however, that the lack of Italian companies to enter this sector, must be flanked by the inability of foreign companies to adapt their products to the needs of the Italian consumer. These characteristics meant that the start up of a real industrial implication in this field, was entrusted to cases of family-run, autonomous and "first generation" entrepreneurship as in the case of Ignis, Zanussi, Candy, Zoppas, etc. [4, p. 13].

[5] The influence of the American market on Italian culture is described in: V. De Grazia, L'impero irresistibile. La societá dei consumi americana alla conquista del mondo, Torino, Einaudi, 2006; E. Scarpellini, Compreare all'americana. Le origini della rivoluzione commerciale in Italia, 1945–1971, Bologna, il Mulino, 2001.

[6] On the Ina Casa Plan see: Di Biagi, P., La grande ricostruzione. Il piano Ina-Casa 1949–1963, Editrice Leonardo, 2001.

[7] On the development of household appliances in Italy and the evolution of Italian entrepreneurship see: R. Giannetti, Tecnologia e sviluppo economico italiano 1870–1990, Bologna, Il Mulino, 1998; C. Castagnoli, E. Scarpellini, Storia degli imprenditori italiani, Torino, Einaudi, 2003.

The first washing machine completely designed and manufactured in Italy was presented at the Milan Fair in 1946, by Officine Meccaniche Eden Fumagalli. It was called Candy 50, and 12 examples were produced and sold like hotcakes. The history of the Candy company began in 1927 with Eden Fumagalli, who started his workshops to specialize in light mechanics. In the period of the two wars it reached a considerable size, but the second war slowed down the company's growth.

The second son Enzo Fumagalli was taken prisoner by the Americans and taken to the United States, while the firstborn Niso remained hidden in the family home. From America Enzo sent some sketches of a car that had attracted his attention during his captivity: a washing machine. After the end of the war, the Fumagalli company reopened to the public with two new techniques: a washing machine and a dishwasher. The first washing machine will be called Candy, because it recalled the refrain of a song spread in Italy by American troops. The success of Candy 50 motivated the company that from that moment on concentrated its efforts on perfecting this new Italian technological "miracle". From there followed the Candy Bi-Matic, semiautomatic with built-in centrifuge, and the Automatic, the first model with anti-movement and anti-noise suspension and washing programs. [4, pp. 27–29]. The real leap came however in coincidence with the first foreign orders, in 1963–64, when a new automatic model, the Superautomatic 5, was launched on the market.

This technological innovation was flanked by a copious advertising campaign that in those years was conveyed by Carosello, a television program dedicated to commercials that represented an obligatory appointment every night for about 10 million Italians. In one of these mini-advertising films, on the notes of a captivating music, a well-dressed housewife dedicated herself to gardening, because finally at home there was a "new friend", the Candy washing machine, who relieved her of the ungrateful task of doing the laundry. It was with the slogan "thank you Candy" that for years Eden Fumagalli's company established itself in the laundry tradition, proposing itself as the "liberator" of women's time.

In reality, the perception of the liberation of time, in those years, is felt not without contradictions. The victory of progress over tradition carries with it a series of feelings related to the sense of bewilderment on the part of women, who should have reconstructed a new role and a new model of identity within the family. Relieved of the physical burden of housework, a good part of women find themselves with a new type of weight: the sense of guilt, the fear of being replaced or feeling useless, not doing enough to receive the deserved sense of gratitude from their loved ones.

We can conclude, without going very far into the analysis of feelings, that the announcement of a new modern era with the advent of household appliances (washing machines in particular) certainly aroused interest and enthusiasm in women but at the same time awakened the fear of losing the primacy of "knowing how to take care" of the domestic space. The time dedicated to the ritual, the slowness, the indispensable knowledge guaranteed the woman an undisputed, though tiring, role of identity. The time freed up should have been used for something else that the Italian woman of those years subtly considered futile (dedicating herself to the care of the body or the mind).

It is undeniable that history has strengthened the presence of this object in the homes of Italians and beyond, and that the woman has long since overcome these feelings worthy of Penelope's syndrome. However, it is not so evident that the

woman's domestic time has really been freed, and that the space of the walls of the house has become fluid again. After all, those who put the pot on the fire and operate the washing machine when they return home after work, still continue to be the woman (with the necessary exceptions).

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Customising Human Factors Information for Better Australian Army Soldier Equipment Design and Acquisition

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Abstract. Australian Army equipment is rarely designed and acquired in a manner that meets the expectations of human factors specialists; early consideration of human factors to inform human centred design. This issue is in part due to the difficulty of accessing Australian soldiers to support human centred design. One strategy to mitigate the consequences of such an issue (equipment that is not fit-for-purpose) is formulation of a human systems integration process within the Army acquisition process. This study describes a process by which end-user human factors information can be collated and provided to suit relevant stakeholders. This dissemination of customised end-user information can assist designers, industry partners, and acquisition personnel to design, request, offer, and acquire fit-for-purpose and user-friendly equipment.

Keywords: Human factors · Human-systems integration · Target Audience Description · Army equipment design · Army equipment acquisition

1 Introduction

Australian Army personnel are largely inaccessible to equipment designers or product suppliers. This restriction hinders Human Centred Design (HCD; a process by which designers focus on the users and their needs to inform design), and, in part, has resulted in the acquisition of Australian Army equipment that does not adequately consider human factors (HF) associated with end users. The acquired equipment commonly requires modification, or presents risk when introduced into service. As an example, the previous Australian combat body armour system known as MCBAS was introduced prior to considering HF in acquisition. This system provided high coverage but was heavy and bulky; hindering soldiers performance. Recognising these issues, Army responded in part by introducing HF expertise into the development process. The Australian Army is now well equipped with the TBAS body armour system; with comparatively better soldier performance and user acceptance. However, each acquisition involves varying levels of HF input because a formal Human Systems Integration

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(HSI) process, in which HF activities are embedded into the acquisition process, does not exist in the Australian Army for acquisition projects to follow. A viable interim strategy is therefore required.

We posit that Australian Army equipment acquisition stakeholders need to understand two forms of information to facilitate HCD [1] for acquisitions: (1) the user population for whom the equipment is sought; and (2) the role of HF at each stage of equipment design and acquisition, inclusive of evaluation (see Fig. 1).

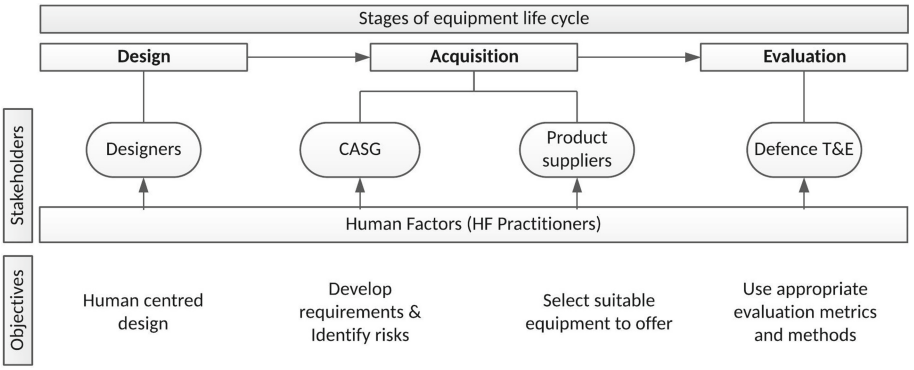

Fig. 1. This figure shows each stakeholder's objectives and involvement at the design, acquisition and evaluations stages of Australian Army equipment acquisition. Note: CASG refers to Capability Acquisition and Sustainment Group and T&E refers to Test and Evaluation.

The aforementioned information is typically collated within a Target Audience Description (TAD) document. Other armies have developed and used TADs to ensure that the end-user is considered in the design and acquisition process. We reviewed a collation of existing Defence TADs within the NATO Soldier TAD [2], but assessed that they were not suitable for the Australian Defence context. Specifically, existing TADs do not present end-user information in a manner that takes into account a range of possible stakeholders. Each stakeholder has different objectives and knowledge of HF, thus end-user information must be presented in a way that is accessible to all and is translatable to a range of objectives and contexts. The reviewed TADs, for example, included information about a minimum fitness level or a minimum education level for a soldier. Whilst this information is helpful in describing the end-user population it cannot be used to inform equipment design without having an understanding of what minimum requirements mean about abilities, capabilities and limitations. Our suggestion is, therefore, that TAD information need not only describe the end-user population, but also needs to translate that description to design criteria and/or evaluation criteria for user testing. The purpose of our study was, therefore, to develop a process by which TAD information can be collated and relayed in a manner that addresses different stakeholder's needs, levels of HF knowledge and range of objectives. Having the information easily accessible when required was also desired.

2 Method

Figure 2 shows the process followed to define a TAD for the Australian Army equipment acquisition process.

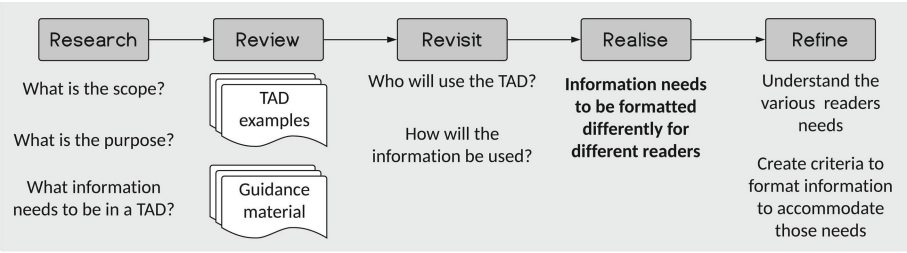

Fig. 2. TAD Project refinement and scope clarification.

2.1 Research

The initial task was to develop a TAD for the Australian dismounted soldier to assist with the acquisition of soldier-borne equipment. The scope of the TAD was limited to dismounted soldiers in a combat role who are "operators" of the equipment. The intention of developing the TAD was to inform several equipment acquisition projects. Consequently, we sought to develop a TAD that would be generic and applicable to a whole range of projects, contexts and equipment. The initial work involved defining a TAD and specifying the information that a range of Army stakeholders would find informative.

2.2 Review and Revisit

UK TAD guidance material [3–5] and Defence TAD information from nine countries within the NATO Soldier TAD [2] were reviewed. We revisited and refined - based on our review of other TADs - the intended readers, the purpose of the document, and the potential use cases (see Fig. 2 for the progression of this scope refinement).

2.3 Realise

Three distinct reader groups were identified based on their HF knowledge and objectives: Defence Acquisition Personnel, Industry, and System Evaluators. This identification was achieved through a combination of document reviews, and consultation with personnel involved in the acquisition process. The Defence Acquisition Personnel known as CASG, were consulted via a small focus-group in which they were asked to describe their information needs for acquisition (what information do they use and when?) and information gaps (what information could they use but do not have access to?). It was not

possible to hold similar focus groups with Industry due to Defence policy. However, CASG were able to provide us with information about their information needs (what information do they use and when for design?; how should information be presented?) and gaps (what information could they use but they do not have access to, or is not in a useful format, for design?). We also reviewed requirements engineering policy, procedures, and handbooks, to gain an understanding of the requirements definition process, e.g. [6–8].

2.4 Refine

A collaborative approach was taken to generate design and evaluation considerations related to the needs of HF practitioners. HF practitioners from differing disciplines within DST were involved in on-going discussions regarding the way in which TAD information could be used. Consideration was also given to when TAD information could be used by the three identified stakeholders.

3 Results and Discussion

The next step in the TAD process - following information collation and definition of design and evaluation consideration - was to specify the way in which information can be effectively relayed to the range of stakeholders. The UK TAD [2] format was considered unsuitable for three main reasons. (1) There is no formal Australian HSI process like there is in the UK, which prompts acquisition personnel to consider the relevant HF when required. (2) The majority of readers would be unable to ensure HF is adequately considered, due to their limited HF knowledge. (3) Traditional TADs tend to contain descriptions of the data, rather than guidance for use. Therefore, there is a significant risk of misuse, especially if stakeholders do not recognise the need to consult HF experts. The first point demonstrates the need for prompts to acquisition personnel to consider HF. The last two points speak to the importance of formatting the information for the reader.

Based on the above evaluation, our approach to TAD formatting enables different stakeholders to use the information for different purposes. The proposed approach differs from a traditional TAD in two main ways (Fig. 3). (1) There are two levels of information: generic and project specific. The generic level information is equipment agnostic and, therefore, appropriate to use at a program level, when the equipment is not yet specified. It prompts acquisition personnel to consult HF practitioners to assist them to develop project specific information when required. Generic information contains examples and guidance for how to generate the appropriate information for each project. (2) A traditional TAD provides information in all HF areas, about specific roles and tasks, and all the associated HF data. While the proposed approach will still include this information; it is formatted for different reader groups and distributed both generically and specifically. Below we outline our formatting for each group.

				Information format		
	HF areas	Context	HF data	For Design	For Acquisition	For Evaluation
Generic	All HF areas*	Generic dismounted soldier, within the Australian regular Army	All HF data*	Example design guidance under all HSI areas	FPS statement templates and guidance	All metrics and methods
Project specific	Only relevant HF areas	Specific roles and tasks*	Only relevant HF data	Comprehensive list of design guidance specific to equipment	Comprehensive list of FPS statements specific to project	Project relevant metrics and methods

Fig. 3. Proposed TAD approach for the Australian Army Acquisition process; *indicates the type of information included in a traditional TAD.

3.1 Defence Acquisition Personnel

The goal of CASG is to manage acquisition projects by defining the capability required and managing the activities to support a successful acquisition. Achievement of the former goal is dependent on requirements development; translating elicited user needs into requirements. To achieve this task, CASG, must have an understanding of the broad range of HF areas that may be affected by equipment use (e.g., physical, cognitive, perceptual). Achievement of the latter goal is determined by assessment of process and risk. To achieve this task, CASG must have an understanding of the end-user and the use context to identify what HF risks are likely, and decide who (and in what way) may be affected by those risks. CASG require a format that enables them to correctly word HF requirements; for example requirement statement templates and guidance. They also require specification of verification methods that can be used to verify HF requirements with high confidence.

3.2 Industry; Designers and Product Suppliers

Designers vary in the process and information they use. HCD, for example, requires direct end-user input to inform design and development as early as the conceptualization stage. As outlined in the introduction, access to the end-user population in representative operational conditions is often limited to the user evaluation stages of acquisition. Consequently, designers require an alternate means of accessing required information to ensure they develop the right solutions for the right problems. To address this issue, the TAD ought to link differing information about the end-user (their anthropometry, their role, their operational context) to formulate design considerations. These statements must provide designers with design parameters without being prescriptive about the specific design solution. Relaying such information provides designers freedom to design within a range of limitations that will ensure suitability for the Australian Army user's capabilities and characteristics.

The goal of Product Suppliers is to offer Defence appropriate equipment. This requires knowing what requirements the equipment needs to meet and the way in which Defence will verify compliance with those requirements. These tasks can be easily met when suppliers work closely with designers who have considered the TAD information

in their design. In situations where such an interaction is not possible then suppliers must - themselves - have access to the requirements and verification methods. Such access will enable suppliers to conduct suitable testing - with similar end-users under representative operating conditions.

3.3 HF Practitioners

One goal of HF practitioners working with the Australian Army is to determine - broadly - what HF to consider and when in the acquisition process. HF practitioners, however, tend to specialise in different areas, and will have varied knowledge and experiences in the application of different HF in different circumstances. HF practitioners could, therefore, benefit from a repository of information about the way in which to consider different HF in various contexts. For example, a handbook of HF methods and metrics associated with both HF attributes and equipment types that incorporates previous knowledge applicable to defence equipment acquisition. Such information can aid HF practitioners in writing requirements and design considerations, in addition to formulating verification and evaluations methods. The format of such information would need to be suitable for entry level HF practitioners. Where it is not possible to provide information that can be appropriately utilised without a suitable skill set, guidance to consult an appropriate expert should be provided.

3.4 Further Considerations

Defence Science and Technology (DST) is currently developing a TAD repository document that contains contextual information about the Army. Information such as the base role of an infantry soldier, the current soldier combat equipment system potentially integrated with all future equipment, the tasks a soldier conducts, the operating conditions in which a soldier works, and the demographics of soldiers will be included. The TAD will also contain all the summary characteristic and capability data categorised into HF areas for use by different stakeholders across the acquisition process.

Opportunities are being identified to incorporate TAD information into other documentation and training across the acquisition process. There are, however, particular criteria for when TAD information should be available to stakeholders. In Industry, for example, the designers need to have TAD information available as early as possible in the design process. As such, a comprehensive set of equipment-specific user requirements, and design considerations, which encompasses all relevant HF areas, will need to be developed. Provision of this information to Industry in the early stages of acquisition ensures that there is sufficient time to conduct HCD activities; increasing the likelihood of providing the Australian Army with fit-for-purpose equipment. For verification and evaluation metrics and methods, a separate HSI handbook document is being developed. This handbook will be available to all HF practitioners involved in Defence acquisition. It will also be available to all other stakeholders with instructions that a HF practitioner will be required to utilise the information correctly, prompting consultation with HF experts in lieu of a HSI process.

4 Conclusions

The proposed approach for development of comprehensive TAD information will aid a range of Australian Army stakeholders. It will provide designers with usable population data that can be used to inform equipment design. It will provide CASG personnel with HF information that can be used to develop requirements that allow industry to offer the most suitable products. It also provides HF evaluators with a range of metrics and methods that can be used to verify equipment is fit-for-purpose. Opportunities to input different types of TAD information have been identified, and all the information is currently being developed in a generic format where possible. This information would target stakeholders at the early stages of the equipment life cycle, ensuring the broad range of HF information can be considered appropriately. Consideration of HF early in the equipment life cycle reduces the cost and effort to manage risk. It is ultimately easier to erase a line on a page than to physically modify equipment after it has caused a problem.

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The Role of Virtual Package Shapes in Digital Product Presentation

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Abstract. The knowledge on how to present visual content in an ergonomic way is crucial in various fields, especially in a current highly digitized world. The current study investigates how various digital presentations of a high-involvement product influence perceived purchase willingness. Undergraduate students performed a series of pairwise comparisons of smartphone packages, presented on a computer screen. Relative degrees of purchase willingness were computed according to Analytic Hierarchy Process which allows for controlling subjects' responses consistencies. Three types of a cuboid package deformations were explored: *Curved*, *Tapered*, and *Tilted*. Each type was designed with different *Distortion direction* (*Left*, *Right* or *Bottom*, *Top*) and *extent* (*Small*, *Big*). The obtained results were compared with a standard cuboid, comprehensively analyzed and thoroughly discussed.

Keywords: Subjective preferences · Display design · Shape perception · Visual information ergonomics · Marketing

1 Introduction

The information about ergonomic visual content demonstration is essential in various fields, especially in a modern highly digitized world. Ergonomics of visual presentation of digital versions of classic banners or packages depend on a variety of factors (e.g., [5, 9, 10, 12, 14], or [16]). One of the characteristics of such a presentation is the product shape. Some neurophysiological experiments suggest that humans perceive objects' shapes differently depending on types of deformations and the extent of deviation from classic cuboid objects (e.g., [2, 3]).

On the other hand, such distorted package variants may be perceived as original and increase the interest towards the given product which may results in higher purchase willingness. Thus, in this research a variety of deformations to a typical box shape has been applied to assess their impact on subjects' purchase willingness. To the best of author's knowledge, these effects have not been investigated systematically in the context of the product package design.

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2 Method

Participants in this study expressed their willingness to buy a fictitious smartphone device after presenting its digital image with the unreal brand name, superimposed on a distorted virtual package. A standard, not distorted three-dimensionally looking package box was added as a point of reference. The product image was obtained by removing brand names and trademarks from a real device picture. The mockup packages were prepared in 3D Studio Max (ver. 6.0) software and resembled three-dimensional looking grey box with the following dimensions' proportions: one unit deep (X axis), three units tall (Y axis), and two units wide (Z axis). The dimensions followed the golden proportion (e.g., [15]).

Distortions were prepared by applying modifiers that do not change the volume of an initial package box. Three types of deformations produced: (1) *Curved*, (2) *Tapered*, and (3) *Tilted* shapes. These types were inspired by object shapes used in neurobiological research articles of Kayaert et al. [11], and later Amir et al. [1]. Each type was differentiated by the distortion direction and magnitude. For *Curved* and *Tilted* variants, the *Distortion* included *Left* and *Right* levels whereas *Tapered* packages – *Bottom* and *Top* ones. The *Distortion degree* factor was specified for all types of box modifications on two levels, namely: *Small* and *Big* which corresponds to the distortion magnitude of .1 and .3 set in an appropriate parameter of the applied object modifier. A combination of these factors' levels resulted in designing twelve different digital versions of product packages. They are shown in Table 1.

Table 1. Examined experimental conditions.

Distortion type	**Distortion direction and degree**			
Curved	2. Left Small (.1)	3. Left Big (.3)	4. Right Small (.1)	5. Right Big (.3)
				
Tapered	6. Bottom Small (.1)	7. Bottom Big (.3)	8. Top Small (.1)	9. Top Big (.3)
				
Tilted	10. Left Small (.1)	11. Left Big (.3)	12. Right Small (.1)	13. Right Big (.3)
				

This study followed a full factorial, within subjects experimental design, so all participants assessed 13 digital versions, that is: 4 *Curved* shapes (with a {*Left* or *Right*} direction of the curvature × {*Small* or *Big*} curvature degree) × 4 *Tapered* shapes ({Bottom, Top} × {Small and Big}) × 4 *Tilted* shapes ({*Left*, *Right*} × {*Small* and *Big*}), plus a regular box shape.

At first, subjects were informed about the general purpose of the study and after giving the informed consent, they provided some basic data about themselves. Next, pairwise comparisons of product package images took place. The participants were instructed to choose such a version which would better incline them to buy it. They also specified the extent of their preference on a linguistic scale: *somewhat more*, *more*, *much more*, and *decidedly more*. Stimuli were presented by custom software developed in *Microsoft Visual Basic* environment (ver. 6.0). The application presented appropriate pairs of images in a random order. Since the number of experimental conditions was 13, the number of comparisons amounted to $(13^2 - 13)/2 = 78$. There were 97 students from Wrocław University of Science and Technology examined in teaching laboratories of the university with identical software and hardware. The age range of these 33 women and 64 men was between 18 and 25 years (Mean = 20.44, SME = .171). They all declared normal or corrected to normal visual acuity.

3 Results

The consistencies ratios (CR) obtained for participants ranged from .0337 up to .368. The means amounted to .118 ± .00574 SME. The one-way Anova revealed no meaningful effect of gender on average CRs [$F(1, 95) = .043$, $p = .84$]. Results presented in the following sections do not include data with CRs bigger than .25. Thus, out of 97 examined subjects, one was excluded.

Mean weights representing subjects' purchase willingness are graphically shown in Fig. 1. The outcomes clearly suggest that examinees favored the standard cuboid product package the most markedly than any other package with a deformed shape. The worst rated variant was the one with bottom big tapered shape. The most preferred standard cuboid package dominated all other conditions. The difference between the classical box and any other package variant in the hierarchy is statistically significant at $\alpha < .0001$ (based on the Fischer's LSD post hoc pairwise comparisons). One can also notice that for each *Distortion type*, almost any *Small* distorted shape is better preferred than any condition with a big deformation. The biggest discrepancy between the *Small* and *Big* level was observed for the left tilted conditions.

To get some more insight into the data a three-way Anova: *Distortion type* × *Distortion extent* × *Gender* was employed. A reference box package was excluded from the examination. The results show statistically significant effects of both factors involving distortion as well as their interaction. The Gender effect together with its interactions were insignificant. The Cohen's [6] rule of thumb suggests that the effect size of the *Distortion extent* factor can be described as big [$F(1, 1140) = 136$, $p < .0001$, $\eta^2 = .11$] while *Distortion type* [$F(2, 1140) = 9.8$, $p < .0001$, $\eta^2 = .017$] together with *Distortion type* × *Distortion extent* interaction [$F(2, 1140) = 11$, $p < .0001$ $\eta^2 = .019$] may be classified between small and medium.

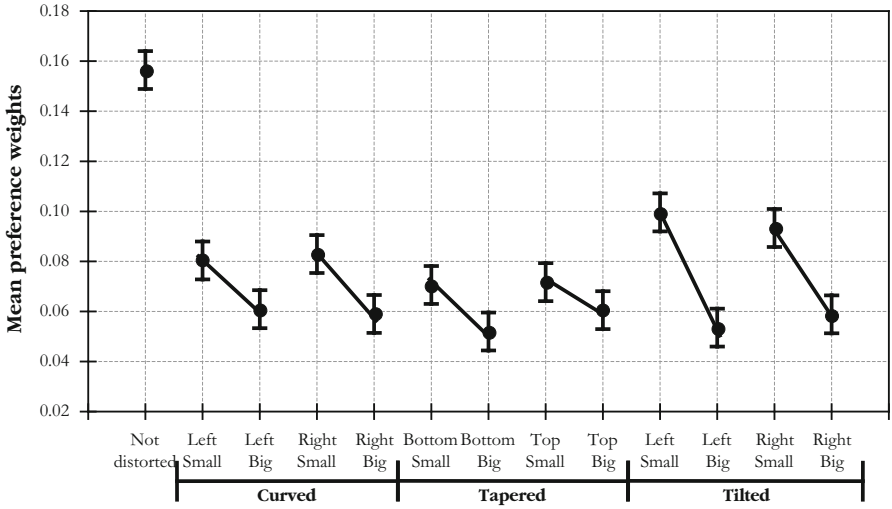

Fig. 1. Mean preference weights for all examined conditions. Whiskers denote mean standard errors

Mean weights of product's purchase willingness for these factors are demonstrated in Figs. 2, 3 and 4. It occurred that *Tilted* versions of packages were more preferred than any other distortions. *Curved* options were in the second place, and presentations with *Tapered* objects encouraged subjects to purchase devices the least (Fig. 2).

According to Fisher's post hoc comparisons, differences between all levels were statistically significant at .05. As demonstrated in Fig. 3, subjects were prone to better rate package boxes when they were only slightly distorted than versions significantly deviating from a classic box. The interaction presented in Fig. 3 shows that for *Small* box deformations the preference hierarchies are very close to the ones form Fig. 2. Mean preference weights for more distorted packages seem to differ less. Additional post hoc investigations revealed statistically insignificant discrepancies ($\alpha > .1$) between average values reported for largely distorted experimental conditions. Thus, the main contribution to the significance of the *Distortion type* effect could be mainly attributed to differences observed in slightly deformed package variants.

To verify the influence of *Distortion direction* (*Top-Bottom*), an additional three-way Anova (*Distortion direction*, *Distortion extent*, *Gender*) was applied separately for *Tapered* packages. Since *Curved* and *Tilted* versions have identical *Distortion directions* (*Left-Right*) they were examined together by another four-way Anova (*Distortion type, Distortion direction*, *Distortion extent*, and *Gender*). It occurred that for *Tapered* variants the *Distortion direction* (*Top-Bottom*) effect did not significantly affected mean preference weights, thus subjects rated *Top* and *Bottom Tapered* variants in a similar way. The *Distortion extent* factor was statistically meaningful just like in the Anova including all experimental conditions. All interactions with *Distortion direction* (*Top-Bottom*) were irrelevant. As reveals the four-way Anova for *Curved* and *Tilted* boxes, the *Distortion direction* (*Left-Right*) effect was not significant suggesting no influence

of this factor on average purchase willingness weights. Post hoc tests showed significant ($\alpha < .05$) difference between *Left* and *Right Distortion direction* only for *Tilted* packages. In such a case, *Right* distorted variants were better perceived than the *Left* ones.

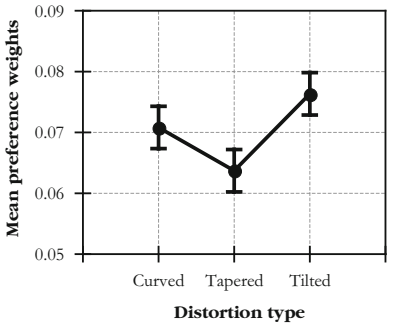

Fig. 2. Effect of *Distortion type* on mean preference weights [$F(2, 1140) = 9.8, p < .0001, \eta^2 = .017$].

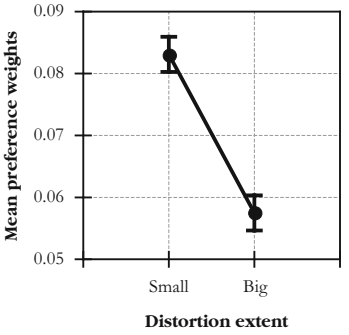

Fig. 3. Effect of *Distortion extent* on mean preference weights [$F(1, 1140) = 136, p < .0001, \eta^2 = .11$].

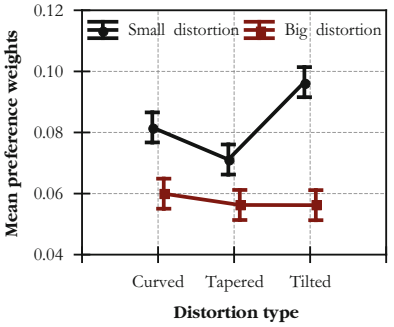

Fig. 4. Effect of *Distortion type* × *Distortion extent* on mean preference weights [$F(2, 1140) = 11, p < .0001\ \eta^2 = .019$].

4 Discussion and Conclusion

The presented data evidently show that any type of distortion applied in this experiment to a classical box shape leads to considerably lower levels of expressed purchase willingness. What is more, a decrease in the purchase willingness degree was systematically observed if the applied deformation was bigger. It occurred that subjects were very conservative about the preferred package shape and any deviations from a standard cuboid resulted in lower rates. Participants apparently did not perceive modified box packages as intriguing or original which could have improved their scores.

Generally, such a finding seems to be logical in light of the work of Leyssen et al. [13] where bigger preferences were attributed to pairs of objects being semantically similar. The result is also in concordance with investigations of Van Rompay et al. [17], where they suggest that stimulus congruence may facilitate processing and contribute to positive attitudes towards a product. In the current experiment, the presented products look like classic devices, thus, the most appropriate package should also be typical. Therefore, probably the highest rates were given to the cuboid package shape.

A general decrease in likings of more and more distorted objects obtained in this experiment is consistent with results obtained by Gordon and Holyoak [8] in their second experiment regarding preferences towards more general two dimensional complex graphical structures consisting of colored squares. They showed significant decrease in likings for patterns being less and less similar to a standard version of the examined structure. Both their findings and our data are seemingly in contrast with Berlyne's [4] theory of affective responding which assumes, among other things, that novelty features would generally result in higher degrees of pleasantness.

Among three different types of box deformations, the tapered versions were the least liked which could be caused by perceiving them as the most unrealistic or too extravagant in relation to the classical shape of the presented devices. Additionally, the bottom-tapered variants may give the impression of being unstable and therefore less preferred. This explanation is in concordance with Berlyne's [4] assumption that graphics being closer to the state of equilibrium are better rated. Research outcomes confirming such a theory were also reported by Westerman et al. [18] where upward oriented graphics were generally preferred more than their downward versions.

In the context of a series of studies described in the literature showing that people prefer curved contours more, it is somewhat surprising that curved shapes were given in the present study lower rates than the tilted versions. This outcome may possibly be ascribed again to the lack of correspondence between the classic product and the irregular box shape.

The significant interaction of the *Distortion type* × *Distortion extent* effect and further post hoc analyses revealed that the *Distortion type* factor was not meaningful in largely deformed package conditions. It seems that in these cases the deviations from a typical shape of a product package were so huge that the nature of the distortion did not matter. This indicates that packaging deformations were not regarded as intriguing or original which could have positively affected purchase willingness as some previous research revealed. Apparently, subjects perceived distorted packages as highly inconsistent with the presented product picture. This experiment showed not only that deformed packages were lower rated than a standard cuboid but also examined which of the deformations induced higher purchase willingness than others. The presented data indicate that customers' perception varies across different types of package distortions when the deviation from a perceived standard package is rather small. Bigger deformations produced smaller levels of purchase willingness almost irrespective of the distortion type. Moreover, the experiment also showed that the *Gender* effect and its interactions were irrelevant, which was not apparent in light of other experimental results.

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Use of Rubber Fibers to Prepare of Impact Resistant Concrete in Factory Slabs

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Abstract. At present, the large amount of pollution generated by used tires in Ecuador is a very serious problem because 2,400,000 tires are discarded annually. A very high percentage of these used tires are those that end up on the banks of roads, vacant lots or water bodies, although it is true there have recycling plants, it is also true that a new way to reuse this material is needed. With regard to rubber, especially synthetic rubber, being this, the one used in the manufacture of tires has very interesting physical properties within the area of concrete manufacturing, such as elasticity, abrasion resistance, warm anti Softener, and sulfate resistance. The use of fibers due his properties helps to improve the adhesion and impact resistance of concrete, starting from this the article seeks to verify the usefulness of rubber as a fiber for the production of concrete, for this, a control mixture will carry out with a defined resistance, from which the amount of rubber fiber will vary depending on the coarse aggregate; The tests to be carried out will be the test of compressive strength, tensile strength, following the guidelines indicated in the INEN standards; taking into account that the results obtained must give an improvement or at least be equal to the resistance of the control specimen to guarantee its use.

Keywords: Rubber fibers · Concrete recycling · Industrial slabs

1 Introduction

Industrial floor slabs are very susceptible to experiencing large loads for short and long periods of time being the first produced by machinery impacts or heavy materials, generating cracks that over time can seriously affect the slab physical structure, other problems that generate the appearance of cracks are drastic changes in temperature and in the case of large lights the lack together. There are different solutions to avoid the appearance of cracks between them we have the construction of simple concrete pavements with or without load transfer devices, reinforced concrete to control the width of cracks, concrete with fibers, compensated shrinkage concrete and finally prestressed concrete [1].

In Ecuador, approximately 2,400,000 tires are disposed of annually, which will end up in water sources, vacant lots and in rural sectors, with a total of 1,000,000 used tires

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being recycled, of which rubber is extracted for use on synthetic courts, for shoes making and finally 8,000 m^2 of rubber without a defined use [2], The amount of unused rubber being of interest to this work. The type of rubber obtained through the recycling processes is synthetic, which has better physical and chemical characteristics than natural rubber, having a better elastic behavior, greater resistance to organic solvents, does not soften with heat and has good abrasion resistance [3].

Many authors have sought ways to incorporate rubber into concrete and mortar mixtures, trying to incorporate the chub characteristics to such mixtures, for example, in the elaboration of self-compacting concrete, a study of the durability properties of rubber was carried out. [4], the use of rubber particles to provide protection against drastic changes in temperature in the concrete [5], performance analysis of the properties and rubber in concrete [6, 7]. This article proposes the implementation of fibers made from recycled rubber, for the slabs construction in industrial floors, to improve the impact resistance of concrete and prevent the appearance of cracks.

2 Industrial Floors

An industrial floor consists of a pavement structure formed by a granular subbase on which a concrete slab sits, the main function of the subbase is to provide a uniform and stable platform for the concrete slab construction [1].

With regard to industrial floors, there are a wide variety of pavements that are used between them, we have the following: simple concrete slabs with joints with or without load transfer devices, reinforced concrete slabs, concrete slabs compensated shrinkage and post-tensioned slabs [1]; in this article emphasis will be placed only on reinforced concrete slabs.

2.1 Reinforced Concrete Slabs

The design basis of reinforced concrete slabs is the control of the width of retraction cracks between joints. The reinforcement consists of the use of steel bars, electro-welded meshes, metallic or synthetic fibers. In reference to the fibers there are several types used in concrete, among the most common we have the metallic ones and those of polypropylene plastic. A correct fibers in the slab distribution, allows a more efficient absorption of retraction efforts by drying the concrete, in the same way with the efforts generated by temperature changes, reducing cracking possibility [1].

The use of fibers generates less construction costs and loss of material, associated with the use of traditional reinforcement systems, in which a greater number of labor and time is necessary, only for the reinforcement location. Thus, when using fiber reinforced concrete, the construction time is reduced to more than half compared to a floor reinforced with traditional systems [1].

3 Experimental Study

3.1 Materials

The following materials were used in the preparation of the concrete mix: ordinary Portland cement with a specific gravity of 3.15, fine aggregate (natural sand) with a specific gravity of 2.58 and coarse aggregate with a maximum nominal size of 19 mm and specific gravity of 2.06, In the mixture, an accelerating superplasticizer additive for reinforced concrete was also incorporated "Sikament HE 200", in order to reduce the amount of water to achieve high strength and provide fluidity and workability to concrete. Table 1 shows the general results of the characterization of aggregates, obtained by laboratory tests following the ASTM standard.

Table 1. Arid characterization

	Thick aggregate	Fine aggregate	Units
Unified compacted mass	1547.14	1486.31	Kg-m^3
Single unit mass	1467.39	1395.07	Kg-m^3
Specific gravity	2.06	2.59	
Absorption	5.94	6.13	%

The rubber fibers have an elastic modulus of 1.72 MPa. The size to use varies between 1.5 to 3 cm long and approximately 2–5 mm wide, This material is obtained through a crushing process, to then be subjected to a screening process to remove small rubber particles and finally eliminating any element that jeopardizes the integrity of the concrete through a washing process.

3.2 Mixture

The concrete base mixture will be prepared with a water-cement ratio of 0.48, then replace percentages of fine aggregate with rubber fibers in a range of 0% to 30%, as indicated in Table 2; The results of the mix design were obtained by applying the design methodology proposed by Committee 211 of the American Concrete Institute (ACI) [8].

Table 2. Concrete dosage.

Materials	Rubber					Units
	0%	10%	15%	20%	30%	
Cement	427.08	427.08	427.08	427.08	427.08	kg/m^3
A. Fine	501.94	451.75	426.65	401.55	351.36	kg/m^3
A. Thick	959.14	959.14	959.14	959.14	959.14	kg/m^3
Water	205	205	205	205	205	lts/m^3
Rubber	0	50.19	75.29	100.39	150.58	kg/m^3

4 Experimental Program

The concrete mixture will be subjected to two physical tests in the laboratory, such as: simple compression resistance and determination of the rupture module, the number of specimens to be analyzed will depend on what is required in each of the tests.

4.1 Simple Compression Resistance

A cylindrical specimen with a height of 20 cm and a diameter of 10 cm, will be used in the sampling for the simple compression test as indicated in the regulations ASTM C39 [9]; being a total of three specimens per mixture.

In some investigations the resistance of concrete when working with rubber tends to decrease, as the percentage of rubber increases, this can be seen in Fig. 1 taken from an investigation with rubber fibers [7].

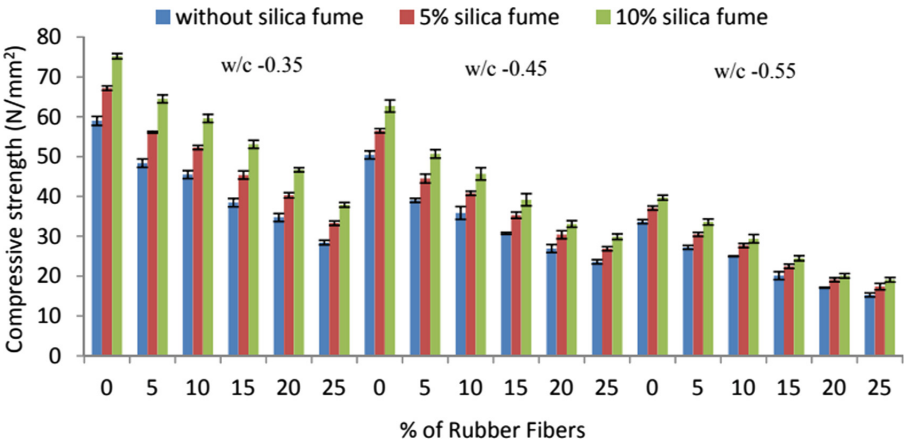

Fig. 1. 28 days compressive strength of rubber fibers concrete (error bars represent standard deviation).

4.2 Rupture Module

In the test, a square cross-section beam with 15 cm side and a 60 cm light will be used, being a single element per mixture, following the guidelines established in ASTM C293 for the three-point test [10].

5 Conclusions

The use of a superplasticizer additive in the preparation of the mixture guarantees us a better workability, in order to obtain a greater resistance with the cement water relation that arises. The importance of a pretreatment of rubber fibers, helps with the elimination of any particle that will affect the life of the concrete.

The physical property that best characterizes a concrete is the resistance to simple compression, which means that the results should aim to obtain an improvement in resistance or to stabilize, with the greatest amount of rubber fibers possible.

In the case of slabs for industrial floors that handle bending forces, the breaking test gives us a comparative value for a correct design.

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Improved Design of She People's "Cai-Dai" Weaving Loom Based on the Protection of the Intangible Cultural Heritage in China

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Abstract. China is a treasure trove of intangible cultural heritages. The She people is one of the farming minorities in China. Based on the understanding of the She people's handicrafts, It was found that there are some problem about the weaving loom: First, the craftsman needs to work at the desk for a long time and lower head, causing cervical spine disease. Secondly, repetitive actions caused shoulder injury. Third, Craftsmen only use upper limbs at work when weaving, and lower limbs are not sufficiently applied to the ribbon weaving process. Aiming at these problems, the scheme of improving the "Cai-Dai" loom is proposed. The digital model of the knitting machine was built by Rhino. The TAT tool in the human factor simulation software named JACK was used to analysis dynamic working strength and predict static strength. The results show that the ribbon loom with ergonomic design has better comfort.

Keywords: Intangible cultural heritage · "Cai-Dai" weaving loom · Ergonomics

1 Overview of the Intangible Cultural Heritage of the She Nationality

China has 5,000-year history of civilization, Folk art and folk customs in China's intangible cultural heritage have enriched people's lives and passed on the precious wealth handed down by their ancestors [1]. These rich cultures and arts are the genes and foundation used to construct the nation's modern culture in the new age. Intangible cultural heritage needs to be inherited and protected to avoid losing. Some folk arts, etiquette and festival heritage that are passed down by oral teaching and behavior are gradually dying, and the inheritance of national folk culture is lacking. Only by inheriting the outstanding intangible cultural heritage can we create our own cultural essence [2].

The intangible cultural heritage of the She people in China are very rich, mainly including: the She language; the religion of the She people; national diet, national costumes, living habits,; She literature and art mainly involves folk music, dance, and poem [3]. Among them, the She ribbon weaving occupies the most important position in the She's intangible cultural heritage.

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The She Cai-Dai are simple and passed down from generation to generation. Girls of the She ethnic group will learn to weave Cai-Dai with their mothers around the age of five or six. The She Cai-Dai are woven with silk threads of various colors, with red and blue flowers on a green background, white flowers on a green background, black characters on a white background, and various specifications from "seven flowers" to "nineteen flowers" [4]. She Cai-Dai, also known as "he shou jin", are used to coat waistbands. There are two types of Cai-Dai: one is the Liang Hua ornamental engraving printing, similar to the printing of white flowers on a blue background of the Han nationality (Fig. 1). The She people are widely distributed in China, and the Jingning Autonomous County in Zhejiang Province has preserved the complete She ribbon weaving skills. The color bandwidth of Jingning area is about 3–5 cm, with larger patterns and shorter lengths. Warp threads are available in multiple colors, while weft threads are white. The warp threads are layered in white and black to create a pattern. The weaving pattern is the middle part, and several colored warp threads are placed on both sides and band edges of the pattern. The side color line and the middle line are white, and the number of warp lines is determined by the narrow color bandwidth. There are the number of black meridians in the middle to determine the name of the ribbon.

Fig. 1. Willow stripes

2 "Cai-Dai" Weaving in She Nationality

To weave a good ribbon, craftsman must choose the good materials and make them strictly. The main line can only be in black and white, with both sides of the band being yellow or green, it must be symmetrical. According to the length of the ribbon you need to use "ribbon bamboo" and "ribbon pendulum" to organize the warp threads on the ribbon rack or table top, and then tie the warp threads into two ends. A thicker cotton thread passes through the warp and tie a section of wheat straw in the middle. The warp thread is tied and the "webbing post" is hung. The woven text pattern must conform to the specifications of the ribbon. It is best to design samples to avoid randomness. Even if you pick the wrong thread or weave the wrong word or pattern, you must disassemble and re-weave to succeed.

Second, it is necessary to make the pattern rich in content, the text is clearly connected, and the style is always oblique. The text and the pattern must be independent, clear, connected to each other and reasonable. A standard "Cai-Dai" should have a flat weave of 13 cm or 4 cm at both ends, without any pattern. A ribbon of

about 10 cm should be left to be tassel, and the middle part should be about 2 m. A good "Cai-Dai" has the characteristics that the silk is fine, the pattern is small, the ribbon is narrow and the texture is hard. The patterns and words on the Cai-Dai carry the blessing information of the residents of the She ethnic group, and it contains the meaning of praying for evil.

2.1 Traditional "Cai-Dai" Weaving Loom

The She people's ribbon loom has a small volume. When weaving Cai-Dai, craftsmen generally lean one side of the loom on the table and the other side of the loom on the leg to fix the loom (Fig. 2). The traditional process of weaving bands is facing the loss, and there are three problems of weaving loom in the heritage of weaving Cai-Dai: First, the craftsman needs to work at the desk for a long time and lower his head, causing cervical spine diseases. Second, repeated lifting and hemming actions cause shoulder injury and increase knitting time 3. The craftsman only has the upper limbs at work when weaving, and the lower limbs are not fully applied to the ribbon weaving process to share the work burden of the upper limbs. Aiming at these existing problems, a new scheme for the ribbon loom is proposed, which meets the requirements of ergonomics and reduces the burden on the human upper limbs.

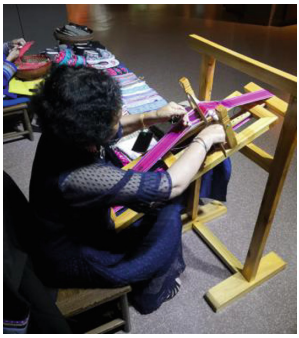

Fig. 2. Traditional weaving loom

3 Model of the Improved "Cai-Dai" Weaving Loom

Referring to the dimensions of a traditional flower loom, a three-dimensional digital model was built by Rhino. It is shown in Fig. 3. that the ribbon loom is composed of three parts: traditional loom, loom stabilizer, and the heddle lifting board (Fig. 4). When in use, the lifting plate can replace the role of the cotton thread in the lifting process. The warp thread is placed in the gap of the lifting plate. After clamping, the foot pedal can be connected with the nylon rope. The other end is connected to the heddle lifting plate, and the craftsman can lift the heddle by pressing the pedal. The repetitive lifting step is finished by the lower limbs to reduce the burden on the upper limbs.

Fig. 3. Improved version of ribbon weaving loom

Fig. 4. Lifting board

4 Ergonomic Analysis of Improved "Cai-Dai" Weaving Loom

To perform ergonomic analysis of the ribbon weaving machine, we first need to use JACK software to build a basic model. It is a virtual model of the craftsman and the ribbon weaving loom. After setting up the simulation environment, the human-machine system performs static simulation. Through static simulation, you can perform comfort analysis, spine stress analysis, and other human factor analysis on the working process of the craftsman.

The two important components of the JACK software human-machine simulation environment are the digital human model and the design model [5], which is the weaving loom in this article. It should be noted that when models created using other modeling software are imported into JACK, they should be exported in a common format, and the default coordinate system of JACK software and other software is different. Imported models need to be converted before use.

The digital human model in JACK is composed of 69 Segments (parts) and 68 Joints, and each size of the human body can be customized during the digital human import process [6]. The posture can be adjusted by controlling only some joints, and the degree of simulation is extremely high [7].

4.1 Analysis Comfort of Improved "Cai-Dai" Weaving Loom

Analyze the bending range of some joints in a specific posture of a digital person by referring to comfort data [8]. The JACK tool provides six comfort reference data, which are Porter, Krist, Grandjean, Rebiffe, Dreyfuss 2D/3D. Krist data was selected in the simulation experiment. The Krist data is different from other data that it only studies single joints. This data studies multi-joint comfort named overall posture. The body parts involved in the data include the neck, shoulders, back, hips, left and right arms, and left and right legs. It gives a numeric score from 0 to 80, with lower scores indicating greater comfort.

Measured by JACK software, the overall comfort score of the traditional weaving loom is 59, and the overall comfort score of the improved weaving loom is 47. Compared with the traditional loom, the design of the improved loom reduces muscle damage and reduces fatigue in the shoulders, neck and back.

5 Discussion

Firstly, draw a model using 3D modeling software and import it into Jack software; then perform static simulation with different percentile digital human models. This method is easy to obtain a wide range of human data, which expands the research object of ergonomic analysis. Secondly, the comfort analysis was performed using Comfort Assessment, an ergonomic analysis tool in Jack software. It can be seen that the main difference between traditional and improved looms is comfort, which is manifested by the effects of the shoulders, neck and back.

The research process of this article provides a reference for the ergonomic analysis of the product. This method reduces the cost and facilitates of further research. There are some deficiencies in the research process, such as the influence of practitioners' knitting experience is not expressed.

6 Summary

The intangible cultural heritage of human contains the core factors of cultural genes, ethos, values, psychological structure, temperament type and emotions in all of the world. It is a common treasure of all humankind. The Cai-Dai of the She people in China have a strong national significance. The She people's ribbon weaving takes a lot of time, and the long-term static muscle force and mechanical movement cause muscle strain. This article combines the principles of ergonomics to improve the traditional She ribbon weaving loom. The loom has the effect of reducing muscle strain of the shoulder, neck and lower back, and has good practicability.

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Ergonomics and Social Considerations in Public Design for Country Parks: A Case Study on Refuse Collection Facilities Against Wildlife's Raids

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Abstract. Under the rapid growth of population and the advancement of technology, human life has started to invade nature. The expansion inevitably affects wildlife, and sometimes wild raids are frequent among the households. Based on a serious of basic research and field studies, this paper puts forward two of the new designs, named roller-fence and two-fold waste skip designs. After testing the prototypes, it was found that both general users and the frontline cleaning workers welcomed the new designs, and their comments were very positive. Despite the success, more factors such as villager's habits and other environmental issues should also be considered. It is argued that designers should take both ergonomics and social considerations into account in order to maintain harmony between human life and wildlife.

Keywords: Coexistence · Waste management system · Wild animals · Densely populated cities

1 Introduction

In ancient time, humans had been living in nature and maintaining harmony with nature. The beginning of civilization had then urged human to develop urban cities and begun to set a boundary between humanlife and wildlife. However, the accelerated urbanization undergoing around the world has changed human way of living [1]. The boundaries of cities have been extended to rural areas. Under the rapid growth of population and the advancement of technology, human life has started to invade nature [2–4]. The expansion inevitably affects wildlife, and sometimes wild raids are frequent among the households. Densely populated cities such as Hong Kong encounters a more difficult situation that people live not only in rural areas but also next to country parks. Lands are extremely limited that village and country parks are often separated by only a roadway. Humanlife and wildlife affect each other, and the refuse disposals have become the target of wildlife. The tension between humanlife and wildlife has been increasing.

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In our serious of studies, the interaction between wild boars and humans in a Hong Kong country park, where the boars are settled, was examined, and the issues and considerations of cleaning contractor staff, village lot residents, and policymakers were investigated through interviews [5]. Based on the design perimeters, eight primary design suggestions were generated. These suggestions were to (1) prevent wild boars raiding garbage bins, (2) help cleaners cleaning the bins more efficiently, (3) allow users to use the bins easily, and (4) facilitate management team to do maintenance. Following the research process of the previous study, several new designs for refuse collection facilities were produced. This paper puts forward two of the new designs, named roller-fence and two-fold waste skip designs. Using Hong Kong as a case study, the effectiveness of the new designs was tested. Observations and interviews were conducted to understand how people (i.e., users) used the facilities. Based on the test results and findings collected from observations and interviews, the paper thus reviews the success and failure of the new designs. The details of ergonomics of the designs and how the designs fit human's and wildlife's needs are discussed.

2 New Waste Management Facilities

2.1 Roller-Fence Design

The roller-fence design has a fixed structure framework and a covered opening (see Fig. 1). It allows people to dispose of waste through the opening directly. The eye-catching form and the high contrasting colors allow people to identify the waste skip in any weather conditions. Also, the operation of cleaning and emptying the waste skip is simple and user-friendly. Frontline workers can perform their duties efficiently. Besides, the existing waste skips can be used in the roller-fence design. Therefore, the production and material costs are much lower without abandoning the existing facilities. Easier maintenance is also concerned in the design development. The design is divided into 4 main parts: (1) a top cover, (2) a series of rollers, (3) a metal frame, and (4) two locking handles.

Fig. 1. Isometric front view and different parts of the Roller-fence design.

The top cover is designed in a dome shape to prevent wild animals from climbing onto the top. The interior of the cover is deep black in color so that wild animals are unable to figure out the depth of the space in the waste skip. The roller series is a combination of short independent rotating rollers under the cover that it can be swung up to prevent wild animals from steeping on and getting in the skip. It can also be swung down so that front line workers can pull out and push in the skip easily.

The metal frame is designed to prevent wild animals such as boars from crashing into the skip. It is secured on the ground as a stand-alone frame at waste collection sites. Looking handles are designed to prevent the skip from rolling out. Workers can lock or unlock the skip by turning up or down the handles.

2.2 Two-Fold Waste Skip

The design of the two-fold waste skip is modified from the current 660-L waste skip. It has two top covers. The small cover which is orange in color that it is opened by stepping on the front pedal. Users can use the small cover for daily waste disposal. The cover would close automatically when the pedal is released. The large cover remains closed most of the time, and it is only used when the refuse collection vehicles arrive to collect refuse. The large cover would be open when it is attached to the refuse collection vehicles. Figure 2 shows the two-fold waste skip with the small (left) and the large (right) covers opened.

Fig. 2. Two-fold waste skip with the small (left) and the large (right) covers opened

3 Methods

3.1 Prototype Testing

Thirty-two roller-fence skip wastes and 26 two-fold skip wastes were placed at different refuse collections points in eight districts in Hong Kong for the first-round prototype tests. These refuse collections points were selected because raids had been observed

on-site. The new designs were installed or allocated at the locations of the existing waste skips so that the wild animals and users can find the facilities easily. More than one waste skips were allocated in different refuse collection points according to the number of the original waste skips.

The team of researchers and designers visited the collection points twice a week to observe if the facilities were damaged. Photos and notes were taken to record the condition of the facilities. The entire testing process lasted for about three months from July to September 2019.

3.2 Field Observation and Interviews

The researchers carried out intensive observations. They stayed at the refuse collection points every week to observe how the facilities were being used. Besides general days, observations were also conducted on festival days and special holidays. Field observations and interviews were conducted to understand the effectiveness of preventing wild raids, users' experience of using the waste skips and experiences of the frontline cleaning workers. Unstructured interviews with 92 users of the general public and 14 frontline cleaning workers were conducted to understand their user experiences and collect feedback about the design of the skip wastes. Each interview lasted for about 30 min, and sometimes interviews were conducted in groups, depending on the number of users appeared on-site, as frontline cleaning workers often worked in a group to empty the skips.

4 Findings

4.1 Conditions of the Waste Skips at the Testing Locations

The Roller-fence design and the waste skips inside were able to be kept in good conditions during the test period. The hygienic condition was greatly improved and no litter being spread outside the waste skips. The roller and the small opening under the dome topic cover successfully kept wild animals away from getting food inside the skip. Figure 3 shows the condition of the design at one of the testing locations.

The design of the two-fold skip waste was also effective that wild animals were unable to open the cover and find food inside the skips, as the two covers were always closed. Raindrops were not accumulated in the skips. Figure 4 shows a wild boar trying to look for food from the two-fold skip waste but in vain.

Fig. 3. Roller-fence design at one of the testing locations.

Fig. 4. A wild boar trying to look for food from the two-fold skip waste but in vain. (Note: This wild boar was identified as one of the largest ones appeared in the nature.)

4.2 Feedback from Users of the General Public

In general, the interviewees reflected that it was easy and convenient for them to use both designs. As most of the skips were located on the roads without street night, it had been difficult for them to identify the skips in the past. The contrasting color of the new designs helps them to find the facilities at nighttime.

The pedal of the two-fold design helped users open the cover easily. The interviewees responded that the design was very user-friendly. They also agreed that the size of the small opening of the roller-fence design and the closed cover of the two-fold waste skips had successfully prevented wild animals' raids. The refuse collection points were much hygienic after the new designs were installed. Figure 5 shows how the general users use the two new designs.

Fig. 5. General users using the roller-fence design and the two-fold waste skip.

4.3 Feedback from the Frontline Cleaning Workers

The frontline cleaning workers also had very positive comments on both designs. They agreed that the designs were able to prevent wildlife raids. They reported that wild boars were unable to damage the roller-fence design. The locking system of the roller-fence design was able to prevent wild animals from pulling the skip out of the fence. There was no raid caused by wild animals after the roller-fence design was installed. Besides, the workers also reported that the design of the two-fold skip waste was very convenient that they needed not to open the large cover manually before attaching the skip to the refuse collection vehicles. Figure 6 shows how the frontline cleaning workers unlocking the waste skip of the roller-fence design and emptying the two-fold waste skip.

Fig. 6. Frontline cleaning workers unlocking the waste skip of the roller-fence design and emptying the two-fold waste.

5 Conclusions

The paper illustrates the two new designs of refuse collection faculties against wildlife's raids, the testing process of the prototypes, and test results and feedback collected from general users and the frontline cleaning workers. Despite the success of the new

designs, there are still rooms for improvement. More factors such as cultural and environmental factors should also be considered. For example, particular waste dumping methods of users, specific preferences of food as well as the results of food waste, particular geographical and weather conditions of different places. This is still an on-going project, and follow-up actions and modifications of the two designs are in progress. Designers should take both ergonomics and social considerations into account in order to maintain harmony between human life and wildlife. Different stakeholders also have to collaborate to conserve wildlife under urbanization [6].

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Design and Research of Tools for Auxiliary Bra Wearing

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Abstract. The wearing of bra needs the cooperation of both hands. It is difficult for the female users with one hand disability to complete this simple action smoothly. They wear bra with one hand. Therefore, the research aims to design a bra wearing accessory with simple structure, convenient use and fast speed, effectively solve the problem of women who can only wear bra with one hand, and improve their experience and happiness of bra wearing. Methods Based on the literature research and the analysis of the behavior of single handed women wearing brassiere, the key factors influencing the wearing of brassiere and the pain points of wearing brassiere were explored, the demand factors for wearing brassiere were extracted, the demand model was established, and the design method of single handed accessories was put forward. The design samples of innovative products were made according to the proposed design method, and the actual situation of the subjects was provided Use, experience and test validation. Results The usability of assistive products was tested and counted, and finally the design method and products of the assistive products for bra wearing that meet the convenience and comfort requirements of the target users were obtained. Conclusion It can be used as a reference for the innovation mode and design evaluation index of assistive devices for the disabled with one hand.

Keywords: One handed disabled users · Bra wearing · Behavior analysis · User needs · Assistive product design

1 Introduction

As of 2018, there are nearly 650 million women in China. Women will wear bras when they enter puberty, while ordinary bras are mostly back button type, which often need the cooperation of hands. Because of the particularity of bra wearing and the high cooperation of hands, the disabled women with one hand can't wear back button bra smoothly. China's physically disabled population ranks first in the world. Most physically disabled people need to use assistive devices to assist their daily life. Assistive devices can help people with physical and mental disorders maintain, improve or increase their individual functions, and achieve the role of daily life assistance and personal ability improvement. The handicapped are divided into upper limb handicapped and lower limb handicapped. People with lower limb handicapped are often paid attention to. The designs for them are common in life, such as crutches, wheelchairs, etc. But there is a special group in the upper

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limb disabled group, the one handed disabled group. Most of them can live, study and work through their own strength or long-term training, so they are often ignored by the society. However, the problems in life are particularly obvious, mainly manifested in the following aspects: physically, facing all kinds of behaviors requiring the participation of hands, it will be difficult to control the objects seriously; psychologically, there will be negative emotions such as inferiority, sensitivity, frustration, etc., so it is urgent to use auxiliary equipment to replace the role of the lost other hand. However, in the market, there are few living aids for the disabled with one hand, and most of them are rehabilitation aids. In addition, it is common for normal people to operate with one hand in a specific environment, so the products of one hand AIDS need to be researched and developed urgently. Academically, the design and development of AIDS are carried out according to the design theory and design procedure of general products, which is relatively lack of reasonable theoretical guidance. In this study, taking the bra with high hand coordination as an example, through the analysis of the action behavior of the target group wearing bra, we can understand the demand for bra wearing accessories, and establish the demand model; propose the design method of one hand wearing bra accessories, in order to reduce the difficulty of one hand disabled people's life and improve their convenience of life.

2 Product Design for the Disabled

In general product design, its factors are function as the core, human-computer design auxiliary conditions, shape, color, material are the guarantee of design, however, due to the physiological and psychological particularity of the disabled people with one hand, these factors lack applicability to the design and development of auxiliary equipment. The most widely used product design methods for the disabled are barrier free design and universal design.

Barrier-free Design. The initial stage of the concept of "Barrier-free Design" is only to meet the minimum physical environment needs of the disabled, especially for the disabled. After the 21st century, the range of service objects of barrier free design has been expanded to "people in need", including the disabled, the elderly, children, pregnant women and other people who are inconvenient to use all kinds of facilities due to physiological barriers and their own poor physical condition, so as to create a comfortable living environment for these vulnerable groups (Fig. 1). However, barrier free design is easy to make the disabled groups special, and easy to make the design alienation, which meets the needs of special groups, but it is too special for ordinary users to use.

Fig. 1 Barrier-free design

Universal Design. Universal design refers to the product, environment and communication that can be used by all without improvement or special design. The seven principles and three supplementary rules of universal design put forward by universal design involve the convenience, economy, beauty, safety and environmental protection elements of the product. But it is easy to ignore the needs of special users due to the consideration of commercial interests.

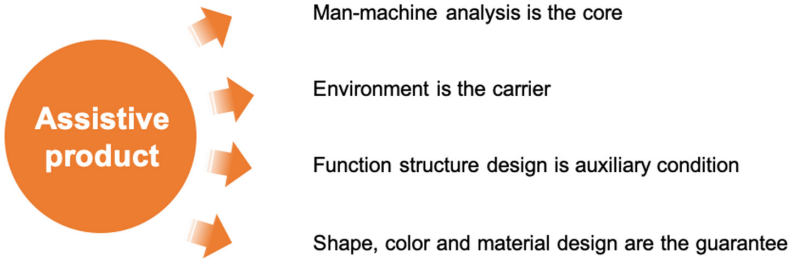

Fig. 2 Barrier-free design

Combining the elements of product design, barrier free design and general design, the design elements of disabled people's products can be summarized (Fig. 2).

3 Product Design for the Disabled

3.1 Behavior Analysis of Wearing Bra with One Hand

Bringing convenience to people's life is the goal of product design, and "being human" is the goal of its design. Through the observation and analysis of human behavior, designers explore the real intention behind human behavior, so as to design products more in line with people's lifestyle and behavior habits, that is, user behavior determines the attributes of products. Therefore, in this study, firstly, the behavior of the target user in wearing bra is analyzed to find the pain points and potential needs of the user in wearing bra.

Through literature review and Simulation of the behavior of single handed women wearing bra, it is found that the steps of wearing bra are roughly divided into seven steps:

(1) Spread out the bra. As the common users, there was no obvious abnormality in hand operation.
(2) Secure one side of the bra with elastic waistband. As the common users, there was no obvious abnormality in hand operation.
(3) Hold the unfixed side of the bra and turn from behind to front. The speed is slow and needs to be adjusted many times to keep the bra flat.
(4) Button up bra with one hand. The speed is slow, the hook and buckle are not fixed firmly, which requires repeated behavior, and it is difficult to buckle with one hand.

(5) Turn the bra cup to the front of you. As the common users, there was no obvious abnormality in hand operation.
(6) Put your arms through the bra straps. As the common users, there was no obvious abnormality in hand operation.
(7) Adjust bra and finish wearing.

3.2 Demand Extraction of One Hand Bra

The decomposition of user behavior is to help designers get complete and comprehensive user requirements, which is very important in the early stage of product design (User Research). Through the analysis of the behavior, it is found that the pain points of wearing bra with one hand are that one side of the bra is not fixed firmly, it is difficult to pull the bra to the front of the body, it is easy to roll back at the back of the bra, and it is difficult to buckle the bra with one hand.

As shown in Fig. 3, when a single handed woman wears a bra, her needs are to compensate for the missing hand by means of the force of the fixed structure and body parts; to compensate for the limitation of the insufficient strength of the single hand by changing the use of the hand force; to optimize the use of the bra by improving the function and operation behavior.

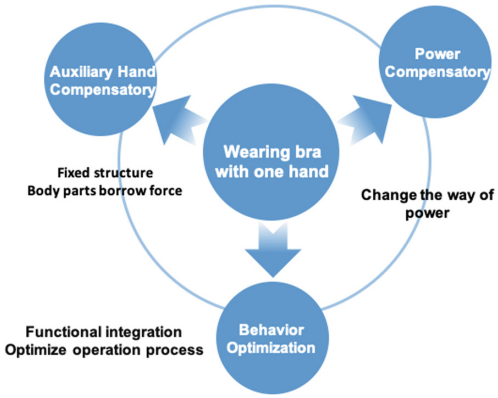

Fig. 3 The need of one handed women to wear bras

3.3 Demand Extraction of One Hand Bra

Before the design of bra accessories for one handed disabled people, combined with the analysis of product design methods and behaviors of disabled people, it can be seen that only by analyzing their needs from multiple dimensions and exploring the metaphor behind the needs, and then establishing a demand theoretical model, can the design of accessories really serve the target group (see Fig. 4). In the demand model, all kinds of needs of single handed disabled users are reflected in the four levels of human and behavior, social environment, physical environment and tool meaning,

covering the motivation, significance and related demand theory of needs, which constitute the demand relationship system of single handed women in bra wearing.

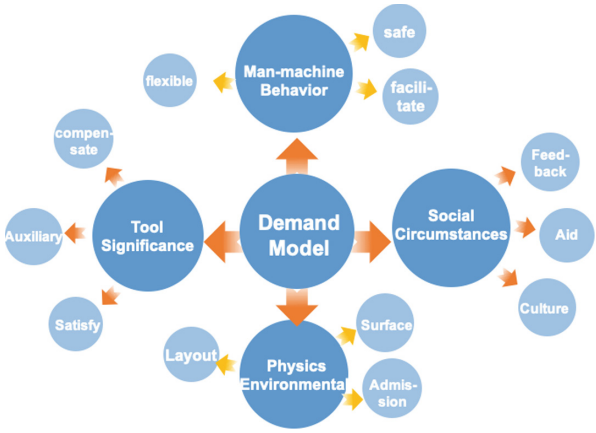

Fig. 4 Bra wear demand model

3.4 Product Design Method of Bra Accessories

After the analysis of the requirement relationship system as the precondition of the study, the second is the analysis of the design method of the bra wearing accessories matching the requirement form, as shown in Fig. 5. Through the figure, it is concluded that the design of auxiliary tools for one handed women to wear bra is targeted and targeted. In the design method, through the needs of three levels of single handed women wearing bra, combined with the four elements of accessory product design, the design method of bra wearing accessories is proposed. This design method can provide theoretical guidance and design reference for the design of assistive devices, make the design of products tend to the real needs of users, and realize the purpose that the assistive tools really serve the target users.

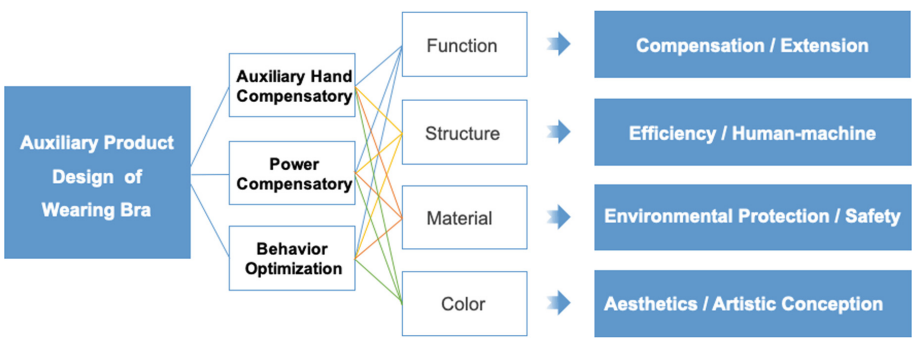

Fig. 5 Design method of brassiere accessories

4 Design Scheme

According to the analysis of the target user's behavior and demand, as shown in Fig. 6, the auxiliary device design includes two parts: clamp part and adjustment part. The clamp part of the auxiliary device includes the clamp handle, the clamp face 1, the clamp face 2, the clamp handle 1, the clamp handle 2 and the connecting part; the adjusting part of the auxiliary device includes the elastic adjusting belt and the hook buckle. Among them, the clamp surface 1 is connected with the clamp handle 1, the clamp surface 2 is connected with the clamp handle 2; the clamp surface 1, the clamp handle 1 and the clamp surface 2 are connected with the middle of the clamp handle 2 by a connecting part; the clamp handle 2 is sewn with an elastic adjusting belt of the adjusting part; the elastic adjusting belt is sewn with the hook buckle.

When using, first fix the clip part at the waist of trousers, then use the hook and buckle of the adjusting part to hook the female buckle of bra, finally pull the side of the male buckle of bra hook and buckle by hand, circle the body to the front of the body, buckle the male buckle of bra hook and the female buckle of bra hook and buckle, and finish wearing the bra.

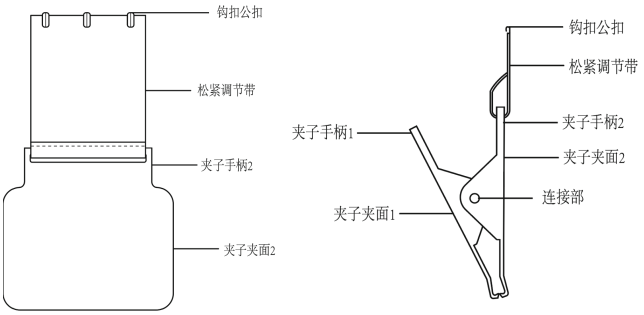

Fig. 6 The structural design of bra accessories

5 Conclusion

Taking the accessory design of one hand wearing bra as an example, this paper analyzes the behavioral characteristics of one hand disabled women wearing bra, obtains the potential needs of the target users, establishes a comprehensive demand model, and puts forward the design method of one hand wearing bra. Through the design proofing and product usability test, it further verifies the feasibility and rationality of the design research method, and reveals the users The importance of behavior and demand in the design of assistive devices provides reference for the development and design of one handed assistive devices. In addition, the theoretical framework and maturity of the auxiliary design method proposed in this study need to be further improved.

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A Web Platform Targeting for Easier Fit Performance Analysis and Headwear Products Aided Design

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Abstract. Human head is the carrier of many functional wearable products, such as VR/AR helmets and glasses, protective helmets. The fit performance between a head and headwear products is closely related with the usability and comfort of these products. In this paper, a headwear product aided design web platform is designed, which can make the fit performance analysis easier and headwear products design more convenient. Because the platform uses three dimensional digital head data, and can visualize fit performance and analyze dynamic multiple percentile of a head. Based on the designed platform, a prototype is also developed. In the design flow, based on the analysis of the existing design platforms and interview of five designers, the main functions of the web platform are established. Then the interaction process of the designer using the head data to improve products fit performance is studied and the page hierarchy of the platform is thus designed. Finally, the proposed web platform targeting for the fit performance and aiding to headwear product design is developed using JavaScript and html5 based on ThreeJs development package.

Keywords: Head model · Percentile · Headwear products · Aided design

1 Introduction

The matching degree between headwear products and head shape, named as fit performance, is closely related to users comfort and safety. The head is one of the most important part of a human being, and thus many products are specially designed for the protection and medical care of a head and face. They need a close cooperation to enhance users comfort and make it more ergonomic [1]. Wearing inappropriate headwear products may greatly reduce a user's life longevity, especially the products whose safety performance is closely related to their fitting degree, e.g. bicycle helmets [2].

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Long-term wearing products that do not match the head shape can also cause chronic physical damage. In order to achieve a good match, the designer should carry out the ergonomic design of a product based on the head shape data during the design process.

There are many software that assist in the design of headset products using head data. Among them, Hunan University [3], Delft University [4, 5], China Institute of Standardization [6], and several teams in South Korea [7] carried out related research and develop website or software. However, there are three main problems in existing design software and method. (1) The existing anthropometric data in China is still two dimensional not three dimensional. Two dimensional data is not intuitive and convenient to use. To properly use those two dimensional data, designers are required to have good data analysis capabilities [8]. (2) The existing three dimensional head data, which are based on people in western countries, are not fit for the headwear products design for Chinese. It has been proven that the head shape of Chinese people is significantly different from the data in The Civilian American and European Surface Anthropometry Resource (CAESAR) [9]. Products such as masks, goggles and gas based on those data will result in adaptation problems. (3) Designer do not have right standard head curve surface data, which are closely related to some structures of headwear products. Obtaining relevant information of head curved surfaces can make it possible to design reasonable ergonomic products [10]. With the huge demand of headwear products in China, obtaining three-dimensional (3D) visual data of Chinese head and face shape is of significant importance [11]. In order to use data Therefore, this paper develops a user friendly web graphics platform, which uses 3D Chinese head and face data, and can make it easier to analyze fit performance analysis and design headwear products.

2 User Requirements Analysis

2.1 User Interview

In order to understand the process of headwear product design and the use of head shape data by various headwear product designers, five young designers were interviewed, all of whom were engaged in headwear product design, one of whom had 5 years of design experience. The interview content mainly includes the following aspects: (1) the process of headwear product design; (2) how to obtain or use data when designing the product; (3) the process of product adaptability analysis; (4) the relevant functions expected when an assistant-design platform exists.

Interviewees said that it is difficult to find the head shape data of the relevant population during the survey. The head size information currently used by designers refers to data from Westerners country, while the head and face shapes of the eastern and western populations were significant differences. Interviewees thought that these data were difficult to use in design work, and it also was difficult to convert the text data from table into 3D visualization model. At the beginning, they did not know which data information would play an important role in the product to be designed. Since the head data used as reference is not a certain standard. Later, designers need to repeatedly modify product model with the structural engineer until the test is satisfactory.

2.2 Demand for Head Data in Design Flow

Through the analysis of user interviews, current situation surveys and other data, it is found that the demand for head data in the design flow through the whole product design process, as shown in Fig. 1.

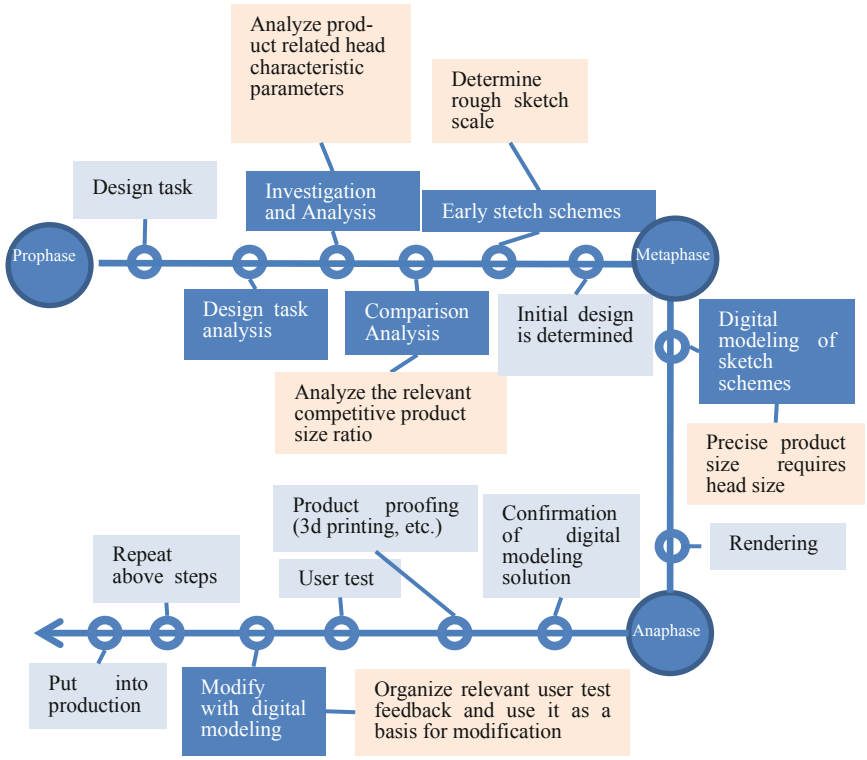


Fig. 1. Data usage of product design flow

(1) In the preliminary research and analysis, the user information, product size and structure information of the product will be analyzed, the approximate proportion will be determined in the product sketch plan, and the plan design shall be carried out.
(2) In the middle stage of digital modeling, relatively accurate product size information is required. During the modeling process and after the completion of the modeling, communication with engineers is required to determine the details of the structure.
(3) In the later proofing and testing, the product will be proofing. Certain users will be selected for the trial test. User's experience and physical interference will be recorded. Based on this, the model shall be modified again, and the above steps shall be repeated until the best effect is achieved.

3 User Interface Design and Development

3.1 Design Interaction Process

From the research in Sect. 2, the aided design platform must conform to the designer's work process, and including functions such as head shape data visualization, product and multiple head shape compatibility analysis, etc., which can help designers to design good headwear products. It will made the product more fit performance before user testing, shortening the product design cycle.

In the early stage of the design flow, relevant head data and product design related parameters can be provided for reference by the designer. After the designer completes the digital modeling, the designer is allowed to place its product on the platform and compare it with the standard head shape provided by the platform. By analysis, the product surface conforms to the standard head and face surface before proofing, assisting the designer from the early stage to the later stage of the design process, and also promoting the use of human body dimension to drive the process of product design.

3.2 User Interface Design

Combined with some design platforms and the interviews mentioned above, this paper analyzes the interaction process when designers use head data to improve product adaptability. The platform page hierarchy relationship and relevant user interfaces that conform to the designer's working habits are summarized, as shown Fig. 2.

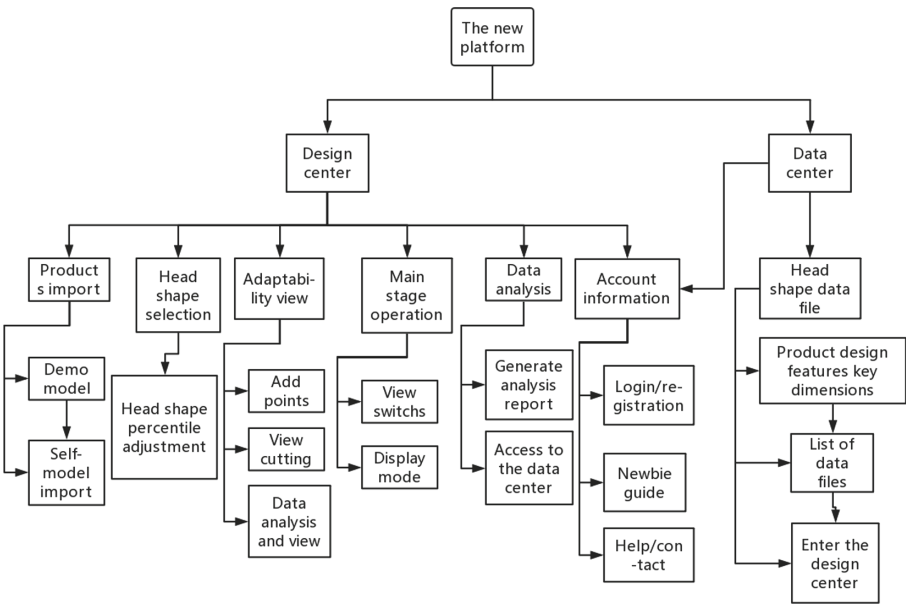
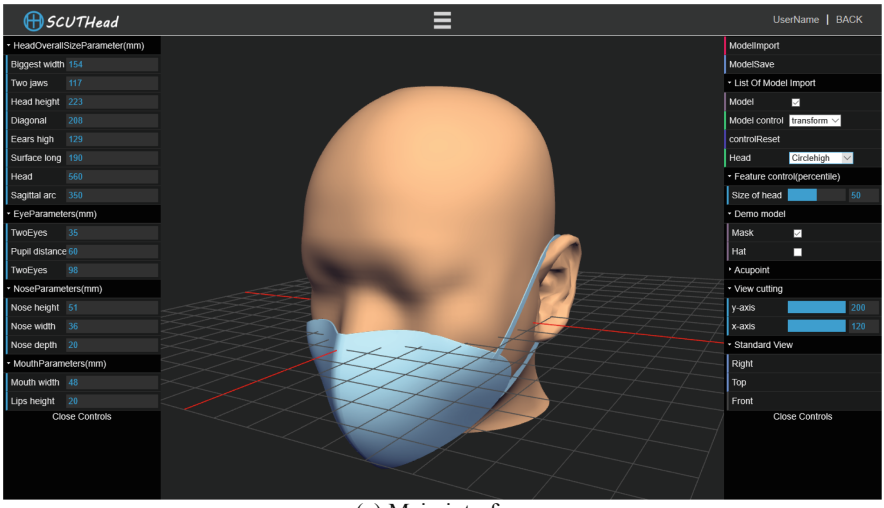


Fig. 2. Page hierarchy diagram of the platform

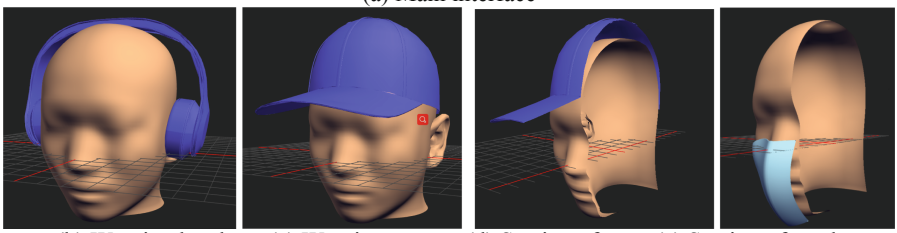
The platform is divided into two modules: data center and design center. (1) The head data center provides the designer with the data files in a visual way. During the design, each product has a corresponding design reference point, and the database provides a design dimension reference according to the product and the head shape selected by the user. (2) The design center is the main interface for user to conduct relevant design analysis.

3.3 Platform Development

Based on the ThreeJs development kit, a web platform for headwear aided design was developed using JavaScript language. Firstly, packaged library files were imported such as Three.js, TrackballControll.js, etc., and the code was written using Javascript and Html5. Then variables were defined, the scene was built. Lighting, camera, and other controls was initialized into the scene. Next, loadModel function was called to upload the background model to the scene. Finally, the rendered scene and model were loaded. Some interface of web platform are shown as Fig. 3.



(a) Main interface



(b) Wearing headset (c) Wearing cap (d) Section of cap (e) Section of mask

Fig. 3. Interface of the web platform

In this platform, Designer can import the personalized product model by themselves and it support a variety of common graphics formats (gltf/json/obj). After importing, they can choose the head shape for wearing display. The platform can directly display the fit performance of the product and the head shape, so it is convenient to choose different head shapes for comparison. Through the section view, the designer can clearly see the fitting degree between the imported product and the standard head, and use the result to modify the model, so that the product has been predicted before the product test.

4 Conclusion

In this paper through the analysis of similar design software and website, and user interviews, it was found that many designers need 3D head and face model. A headwear product aided design web platform was designed, which can make the fit performance analysis easier and headwear products design more convenient. Because the platform uses three dimensional digital head data, and can visualize fit performance and analyze dynamic multiple percentile of a head. Based on the designed platform, a prototype was also developed. By importing the designed product into the platform with the certain format, the fit performance between the product with different percentile heads can be found to improve the structure of the headwear product. In the following research, this platform also will provides the distribution display of acupoints of corresponding head shape for head massage product design.

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Design Strategies and Innovation

Visual Identity Design as a Cultural Interface of a Territory

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Abstract. The purpose of the article is to study how the brand's visual identity contributes to the understanding, accessibility and enjoyment of information, adapting the message to different cultures and profiles of people, users or target audiences. Identity promotes sustainability and respect for people's quality of life. The methodology used is mixed, including a non-interventionist phase consisting in the study of competing brands, audience map and persona method and an interventionist component through project-grounded design research, which includes participatory methods such as co-design and Design thinking. The results are a visual identity of the mountain olive oils brand that acts simultaneously as an interface of representation of the collective, the individual and the region (internal audiences), fulfilling the expectations and needs of the target public and other stakeholders. Design principles and good practices are also defined to ensure that visual identity continues to function as a cultural interface of the territory in a sustainable logic and not just business requirements.

Keywords: Brand visual identity · Brand of mountain olive oils · Brand mark · Project-grounded research

1 Introduction

Nowadays, efforts to compete and communicate in a global marketplace means creating a brand. However, little data remains on how to create an effective and efficient brand.

For most cases there is a wide range of products and services that compete for a prominent place. In this scenario of large product offering, brand creation has been a way of emphasizing the differentiating characteristics of products or services or its emotional associations. An example of this are the brand portfolios of Consumer

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Packaged Goods (CPG), which after decades of unfocused growth had left companies such as H.J. Heinz, Sara Lee, Kraft to financial problems, or Unilever and Procter & Gamble which faced the difficulties and complexity of managing a large number of brands with an international dimension, each with its own local requirements and adaptations needs. In general, these multi-brand strategies tend to increase production and communication costs, the need for new means or channels of communication, slow decision-making, poor circulation of information, the challenges in monitoring the impact of actions according to targets, problems in growing the reputation of each brand and impatience for a return on investment. On the other hand, the proliferation of small brands with low notoriety and without a strong identity easily translates into visual noise. Products with a brand mark (logotype and/or symbol) or visual identity but without a real brand, incapable of generating memorization and emotional attachment in the minds of stakeholders. This is especially the case of micro, small and medium enterprises whom seem to have brand management problems, highlighting problems such as the lack of resident human resources specialized in brand, a low number of media and means of communication, the absence of strategies, the poor knowledge of the target audiences and the actions of competitors, a low annual budget to invest in communication, a disjointed or wrong presence in social networks and digital media or the absence of investment in advertising.

The previous literature tends to consider that only producers, manufacturers and retailers develop brands [1], with little emphasis on brands that build a reputation and sell products they do not produce (called black brands by [2]), barely mention the brands created by cooperation or in communities, particularly rural ones, and the first articles on co-branding date from the mid-1990 s [3]. Most of the literature on place branding refers to countries and large regions or cities, leaving out rural or sparsely populated areas.

In the same sense, publications on Place Branding refer to the efforts of countries, tourism management bodies or municipalities, tending to forget the participation of local communities or private companies in the construction of the "identity of a region" and "regional identity". The identity of a region is the set of traits and characteristics that distinguish it in geographical and physical, cultural and historical terms, while regional identity refers to institutionalized practices, discourses and symbols that result from social interaction over time and that characterize how people identify with the region [4, 5]. There seems to be the idea that Place Branding positions a region by what it says about itself, forgetting that a place is always judged by what it does over time. But if the notion of a place results from an open system of interdependent, from the action of multiple stakeholders whose action impacts on other community members [6], Branding is a way of relating and combining the interests of various stakeholders and integrating actions [7] and communications according to a purpose, a shared brand vision [8] or a way of relating brand, people and place [9].

As declared by Vuorinen and Vos [10] conceptualizing places as brands have competitive advantages and implications for community and place development (Rannikko 2000). We intend to explain how a brand creation with and for a community of olive oil producers can shape an identity and vision about a region from a local product.

2 The Context of the Brand Mountain Olive Oils

The brand Azeites de Montanha (Mountain Olive Oils) is a result of the research project "Promotion and Valorization of Mountain Olive Oil" promoted by the Castelo Branco Polytechnic Institute and the Guarda Polytechnic Institute, with the Intermunicipal Community of Beiras and Serra da Estrela and the Biotechnology Center of Plants of Beira Interior. The project intended to develop a set of actions to strengthen the positioning of companies in the oil sector in Beiras and Serra da Estrela, through best practices, introducing new methods, techniques and innovative processes leading to differentiated olive oils by their quality and distinct organoleptic characteristics. This region represents the territorial area of more than 6000 km^2, corresponding to 22% of the central region of the country, including 15 municipalities and 266 civil parishes. In the European Union (EU), Portugal is the second country with the highest number of SMEs per 100 inhabitants and the third largest exporter of olive oil in the European Union.

In Portugal, there are traces of an olive oil culture since the Bronze Age. And in the region of Beiras and Serras da Estrela olive oil has been part of the agricultural activities and the Mediterranean diet for several centuries, with olive oil occupying a relevant position in commerce since the 13th century. Therefore, in the national context, olive oil from the Beiras and Serra da Estrela regions is easily associated with quality olive oil. Nevertheless, olive oil brands from the Alentejo region of Portugal are the reference. In international terms, Portugal is associated with quality olive oil, although a considerable portion of the national olive oil production is sold by Spanish and Italian brands.

In Beiras and Serra da Estrela region, olive oil brands are created by cooperatives of producers, farmers/olive growers, packers, distributors/sellers of olive oil. Most of these brands contribute to the sale of a small annual production, which lasts for several months. Most of these brands are not associated with a marketing strategy defined as such and the visual identity is limited to a Brand Mark and the label. The bottle tends to be chosen exclusively for reasons of price and ease of purchase, normally they adopted unsuitable brand names, there is rarely a packaging or other media and means of communication, particularly stationary, website or advertising. With few exceptions, presence on social networks is done in an amateurish and rather disjointed way, confusing brand communication with the CEO's discourse and tone or selected images without a graphic and semantic criterion. In market terms, these small producers compete with national brands and the more organized one's export to various markets although sales are still based on the notoriety built by the experience of the consumer who repeats the purchase and on the word of mouth.

The study was initiated with a non-interventionist methodology, including the review of the literature and methods such as the study of competing brands, audience map and persona method. Next, was adopted an interventionist methodology, specifically, a project-grounded design research, including focus groups and participatory methods to define and test a mountain olive oil brand and its visual identity design.

3 Noninterventionist Research

The brand is essentially a set of intangible concepts that are associated with a place, company, product or service which results from the perception of stakeholders about everything associated with the brand: what the company does, how it communicates, what it says and what values it, what it does, price policies, points of sale, etc.

The brand management process (Branding or brand management) consists of adopting control mechanisms and reformulating the brand or company as an articulated whole (taking into account the desired brand image), that is, forms of monitoring that all points of contact between the brand and the public, proceeding to correct the conduct and communication, whenever necessary [11]. A process to guarantee public awareness and brand dimension, maintain its good reputation and foster customer loyalty [12].

Commercial competition in global market is part of nowadays reality [13] and in this scenario also the territories are in competition [14] in various sizes ranging from producer brands to place brands.

The brand Mountain Olive Oils is associated with the identity of the territory of Beiras and Serra da Estrela, and is inseparable from the brand Portugal, the Mediterranean and Portuguese culture and gastronomy.

The Brand Mountain Olive Oils therefore has the purpose of doing for the producers what they cannot alone: To gain brand reputation on a large scale; Create a brand with added value; Develop a Brand Visual Identity, communicated effectively and consistently in a strategic manner; To value Mountain Olive Oils by their qualities and through the territory; Implement a solid and purposeful advertising campaigns and promotional actions. Ensure brand management in terms of communication effectiveness and according to objectives.

A product with a logo, label and packaging is not a branded product if these are not associated with a Personality and brand concept that is recognized as such by the audience. The brand is always more than the product's characteristics and no company's decision is unrelated to the brand's success.

In concrete terms, was developed a Study of territory and Competitors Maps; a Public Map; a SWOT Analysis; and a Brand Diagnosis. The competitors map is a visual research tool to analyze brand marks and visual identities of competitor brands, in order to detect sector graphic codes, their graphic tones or styles, the brand language and the symbolic positioning of competitors [15].

The main conclusions of the competitors analyzed in the category of extra virgin olive oil are: About 80% of the Brand marks contain gold, yellow and green. However, black is present in almost all; The symbols tend to use the olive, olive leaf, drip of oil and the olive tree itself, with both more geometrical and expressive approaches; There are fewer Brand marks with direct allusion to the mountain; About 20% of the Brand marks analyzed have only a logotype, without a symbol.

To complement the research, the competing brands were positioned between two axes of cross-positioning, in the vertical between traditional and contemporary and horizontally from emotional to rational.

4 Project-Grounded Design Research

The brand definition started with the brand platform, a synthesis of the brand's Identity or DNA (essence, culture, vision and central idea) and its Positioning (affirmation in the market in relation to the expectations of the public and in comparison to the competitors) and according to the brand contract (value proposal).

In parallel, the Brand Personality was defined. Brand Personality is a strategic decision taking into account the place, producers and community identity related to what the market requires in order for such a brand to be clearly differentiated from its competitors and to meet the needs and expectations of the audience (Public Map).

Defining brand personality requires a sense of the desired brand image. Defining the desired Brand Image, namely its values, emotions and main symbolic characteristics capable of establishing the Brand Positioning, first in textual terms and then visually by an Image panel to express sensations, feelings and its brand (Costa 2010). A similar process to the way a fictional character is defined, since the brand is associated with behaviors similar to human beings (Aaker 1997 and Kapferer 2012).

The brand platform and the brand personality will work as a design principle and script for visual identity and brand communication, in strategic, tactical and operational terms, in particular in the communication plan and points of contact: service, sponsorship, advertising, events, name, verbal identity, visual identity, product design, etc. The potential development of a shared brand, by producers and congregation of an identity with community, regional and provincial levels was agreed in public discussions, as a cooperation process or co-creation between various stakeholders. This process allowed to clarify needs, expectations and to conceptualize a common goal, as also the intended brand image for Beiras and Serra da Estrela region, used as key reference for the place branding process as long-term commitment.

In this way, the positioning was defined as a participatory process, reinforcing the identity of the place and strengthening the link between local stakeholders and the brand. We took advantage of rurality, the mountain, the altitude, in sustainable olive groves, taking advantage of the best of traditional cultivars allied to contemporary demands as part of a high-quality olive oil culture. It was considered possible to highlight through the brand Mountain Olive Oils the type of bond, culture, history and know-how of the region with the olive oil. In order to emphasize the quality of the Olive Oil from Beiras and Serra da Estrela, the brand Mountain Olive Oils focuses exclusively on olive oil of superior quality such as Extra Virgin Olive Oil.

The Visual Identity of the brand, as well as the brand language must express the Brand Personality and its positioning. After all, Visual Identity is a way of visualizing intangible concepts about what is the Brand Mountain Olive Oil.

To ensure a greater sense of belonging, empathy and self-identification of olive growers and stakeholders with the brand, three Brand mark options were designed, each one corresponding to different expressions of the Brand Personality. The selection of Brand mark was made using different processes, namely through a questionnaire, in public discussions and through Focus Groups.

The questionnaire was applied via Internet and in person to consumers with a sample of 30 respondents and to olive growers and farmers, with a sample of 33

respondents, allowing to exclude the Brand mark with the worst results or lack of association with Extra Virgin Olive Oil, Mountain Olive Oil, Beiras e Serra da Estrela, High and Medium High Quality and High Average Price.

Considering the two remaining Brand mark, Focus Groups were performed to identify secondary associations and to characterize the perception of value in relation to the positioning and initial premises. In this regard Lupton [16] stated that the easiest way to test the effectiveness of design is to ask the target audience, considering that Focus Groups can be used to generate ideas or evaluate proposals through organized conversations and with questions prepared in advance.

Three Focus Groups were held, each with distinct groups of six to eight participants. The first group with six olive growers, farmers, packers, olive oil distributors/resellers (three women and three men aged between 25 and 80); the second with seven specialists in Marketing, Design and Brand Communication and business associations (three women and four men aged between 30 and 65); and the third with eight consumers (five women and three men aged between 20 and 70). All focus groups were conducted by external specialists, which registered the process in video and complemented the data with questionnaires, as well as final reports of each Focus Groups. To organize each Focus Group, desks were arranged in a U-shaped format and began with a brief contextualization of the Mountain Olive Oils brand and the main features identified in the Brand Book and Graphic Standards Kit. A set of exercises was applied that work like open diagrams with a voting system to detect trends for each possibility: Exercise 1—Emotional Archetypes of the brand; Exercise 2—Uses for olive oil; Exercise 3—Attributes and Benefits of olive oil; Exercise 4—Importance of label information.

The final Brand mark was registered at an international level and criteria for awarding the brand Mountain Olive Oils were defined, a slogan was created, and a label and seal were designed. It was designed a common brand label for olive oil producers, increasing brand awareness and dimension. In addition, it allows the producer to be identified with or without his own brand. An alternative is to include a brand stamp in a preexisting label, for those who already have their own brand with some reputation, obtaining added value by the association to the Mountain Olive Oils Brand.

In order to ensure a coherent and efficient brand communication, were developed a Brand Book, a Graphic Standards Manual and a Graphic Standards. In addition, associated to the Brand Book, the Brand Video was developed, which aims to present the brand as an aggregating concept and interface between the region and the various audiences. In the same sense, the Brand Management and Use Video and the Brand Management and Use Manual for Mountain Olive Oils were made.

5 Results and Findings

The brand Mountain Olive Oils corresponds to the identity of the territory and meets the needs of farmers, olive growers, packers and associations in the Beiras and Serra da Estrela region. Not only does the brand Mountain Olive Oils meet the requirements to achieve visibility, notoriety and competitiveness as well it is associated with high-quality

product, specifically Extra Virgin Olive Oil, produced in the region of Beiras and Serra da Estrela, positioned according to the demands of consumers and contemporary stakeholders. The tools and guidelines for the success of the brand Mountain Olive Oils are available and at the service of the Beiras and Serra da Estrela region.

The visual identity of the mountain olive oils brand acts simultaneously as an interface of representation of the collective, the individual and the region and fulfils the expectations and needs of the target public and other stakeholders. In addition, the implemented design principles and guidance of good practices ensure that visual identity continues to function as a cultural interface of the territory in a sustainable logic and not just serving financial interests. It has been possible to develop a visual brand identity common to local olive growers and other olive oil brand sellers as a single community, acting as place brand. The brands associated with the territory have the potential to foster the cohesion of the place and to bring together individual efforts so that they have more impact with the public. To do so, the brand must be a mobilizer of wills around a vision, that is, the brand must belong to the people of the region and managed in a way that captivates investors and consumers.

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Innovation in Traditional Productive Sectors - Visual Curation in Design

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Abstract. The purpose of this paper aims to describe the implementation of a Design Diagnosis practice within the scope of an International project under the acronym – REINOVA (Reindustrialization, entrepreneurship, and innovation in traditional productive sectors) was a project conducted by an international consortium composed by Portuguese and Spanish Institutions. The research presented is based on specific implementation of a strategy for the development of solutions within the scope of Design from the ESART partner within the REINOVA methodology. The discussion sessions that included the display of visual boards to the micro-entrepreneurs summarized the results of the image diagnosis and positively influenced the consumption context of some of the products previously idealized, namely the target audience, as well as the doses and form of presentation/communication of the product. The incentive programs for micro-companies must consider the volume of information that entrepreneurs need to address regularly, avoiding entropy in communication with small organizations.

Keywords: Image curation · Design project · Visual literacy · Visual diagnostic · Agri-food

1 Introduction

This article follows the assumption of qualitative research, for Jackson et al. [1] qualitative research is primarily concerned understanding human beings' experiences in a humanistic, interpretive approach. Through content analysis involves interpreting, theorizing, or making sense of data, breaking it down into segments that can be categorized and coded, and then establishing a pattern. The study falls in part in a "transformational research", meaning that does not focus on 'what is' but that deals more broadly with 'what ought to be [2]. According to the objectives of the REINOVA project (developed between 2017 and 2020) regarded among other subjects the

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"Technology and knowledge increase looking for creating products of excellence (totally new or adapting new ones) adjusted to external market niches;"

The REINOVA project consisted of the creation and testing of a new international methodology for the incubation of ideas. A methodology adapted to micro-enterprises in the agri-food sector, which increases the technological intensity and knowledge with a view to formulating excellent products (totally new or adapting the existing ones), adjusted to external niche markets.

Through an open innovation process, entrepreneurial attitude, creativity, and innovation, the project stimulated the different stages of the value chain from the idea to the entry into the market. Cooperation was a decisive factor in promoting disruptive innovation, optimizing processes, sharing knowledge and markets, reaching critical dimensions and minimizing cultural barriers.

The project by the ESART - IPCB, partner promoted Design consultancy actions in an area characterized by sparsely populated territory [3]. In this type of territory, entrepreneurs, particularly small and medium-sized companies, to participate in support programs need all their time to production. Making it difficult to manage the various initiatives that are presented to you. An increased effort is required in the consultancy service to simplify information and "translate" complex information.

There is a severe difficulty for small business owners to assimilate large amounts of information promptly. The project managed to gather capital gains referring to a methodological strategy carried out in the context of project development in the project chairs associated with the Master of Graphic Design at ESART - FA/UL. The methodological approach refers to the visual diagnosis on the scope of a Communication Design project. Of the eight projects developed by the partner in the REINOVA project, the present article presents the Zé dos Caracóis project.

The purpose of this paper is to present the potential of a Visual Communication Diagnostic Methodology in the context of a Visual Communication Design Project. Composed of a visual diagnostic exploratory study that combines several aspects of image contextualization according to emotional archetypes, an interpretive code of product through the discovery of keywords and the construction of a narrative according to a principle of the consumer journey. This diagnostic aims to introduce the development of graphic solutions, creating a basis of image reasoning.

Certain theoretical concepts can be used as information filters and are quite useful in exploratory studies to determine cultural contexts [4]. The experience of image diagnostic through exploratory studies allows designers to "feel" the rationale of their argument and to structure what are archetypal influences according to contemporary tendencies and ways of making explicit familiar knowledge to those who construct the diagnostic study, [5–7].

Building a design project leveraged by a diagnostic phase highlights the use of image mosaics, concept that can be related to the concept of bricolage. According to the perspective of anthropologist Claude Levi-Strauss, bricolage is the skill of using whatever is at hand and recombining them to create something new. For Levi-Strauss, the bricoleur, who is the savage mind, works with his hands in devious ways, puts pre-existing things together in new ways, and makes whatever with the hand [8]. The diagnostic strategy has the potential to increase the acuity of the qualitative information to signal not only the communication of the product but also its perspective of use.

2 Problem

Given the wide variety of visual information available in different media and contexts, it becomes difficult for small entrepreneurs to start new project without developing support that delimits the development of communication solutions.

3 Hypothesis

It is presented as a hypothesis to explore, the possibility of this strategy to support the development of graphics solutions and increase the support in the argumentation and conduction of the project.

4 Objectives

The objectives were the following:

- Provide to entrepreneurs the experience of a Visual Communication Diagnostic Methodology.
- Influence new experimental approaches to product design.

5 Methodology

This article describes a case, according to Yin [9] a case is a "contemporary phenomenon within its real life context, especially when the boundaries between the phenomenon and the context are not clear and the researcher has little control over the phenomenon and the context".

The Visual Communication Diagnostic Methodology followed a Context-Definition methodology, according with [10] Initial work in this model usually involves a analysis of a range of secondary research, mapping the territory to be investigated and determining influences. Once a solid understanding of the context has been reached, the focus and research question for the project can be determined and a working methodology can be defined.

A primary research is usually beneficial at this stage, in the form of direct surveys of visual elements. The results of these preliminary visual and contextual experiments can then help to define the specific project intention, together with an appropriate methodology that allows the testing of a range of potential outcomes. In the context of this methodology, the design team worked another methodology specifically related to the creation of narratives with the entrepreneur, called Narrative Inquiry, not about past experiences, but about future experiences associated with future fictional scenarios of consumption, but that start from the real experience of the interviewer (design team) and interviewees (entrepreneur). According to [11] narrative inquiry involves working with metaphors, creating visual and textual collages, found poetry, word images and

photographs, narrative inquirers create research texts that show the complex and multi-layered storied nature of experience.

6 Development

The REINOVA project, in its methodological proposal, present the necessary conditions for the implementation of a new international service that promotes networking, the creation of innovative companies with high potential and the reindustrialization of existing companies, increasing the competitiveness and growth of the sector agri-food. The specialization in this sector and the focus on niche strategies are innovations of the project, as well as the international character of the service implementation, with the sharing of the value chain. The good practice resulting from the project will serve as the basis for the definition of a collective cross-border strategy of the International partners, which consolidates the innovation ecosystem created and enhances the appreciation of the geographical origin of the new products.

The Project design component included the diagnostic strategy, Visual Communication Diagnostic Methodology (VCDM's), with the acronym in Portuguese of ME.DI.CO., That word in Portuguese, use the same letters, from the word "doctor" and works as a metaphor for communicating its purpose as a tool a project sequence (Fig. 1).

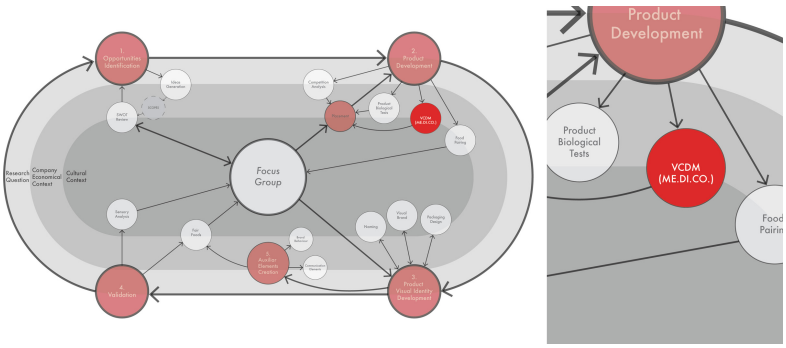

Fig. 1. VCDM's position in the design project cycle.

This strategy supports the development of Communication Design solutions. After developing the diagnostic study, the design team presented to entrepreneurs the results through imageboards and observed their reactions, in specific how the diagnostic results inferred about the development of the product in terms of its consumption context.

The strategy related with the Visual Communication Diagnostic Methodology (VCDM) involved the collection of visual information with different attributes and applications. The concepts behind each of the phases of the strategy followed a perspective of conceptual filters. Each phase results in a summary of information, which,

when added to the summaries of the remaining phases, qualitatively allows the development of the communication context. The VCDM as the name suggests, consists of making a diagnosis of the product to find a way to solve the problem. So, this tool starts by defining the emotional archetypes that most show this collective unconscious.

According to Carl Jung [12], within the Collective Unconscious, there are psychic or archetypal structures. These archetypes are forms without their content that serve to organize or indicate psychological material. As he says, archetypes are primordial images, because they often correspond to mythological themes that reappear in popular tales or legends.

"Archetypes are not only impregnations of typical, regularly repeated experiences, but also behave empirically as forces or tendencies to repeat the same experiences. Each time an archetype appears in a dream, in fantasy or in life, it brings with it a specific "influence" or force that gives it a numinous and fascinating effect or impels action" [12].

José Martins [13] states that emotional archetypes are common patterns throughout human culture, and perceived as states of mind or ways of understanding the world, directly linked to motivations and purchasing preferences.

The archetypal orientation is formed by Images that form a constellation of references of archetypal images according to cultural and commercial identifiers. From the different configurations of symbolic attributes and reference tables, the Martins model [13] offers several possibilities of associations between images and archetypes, providing a nice didactic approach. The contextualization of cultural positioning follows the selection of emotional archetypes at different levels of intensity. Cultural positioning is achieved through cultural synonyms of the selected emotional archetypes, surveyed in commercial online image services, by means of the identification of image tags. "Purchasing motivations are related to individual needs, beliefs, and desires. The preference is aroused by images that are in the collective unconscious of people." [13].

That is, the purchase motivation is related to personal needs and desires, and brand preference is associated with the feeling present in the collective imagination, thus, occurs an association with the brand image. If a brand only attracts its consumers to satisfy their personal needs, its margin of progression in the market is limited, but if the brand has an archetypal definition of the product it sells, the possibilities of expanding the market and increasing its sales grow dramatically.

After the definition of emotional archetypes, occurs a classification by the degree of importance to better classify the personality of the brand. That classification aims to present a set of human characteristics, such as emotions and feelings, in the minds of consumers. The easiest way to show these human characteristics is through images that result in a semantic panel that translates through images of these human characteristics that the brand should have in its personality, called Brand Picture.

Through the Brand Picture, it is already possible to start defining consumer profiles using the persona method. The persona method creates an imaginary character in his interaction with the real day-to-day, perceiving the behaviors and attitudes, to represent consumers or groups of specific consumers.

This method is useful for considering brand objectives, desires, or limitations, perceiving consumers, to help guide decisions about a service or product. For each product, results in more than one persona, but only one should be the primary focus for

the design. The persona method also helps to avoid some common design pitfalls, which can determine the failure of a product in its design.

Once defined the personas, we should focus on just one, idealizing their day-to-day life, and then transposed into a graph entitled consumer decision journey, where we determine, through tools such as Google maps, the points of contact between the consumer and the brand.

There are several models to map the consumer's decision journey. The McKinsey model [14] is one of them and involves the mapping of 5 steps:

- Consideration: This is the stage in which the consumer recognizes having a need and seeks information. It is common to resort mainly to search engines, the website of the brands you are considering, social networks, and forums.
- Evaluation: When evaluating existing alternatives, several studies indicate that consumers trust consumers' reviews much more than descriptions resulting from the company. In this phase, influencers (bloggers, friends, experts, etc.) have an essential role.
- Purchase: The purchase process is increasingly omnichannel, and there is a need to understand which channels the consumer selects to convert.
- Experience: After purchase, many consumers share their experiences with the brand/product/service through social networks.
- Loyalty: This is the point where the experience with the brand can contribute to customer loyalty, and here, applications in certain areas can make a difference, adding value to the customer and ensuring the continuity of the experience.

This mapping is beneficial to understand:

- Actions: What is the consumer doing at each stage? What activities are needed to move on to the next step? What kind of tactical operations can we implement (discounts, vouchers, etc.)?
- Motivations: Why is the consumer motivated to move to the next phase? What emotions are you feeling? Which touchpoints can be activated?
- Questions: What are the uncertainties that are preventing the consumer from moving to the next step?
- Obstacles: What structural barriers, costs, difficulties are retaining the consumer at a given stage?

The purpose of this mapping is to define the various stages in the process, indicators and metrics so that it is possible to integrate offline and online strategies in the communication plan, creating, if necessary, touchpoints. Involve the consumer in a story is an excellent strategy to captivate him and to guarantee a smooth interaction. The storytelling technique enables to transpose the company's vision and its purposes into a communication plan, using narrative as a tool. This narrative must be attractive and accessible in order to be timeless in a harmonious and emotional way. As Mootee [15] suggests, the storytelling narrative must follow the following councils:

It must be participatory: If we involve a lot of people in the narrative, or if your exposure goes through social networks where people interact, or if we still collect personal feedback information from employees, we must ensure that people feel part of the story. That these persons feel that history is familiar to them.

It must be attractive: The platform conveying the story can make it a success or a failure. To make the message attractive, we must transpose the listeners to other places, experiences, spaces.

It must involve structure: In storytelling, the narrative serves to organize the information in a logical structure that must be followed, with beginning, middle and end. Because the narrator and the audience know this structure, they can focus on the content of the story. When content flows, a good storyteller can present challenges and complex information in a more precise and more familiar format to the audience.

It must be performative: When telling a story, efficient oratory expression involves the listener. A compelling narrator conveys the words alive, using dramatic techniques such as body language, tone, rhythm and the search for the right moment.

It must be tangible: People like things they can see and touch. Prototypes help us to be able to convey an idea tangibly, expressing the company's strategic intentions, chaining the way forward towards something concrete.

It should be fun: The narrative should be interactive just like the games, giving the listener the chance to understand the story as a whole, in a personal and interactive way. These "serious games" provide the possibility to explore and live the roles, tasks, and relationships within a system defined by rules within an already understood context.

It must be realistic: The narrative must be tangent to reality. Although the listener knows that it is a fiction, he must be able to identify its applicability. Then, the narrative must include a vision of the future and a possible growth that is beyond the reach of the listener, maintaining a plausible basis of being reasonable. Only then can the story inspire and stimulate, providing the necessary information to guide the listener. This whole process, if well accomplished, is able to diagnose the problem that the product has to answer, being an essential motto for defining the positioning of the brand or product (Fig. 2).

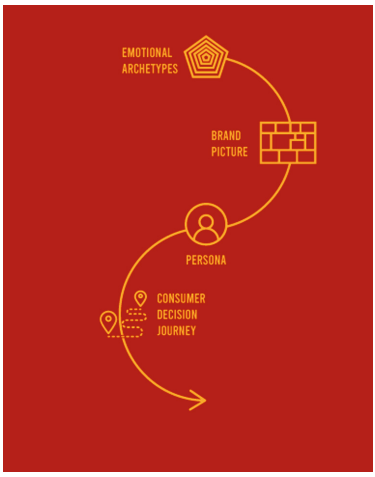

Fig. 2. VCDM's sequence.

6.1 Discovery Session

At the end of the diagnosis, the entrepreneur in the discussion with the design team understood the new logics provided by the product narrative creation. The narrative resulted from creating sequences and logics from the diagnosis image boards, that displayed a curation of visual information about the product. In the discussion meeting that lasted about two hours, the Design team and the entrepreneur constructed together a "discovery session" through images of multi-layered storied nature of experience and scenarios. According to a previous study [16] image maps allow the creation of narratives suggested by constant comparison in image maps arranged in mosaic.

According to Winifred [17] Designers can use maps to curate and synthesize their observations, mapmaking include three basic activities: capture, curation, and analysis. The complexity and amount of data, nowadays available, makes curation more difficult. This means translating data collected through different means into legible output, maps and mapping can be a mean to curate information.

The resulting communication follows the perspective that it is more than mere communication, presenting itself as a perspective of product use. The three phases involved the collection of information of a distinct nature, the strategy for the first phase uses image references. According to a previous article Silva [6]. The phases involve the collection of visual information structured to filter information according to the project subject. In this research the designers worked the reasoning of the image and the correlation of the concepts of the emotional archetypes. Systematic approach to visual research, uses tools consistent with the design of visual communication and designers update the visual literacy through the investigation of different cultural settings. According to Lopez Leon [18] referring an experience developed with design students, when developing visual literacy in design through visual reports, students report that unlike a written report, generating an image make them reflect on the interpretation, stop for a moment to think and sometimes, even go back and corroborate information. Also, the VCDM aims to overcome some lack of structure in the introduction of the design project. The strategy allows for a more detailed approach to a consulting perspective.

7 Results

In applying the VCDM the interviews, informally allowed entrepreneurs, in a short time, to build scenarios, logics, and consumer narratives. These narratives must result from a "meeting" with consumer behaviors and forms familiar to potential consumers, in the channels where a product can seduce. The VCDM values two ways, on the one hand, it allows the sustained development of the strategies in the Design project. On the other hand, it will enable to enhance the curation and output of images associated with the project. Visual presentation extends the cognitive ability of humans to some extent. Visualizations are regarded as way to relieve the cognitive burden and speed up processing according with [19], the visual presentations reduce search efforts, enhancing recognition of patterns [20]. The VCDM Images boards may represent a strategy in

alleviating the cognitive load. Finding ways to reduce extraneous cognitive load may be an avenue to improving creative thinking [21].

8 Conclusion

After building consumer narratives with the help of image boards, entrepreneurs were able to understand and internalize the Design solutions proposed for the project in a more fluid way. Triggering better reasonings in the final design proposals and easily justifying the why, becoming ambassadors for the strategies adopted. At the level of the effectiveness of the VCDM, it can guide creativity solutions delimited by three perspectives, archetypes, product cultural code, and customer journey. These three levels work as information filters and allow a greater security in the project's argumentation and safety in the development of the project, to some extent alleviate the "cognitive load" of the challenge presented by the project. The design project can value VCDM in two ways. On one hand, it allows the sustained development of the strategies in the design project, on the other hand, it allows to enhance the curation and output of images associated with the project. It fosters the argumentation of both designers and entrepreneurs in the communication and even in the product discovery.

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New Chromatic Planning Strategies for Urban Furniture

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Abstract. This paper presents a new approach to different typologies of settlements or cities, when creating urban chromatic plans to urban furniture, improving their visibility and readability. The applied methodology may take different steps, depending on whether it is an old settlement, a newly built neighborhood, or an unfinished project whose color plan hasn't yet been defined. Usually, ancient urban spaces don't have chromatic plans, being their buildings constructed at different periods, with a large chromatic range. On modern neighborhoods, the buildings are relatively homogeneous, which makes it easier to create an effective chromatic strategy. Considering the construction of a population cluster under development, it is easier to decide the color scheme for its urban furniture, because the choice of colors meets the same criteria of the architecture and may be included in the general project. Therefore, we aim to demonstrate that the elaboration of Urban Furniture Chromatic Plans must take different strategies according to the place specifications.

Keywords: Urban furniture · Color strategies chromatic plans · Visibility · Legibility

1 Introduction

Considering the inclusivity and wellbeing of the urban population, it becomes increasingly necessary to improve the orientation within cities and minor settlements, through elements that convey information and provide comfort to the entire population, be it temporary or permanent. Since the mid-20th century, the term Urban Furniture encompasses all these elements that are present in every population clusters.

In order to be effective and accomplish fully its functions, Urban Furniture should convey the idea of a whole, besides being completely visible and legible. The best way to achieve this, may be through the implantation of a coherent chromatic plan, that must be, simultaneously, uniform and establish a chromatic and luminous contrast with the natural and built environment, and for this purpose was developed a Methodology that allows the creation of these plans. However, this Methodology can adopt different strategies depending on the villages to which it is applied. In this paper we will consider three different examples: a city/town that grew over time without obeying any established plan; a modern city or urban area which was built at one time and obeying

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to an architectonic chromatic plan; and a project which is still on preparation and may include chromatic plans for both architecture and urban furniture.

2 Urban Design and the Use of Soft and Hard Projects

Nowadays, in the context of project and program management, we often see the use of the concepts "hard" and "soft". Firstly, it is important to clarify the use of these two terms.

Crawford and Pollack (2004) addressed this issue using the authors' practice-based research into large organizational change programs in a variety of contexts, and the literature on project management, systems thinking and evaluation. The term "soft projects" refers to a new way of approaching design where priority is given to minimal actions targeting on the effectiveness and efficacy of urban sign rather than its invasiveness. Most of the times, designers prefer to focus on processes and meanings rather than their evidence, or on perceptive aspects rather than structural elements. For project development and management, "soft projects" use more the people-oriented skills of empathy, collaboration, influence, and leadership. These skills are marked by high levels of 'emotional intelligence' which is usually taken to be a combination of self-awareness, self-control, empathy for others' feelings and social skills. So, they tend to have a much wider business and social application.

When we refer to "hard projects", we are more focused on the technical skills of analysis, planning, tracking, and problem solving, being these skills often numerical, logical, and data oriented, i.e. the implementation of discipline, rationality, and cool rigor.

In most of the cases, a good Project Management is a mixed of Hard and Soft Project Management, i.e. being able to deploy hard and soft project management skills, choosing which ones to focus on at any time, combining hard and soft project management approaches. Therefore, it is vital for project managers to incorporate performance feedback into their management practices. Traditional hard project management practices, such as careful planning and monitoring (Crawford and Pollack 2004), may be sufficient to achieve adequate process performance, leading to successful execution, in many projects. However, in numerous other cases, softer approaches, such as efforts to foster collaboration and learning, may be required for successful execution, involving complex interrelations between both people and processes.

Most of the color interventions in urban spaces are often problematic because they use color as "a privileged communicative and emotional means to launch aesthetical, cultural, and social revitalization processes and also to affirm new identities" (Boeri 2017, p. 641). Many municipal interventions look at color as a major advantage, as Bruno Taut stated about colored architecture, once color is at the same time the most economic and effective means to transform the urban environment and launch a social strategy aimed at instilling visual pleasure and joy of living urban spaces (Taut 1919).

So, unfortunately, most of the times color is used as result of a "soft project" decision and management, resulting in "soft regeneration" strategies for urban spaces.

"A desire of color and differentiation without rules that after years have brought to a general fragmentation and reading confusion of the urban environment" (Boeri 2017, p. 642).

Urban regeneration is a way to reorganize and upgrade existing places rather than planning new urbanization, framing a range of strategies or initiatives, encompassing and addressing a number of inter-related economic, social, environmental, institutional or physical aspects of urban areas.

Urban regeneration is primarily concerned with regenerating city centers, former industrial areas and early/inner ring suburbs facing periods of decline due to compounding and intersecting pressures. It is crucial to consider that only the horizontal and vertical integration of different policy tools can achieve the full potential of sustainable regeneration of urban areas.

Factors underlying the adoption of urban regeneration policies and projects include pressures from major short- or long-term economic problems, deindustrialization, demographic changes, underinvestment, infrastructural obsolescence, structural or cyclical employment issues, political disenfranchisement, racial or social tensions, physical deterioration, and physical changes to urban areas. Typically, urban regeneration actions involve economic, social and physical/environmental improvement measures of the areas under intervention (Czischke et al. 2014).

A good and successful urban regeneration is the result of a collective vision, realized through creative and enduring relationships between several stakeholders, such as the community, government, developers, academia and professionals involved in its design, delivery, governance and maintenance. Strategic thinking about our cities, what they should look like and how they should perform, is more important than ever (Lehmann 2019).

So, it is important to develop assets involving local communities but using the rigor of a specific and validated color methodology for urban color plans.

3 Implanting Urban Furniture Chromatic Plans

The concern to establish a coherent urban image through color studies and chromatic plans is relatively recent, despite some pioneer cases, and led to the conception of chromatic planning methodologies, gathering the necessary steps for the selection of a color palette that would constitute the urban image. However, these plans are mainly intended for Architecture and do not take into account the presence of urban furniture, nor the importance that these elements can have in the orientation within the city. Therefore, it became evident that there was a necessity to create a different methodology that would respond to the needs of creating chromatic plans for urban furniture, allowing these elements to fully fulfill their functions.

This methodology aims to originate a system that will ameliorate urban furniture use, improving the visibility and legibility of its elements, transforming them in identification factors for the different city neighborhoods, and contributing to a better orientation within the cities. This new methodology, is intent to be applied solely to urban furniture, which will become an ergonomic and inclusive factor, and not interfering with other elements of city signage, which are encoded by road legislation.

Thus, this methodology basically consists of the global survey of all colors present in the urban area to be intervened, in order to be able to establish a map of its dominant colors. This map will allow the choice of chromatism for urban furniture, which should always establish a color and light contrast with its surroundings.

The first step of the Methodology application, is an extensive direct observation, with the use of mechanical devices, including photographic mapping of the existent urban furniture and signage, in order to evaluate their visibility and legibility, as well as their color applications.

Along the chosen areas, an exhaustive record of all the environmental colors must be made, including material samples not only from the buildings, but also from pavements, vegetation and any additional elements present with a relative permanence in the urban environment − the non-permanent colors − that should be taken into account for the spatial chromatic readings. All of them will then be classified using the Natural Color System (NCS), that was chosen because it allows the easy identification of every color, even when they are located out of reach, and without needing additional equipment. It must be underlined that the recorded colors are perceived colors, not always coincident with the inherent colors (those belonging to pigments and materials). The perceived colors may also be a partitive synthesis, particularly in the case of vegetation and tiles coated walls. Besides the NCS classification, whenever it is possible, the colorimeter may be used for a confirmation of measured colors.

All these recorded colors must be completed with the background dominant colors, and with photographs of the several environment elements and panoramic views from the different blocks using urban plans, architectural elevations and sections of the selected paths, which will act as elements of the environment color components.

The streets angle must be evaluated in order to determine the percentage of sky color present in each street, because this presence interferes on the urban area color and, therefore, must be included in the chromatic palette.

Also, when recording the environmental colors, we must take in account all the perceptive factors related with color interactions, as well as the geographic and atmospheric conditions and the chromatic variations along the different climatic seasons. With this purpose, the palette shall be tested along the seasons' changes to judge the chromatic alterations aroused from the different colors of the vegetation as well as day light variations and sky colors according to weather changes to evaluate the chromatic plan pertinence. Then, all these are recorded on forms and maps, previously designed and tested, in order to create a data base that will allow the identification of the town dominant colors.

In order to guarantee the scientific rigor on each quarter chromatic plan determination, the dominant colors must be proportionally represented on a map, allowing the colors choice to the urban furniture, which should establish an adequate chromatic and luminosity contrast with the dominant colors and, also, respect the traditions, culture, identity and history of the quarter. These contrasts must be observed under the possible local illumination variations, in order to be sure that they accomplish efficiently their functions.

4 The Different Strategies

The color planning considered in urban planning strategies is rarely applied globally. Most of the color plans drawn up till today are a useful urban planning tools to recover color tones, original materials and manufacturing techniques of historical buildings, to ensure the maintenance and the conservation in time, contributing to define a coherent image of the town. Considering the creation of Chromatic Plans for Urban Furniture, and the application of the respective Methodology, we must take in account that not all the cities or urban areas are alike and that we shall establish different strategies depending on whether it is an old population cluster, which grew anarchically over time, with no established chromatic plan (Sect. 4.1); or a new urban area built with its own chromatic plan regarding the built environment (Sect. 4.2); or even, a project in the process of being completed for which the chromatic plans of architecture and urban furniture must be studied simultaneously (Sect. 4.3).

4.1 Old Cities' Settlements

With few exceptions, most of ancient urban spaces don't have chromatic plans, being their buildings constructed at different periods, with a large chromatic range as well as different sizes and importance. Therefore, the registration of the present colors should be more exhaustive, taking in account more accurately the relative importance of the buildings.

Often, these settlements have a lot of small houses with one or two stores, making the natural environment and the sky more present, and these conditions make the definition of these places' dominant colors more complex. In these cases, the urban furniture may be more difficult to establish and fulfil its functions with lower efficiency.

This is the case of Bucelas, a small town from Loures municipality near Lisbon, with an ancient origin. It is a rural town, surrounded by vineyards and meadows, without industries or factories excepting the ones related with wine production. Its buildings, with few exceptions, don't exceed two-stories, with colors that don't obey to any color plan. In this case, the exhaustive recorded existent colors conduced to a dominant color palette with a pre-dominance of white and a small quantity of burgundy, blue and yellow.

4.2 Modern Cities and New Built Quarters

On modern cities or urban areas recently built, the Methodology application process is more or less the same as the one applied to old cities. But, in these cases, the buildings have more or less the same size and although they may have some variants of shape and color, they are relatively homogeneous, which makes it easier to identify their dominant colors and, consequently, the creation of a coherent chromatic strategy can be more effective.

This is the case of Infantado, a new neighborhood also from Loures municipality, recently built. It consists of three groups of tall buildings, with similar colors and appearance, and without great interference from the sky color or the natural environment. These conditions, in addition to the lack of local history and chromatic traditions, considerably facilitate the establishment of an effective chromatic plan for urban furniture.

4.3 Unbuilt Projects

The chromatic planning methodology meant to be applied to new cities or zones, which are yet to be build, cannot use historic file collections except for the mention of the region traditional colors. Also, it refers to the natural environment colors, and not the surveys of building existing colors.

When the construction of a population cluster is still under development, it is easier to decide the color scheme for its urban furniture, because the choice of colors meets the same criteria of the architecture and is included in the general project. Then, the choice is based on the registration of the colors of the surrounding natural environment and the buildings chosen palette. The difference between the colors of the buildings and those of urban furniture is that the first ones may contrast or integrate the environment chromatism, while the urban furniture chosen palette must establish a luminous and chromatic contrast with both architecture and environment.

5 Virtual Reality for Furniture Color Planning

The color planning or color development within the built environment is very little considered in urban planning strategies, except in protected areas with historical buildings. Most of the color plans drawn up till today are a useful urban planning tools to recover color tones, original materials and manufacturing techniques of historical buildings, to ensure the maintenance and the conservation in time, contributing to define a coherent image of the town.

However, their main target is always the buildings, essentially the buildings' façades, not the urban furniture, or any other elements.

Urban space furniture is a relevant component that connote and characterize the public space and represent the "urban detail". So, a special attention must be given to the urban furniture and its color.

According to Ceconello and Spallazzo (2010), this was the case of the Urban Furniture department of Milan City Council which entrusted a study to a local Color Lab focused on the management and the planning of the urban furniture chromatic component. The first part of the research, which was carried out by the Color Lab, deeply analyzed the chromatic component in all furniture elements present in the area. The analysis and the mapping of the existing chromatic component was synthesized in a database aimed both at highlighting its qualities and as organization tool of the urban furniture characteristics. This database is focused on different kinds of information: visual features (picture and drawing), historical, cultural and technical data (materials, productive technology, maintenance cycle) and the coding of the perceived color needed to manage the chromatic component. The second part of the research was the visualization of the proposed action using virtual reality: the basic idea was to use the virtual reconstruction in order to evaluate the re-design of the site without doing drastic intervention by trying to understand if color could help to improve the appearance and the perception of the site.

This example evidences the importance of virtual reality to develop models for urban color applications, namely for urban furniture. This will be the next strategic step

for our color methodology, by adding more accurate information from drawings and plans of the buildings, improving a better definition of balconies, ornaments, and complex shape, rendered with textures. With virtual prototypes, it will be possible to evaluate the most relevant scenarios in real-time on a cognitive basis, using participatory design and user-centered design methods.

6 Conclusions

The new methodology to establish color plans to urban furniture is more holistic and as includes the final user point of view. This methodology consists in recording all the existent settlement colors, arousing from the environment, including the existent building colors, which are the elements that interfere most with the visibility of urban furniture; the vegetation and the sky colors, and their climatic variations; and the colors of other elements whose presence may also affect the urban furniture chromatic application. This systematic process will allow not only the determination of the local dominant colors, as well as the establishment of coherent urban furniture chromatic strategies.

The tests in different urban areas were fundamental to validate the methodology and the used processes, focusing in the establishment of the color schemes for the urban furniture, allowing the existence of a luminous and chromatic contrast with both architecture and environment. The next step will be to test the use of virtual reality to help the designers on the chromatic decisions for urban furniture.

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strateegia: A Framework that Assumes Design as a Strategic Tool

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Abstract. Our challenge is addressing the time, scale, and space of strategies for creating, adapting, evolving, changing, transforming, and undertaking a business, product, or service to the platform economy in a detailed, comprehensive, deep, sophisticated in a simple, elegant, effective and efficient way. It is in this sense that we present the strateegia framework, the result of years of experience in creating, evolving and transforming business from design as a strategic approach in Brazil.

Keywords: Digital transformation · Platform economy · Design thinking · Strategy · Business design

1 Introduction

Every transformation is complex. Especially a shift that requires the rethinking of the foundations of business, crossing from analog to digital platforms, that new and unknown substrate so vital to those that want to compete in contemporary markets. It is no different when it comes to the transformation of successful organizations. Those where history and legacy are governed by rules of performance that makes everyone proud, but took time (sometimes decades) to be established, are no longer fitting with contemporary digital markets. It is in this context that strateegia is presented, a framework that assumes design as a strategic tool.

All businesses, large and consolidated, or small and growing - need to adapt to the platform economy. Adapting to these digital platforms means being prepared for continuous and (most frequently) rapid changes. The digital, unlike the analog, is fluid and goes through uninterrupted evolution. In this context, nothing is definitely ready, everything could change in response to a series of possibilities and situations, according to a multitude of scenarios. The digital around us is mutable, programmable and is being programmed; therefore, it is changing all the time. All businesses, big and small, need models (framework) and tools (platforms) in order to move from the past (analogical) to the future (digital).

Understanding design as a tool to create and build futures is critical to discovering the suitable models and designing the tools required for this journey. In strateegia,

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we adopt design as our own way of intervening that observes people and organizations, besides exploiting technologies to infer viable business opportunities in order to transform the environment in which they operate. From this perspective, design not only adds value to a product, service, or business; design is value, and, for our context, value is strategy. Through this design thinking we believe be able to lead individuals, teams and organizations to imagine and create digital futures. It is in this sense that we present the strateegia framework. Our framework encourages a conversational environment that leads to actions which uses design methods, business models and digital systems for an emergent strategy.

2 Time to Transform

One of the most striking features of digital platforms is that all of its facets are – and are defined by - interconnected through a digital network.

People's working methods within business are connected; if this is not the case – when there are no degrees of freedom of decision making and action, the efficiency and effectiveness of articulations within the business will not be able to create - and will not keep up with - the network effects on the market. Business systems - at least those that want to survive - are interconnected. They use the network to cooperate and at the same time are inputs to network competition. They enable the largest and most competitive yet collaborative set of agents (to compete and collaborate) that will define their markets.

The same is true of (business) models, which have always been networked in one form or another. They are now in real-time digital networks, thus enabling agents who can fully and individually address each member of their network, whether it's a supplier, consumer, partner, or collaborator, while creates multifaceted, transparent, networked forms for creation, delivery, and capturing value: digital value, inside a digital network. Historically, one of the biggest challenge when it comes to changing processes is that the process itself and its outcomes are evaluated by indicators of the past – and perhaps even the present - rather than the future of the business itself. One of the advantages of digital (business) space over analog is that the digital is - should be - nearly real time, just like its performance indicators.

A networked business is, therefore, connected, based on methods, systems, models and indicators which are connected, digital and real-time operated. The transformation (or adaptation) from analogue to digital cannot be dragged down by rational excuses that lead to analysis paralysis, nor to stick to fears and emotional reactions, which ultimately prevent us from doing what is known to be right.

In strateegia, we work on the digital transformation (or adaptation) process from a continuous spiral, in which the creation, development and dissemination of digital platforms takes place in evolutionary redesign and refinery cycles.

strateegia encourages a short design effort [little design up front] that leads to agile development based on rapid prototyping [lean development] in addition to dissemination mechanisms that use permanent monitoring and analysis of performance data [big data analytics] for the [re] design and the adequate adjustments in time of use [redesign loop]. It is this approach that enables us to incrementally and iteratively produce innovative solutions.

3 Design as a Strategic Approach

In building strateegia, we adopt design as our own way of intervening, people-watching and exploring technologies to infer business opportunities that transform the environment in which we operate. From this perspective, design not only adds value to a product, service, or business; design is value and, for our context, value is strategy. It is through this thinking that strateegia leads individuals, teams and organizations to imagine and create digital futures.

3.1 Strateegia Toolbox

Metaphorically, strategia is a set of toolboxes, in which its modules represent the components of a framework for digital transformation (or adaptation). Currently, strateegia is composed of four toolboxes: (work) method box, (business) models box, (tech) systems box, and lastly a (performance) indicators box.

The [work] methods box is made of modules that were brought mainly from design thinking, agile methodologies and lean development techniques. The [business] model box contains models that are part of the business essence of the platform economy. The [technology] systems box is where we point out the main software solutions to be applied in the creation, development and operation of digital solutions. The [performance] indicator box is where the KPIs and OKRs that assist in monitoring results are located.

3.2 Modular over Time

Each strateegia project is unique and therefore follows different paths between the modules of the tool boxes. In order to simplify the visualization of these paths, we use a modular map in time where the modules of the boxes are added as the projects advance in time. Each project has a modular map in its own time that represents the creation, development and implementation of the business. Unlike the methodologies adopted in the analogical paradigm for product development, we understand that the choice of methods is part of the dialogic experience of digital culture. In other words, strateegia is a digital framework for those going digital.

3.3 Modular and Minimalist

In general, frameworks for digital transformation usually put a paradoxical situation for those who apply them: sometimes they restrict the number of techniques and thereby limit the scope of the transformation, whereas sometimes they expand the techniques and limit the audience capable of dealing with the diversity of maps, graphics, canvas and other structures that each technique requires.

In strateegia we adapt the application of (work) methods, (business) models, [technology] systems and [performance] indicators to a unique technique, based on the formulation of essential questions corresponding to each module of the toolboxes. The essential questions of each module are defined based on a filter that reduces syntactic, semantic and pragmatic aspects to the central points of each technique. The use of any

module in the strateegia toolbox enables individuals to apply the other modules, thus reducing the learning curve of the framework and simplifying its application in multidisciplinary teams.

4 Experimentation and Performance Strateegia Labs

strateegia has as its main foundation the acculturation around the digital through stages of maturity with innovative digital experiences that lead from an analog culture to a digital culture path.

In order to implement the process of acculturation through strateegia, we propose experimentation and performance laboratories. These are structures that mix the physical and the virtual, and aim to provoke divergence cycles, contacts with new methods [of work], systems [of technology], models [of business] and [performance] and convergence indicators, while building innovative businesses based on the platform economy.

4.1 Archi (Opportunities)

In order to start a digital transformation (or adaptation) journey, we created the archi laboratories. Archi represents the beginning, the development and the end of a cycle. In other words, it is an experiential space of very short duration.

Since we are dealing with cultural adaptation, we understand that an initial immersion action works as the spark that ignites the laboratories of experimentation and digital performance: poiesis, praxis and paideia. Archi, as the gateway to strateegia, represents the state in which we map opportunities and design departure strategies for innovative and sustainable businesses.

4.2 Poiesis (Prototypes)

In poiesis laboratories, businesses based on the economy of digital platforms have the status of high-fidelity prototypes, with real applications and measurable initial results.

During the poiesis laboratory, businesses will have experienced a greater set of methods and systems for creating, developing and deploying digital platforms. The activities in the poiesis are carried out in continuous co-creation, offering a permanent learning environment throughout the process. It is important to point out that poiesis is oriented towards prototypes and not performance.

4.3 Praxis (Platforms)

Praxis laboratories focus on the concept of digital platforms. In these labs, digital platforms are becoming part of the organization's business.

During praxis, individuals and organizations mature and undertake activities of creation, development and implantation of medium-sized digital platforms with an emphasis on monitoring and analyzing data as part of the decision-making processes. The actions in the praxis laboratories are already connected to the organization's

actions and systems. Praxis, much more than poiesis, is performance oriented, yet without losing the experimental character.

4.4 Paideia (Platforms)

In paideia laboratories, the objective is the construction and sustainable evolution of innovative businesses for the platform economy.

Upon reaching this stage of digital culture maturity, businesses are scalable and heavily based on data and its analysis. Paideia laboratories are incorporated into businesses and their culture is internalized and disseminated. Businesses that already operate paideia laboratories are becoming digital players in their sectors and responsible for the direct construction of their digital futures.

In addition to this, they are also in an advanced stage of preparation to digitally lead their markets.

5 Conclusion

As mentioned earlier, no transformation is easy, it requires an effort by companies, both in rethinking their business models and in new processes and technologies that could lead change.

This article pretended to briefly present strateegia, a framework of strategies for digital transformation [or adaptation], based on the principle that each business is unique and each transformation is unique. Reinforcing our idea that there is no single method capable of instantiating transformation.

To understand strateegia it is essential to consider design as an approach to create and build futures, that is, design as an observation and experimentation process for making decisions (x) that form a strategy (y) for the project or the company itself. This effort should result in a goal, preferably innovative.

Thus, our framework would be ideal to instantiate these processes, through its modular and flexible logic described above, in which projects, teams and methods are organized in a single language, easy to understand and simple to follow.

From everything explained in this article, we conclude by stating that much can still be improved, that the strategy is totally based on flexibility and continuous feeding of its methods. In addition to having a logic of continuous learning based on its application in different companies, markets and contexts.

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Research Project Management in Communication Design: Methodology Proposal

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Abstract. The present article results of a research project, which as the main objective simplifying the research project management in communication design. This project intends to demonstrate the importance of an application of a research methodology in professional practice context, to contribute for scientific knowledge, and at last understanding which form the project management can help whether understanding the problem in a holistic view or with respective solution, contributing for communication design projects user centered, taking into account the ergonomics and human factors.

Keywords: Design management · Project management · Communication design · Research in communication design · Ergonomics

1 Introduction

Design management and project management in communication design are fundamental tools to projects being developed within the time limit, accomplish the budget and reach the defined objectives.

At the same time that the importance of design and project management takes, the research in design and the research for the design practice have a lot of relevance for a consolidation of a modern and competitive scientific system, which through appearing new creative and innovative ideas, appropriates to the realization of scientific projects and to aimed solutioning the user necessities, considering human factors and ergonomics.

Therefore, the research project has as main objectives the simplification of process of research project management in communication design, to evidence the importance of the design research applied in practice professional context, to contribute to scientific knowledge and, at last, understanding which form the project management can help whether in holistic understanding of the problem, or in respective solution, contributing for design projects in management design user centered, considering human factors and ergonomics.

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Once that study focuses on project management in communication design research, were selected five case studies, realized by RETHINK – Research Group on Design for the Territory.

2 Rethink

The RETHINK – Research Group on Design for the Territory is a group integrated into the Design Center of the CIAUD (Center for Research in Architecture, Urban Design, and Design) of the Faculty of Architecture of the University of Lisbon, based at the School of Applied Arts of the Polytechnic Institute of Castelo Branco.

The Research Group on Design for the Territory integrates members with different formations, understanding the multidisciplinarity of the research developed as a factor of differentiation and a guarantor of results for the processes.

The scope of action of the Group covers the different areas of design, but also other disciplines and complementary areas of study, in a logic of valorization of territories, identity, society and the environment.

The Research Group on Design for the Territory has as primary objective the development of applied research projects, with a methodological focus in the triad Territory, Design, and Process, promoting and valuing Culture, Material and immaterial Patrimony, Identity, Sustainability and the Society.

The Group develops research that is geared towards the enhancement of territory and innovation through design, whether concerning a geographical place or through the methodology or processes applied to the projects, using research in design and research for design practice.

3 Projects – Cases Studies

Within the scope of the research theme, were selected five cases studies related with areas of agri-food, cosmetic/pharmaceutic development; exportation markets; cultural research; and, environmental promotion and valorization. Towards to understand what methodologies were used in each project, were realized exploratory interviews to the designers and other professionals involved on projects. The projects realized aimed the involvement and the valorization of resources and local communities, as well as respective involved regions. After an analysis of the research methodologies and the design methodologies applied on projects, we could observe some common points, mainly exploratory studies, the state of the art related with each problem, followed by an analysis and synthesis phase of the accomplished study.

3.1 Montain Olive Oil Promotion and Valorization Project

The Montain Olive Oil Promotion and Valorization Project was intended to increase the sector productivity and competitivity, the innovative products development, with quality and added value, as well as the economic and social development of Beiras and Serra da Estrela sub-regions. In order to achieve these objectives, the project

methodology was split into two parts: one related with research project and the other with promotion and design. However, the component of project management integrated the whole methodology at the beginning to the end of the project. Towards, was developed an action plan constituted of six actions. In the first action, appeared the promotion of productivity process; in the second action, the control and management of olive grove; in the third action, the identification of nutritional and organoleptic characteristics; in the fourth action, the demonstrative unity of marketing; in the fifth action, the promotion, divulgation and positioning strategies; and lastly, in the sixth action, the management, monitoring and evaluation of the project. Relatively to the methodologic part related with promotion and design of the project, this was subdivided into two stages: the first one related with the project and the second related with the product. However, both parts had an identical design process. Were developed communication elements for the project and for the product such as: the visual identity, the communication strategy, definition of means and their respective production. However, the contents for promotional brand of the product were only developed after the realization of the tasks related to the project brand. Lastly, were presented, implemented and disseminated the results at a scientific level.

3.2 Project to Promote and Enhance PNTI - Tejo Internacional Natural Park

The Project to Promote and Enhance PNTI - Tejo Internacional Natural Park, had as main objectives the promotion of the dissemination, the promotion and the valorization of territory, in harmony with fundamental principles of nature conservation and biodiversity. Towards to promote and improve visitation conditions, were defined many means, particularly the development of corporate and visual identity and an elaboration of information and orientation system. Thus, was possible to observe that the project methodology was split into two parts: The visual identity system and the orientation and information system. Each one of the programs contains their action plan. Therefore, in which concerns to development of visual identity system, the action one, understand the draw of visual identity system; the action two, the contents production; and, the three action, the design and pre-production of means, following your production after a validation. Relatively to the information and orientation system, the first action, consists in the surveying of the territory; the second action, in the definition of information and orientation system; the third action, in pre-production of signage and information supports; the fourth action, in production, implementation and land maintenance; and the fifth action, in acquisition and placement of urban furniture. In the both parts of the methodology, after the conclusion of each action, has been a validation phase before following to the next action. Lastly, were presented, implemented and disseminated the results at a scientific level.

3.3 DERMOBIO - The Development of Dermo-Biotechnological Applications Using Natural Resources in the Beira and Serra da Estrela Regions

The development of dermo-biotechnological applications using natural resources in the Beira and Serra da Estrela regions Project, consisted in the exploration of this territory, with the objective to develop new innovative products for health sector, settled in the concept of nature territory, through the thermal water use and essential oils. This project methodology was divided into three parts: the development of pharmaceutic product, the project communication and the product communication. For the development of this project, was realized an action plan with nine actions. The first action consisted in project management and coordination and integrated the whole part of actions at the beginning to the end of the project. The methodology part that understands the pharmaceutic product development, contains a considerable part of the project actions, specially, the action two, that consists in the obtention and characterization of essential oils; the action three, in the formulation studies and pharmaceutic development; the action four, in the characterization of formulations; the five action, in the stability tests; and the six action, in the realization of safety and effectiveness evaluation test. After finished each action, has been one stage of validation before following to the next action. Lastly, the eight action, it concerns to elaboration of a product safety report and an information archive about the product. Relatively to the part of communication project, was realized a visual and identity system of project. Regarding to the product communication, this methodological part integrated the seven action, related with the packaging and labeling development, that included in design process aspects as research, diagnosis and communication strategy, the construction of a visual and identity system, and the brand communication and promotion. There were also realized prototypes and the respective validation. Lastly, in the action nine, were presented, implemented and disseminated the results at a scientific level.

3.4 Ordo Christi - Artistic Heritage of the Order of Christ Between the Zêzere and Tejo (Centuries XV and XVI) Project

Through the Ordo Christi - Artistic heritage of the Order of Christ between the Zêzere and Tejo (centuries XV and XVI) Project, it was expected the development of an holistic vision of territorial brand, in the way to promote cohesion and the reinforcement of identity, with focus on valorization of patrimonial properties, in definition of interurban routes, along with the promotion of Heritage of the Order of Christ. The intention wasn't about creating a new brand, but to motivate and to promote synergies existing between the many public, religious and private organizations. In this way, the project methodology integrated an action plan constituted for seven actions. The action one, consisted in the project management that occurred since the beginning to the end of the project; the action two, in the historiographic research and contents production; the action three, in the development of innovative solutions; the fourth action in the development of communication and marketing strategies for the territory; the fifth action, in the definition of tourist itineraries; the action six, in the production of

communication means for digital and analogic media; and lastly, in the action seven were presented, implemented and disseminated the results at a scientific level.

3.5 REINOVA – Re-industrialization, Entrepreneurship and Innovation in the Traditional Productive Sectors

The REINOVA - Re-industrialization, Entrepreneurship and Innovation in the traditional productive sectors Project, had as main goal the development of a business model that stimulates creativity, favoring entrepreneurships and SMEs of agri-food sector. Considering the various portuguese and spanish partners, was realized an activity and action plan, in the way to achieve the objectives of the project. Thus, the methodology was developed in seven stages, six main activities, sub-divided into various actions, which through was possible to obtain some pre-results and, thereafter, pre-conclusions. In this way, the stage one, consisted in the capacitation for innovation, and integrated the activity one, related with the draw and conception of methodology. The second stage, it concerns to the creative process and understood the activity three, which integrated the implementation of new service, particularly, the product development. The stage three, it concerns to trends analysis, the stage four, to the development of prototype and the stage five to the concept proof. These three stages integrated the activity two, relative to implementation of a new service. The activity four, related with implementation of the new service, mainly, the validation, was part of stages six and seven, related with business plan and the market entry, respectively. At the same time to the seven stages, occurred the activity five, related with project coordination and management and the activity six that understood their communication. Lastly, were presented, implemented and disseminated the results at a scientific level.

4 Design Management and Project Management

Considering the literature review realized, which were analyzed the perspectives of several authors as Best, K. [1], Borja de Mozota, B. [2] and Cooper et al. [3] it was possible to observe that they shared the same opinion about the importance that design and project management assumed in the success of a design project, as well as in the success of organizations.

Being the design management a key factor to answer to the extern changes and challenges of the actual world, is also a mental and strategic process that allows the development of innovative, sustainable and benefit solutions to improve the user life quality. Besides, is expectable that organizations benefit in economic terms and increase their market competitivity.

The design management allied to project management, allows that design process and creative process can be coordinated and planned in operationally, tactically and strategic mode, in the way to ensure that the project is developed into time limit and fulfil the budget defined.

Thus, considering the case studies, was verified that in all projects existed a coordination of tasks, that resulted in the fulfilment of deadlines and in the budgets defined.

In this way, the researchers gathered all the information relative to the project development phases in a board, which helps in the dialogue and discuss with other researches in the described projects. In these sessions of discovery, was developed comparative readings of the many projects, searching for relations and patterns. This global vision was crucial to constitute a future contribute for the development of the present research, Fig. 1.

In conclusion, the design management and the project management allied to the scientific knowledge, are strategic methods that enable the design valorization at corporative environment, increases the market competitivity, and the development of innovative products suitable to the user necessities, being beneficial to the both parts involved.

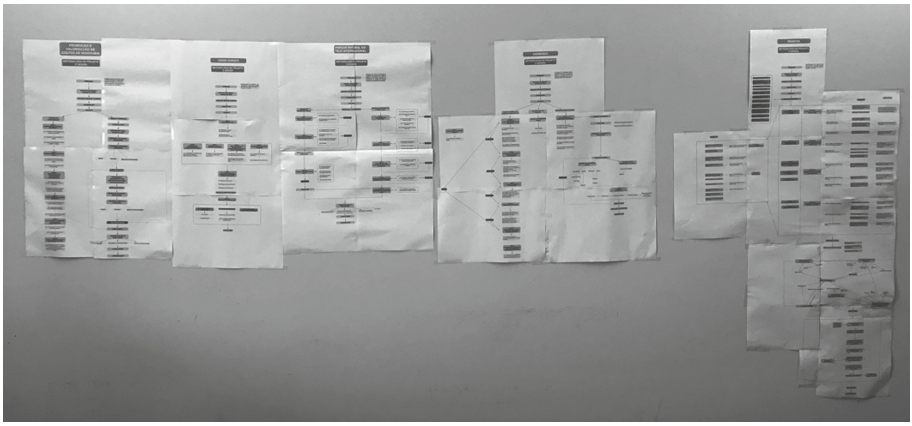

Fig. 1. Diagrams group of the design and project methodologies of the five cases studies. (*Source*: The Authors).

5 Results

Considering the case studies and the literature review, we can conclude that the design process is essential to the development and to the respective adaptations for the world created by the Man, forcing the designers search for significance informations exterior of their immediate thought, which usually culminate in the generation of innovative solutions [5]. Besides Walsh et al. (1988) affirms that "Research provides evidence of a correlation between company performance and design management." (Walsh et al. 1988 apud [2], p. 48).

Synthesizing the project methodologies analyzed in the cases studies, we ascertain that they have some common points between them, particularly: The state of the art; the

analysis and synthesis; the beginning of the realization of the project; the design communication management, which integrate the definition of means and communication strategies, the content production (prototyping and validation with public/consumer); the final product; the project implementation (in market); and lastly, the contents dissemination at scientific level.

According to Cross [4], perspective, the methodology of design is essential to understand the problem structure [4]. Thus, after their clarification and through the design process, using the design management and project management tools, is possible to develop innovative solutions suitable to the user necessities.

In the developed study, was considered important the application of a research methodology in professional practice context in Communication Design, contributing for the aesthetical and functional quality of the projects user centered, being possible to use the applied research methods and methodologies and the experimental development of projects that promote great solutions of communication centered in cognitive and visual ergonomics principles.

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Promotion and Valorization of the International Tagus Natural Park: A Projectual Approach to Holistic Design

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Abstract. This article results from the analysis of the results of the Project for the Promotion and Valorization of the International Tagus Natural Park (PNTI), developed from the management model of the National Network of Protected Areas and implemented in 2017 from the pilot project for the collaborative management of the PNTI, involving multiple organizations of the territory. The aim was to develop a communication strategy appropriate to the PNTI and its territories, and it was found in the communication design discipline a strategic tool for the development of means and supports that could promote the dissemination, promotion and valorization of the territory, in harmony with the fundamental principles of nature conservation and biodiversity.

Keywords: Communication design · Communication strategy · Visual identity · Information systems · Tourism

1 Introduction

In 2016, the Portuguese Government considered the need to institute dynamics of participation in the life of Protected Areas, facilitating their visit by citizens and their valorization as strategic assets. Based on these principles, a management model of the National Network of Protected Areas was designed and it was decided to implement in 2017 a pilot project for the collaborative management of the International Tagus Natural Park (PNTI), involving multiple organizations of the territory.

The aim was to develop a communication strategy appropriate to the PNTI and its territories, which would allow achieving the objectives of enhancing and safeguarding the natural, architectural, archaeological and ethnological heritage of the region, promoting its dissemination, and developing the means to achieve them.

It was found in the communication design discipline a strategic tool for the development of means and supports that could promote the dissemination, promotion and valorization of the territory, in harmony with the fundamental principles of nature conservation and biodiversity.

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The overall objective of the project was to promote and improve the visitation conditions of the Park, expressed through a visual identity system and a guidance and information system related with the communication objectives. The starting point was the study and development of a graphic language for visual identity, capable of being transposed into other media and for the orientation and information system, which covered three areas: the information, the interpretation and the orientation of tourists and visitors on the territory concerned.

The project resulted in the study, development and implementation of a coherent graphic system, which aimed to highlight the interaction between tourists and visitors, the defined territory and the developed system, using principles and methods of development of systems applied to design that value performance of system and the man-artifact interaction.

2 Sustainable Tourism – An Overview

The need to reorient the negative impact of the conventional mass tourism development model implied that in the 1990s, as a consequence of the debates following the publication of the Brundtland Report, tourism incorporated the sustainability paradigm. Therefore, sustainable tourism emerges as a remedy to meet the needs of different stakeholders, minimizing the negative impacts of tourism, while seeking to optimize the benefits to the destination.

The most widespread definition of sustainable tourism understands that tourism meets the needs of present generations without compromising the ability of future generations to meet their own needs while avoiding economic, social and environmental threats [7]. According to this definition, sustainable tourism has as its key element the balance of opportunities and the rational use of natural resources, trying to maintain the viability of the activity in the long term and seeking a more productive and harmonious relationship between the visitor, the local community and the place visited.

However, while the argument for sustainable tourism is apparently clear and quite reasonable, the tourism-sustainability binomial does not seem to be consolidated and suffers from major limitations [1]. As with sustainable development, sustainable tourism is not defined in precise terms. Since it is a socially constructed concept that reflects the interests and beliefs of different actors to achieve their socioeconomic and political goals, it has several points of view. There is no single definition, no consensus on their associated aspects and criteria, which leaves ample scope for all kinds of interpretations. This circumstance would be turning sustainable tourism into a malleable concept, often incorporating false assumptions and arguments into the discussion and thus making the debate on this subject sterile and wrong [3, 6]. In addition, many of the problems related to the ambiguity of using the concept of sustainable development are that the term is often used interchangeably as a synonym for specific forms of tourism such as alternative tourism, green tourism, ecotourism or soft tourism, among others [2].

The notion of sustainability in tourism implies a continuous process of improvement to which all tourism initiatives, including mass tourism, should aim at all types of destinations. In other words, sustainability is not an exclusive feature of those supposedly "alternative" tourist manifestations, but a situation that should be achieved for all forms of tourism regardless of scale and evolutionary state [4, 5]. After all, the challenge may be to develop another environmentally benign tourism model that best fits a destination's social and economic criteria, regardless of the adjective used to define it.

That seems to be an interesting challenge for the PNTI, to understand the search for an adequate form of sustainable tourism as a strategic instrument to accomplish broader objectives of local development, on a context of collective learning and innovative process.

3 The International Tagus Natural Park

The International Tagus Natural Park (PNTI) is located in a vast territory of low demographic density, bordering Spain, comprising part of the municipalities of Castelo Branco, Idanha-a-Nova and Vila Velha de Ródão, and covers a population of 69.091 inhabitants, according to the data of the last demographic censos (2011).

A globally recessive demographic dynamic - in two decades, from 1991 to 2011, these three municipalities together lost 5.2% of their resident population. It should be noted, however, the divergent pattern observed between the municipality of Castelo Branco which, during this period, saw its population increase by 2.9%, while the municipalities of Idanha-a-Nova and Vila Velha de Ródão lost almost a third of their residentes.

It is therefore a globally negative demographic scenary, marked by a high ageing of its population, also with low demographic densities - according to the last Census of 2011, from the 39.0 inhabitants/Km^2 in Castelo Branco to only 6.9 inhabitants/km^2 in Idanha-a-Nova. The decline in the young population, as a consequence of the decrease in fertility rates and the outflow of the active population, together with the increase in life expectancy, determines an age structure with a large percentage of the population over 65 years old – the so-called inverted age pyramids.

The PNTI, as well as its proximity territorial environment, show a worrying demographic picture from the point of view of sustainable development. This is a structural phenomenon that has been accentuating the demographic anemia, ageing and depopulation of this protected natural space.

The PNTI has basically till now assumed itself as an instrument of conservation of the endogenous flora and fauna, sustainable economic objectives have been a minor role. Thus, this context is challenging also the PNTI to act, also, naturally, as a means to achieve more sustainable development paths. In fact, the economy of this territory is rather weak, based mainly on agriculture and some small agro-food firms (olive oil and cheese).

Tourism also plays a residual role in the local economic fabric and is mainly linked to a few investments in rural accommodation, if only considered those within the limits of the Park. The PNTI nowadays looks at this situation on a quite different perspective,

as it could boost the development of sustainable modalities of tourism, exploiting the numerous natural, and cultural, resources found on this territory.

4 Pilot Project for the Collaborative Management of the PNTI

In order to improve conservation values and to preserve biological resources by ensuring breeding conditions for highly susceptible bird species (such as the Black Stork, Egyptian Vulture, Bonelli's Eagle, Griffon vulture and Eagle owl, among other species), Portuguese Government established in 2008, a natural park along the international border of the Tagus River (PNTI) in the central region of mainland's. Since there, until 2018 the management of this area had been carried out by the National Nature Conservation Institute, although with some difficulties, namely because e the lack of technological and human resources, and because of communication problems between park officers, locals and visitors.

Facing these constrains the Ministry decided to develop a different management system, based on the involvement and participation of the municipalities, NGOs, university and research institutions, enterprises organizations, and some relevant partners, keeping the NNCI the role of assure the pursuing of conservations goals.

This initiative, named as Pilot Project for the Collaborative Management of the Natural Park, was strongly supported by the government under the objective to figure out the improvements that the collaborative management system brings to the development and implementation of the solutions regarding the mentioned difficulties. As such, the generalization of the methodology trough all natural protected areas in the country, it was dependent of the success of this pilot initiative.

Once organized the working group (Strategic Council), and well-defined the governance system, under the supervision the government agency, the firsts step was to develop a strategic action plan for the next two years, following a participatory approach, including local leaders and the communities. The plan, designed upon the information form the local communities, gathered during several meetings, tries to answer the expectations and the major needs presented by the participants: To increase the sense of belonging and ownership related to the territory; To guide and inform residents, tourists and visitors; To help them in recognizing the Park's natural values; to improving the knowledge through research and conservation schemes.

Hence, the Polytechnic Institute of Castelo Branco was in charged to present a project able to improve the visitation conditions of the Park, based on the development of a visual identity system and a guidance and information system, consistent with the communication proposes.

5 Visual Identity System

Among other factors, the sustainability of the places depends on the created capacity and the possibilities to generate attractiveness, recognition and notoriety about these same territories. The potential for identification, contrast, differentiation and

effectiveness of identity elements depends on their relevance to people, which is catalyzed when they are organized in a system of signs that regulates the design of artefacts integrated in a global logic, flexible enough to adjust the discourse to particular contexts and audiences.

Visual identity is a way of giving visible form to a territorially concept and simultaneously a way of fostering the fruition of spaces, namely by the unity and relation that it gives to graphic artefacts, making them recognizable and identifiable. In all territories there are buildings or constructed objects that constitute identity references to situate the user in the territory [8].

We wanted the visual identity design process for the PNTI to be global, integrated and respectful of the landscape, fauna, flora, people and the pre-existing graphic heritage.

With regard to the identification of Identity elements, the black stork symbol (Ciconia nigra) stood out as the predominant element and as one of the most used in the scarce communication in force. Furthermore, having a Vulnerable animal status, the Black Stork represents well the values associated with the PNTI and common to the ICNF, particularly those relating to Nature Conservation and Floor Forests.

The analysis of the current supports allowed us to observe the lack of a clear and cohesive visual identity system in graphic and symbolic terms.

The creation of the Visual Identity system of the PNTI brand started with the redesign of the black stork symbol, seeking to simplify and improve the design.

The simplification process sought to maintain the recognition of the black stork and, simultaneously, improve the ease of memorization, increase the possibility of use in reduced sizes, improve visibility at a distance and ensure consistency with the pictographic system to be developed in consecutive action.

In this way, non-relevant details were eliminated and the contrast between the two planes of the symbol - black stork and Tagus rite - was increased, ensuring its visibility in smaller dimensions, longer distances, low brightness or in printing processes with low fidelity. In addition, it increases the flexibility of use of the symbol in analog and digital media, increasing in number, diversity and complexity, which characterize the globalized world and increasingly digital.

The Roboto typography and Slab Roboto, designed at Google, under the guidance of designer Christian Robertson, was selected for use in the brand and communication of the PNTI brand. The typography guarantees readability (contrast, identification and differentiation) and readability (comfort and enjoyability) of the name in multiple situations of use, which combines with the symbol and works in digital environment.

The brand mark is the set of symbol (black stork inscribed in the circle with the color of the river Tagus) and logotype (graphic representation of the name through letters). Three variants have been defined, one main and two secondary, which are standardized according to the priorities and contexts of use.

The identity system was consolidated by the way in which the various components were articulated in graphic-symbolic terms: graphic mark, color, typography, orientation system, pictographic system, sign system, website, maps, editorial design, App, mascot, as well as their usefulness and link to the territory.

6 Guidance and Information System

The Information and Guidance System of the PNTI was divided into four main Actions and multiple tasks. The first action consisted of surveying the territory, including the identification and georeferencing of sites with promotional interest.

Multiple tasks were developed such as the survey in the territory, the identification of spaces to intervene, the geographical referencing of spaces, the analysis of pedestrian routes and new routes were proposed.

In the second Action, the Park's information and guidance system, circulation plans and graphic design were defined. First, a set of standard rules was developed, based on the elements defined in the visual identity system, starting from the uniformity of colors (chromatic code), selection of the typography to be applied (typographic code), listing of references to be identified and pictograms to be used (pictographic code) and finally the standardized program was applied in the development of the Information and Orientation System of the National Park.

Subsequently, the Park's circulation plans were analyzed and defined, which aimed to improve environmental preservation, access, traffic flow, accessibility and safety for tourists, visitors and inhabitants of the Park and surrounding areas. The graphic design of the Information and Guidance System was divided into four phases:

(a) Definition of the system: Starting from the application of the legislation that regulates the signaling models of the Portuguese network of protected areas (Ordinance No. 98/2015 of March 31);
(b) Guidance System: Design of signage, composed by two subsystems, the signage of protected areas (Ordinance no. 98/2015 of March 31) and the road signage (Regulatory Decree No. 22-A/98 of October 1);
(c) Interpretation System: Network composed by three interpreting centers, six interpreting spaces present in the tourist offices and interpreting boards in the spots with interest to visit, to promote interpretation and environmental education;
(d) Information System: Informative points to support decision making by tourists and visitors and to inform about points of interest, routes, infrastructure, products or services available in the territory.

After the graphic design of the supports and their maquetisation, the third Action was developed, which consisted in the pre-production of the signage and information supports. The fourth Action had as tasks associated with the production, implementation and maintenance in the field of supports, equipment and urban furniture.

7 Results

The results of this project have been strongly conditioned by the articulation between the multiple entities involved, from government agencies, universities, NGOs, business and environmental associations, among others. It was considered to be a true participatory design project, based on design project methodologies, without ever compromising the focus on the user, but opening the discussion to the various actors.

The project described was thus a sum of several partial views, in areas as distinct as tourism, environment, agronomy, engineering, sciences or design, managing to result in an integrating and diversified system. Thus, along with the application of a methodology used in the design project, it was possible to go beyond the resolution of design problems, to incorporate all aspects of using the system.

Considering in the present context design as a projectual discipline, which aims to solve communication, information and orientation problems, this concept becomes reductive due to the complexity of development, production and context of use of the system created. In this sense, design can be understood as a whole, which goes beyond the resolution of problems, incorporating the multiple variables of the ecosystem of use of the developed system: this is the concept of Holistic Design.

The multiple methodologies/processes applied in complex projects, as was the case, cannot be seen only as the sum of the parts, but rather based on the totality. It is the system as a whole that determines how the parts behave. It is a holistic vision, of desirable appropriation by designers and project teams, in order to find innovative solutions, user centered and considering aesthetic, functional, cognitive and emotional factors.

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Design for Visibility and Comfort

Hybrid Approach for Evaluation of Visibility of Platform Display: Subjective Ratings Combined with Gaze Behavior Elicited from Eye Movement Data

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Abstract. In the present paper, we propose a hybrid approach for visibility evaluation based on both of conventional subjective ratings and eye tracking data analysis. In the hybrid approach, we obtain responses to questionnaire consisting of questions of visibility and aesthetic impressions. Additionally, we record eye movement data during seeing platform displays shown in a standard train station environment. From eye movement data, various indices representing how difficult it is to find a specific display and how much readable the texts on a specific display are calculated. By combining both of the data, interpretations regarding visibility are given. The proposed approach was applied to comparative visibility evaluations between three platform displays. Results of visibility evaluations as well as consistency between perceived visibility and gaze behavior are discussed.

Keywords: Platform display · Factors affecting visibility · Eye tracking

1 Introduction

It is of great importance, in general, to enhance the visibility of platform display in train stations. In most of previous relating works, it seems that the evaluation of visibility was performed mainly based on subjective ratings using Likert scales (e.g., [1]). In the present paper, we propose a new approach for visibility evaluation where both of conventional subjective ratings and eye tracking data analysis are adopted. Underlying idea of the proposed hybrid approach is to enable us to examine visibility of platform displays more accurately by considering attention allocation processes that can be inferred by eye movement data. This approach is very promising since the perceived visibility is expected to be generated/affected by some cognitive processes which is strongly connected with, and can be inferred from human attention allocation processes. By analyzing perceived visibility in combination with the attention allocations during seeing, therefore, we may be able to explore root causes/factors determining the perceived visibility.

Very few works based on the similar ideas could be found in previous literatures where perceived quality of images was examined by considering eye tracking data

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(e.g., [2, 3]). The idea seems very promising, however, in some cases no clear relation was found between perceived quality and gazes [3]. Therefore we need to accumulate more scientific knowledge about potential ability of eye tracking approach to efficiently predict human perceived visibility.

Considering the above-mentioned background, the objective of this study is to develop an analysis procedure in which responses to questionnaire consisting of questions of visibility and aesthetic impressions and eye movement during seeing platform displays shown in a standard train station environment are used. From eye movement data, various indices representing how difficult it is to find a specific display and how much readable the texts on a specific display are calculated. By combining both of the data, interpretations regarding visibility are given. We conduct a pilot study where the proposed procedure is applied to the evaluation of a new platform display released to market.

2 Platform Display Focused in the Present Study

An examples of platform displays used in the study are shown in Fig. 1. The display in Fig. 1 shows the current station as well as its preceding and succeeding stations. The current station written in Kanji characters is shown in a large font in the center of the display (大安寺) with its Hiragana characters (だいあんじ) and Romanized version (Daianji). They are written by black characters on white background. The preceding and succeeding stations are shown in relatively a small font in the left and right of the display, respectively. These are white characters written on a green line. This display is set up at platforms in train stations for passengers.

One of Japan's manufacturing companies, with which we collaborated for the present study, started to release a new display where novel materials are implemented. The material has some unique characteristics in its diffuse reflection of light. The characteristic contributes to effective and efficient reflection of outer illumination, and is expected to enable us to obtain brighter outer illumination type displays having good visibility but low operating cost (mainly low electricity cost) compared to conventional materials. Therefore, the company needed to know how much its new display's visibility is enhanced compared to conventional displays in various visual angles conditions.

Fig. 1. An example platform display showing current, preceding and succeeding stations. This is set in outer illumination conditions.

3 Overview of Hybrid Approach for Visibility Evaluation

In our hybrid approach, we obtain responses to questionnaire consisting of questions of visibility, glare and aesthetic impressions. In addition to these subjective assessment, we record eye movement data during seeing platform displays shown in a standard train station environment. From eye movement data, two metrics representing the followings are expected to be closely relating to subjectively perceived visibility. One of the metrics is the time needed to find a platform display (abbreviated as TF). This metric can be obtained by measuring time spent to start gazing at the platform display. TF seems to be directly connected with the degree in which how much difficult it is to find a specific display. Another metric is the time needed to recognize information shown in a display (abbreviated as TR). This is measured by identifying time spent to read information after a specific display is detected. We can expect that TF is strongly affected by the degree in which how much readable/understandable information on a specific display is. By combining both of the subjective assessments and relating behavior index elicited from eye movement data, interpretations regarding visibility are given.

4 Case Study

4.1 Participants

Twenty-three healthy individuals (3 women and 20 men) participated in our pilot study as paid volunteers. They were university students with a median age of 21 years old (ranged from 18–24). They had normal or corrected-to-normal vision. All participants signed an informed consent form approved by the ethics committee of Tokyo Institute of Technology (A18087).

4.2 Apparatus

Platform Display Used. A new outer illuminated platform display made by novel materials (D1) and its competitive displays D2 and D3 were exposed to participants. D2 was also an outer illumination type display made by conventional material. D3 was an internally illuminated display which is illuminated by multiple LED lights. All displays' size was 450 mm $\times$ 1280 mm.

Experimental Setup. Figure 2 shows schematic descriptions of experimental environment. A participant was asked to be seated in a chair. Each display was set at a distance of 6.0 m from a participant, and the height of the display was 2.4 m. The visual angle from a participant was set the following three conditions: 0°, 45° and 60°. We used a head mount eye tracking system (TalkEye III, Takei Scientific Instruments) having a spatial accuracy of 0.1° and its sampling frequency was 60 Hz.

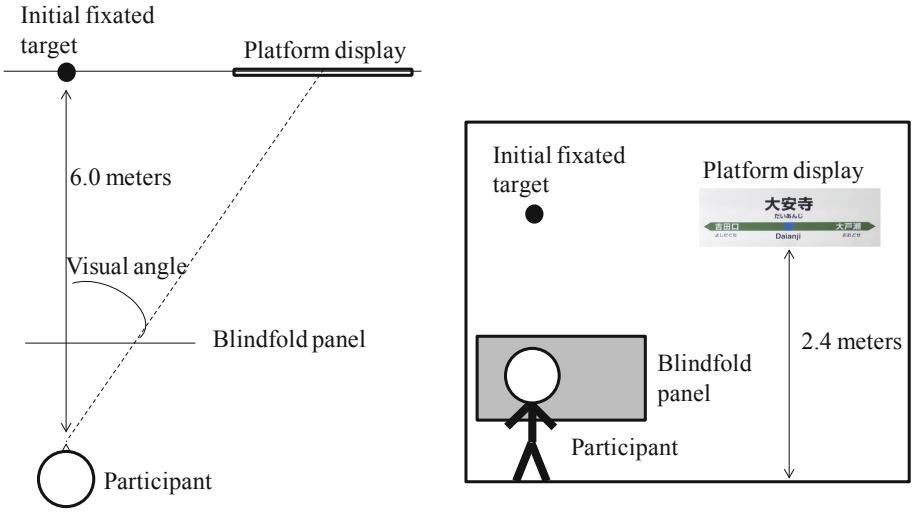

Fig. 2. Experimental environment (left: from above, right: from the side.)

4.3 Task

Each subject was asked to find a display which appeared from his/her peripheral vision areas without notice as quick as possible, and to recognize the three stations (current, preceding and succeeding stations). We instructed that a blindfold panel interfered with the visual field of a participant just before starting the task. When starting the task, the blindfold panel was removed. A participant was asked to gaze at an initial fixated target first, and then to detect a platform display as fast as possible while keeping gazing at the target. When the participant perceived the platform display, in his/her peripheral vision, he/she directed his/her gaze to the display and to read the written stations silently. Finishing reading the stations, the participant was asked to move his/her gaze to the target as quick as possible.

4.4 Procedure

Upon arrival at our experimental site, each participant was briefed on the objective of the experiment, the task to be conducted, calibration processes of our eye tracker, and questionnaire. After carrying out calibration, experimental tasks composed of 11 trials were started. The trials included 9 experimental conditions (3 types of displays $\times$ 3 visual angle levels) and 2 distracters where no display was exposed. In the end of each trial, a participant was instructed to read the stations aloud and provide his/her responses to the questionnaire.

4.5 Metrics Collected

As explained before, we collect both of conventional subjective ratings regarding perceived visibility and relating perceptions and eye tracking data. Table 1 summarizes the scales/metrics obtained from our experimental data.

Table 1. Scales/metrics obtained.

Aspect for evaluation	Subjective assessment	Eye movement-based metrics
Saliency of a display	Perceived saliency is measured using the question: "How easily the display could be detected?" Five-point rating scale (very easy to very difficult)	Time needed to find a platform display (TF) is measured Time duration from a point when a participant started to gaze at an initial fixated target until he/she directed his/her gaze to the display
View desirability of a display	Perceived desirability of information representation is measured using the question: "How easily the texts could be read? Five-point rating scale (very easy to very difficult)	Time needed to read texts on a display (TR) is measured Time duration from a point when a participant started to gaze at the display until he/she directed his/her gaze back to the initial fixated target

5 Result

The results obtained indicated that subjective rating scores on how easily a display could be detected were negatively influenced by the angles conditions (3.9, 3.6 and 3.1 under 0°, 45° and 60°, respectively. $F_0(2, 176) = 22.4$, $p < 0.01$). A tricky result was obtained in the time needed to find a target display, which is an eye tracking-based index representing how rapidly a target display can be detected. Though a significant influence of the angles conditions was found ($F_0(2, 109) = 5.9$, $p < 0.01$), the mean scores for the conditions of 0°, 45° and 60° were 1.11 s, 0.84 s, and 0.92 s, respectively. The tendency with the angles conditions in the eye tracking-based index differed from those in subjective rating scores. As for subjective ratings given to each display, positive rating scores were obtained only in D3 (4.3 in average) while D1 and D2 showed neutral rating scores (3.1 and 3.2 in average, respectively. F_0 (2, 176) = 36.6, $p < 0.01$). Regarding the mean of time needed to finish reading texts for displays, however, there are no differences. The mean scores for D1, D2 and D3 were 0.95 s, 0.90 s, and 0.95 s, respectively (F_0 (2, 109) = 0.84, $p > 0.05$.) The tendency found is also contrary to that in subjective rating scores.

As for the subjective scores on how easily information in a display could be read, the negative influence of the angles conditions was found (4.5, 3.7 and 2.6 under 0°, 45° and 60°, respectively. F_0 (2, 176) = 107.9, $p < 0.01$). There was no significant effect of displays in these scores (3.4, 3.5 and 3.8 in average in D1, D2 and D3, respectively. F_0 (2, 176) = 11.7, p < 0.01). The time needed to finish reading texts

representing how easily the texts could be read, however, didn't show any significant effects of the angles nor displays. All of mean scores for each condition showed numerical values which were very close to its grand mean (3.2 s.), which seemed to be different from the tendency found in subjective ratings.

We expected a clear coincidence between the subjectively perceived visibility and the corresponding eye tracking-based indices. However, such a simple coincidence cannot be identified. We may be able to give the following interpretations to this: The time needed to find a target display which is closely connected with how salient a target display is may be an influential factor to the visibility. However, the influence is not an one-dimensional, meaning that there may exist some saliency threshold beyond which people are insensitive to lack of saliency. Also it may be said that our hybrid approach indicates a potential ability of an eye tracking-based index (time needed to find a target display) to predict display's visibility. This is quite promising and cost effective because thanks to the advancement of technologies, recordings of eye tracking is not much time-consuming compared to conventional questionnaire survey approach.

6 Conclusion

In the present paper, we develop an analysis procedure for evaluation of visibility where subjective assessment as well as eye movement are adopted. The procedure was applied to a series of evaluations of platform displays' visibility. As a future investigation, we plan to implement other eye movement-based metrics considering both of scan-paths and number of fixations in order to examine the potential ability of the metrics to predict visibility, deeply. We think these new metrics seem to have great potential since they may enable us to measure the degree of difficulty perceived during cognitive processing (e.g., [4]).

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A Study on the Influence of Refrigerator Lighting Layout on Visual Comfort

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Abstract. This study adopts psychophysical experiment method to conduct the ergonomics research for the refrigerator lightings in the store and the household external environments. The technical parameters of refrigerator lighting design in different external environments were determined. The research result could provide reference for the humanized design and evaluation of refrigerators.

Keywords: Refrigerator lighting · Layout · Visual comfort

1 Introduction

The interior lightings of refrigerators are necessary visual conditions for people to check the interior items of refrigerators. With the increase of the brightness in the refrigerator, the visual efficiency increases, but after reaching a certain brightness level, the improvement of visual performance is not obvious. With the increase of brightness, there will be some problems such as glare and unsuitable brightness distribution. In recent years, LED lighting products have been widely used in refrigerator lighting. However, due to the good singleness and small volume of LED light source, the surface brightness of LED light source is very high, which is easy to produce glare in lighting applications, making people feel uncomfortable. Under the situation that product homogeneity is becoming more and more serious, more humanized refrigerator products will certainly be more favored by consumers.

In the area of space lighting, the current research mainly focuses on the lighting of office, home, locomotive, aircraft and so on. Huang haijing [1] made a comprehensive investigation for the subjective perception evaluation on the lighting status and visual environment in different classrooms' environment of Chongqing Universitys' new and old campus. Su Haiyan [2] studied the mathematical model relationship between illumination and human visual comfort based on specific circumstances of China's high-speed train. Xu Junli [3] simulated CICU with different lighting scenarios and studied the impact of illuminance and lighting modes on patients and staff's satisfaction at color temperature of 4000 K by subjective questionnaires and physiological data.

At present, there are few researches on the interior lighting of refrigerators. CNIS has conducted a survey on the interior lighting effect of refrigerators for nearly 100

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people. 63% of the users think that there are various problems in their own refrigerator lighting, 61% of the users think that the refrigerator lighting has an impact on their purchase intention, and if the lighting is poor, they will not buy or hesitate to buy the refrigerators. In this study, psychophysical experimental methods were used to study the visual comfort for refrigerator lighting in two external environments to determine the technical parameters of refrigerator lighting illumination, so as to provide references for the humanized design and testing of refrigerators.

2 Experimental Methods

2.1 Experimental Environments

In this study, two kinds of external experimental environments were designed: the store environment (big supermarket or hypermarket) and the household environment (kitchen, living room).

The parameters of household environment are determined according to the provisions of the standard GB 50034-2013[4]. The standard value of general activity illuminance of kitchen in residential building is not less than 100 lx at 0.75 m level, and that of restaurant is not less than 150 lx at 0.75 m level. Considering that different refrigerators may be placed in different locations, the illumination value of 0.75 m horizontal plane 150 lx is selected as the indoor illumination environment simulated in this experiment. In the GB 50034-2013, the color mark features with color temperature of 3300–5300 k belong to the middle, neither warm nor cold. Therefore, 4000 K color temperature is selected as the simulated color environment of home light source in this experiment. The parameters of the store environment are determined by the actual measurement of the environmental illumination and color temperature of several brands of household appliances.

The parameter values of the two external environments are shown in the following table (Table 1).

Table 1. The parameters for two external environments.

External environments	Illuminance (lx)	Color temperature (K)
The store environment	820	6700
The household environment	150	4000

The experimental environments can be adjusted by LEDCube lighting scene simulator to realize the simulation of the store and household environment.

2.2 Experimental Equipments

The volume of the selected refrigerator was 343 L. In the store environment, the refrigerator cavity is empty. In the household environment, about 50% of the space inside the refrigerator is placed with items.

Six typical lighting layout modes were designed according to the lights position: three kinds of single lights positions: top light, back light and side light; three kinds of combined light positions: top + back light; top + side light; back + side light. All the light sources are white, the top light and the back light are both LED surface light source, and the side light is LED point light source. Each light source was equipped with a non-polar dimming device, which can be used to adjust the brightness of the light source. Before the experiment, the illumination of the inner cavity of the refrigerator under two experimental environments and different lighting layouts were measured.

2.3 Experimental Subjects

Through recruitment, 30 participants were randomly selected, with age from 20 to 65. The subjects had no visual disorders or visual impairments. The ratio of men to women is 1:1.

3 Experimental Process

In the experiment, the subjects were given instructions at first, and the dimming practice was required before the formal experiment. In the formal experiment, two dimming operations were carried out under each experimental condition, and one adjustment was made from the lowest brightness level to the most comfortable visual stop; the other adjustment was to adjust from the highest brightness gear to the most comfortable visual stop. The dimming gear for each visual comfort was recorded.

In the experiment, two external environments and six lighting layouts were arranged in a random order. After completing each experiment under ambient brightness, the subjects took a 10 min break to continue to complete the experiment under the next condition.

4 Experimental Results

Through statistical analysis of user test results, the most comfortable value and recommended range of illuminance in refrigerator inner cavity under two external environments and six lamp layout modes are obtained. The parameters are shown in the following tables.

Table 2. Comfortable illuminance value in the store environment

Lighting layouts	The most comfortable value (lx)	Recommended range of illuminance (lx)
top light	800	700–900
back light	600	520–650
side light	520	440–600
top + side light	850	700–1000
top + back light	980	800–1160
back + side light	680	560–800

Table 3. Comfortable illuminance value in the household environment

Lighting layouts	The most comfortable value (lx)	Recommended range of illuminance (lx)
top light	350	210–500
back light	240	160–310
side light	350	300–400
top + side light	350	310–380
top + back light	460	320–600
back + side light	440	350–520

5 Discussion

Under two external environments, the most comfortable illuminance values of the six lighting layouts are shown in the following figures.

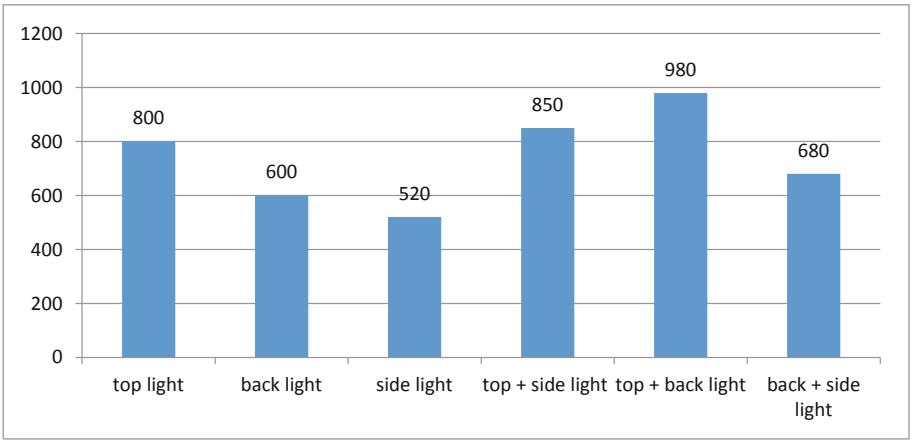

Fig. 1. The most comfortable value in the store environment

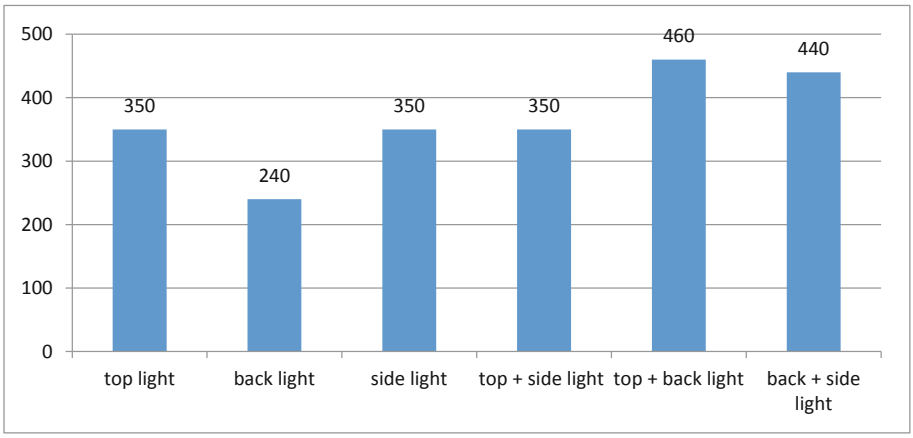

Fig. 2. The most comfortable value in the household environment.

From Table 2, Table 3, Fig. 1 and Fig. 2, it can be seen that the range of the most comfortable illuminance value is different under different lighting position layouts:

The top + back light combination lighting comfortable illumination value is the highest for both the store environment and household environment.

The layout of comfort value in the store environment from high to low is: top + back light > top + side light > top light > side + back light > back light > side light. The difference between the highest and lowest is 460 lx. For the combined layout of two kinds of lights, the required comfortable illumination value is slightly larger when the top light is included (the first three layouts all contain the top light, with the most comfortable value ranging from 620–780 lx); Back light are included in the 4th to 5th layout, and the comfortable illumination value is between 400–510 lx; Individual side light requires the lowest level of comfortable illumination.

The layout of comfort value in the home environment from high to low is: top + back light > side + back light > top light = top + side light = side light > back light, and the difference between the highest and lowest value is 220 lx. Individual back light requires the lowest level of comfortable illumination.

In both illumination environments, the comfort illumination in the store environment (820 lx) is higher than that in the household environment (150 lx). Under the layout of different lighting, the most comfortable illumination value in the store environment is higher than the most comfortable illumination value in the home environment.

The most comfortable illuminance value of combination mode of top light and top + side light is close to or equal to each other in the two external environments.

6 Conclusion

This paper studies the relationship between comfortable illumination value and user subjective evaluation of refrigerator under two kinds of external illuminance and six kinds of lighting layouts. The results show that the range of the comfortable illumination is different under different lighting positions and the comfortable values were given in this paper. The research results can be used in the ergonomic design and evaluation of the interior lighting of refrigerators.

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A Study on the Lighting Visual Comfort for Refrigerators with Different Volumes

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Abstract. This study conducted the ergonomics research for the lighting comfort of refrigerators with different volumes in two external environments of store and household. The change trend of visual comfort illuminance level of refrigerators with different volumes was obtained. Based on the most comfortable illuminance value, the multinomial regression equation between the volume of refrigerators and human visual subjective comfort were established. The research results can be used to design and evaluation of the lighting of refrigerators.

Keywords: Visual comfort · Refrigerator lighting · Regression equation

1 Introduction

With the development of social economy and living standards, simple functional lighting has been unable to meet the Chinese people's needs for lighting quality and humanization. The interior lighting of a refrigerator is an important visual condition for people to view and take the refrigerator items. The quality of refrigerator lighting design has an important impact on the humanized design of the refrigerators.

Research on the visual comfort of space lighting is mainly focused on spaces such as classrooms, offices, homes, locomotives and airplanes. Su Yanchen et al. [1] studied the relationship between interior lighting of high-speed trains and comfort from the perspective of human subjective evaluation, and established a mathematical relationship model between the interior illumination and the visual comfort of people. Based on Weber-Fechner's law, Liu Qin et al. [2] established a mathematical model of visual comfort, and derived formulas and curves for visual comfort under four light environments in the living room. Wang Yingjie et al. [3] established a mathematical model of lighting comfort and average blackboard illuminance by scoring subjects' visual comfort on average blackboard illumination.

At present, the research on the interior lighting of refrigerators only involves the physical indicators of light, and the research on the lighting quality from the aspects of physiology and psychology, that is, the research on the comfort of illuminance, is

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almost absent. In this paper, the lighting visual comfort for different volumes of refrigerator freezers under two kinds of external environments was studied with the psychological physics experiment method.

2 Experimental Methods

2.1 Experimental Environments

Two external experimental environments were designed for this experiment: the store environment with illumination 820 lx and the color temperature 6700 K. Household environment with illumination 150 lx and the color temperature 4000 K. The experimental environment was adjusted by LEDCube lighting scene simulator.

2.2 Experimental Equipments

Refrigerator freezer volume has 4 levels: 221 L, 279 L, 343 L and 350 L, which have the same inner structure. In the store environment, the refrigerator cavity is empty; in the household environment, freezer filled about 50% inside cavity space.

Three kinds of typical lightings layout were designed, which include top light, back light and side light. All the light sources were white. The side light is LED point light source, and the top light and the back light are both LED surface light source. Each light source is equipped with a non-polar dimming device, which can adjust the brightness of the light source by itself. Before the experiment, the illuminometer was used to measure the illumination level of the refrigerator inner chamber under 2 kinds of environmental illumination, 3 kinds of lighting layout and 4 kinds of refrigerator volumes, and the illumination values of the refrigerator under different experimental conditions were obtained.

2.3 Experimental Subjects

A sample of 30 subjects was randomly selected with age from 20 to 65. The subjects were free of visual disease or visual impairment. The male to female ratio is 1:1.

3 Experimental Process

In the experiment, two external environments, three lighting layouts and four internal cavity volume refrigerators were tested in random order. Each subject was required to complete 24 sets of experiment. After each participant completed a set of experiment, he had a rest for 10 min, then to continue to complete the next set of experiment. In the formal experiment, each subjects performed two dimming operations, one adjusted from the lowest brightness level to the most comfortable stop of vision; the other was to adjust from the highest brightness level to the most comfortable vision stop. The dimming position of each visual comfort was recorded.

4 Experimental Results

Based on the statistics of the experimental data, the illumination comfort values of different refrigerator volumes and different lighting layouts in the store environment and household environment are obtained, as shown in Table 1 and Table 2.

Table 1. Comfortable illumination value in store environment.

Volume (L)	Top light (lx)		Back light (lx)		Side light (lx)	
	The most comfortable value	Comfort range	The most comfortable value	Comfort range	The most comfortable value	Comfort range
221	620	520–720	400	300–500	330	240–430
279	770	700–900	530	520–650	470	440–600
343	800	670–870	600	470–600	520	400–550
350	850	750–950	620	550–680	560	480–630

Table 2. Comfortable illumination value in household environment

Volume (L)	Top light (lx)		Back light (lx)		Side light (lx)	
	The most comfortable value	Comfort range	The most comfortable value	Comfort range	The most comfortable value	Comfort range
221	390	230–530	290	190–380	380	330–430
279	360	210–500	280	160–310	360	300–400
343	350	220–510	240	200–350	350	300–410
350	350	200–500	230	160–310	350	300–400

5 Discussion

5.1 Analysis of the Most Comfortable Illumination Value for Refrigerators with Different Volumes

According to Table 1 and Table 2, the curve of the most comfortable illuminance value with different refrigerator volumes in the store and household environment were drawn, as shown in Fig. 1 and Fig. 2.

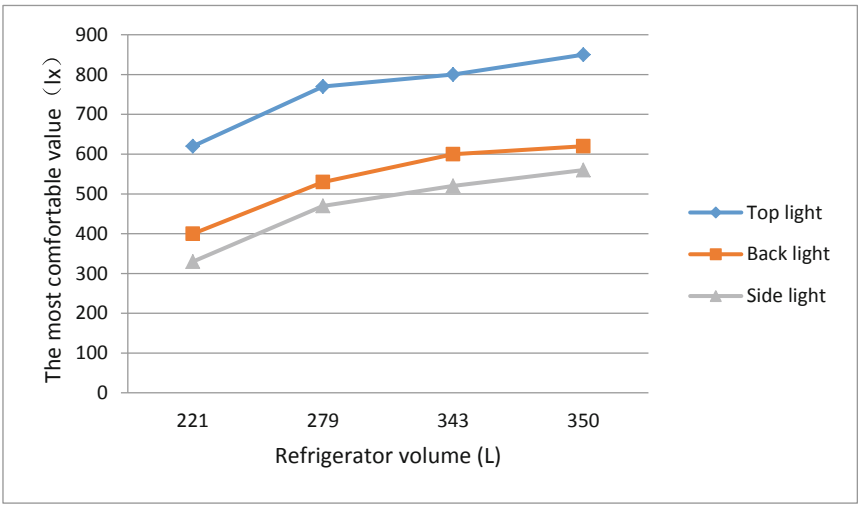

Fig. 1. Change curve of the most comfortable illuminance value with the refrigerator volumes in the store environment

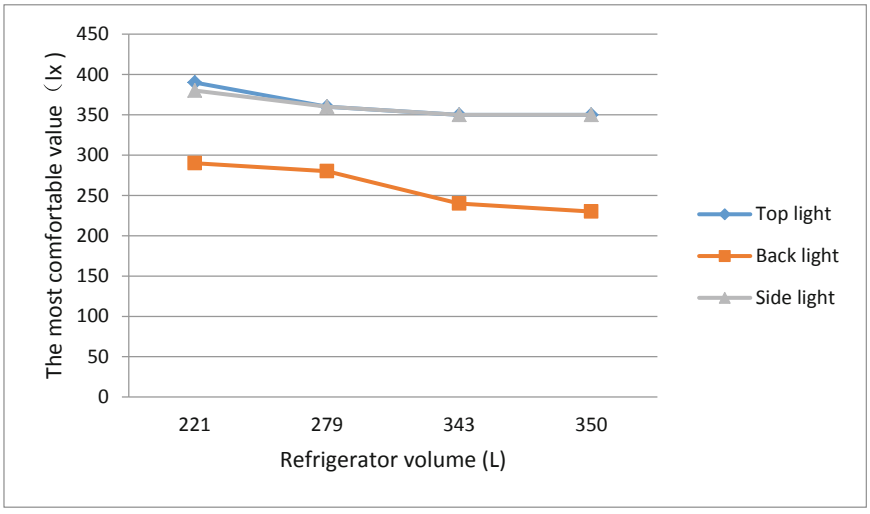

Fig. 2. Change curve of the most comfortable illuminance value with the refrigerator volumes in the household environment

The correlation of different volume refrigerators and the user visual subjective evaluation can be seen from Table 1, Table 2, Fig. 1 and Fig. 2.

In the store environment, for the top light, back light and side light, with the increase of the refrigerator volumes, the illumination level to maintain visual comfort also increased, that is, for the larger volume of the refrigerator, the average comfort

illumination level for its cavity should be higher, so as to meet the user's visual comfort requirements. In the store environment, under each refrigerator volume, the comfortable illuminance required by the top light is the largest, followed by the back light, and the most comfortable illuminance required by the side light is the smallest.

In the household environment, there is an opposite trend. For top light, back light and side light, with the increase of refrigerator volumes, the illumination level to maintain visual comfort decreases, that is, refrigerator freezer volume is larger, the average comfort illumination level for its cavity reduced accordingly. In the household environment, the most comfortable illuminance value required by the top light and side light is greater than that required by the back light, and the most comfortable illuminance value required by the top light and side light with the change of refrigerator volume is very close.

5.2 Construction of Mathematical Model of Refrigerator Volume and Visual Comfort

Based on the most comfortable illuminance value, this study established the binary polynomial regression equation between the refrigerator freezer volume and the visual subjective comfort, which can be used to calculate the required comfort illumination level under different refrigerator freezer volumes (Tables 3 and 4).

Table 3. Mathematical model of refrigerator volumes and visual comfort under the store environment

Light layouts	Regression equations	R^2
Top light	$y = -0.0122x^2 + 8.5822x - 677.39$	$R^2 = 0.9573$
Back light	$y = -0.0078x^2 + 6.12x - 569.48$	$R^2 = 0.996$
Side light	$y = -0.0096x^2 + 7.1088x - 772.33$	$R^2 = 0.977$

Table 4. Mathematical model of refrigerator volumes and visual comfort under the household environment

Light layouts	Regression equations	R^2
Top light	$y = 0.0029x^2 - 1.9785x + 684.41$	$R^2 = 0.9999$
Back light	$y = -0.0041x^2 + 1.8657x + 75.841$	$R^2 = 0.9977$
Side light	$y = 0.0016x^2 - 1.1335x + 553.54$	$R^2 = 0.9999$

6 Conclusion

In this paper, the lighting comfort of refrigerators with different volumes in two external environments of store and household was studied, and the change trend of visual comfort illuminance level of refrigerators with different volumes was obtained. Based on the most comfortable illuminance value obtained, the multinomial regression

equation between the volume of refrigerators and human visual subjective comfort are established under two external environments and three light layout modes. The mathematical model can be used to calculate the level of comfort illuminance under the volume of different refrigerators.

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The Influence of Reading and Writing Table Lamp Illumination Parameters on Visual Fatigue

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Abstract. As the main light source for reading in the home environment, the scientific lighting parameters have a very significant impact on the health of human eyes. In this experiment, the psychophysical method was used to study the visual fatigue of 30 young people under different color temperature and illumination. The degree of visual influence was determined by the physiological index, behavioral index and subjective feeling of the subjects. The results show that it is a comfortable parameter range suitable for human eyes to read. When the color temperature is 4000 K and the illumination is 500 lx.

Keywords: Table lamp · Design · Color temperature · Illumination · Visual fatigue

1 Introduction

At present, some data show that the myopia rate of Chinese teenagers is the second in the world, especially the detection rate of poor vision of college students is as high as 82.68%.

The formation of myopia is not only related to factors such as improper sitting posture, fatigue reading and personal physical condition, but also many objective environmental reasons, including the surrounding lighting quality. As a popular lighting tool, reading and writing desk lamp's lighting quality directly affects people's visual experience. If the illuminance value is too low, it is very easy to cause visual fatigue and is not conducive to the protection of vision. In addition, the differences of spectrum and light intensity of different color temperature light sources not only directly affect vision, but also affect the physiological rhythm (excitement or fatigue) of human body, which has a significant impact on the function of human central nervous system.

LED table lamp is a popular lighting tool in recent years. It is favored by many consumers for its energy saving, environmental protection, long life and effective reduction of stroboscopic. At present, some researchers have studied the LED reading and writing illumination, Yan Yonghong et al. [1] studied the influence of the color temperature of the fluorescent lamp in the classroom on the students' learning

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efficiency and physiological rhythm. The results show that the main lighting source of classroom lighting should be about 4000 K fluorescent lamp with medium color temperature, and the best illuminance value of fluorescent lamp with different color temperature is not the same. Liu Na et al. [2] studied the influence of reading lamp color temperature on visual efficacy. In the experiment, the degree of visual fatigue under three color temperatures was determined by measuring the visual changes of subjects before and after the experiment. The results showed that the subjects' visual fatigue was the least at 4500k. In the performance requirements for reading and writing table lamp (GB/T 9473-2017) [3], the requirements for reading and writing table lamp parameters are only the lowest illuminance value, but there is no specific provision for color temperature value. At present, most of the researches on the lighting parameters of reading and writing table lamps are to detect the single lighting parameters of the current market table lamps, and there is no cross experimental research on these two parameters at the same time. Moreover, there is a lack of theoretical research on the relationship between the lighting parameters of reading and writing desk lamp and visual fatigue.

The purpose of this experiment is to explore the different levels of visual fatigue of subjects under 9 experimental conditions, which include three color temperatures levels (3000 K, 4000 K, 6500 K) and three illuminances levels (200 lx, 500 lx, 800 lx), to obtain the relationship between visual fatigue and lighting parameters.

2 Experimental Design

2.1 Selection of Subjects

Through recruitment, 30 subjects were randomly selected, aged from 18 to 25, with an average age of 21. The subjects had no visual impairment or visual impairment. The ratio of men to women is 1:1.

2.2 Experimental Equipment and Environment

The table lamp selected in the experiment is LED light source. It's color temperature, illumination and height are adjustable in multiple levels. Full digital colorimeter color temperature display, hand-held spectroradiometer, flash fusion frequency meter, timer were used in this experiment.

The experiment was carried out in a full black laboratory with a space size 6 m * 4 m * 3 m. The LED lamp used in the experiment is the only light source. By changing the color temperature and illuminance of the table lamp, the experimental lighting conditions can be achieved.

2.3 Experimental Method

1. Illuminance and color temperature

The right lower part of the table lamp was selected as the illumination test point. The light illumination could be adjusted manually, and the illuminometer was used to

test the illumination at the test point. The illuminance is determined as 200 lx, 500 lx and 800 lx. And the three color temperature with 3000 K, 4000 K, 6500 K are selected as experimental color temperature.

2. Reading materials

The reading materials are 50 pieces of essays, which are in song style, five sizes and black, with a line spacing of 1.5 times.

3. Flash fusion critical frequency recording

The objective data collection of human eye fatigue was measured by flash fusion frequency meter, that is, the critical frequency of human eye flash fusion was measured. It shows the limit of the visual system's ability to distinguish time. It shows the level of people's ability to distinguish flash.

4. Visual fatigue assessment questionnaire

The evaluation indexes of subjective evaluation table were ophthalmic acid, ophthalmalgia, dry eyes, burning eyes, double shadow, blurred vision, dizziness, headache, and shoulder and neck fatigue. The evaluation level was 1–5 score (1: no discomfort; 2: slight discomfort; 3: medium; 4: severe; 5: severe discomfort).

3 Experimental Process

3.1 Preparation

In the preparation stage, the purpose, process and relevant requirements of the experiment were introduced to the subjects. When the subjects were fully familiar with the whole experiment, the formal test begins.

3.2 Test

(1) Subjects filled in the subjective evaluation form of visual fatigue, tested the flash fusion value (test twice and take the average value).
(2) Subjects readed the designated paper materials at the designated location and the specified experimental conditions (color temperature and illumination) for 15 min.
(3) After reading the designated paper materials, the subjects needed to measure the flash fusion value again immediately (test twice and take the average value), and filled in the subjective evaluation form of visual fatigue again.
(4) After the test of one experimental condition, the subjects needed to close their eyes and rested for at least 5 min, and then repeated the above process to test the next experimental condition. Each subject is required to test 9 experimental conditions. The experimental order was randomly arranged after 9 experimental conditions were disrupted.

4 Experimental Results

The average difference of flash fusion values before and after the experiment under different color temperature and illumination is shown in Table 1.

Table 1. Average difference of flash fusion value before and after the experiment

	Before experiment	After experiment	Difference value
3000 K/200 lx	36.91	35.81	1.10
4000 K/200 lx	37.68	36.75	0.92
6500 K/200 lx	37.22	36.14	1.08
3000 K/500 lx	37.72	36.65	1.07
4000 K/500 lx	37.90	37.17	0.74
6500 K/500 lx	38.03	36.94	1.09
3000 K/800 lx	37.83	36.73	1.10
4000 K/800 lx	37.84	36.95	0.89
6500 K/800 lx	37.87	36.78	1.09

The average difference of subjective evaluation before and after the experiment is shown in Table 2.

Table 2. Average difference of subjective evaluation before and after the experiment

	Before experiment	After experiment	Difference value
3000 K/200 lx	1	4	3
4000 K/200 lx	1.5	3.5	2
6500 K/200 lx	1.5	4	2.5
3000 K/500 lx	1	3	2
4000 K/500 lx	1.5	2.5	1
6500 K/500 lx	1.5	3.5	2
3000 K/800 lx	2	4.5	2.5
4000 K/800 lx	1	2.5	1.5
6500 K/800 lx	1.5	3.5	2

5 Experimental Data Analysis

5.1 Analyze Flash Fusion Value

The difference of flash fusion values under 9 experimental conditions is shown in Fig. 1.

From Fig. 1, it can be seen the illumination of 500 lx and the color temperature of 4000 K has the lowest difference of flash fusion value before and after the experiment

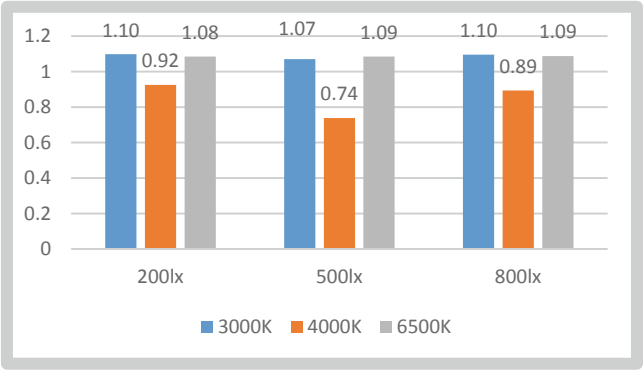

Fig. 1. Average difference of flash fusion value before and after the test

in 9 experimental conditions, which shows that the visual fatigue of the subjects is the lightest under this experimental conditions.

5.2 Analysis of Subjective Evaluation

The difference of subjective evaluation under 9 experimental conditions is shown in Fig. 2.

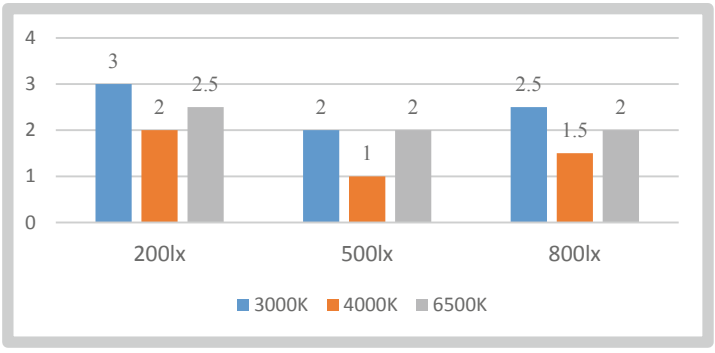

Fig. 2. Average difference of subjective evaluation before and after the test

The average difference of subjective evaluation show that in the 9 experimental conditions, the average difference of subjective evaluation before and after the experiment is the smallest under the illumination of 500 lx and the color temperature of 4000 K, which indicates that the subjects feel the least visual fatigue under this experimental condition.

6 Conclusions

In this experiment, psychophysical methods and user experience methods were used to study the visual fatigue of 30 young people under 9 experimental conditions with different color temperature and illumination, and the visual impact degree was determined by the physiological indexes and subjective feelings of the subjects. The experiment results show that it has the least effect on human visual fatigue when the color temperature with 4000 K and the illuminance with 500 lx.

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Support Factor of Upholstered Seat Cushions

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Abstract. Polyurethane foams are commonly used in the upholstered seat cushions, providing a sitter with a comfort sitting experience. According to the foam testing standard of American association for material testing, the compression testing for sofa cushions with two layers of foam were conducted to investigate the effects of the elastic modulus of upper and lower foams on the support factor of seat cushion. The results indicated that the interaction of elastic modulus of upper and lower foams has significant influence on support factor. The support factor is significant higher when the foam with elastic modulus of 0.19 MPa was used as the upper layer, which means those foam cushions had good support performance. In addition, a regression technique was proposed to drive power equation for the estimation of support factor as a function of elastic modulus of upper and lower foams for sofa seat cushion.

Keywords: Sofa cushion · Foam · Elastic modulus · Support performance

1 Introduction

The support performance of foams in sofa seat cushions has an important impact on the sitting feeling of sofa, mainly including soft or hard feeling, bottom-out feeling, instability and so on [1–3]. As an important part of sofa seat cushion, foam layer is closely related to the support performance of sofa [4, 5]. Elastic modulus (MOE) of foam refers to the stress required for foam material to produce elastic deformation under external force, which is an important index to measure the support performance of sofa [6]. However, a few related studies and standard were reported about the effects of elastic modulus of foam on the support performance for upholstered furniture [7]. Due to the lack of systematic quantitative research on the support performance of sofa seat cushion, the existing sofa enterprises mainly rely on experience to select foam materials in design and production, and have not yet formed a support performance evaluation system for foams in sofa seat cushions [8].

Sofa seat cushions are usually designed as the combination of two or more foam material layers for sitting comfort. Based on the foam-testing standard of American

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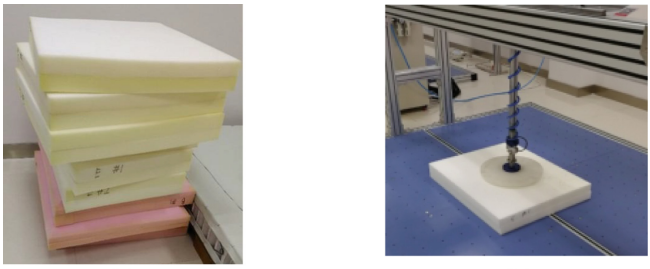
association for material testing (ASTM D3574-B1), two layers of foam structure was investigated in this study. The load-deformation testing were carried out for the seat cushions to investigate the effects of the MOE of upper and lower foams on the support performance for foam combinations, which aims to guide the furniture manufacturing enterprises and designers to choose material for sofa.

2 Materials and Methods

2.1 Materials

In this study, four different foams with different elastic moduli (Fig. 1a) were used and provided by Xilinmen Furniture Co., Ltd. (Shaoxing, Zhejiang, China). The MOE of the foams were 0.19, 0.25, 0.61 and 0.93 MPa. For the foam combinations, the foams with MOE at 0.19 and 0.61 MPa foams were selected as upper foams and the ones at 0.25, 0.61 and 0.93 MPa were selected as lower foams. Load-deformation tests were carried out on the six combinations of foams. The foams with MOE at 0.19 and 0.93 MPa were ordinary foams whose main components were polyurethane, and the ones with MOE at 0.25 and 0.61 MPa were high resilience foams whose main components were polyether polyol. The size of single layer foam is 740 × 740 × 100 mm, and that of combined foam cushion is 740 × 740 × 200 mm.



(a) (b)

Fig. 1. Foam materials (a); Mechanic measurement tester (b)

2.2 Equipment and Procedures

According to ASTM D3574-B1, six different foam specimens with three replications were tested with TST-CD001 Mechanical Tester (Fig. 1a and 1b). The diameter of the loading head for testing was 350 mm. Testing procedures as follows:

(1) Mark the center point on the foam specimen, aligns with the center point of the loading head.
(2) Pre-compress foam specimens twice to 80% of their thickness and the velocity is 50 mm/min.
(3) Wait for 5 min after the pre-compression.

(4) Compress the foam specimen again to 75% of its thickness at a speed of 100 mm/min, and record the load and deformation data continuously at the frequency of 13 times/sec.

2.3 Analysis

This study mainly analyzed effects of the MOE of upper and lower foams on the support factor for foam combinations. The calculation formula is as follow:

$$SF = 65\%IFD/25\%IFD \tag{1}$$

Note: The Indentation Force Deflection (IFD) is the magnitude of the loading force required when the foam is compressed to a specific proportion of its original thickness. For example, 65% IFD is the load required when compress the foam cushion to 65% of its original thickness [9].

The Statistical Analysis System (SAS) 9.3 was used for the two-way ANOVA and Least-Significant Difference. The influence of MOE of upper and lower foams on the SF of the cushion foam is mainly analyzed, and the hypothesis test is carried out at the 5% significance level.

3 Results and Discussion

3.1 Results

The mean values of SF and their variation coefficients for six foam combinations are shown in Table 1. Coefficient of Variation (COV) of each data set ranged from 1.2% to 4.2%, which indicated that there was little difference in mean SF values among each group of foam specimens. As shown in Table 2, ANOVA results showed that the interaction of MOE of upper and lower foams was significant on SF in foam combinations.

Table 1. Mean values and COV of SF for seat cushions

Foam combination type		SF	
Elastic modulus of upper foam (MPa)	Elastic modulus of lower foam (MPa)	Average	COV (%)
0.19	0.25	4.45	4.20
0.19	0.61	3.26	2.00
0.19	0.93	4.03	1.50
0.61	0.25	2.93	1.20
0.61	0.61	2.55	4.00
0.61	0.93	2.81	2.00

Table 2. P value of two-way ANOVA analysis for SF of seat cushions

Source	P value
Elastic modulus of upper foam	<.0001
Elastic modulus of lower foam	<.0001
Elastic modulus of upper foam × the elastic modulus of lower foam	<.0001

3.2 Discussion

Support factor (SF) is also known as "compression factor" or "comfort factor". The higher the SF value is, the better supporting ability the foam seat cushion has. In general, the interaction of MOE of upper and lower foams has significant effect on the SF of foam combination. The LSD value was 0.1732 according to the further Least Significant Difference. As shown in Table 3, when the MOE of the upper foam is 0.19 MPa, the SF values of the foam combinations are significantly higher than of the ones in the upper foam with the MOE of 0.61 MPa. As a consequence, if the MOE of the upper foam is lower than the one in the lower foam, which can effectively improve the supporting nature of the sofa foam cushion [10–13].

Table 3. The mean comparison of SF for seat cushions

Elastic modulus of lower foam	Elastic modulus of upper foam		Elastic modulus of upper foam	Elastic modulus of lower foam		
	0.19	0.61		0.25	0.61	0.93
0.25	4.45 A	2.93 B	0.19	4.45 A	3.26 C	4.03 B
0.61	3.26 A	2.55 B	0.61	2.93 A	2.55 B	2.81 A
0.93	4.03 A	2.81 B				

When the MOE of upper foam was 0.19 MPa and 0.25, 0.93 and 0.61 MPa for lower foam, the SF values of the foam combination were 4.45, 4.03, and 3.26 for the situations, respectively. The higher the SF value was, the better the cushion support performance was [13]. The results showed that the SF was the highest when MOE of upper and lower foam were 0.19 MPa and 0.25 MPa, which means this kind of foam combination had the highest support performance.

No significant difference was obtained when the MOE of upper foam was 0.61 MPa and MOE of lower foam were 0.25 MPa and 0.93 MPa, the mean SF value were 2.87 and 2.55 which was the lowest SF. According to a research result in 1982 by Wolfe [14], the foam cushion is considered to be comfortable when SF value is greater than 2.8, the foam cushions are easily to "touch bottom" when SF value is smaller than 2.8, therefore, these kinds of foam cushions are considered to be uncomfortable. In another word, when foam cushions with MOE of upper and lower foams of both 0.61 MPa, the SF value is 2.55, which is considered to be uncomfortable.

SF is a vital index for sitting comfort evaluation. To quantify the effects of foam MOE on SF of seat cushion and obtain functional relationships between them that might be practical for sofa design purposes, the least squares regression technique of using the following power Eq. (2) was proposed to fit to the individual test data points:

$$K = a\alpha^{b} \times \beta^{c} \times \gamma^{d} \tag{2}$$

Note: Where SF is support factor; α is elastic modulus of upper foam; β is elastic modulus of lower foam; a, b, c are regression fitting constants.

In addition, a linear equation was also investigated to fit to test data, but its r square value was lower than the one of power equation. The regression analysis yielded the following significant power Eq. (3) below with its coefficient of determination shown and p-value of both less than 0.0001, and the related coefficient $R^2 = 0.7854$:

$$SF = 0.355\alpha^{-0.29} \times \beta^{-0.09} \tag{3}$$

4 Conclusion

In this study, the effects of the MOE of upper and lower foams on the SF were investigated for the sofa cushion by quantifying the support performance of six combinations that were extensively used in sofa enterprises. The results indicated that the interaction of MOE of upper and lower foams had significant influence on SF. The SF was significant higher when the foam with MOE of 0.19 MPa was used as the upper layer, which meant those foam cushions had good support performance. In addition, the prediction equations of SF can be used to guide the foam selections for the sofa designers.

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Anthropometric Design

Parametric Design Method for Personalized Bras

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Abstract. One of the important issues in the bra industry is the size fitting problem, which results in discomfort and dissatisfaction among women users. The traditional way of bra sizing cannot serve the entire range of all women's body shapes. This study develops a parametric personalized bra design algorithm that can generate personalized bra by using self-measurements of women users. In this study, we investigate the bra industry to develop a new self-measuring approach and create a parametric modeling method to design personalized bras. To evaluate the capacity and the accuracy of this algorithm, we compare the measurements from 3D printed bra prototypes with the self-measurements of the women participants. The preliminary result of this study shows that the parametric personalized bra design algorithm can generate more accurate bra models for different types of body shapes.

Keywords: Bra design · Body fit · Parametric algorithm · 3D print · 3D body scan · Personalization · Anthropometry

1 Introduction

1.1 Background

The modern bras were invented in the 19th century, developed for hundreds of years [1] and have been evolved into today's mass production stage where the predominant sizing and grading methods take the lead. The traditional methods of bra sizing and grading take two body measurements, the upper and under chest circumferences, to develop cup sizes and band sizes [6]. However, such methods vary between companies, standards, regions, and populations with various factors involved [2]. This leads to an important problem of body fit, where over 70% of women wear the wrong size bras [5].

1.2 Motivation and Objectives

The goal of this study is to develop a parametric algorithm that can create a personalized bra design for individual woman by using their self-taken body measurements. This personalized algorithm requires acquiring accurate body measurement data, manipulating and analyzing the data, and morphing the CAD (Computer-Aided Design) bra model accordingly. With the algorithm, women wearers won't need to

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sacrifice their comfort by wearing standard sizes. Instead, the algorithmic system will generate the bra model in exact sizes to fit women wearers. To accomplish the goal, we specifically focus on three tasks:

1. Construct a self-measuring approach which can collect adequate and accurate data on breast shape and size.
2. Establish a parametric algorithm for personalized bras.
3. Evaluate the algorithm by comparing the dimensions between the self-taken measurements and a 3D printed bra prototype.

2 Exploration, Design and Development

2.1 The Self-measuring Approach

Two studies offer us practical methods for locating the landmarks and dimensions on women breasts. These two methods, the "breast arc length method" [4] and the "folding line method" [3] are crucial to our study and serve as potential supports for the parametric design. Based on reviewing their methods, we present a new self-measuring approach that can easily collect individual measurements for the further parametric algorithm. The new self-measuring approach includes seven dimensions around the breast area. To make the procedure clearer and easier, we name each landmark and dimensions as follows. Figure 1 illustrates these landmarks and dimensions in the self-measuring approach.

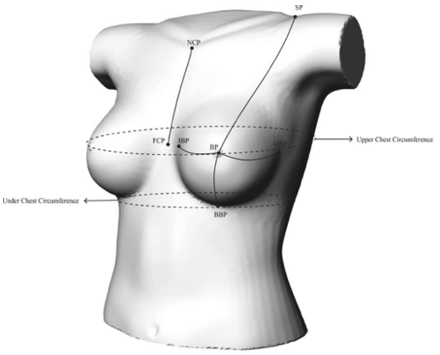

Fig. 1. The landmarks and arc lengths of the self-measuring approach (only shown on the left side of the body)

Landmarks

1. BP refers to the nipple points on both sides.
2. IBP refers to inner bust points on both sides.
3. OBP refers to outer bust points on both sides.

4. BBP refers to bottom bust points on both sides.
5. SP refers to shoulder points on both sides.
6. FCP refers to the front center point, which is on the center between two nipple points on the sternum.
7. NCP refers to the neck center point, which is on the center between two collar bones on the front neck.

Arc Lengths

1. BP-IBP refers to the inner arc length on both sides.
2. BP-OBP refers to the outer arc length on both sides.
3. BP-BBP refers to the bottom arc length on both sides.
4. BP-SP refers to the surface arc length from nipple points to shoulder points on both sides.
5. FCP-NCP refers to the surface arc length from the front center point to the neck center point.
6. The upper chest circumference is the circumference through two nipple points around the chest.
7. The under-chest circumference is the circumference through two bottom breast points (BBP) and the bottom folding line around the torso.

2.2 Parametric Algorithm

We construct the parametric personalized bra algorithm with Rhino and Grasshopper program. In this algorithm, we build an initial basic T-shirt styled bra 3D model which is derived from a 3D scanned mannequin form. This scanned mannequin form serves as an original reference for centering and positioning the bra model in the algorithm. More importantly, the contours extracted from the mannequin form accord with the needed dimensions in our self-measuring approach and composite the initial bra model structure. By simply adjusting the "parameters" (length and distance between landmarks) of the contours, we can morph the bra model accordingly.

In the algorithm, the output is the geometrical 3D bra model displayed on the Rhino interface, and the inputs are the parameters on the Grasshopper processor interface. The parameters are namely the measurement value which are self-measured from women users. By changing the values of each measurement, the contour lengths on the initial bra model will expand or shrink to the correct size and scale. Consequently, the output of the bra model morphs in coordinating with the real measurements from women users. Figure 2 shows the general layout of the parametric algorithm. On the left side is the generated bra contours displayed on Rhino screen, while on the right side is the parametric processor on the Grasshopper interface.

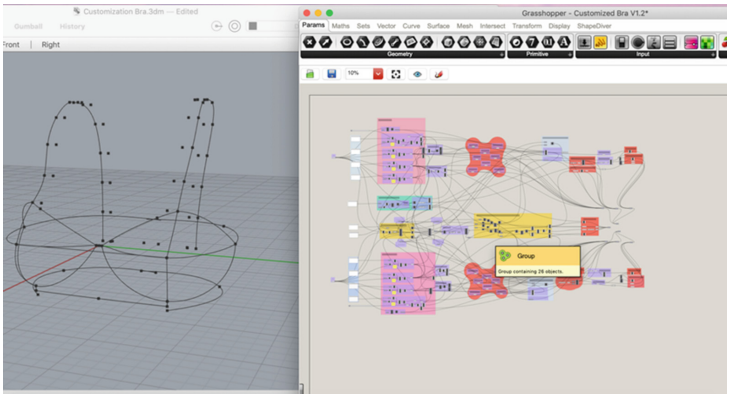

Fig. 2. General layout of the parametric algorithm in Rhino/Grasshopper display

3 User Test and Evaluation

3.1 Purpose and Methods

To evaluate the capacity and accuracy of the parametric algorithm, we conducted a user test by recruiting three female participants and making 3D printed bra prototypes for them. By comparing the measurements between participants bra prototypes, we can assess the algorithm efficiency.

The three participants vary in body sizes including a relatively small size, average size and a relatively large size. They were assigned to measure themselves according to our measuring instructions. We then collected their measurement data and input them into the parametric algorithm, generated personalized bra models, 3D printed the bra prototypes, and eventually measured the prototypes to justify the accuracy of the algorithm. All of the personally identifiable information of participants is NOT included in the study.

3.2 Evaluation Results

The algorithm correctly generated three different sized bra models. We used white SLA filament for 3D print prototypes. To reinforce the structure, we thicken the bra surface inwards by 3 mm to ensure the measurements taken on the outer surface are not biased. Figure 3 shows the 3D printed bra prototypes.

We then measured the 3D printed bra prototypes with masking tape on each designated dimension and compared the results to the participants' measurements. Table 1 illustrates the comparison results between three bra prototypes and three participants' measurements.

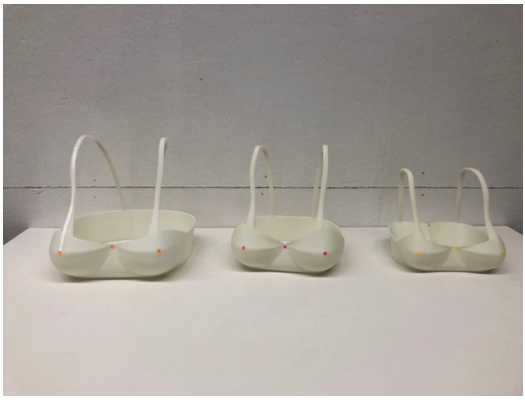

Fig. 3. Three 3D printed bra prototypes in different sizes

Table 1. Comparison results between bra prototypes and participants' measurements in three different sizes. All the measurements below are in centimeters (cm).

Size	Object	Body side	BP-SP	BP-OBP	BP-BBP	BP-IBP	FCP-NCP	Upper chest circumference	Under chest circumference
Small	Participant	Left	20.0	6.3	5.5	8.0	10.9	67.6	55.0
		Right	20.0	6.3	5.5	8.0			
	Prototype	Left	20.0	6.3	5.5	8.0	N/A	68.0	55.0
		Right	20.0	6.3	5.5	8.0			
Medium	Participant	Left	24.0	9.5	6.5	8.0	17.5	78.0	67.0
		Right	24.0	9.5	6.5	8.5			
	Prototype	Left	24.0	9.5	6.5	8.0	N/A	74.0	63.0
		Right	24.0	9.5	6.5	9.5			
Large	Participant	Left	25.8	10.5	8.2	9.0	9.0	88.0	74.3
		Right	25.8	10.8	8.2	9.3			
	Prototype	Left	25.8	10.5	8.2	9.5	N/A	89.0	75.0
		Right	25.8	10.8	8.2	9.3			

3.3 Discussion

The overall measurement results of 3D printed bra prototypes are accurate. For all the three sets of comparisons, most of the measurements on the cup arc length are exactly as same as the inputted measurement values, except for the difference within 1 cm of the BP-IBP arc length on medium and big size bras. This might be caused by the manual operation using masking tape on the curvy surface. However, for all the three sets of comparison, the circumference lengths of the upper and under chest circumferences have relative higher value of errors. On small and big ones, the differences are confined within 1 cm, while on medium one, the difference is 4 cm on both circumferences. A probable reason for this difference is the defaulted set in the algorithm.

When scaling up or down the circumference length, the curves keep the arc radian as defaulted setting and only expand or shrink the length. Thus, it causes the overlapping on the back-center part which affects the length when patching the surfaces together. We consider this difference is within the limit of tolerance, since for real knitted bra manufactures, we need to leave the space for back hook which is about 5 cm long [7]. The back hook is for users to adjust the tightness of band.

4 Future Study

This study has accomplished a significant task of establishing the first-stage parametric algorithm, but it is not limited to what it has already done. According to the user test and evaluation, we present some implications for the future study.

4.1 Optimization of the Parametric Algorithm

The current parametric algorithm is specifically based on the mannequin scanned data as the reference and solves the potential problem of size fitting, particularly based upon a length-driven method. In further study, we expect to extend the algorithm with more parameters that can cover more extreme cases with higher flexibility. We also expect to include the 3D body scan technology to capture the body shape in order take the body morphology into account.

4.2 Manufacturing and Fit Tests

We propose to utilize 3D knitting as a producing technique to offer high-quality bras. In this way, we can conduct a real trying-on experience for users. We will make efforts to get access to the 3D knitting manufacture, to understand the mechanism of how 3D knitting works, and further study on the method of transforming between 3D models and knitting patterns.

4.3 Personalization Era for Women Bras

Our vision is not only limited to improve the personalized fit bra design, but to provide a new model of service for women bra personalization. This requires a comprehensive development on user experience, service design, and manufacture. With the technologies emerging into our daily life and changing the way people thinking, designing and manufacturing, personalization will be a new world ahead to conquer. We will be continuously working on this research topic to embrace this new realm where people can enjoy personalized wearable products with high quality, maximal fit, and elaborated service.

Acknowledgement. I would like to express my deepest appreciation to all those who provided me the opportunity to complete this project.

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Furthermore, many thanks go to those lovely schoolmates who assisted me in finishing the tasks of user test study; Xiaoshen Wang as my friend and classmate who had always been discussing the parametric methods with me; And my dear boyfriend Mr. Fan Geng who intensely encourages me all the time. Finally, I appreciate my parents who were always having my back and gave me the warmest support and wise advice.

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A Gender Comparison of Portuguese Firefighters' Perceptions Concerning Personal Protective Equipment: Results from a Pilot Study

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Abstract. Over the years, the nature of firefighting and the role of firefighters has evolved including a demographic change, with an increasing number of women in this profession. Recent studies have specifically addressed the particular needs of female firefighters. Ill-fitting turnout gear, protective gloves, and other personal protective equipment make female firefighters' tasks not only uncomfortable but also more difficult and dangerous. A pilot study comprising both male and female firefighters from a fire brigade located in the North of Portugal was conducted. The goal was to investigate the fit of the Portuguese firefighters' personal protective equipment, its level of adjustment to their anthropometrics and to identify areas that need improvement. This paper focuses on gender differences and presents the preliminary results regarding size selection and purchasing of protective clothing as well as the level of protection experienced among participants.

Keywords: Female firefighters · Fit and Size · Human Factors and Ergonomics · Protection level

1 Introduction

Over the years, the nature of firefighting and the role of firefighters has evolved [1, 2]. Though challenging, firefighting continues to be necessary and critical [3] and is considered one of the most dangerous, arduous, and physically demanding occupations [4–6]. Firefighters' personal protective equipment[1] has been designed to provide protection against multiple hazards [7] and has changed greatly from the equipment worn in the past [1]. Despite the advances in materials technology, many studies have shown several issues regarding the effective use of firefighters' personal protective equipment

[1] In general, includes a turnout gear (coat and pants), helmet, hood, gloves, boots, and a self-contained breathing apparatus.

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(PPE), including issues with comfort, fit, sizing, mobility restriction, bulkiness as well as maintenance and cleaning aspects [4, 7].

Furthermore, we can highlight a demographic change in firefighting, with an increasing number of women in this profession. According to the National Fire Protection Association, the number of women serving as firefighters in the United States has increased over the years. Recent data report a total of 13,400 female career firefighters and 64,500 female volunteer firefighters[2] in the country [8]. In Portugal, it is possible to identify a similar trend. In 2018, 18.64% of Portuguese firefighters[3] were women, with a total of 5,155 female firefighters [9].

This demographic change has been encouraging studies that specifically address the particular difficulties and needs of female firefighters. The fit of PPE appears in most of these studies as a common dissatisfaction among female participants. In a report on women in firefighting [11], "encountering problems with ill- fitting equipment" was evaluated with the highest rate of discrimination or harassment issues experienced. As stated by Boorady *et al*. [10], female firefighters commonly wear equipment designed and sized for men, in general, incorrectly sized and ill-fitted, affecting both job satisfaction and job performance. According to another study, ill-fitting PPE is a physical stressor for female firefighters [12]. Results of the Park & Langseth-Schmidt study [13] showed significantly lower survey ratings on overall satisfaction, perceived comfort, and performance of the turnout pants among women. Moreover, these issues are considered big threats to safety, increasing the risk of injury among female firefighters [14].

1.1 Portuguese Firefighters' PPE Study

In order to understand if the Portuguese firefighters' PPE is adjusted to their anthropometrics and determine areas needing improvement, an on-going study designated as *SizeFF Portugal – Anthropometric Study of Firefighters* is being developed by the *2C2T – Centre for Textile Science and Technology*, in the *Department of Textile Engineering* at the *University of Minho*, in partnership with a U.S. study. In order to validate the study methods and tools as well as obtain the first insights from firefighters' experiences concerning their PPE, a pilot study was conducted in a fire brigade located in the North of Portugal. Preliminary results regarding fire gloves[4], turnout coat and pants[5], and fire boots[6] were presented elsewhere. This paper presents

[2] Corresponding to 3.6% of total career firefighters and 9.4% of total volunteer firefighters.

[3] Including both career and volunteer.

[4] Moraes, A., Boldt, R. Carvalho, M., Ferreira, F. Portuguese firefighters' perceptions concerning protective gloves. In: Proceedings of AUTEX 2019 – 19th World Textile Conference. 11–19 June 2019, Ghent, Belgium (2019).

[5] Moraes, A.S.P., Boldts, R.S., Ferreira, F.N., Carvalho, M.A.F, Ashdown, S.P. Assessment of Portuguese firefighters' needs: preliminary results of a pilot study. In: F. Rebelo and M.M. Soares (Eds). Advances in Ergonomics in Design. 721–732 (2020).

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the preliminary results of gender differences concerning the purchasing, size selection, and protection level provided by turnout coats and pants as reported by the pilot study participants.

2 Material and Methods

For data collection, an online survey and an in-person semi-structured interview were administered. Participants were requested to answer the questions based on their perceptions and personal experience when selecting and wearing specific equipment for structural fires.

2.1 Online Survey

The survey was applied using an online platform[7] and comprised 87 questions, divided into five parts. The first part included 11 socio-demographic questions including gender, age, race and ethnicity, firefighting status (type of commitment, experience, types of firefighting missions), and municipality identification questions (city and state, number of inhabitants, type of environment protected by the fire brigade). The following 4 parts included questions about specific personal protective items[8] and focused on 4 topics: (i) brand, style, gender, and size identification; (ii) purchasing and selection process; (iii) equipment length of service, level of protection, injuries; and (iv) fit issues related to specific areas of personal protective items.

2.2 Semi-structured Interview

The semi-structured interview questions were initially formulated based on results from similar studies [2, 4, 10]. Throughout the pilot study, additional questions were included in the interview, as the participants shared their perceptions and mentioned other items or issues not previously considered.

2.3 Data Collection Protocol

After obtaining permission from the fire brigade's chief in command, all firefighters of the brigade were invited to participate. Once the consent of participants was obtained, a unique identifying number was assigned to each participant to protect privacy and maintain confidentiality.

A researcher was available throughout data collection to assist in filling out the survey, administer the interview questions, answer any questions participants may have had, as well as address additional questions when responses required further information and clarification.

[7] *Qualtrics Survey Platform*.

[8] Including turnout coat, turnout pants, fire boots, and fire gloves.

The survey/interviews were audio-recorded and further verbatim transcribed for the sake of data analysis accuracy. Data were collected from December 2018 to September 2019, and each interview/survey took approximately 40 min to be completed. Data were organized by classifying the most common issues and areas needing improvement identified by the participants.

3 Results and Discussion

Preliminary results of the pilot study are presented as follows. Gender differences regarding the purchasing process, difficulties in selecting the turnout coat and pants size, as well as the protection level experienced are discussed.

3.1 Demographic Information

The fire brigade comprises about 140 firefighters, including about 45 firefighters that are both career-volunteer[9] personnel and about 95 only volunteer personnel. The brigade serves a medium-size municipality[10], covering urban and suburban populations, as well as the wildland environment surrounding the city.

Forty-nine firefighters participated in the pilot study. Most participants were men, corresponding to 73.47% (n = 36), and 26.53% (n = 13) of the participants were women. Regarding their type of commitment, 26 male and 5 female participants were career-volunteer (63.27% in total), 9 male and 6 female participants were only volunteer firefighters (30.61% in total) and 2 female participants were trainees (4.08% in total). The assistant chief responsible for the brigade also participated in the study. The average age of the respondents was 40 among male participants and 30 among female participants. Firefighting experience was significantly different between gender, varying from 6.10 years for female participants to 18.69 years for male participants. Sociodemographic information is summarized in Table 1.

[9] In Portugal, career firefighters commonly offer their services on a volunteer basis to their fire brigade in the hours that they are not regularly paid. Usually, they volunteer during night shits and weekend shifts.

[10] About 160,000 inhabitants.

Table 1. Participants socio-demographic information

	Total	Male	Female
# Participants	49 (100.00%)	36 (73.47%)	13 (26.53%)
Age (yrs)			
Mean (SD)	37.49 (10.23)	40.00 (10.13)	30.54 (6.94)
Min – Max	21–62	25–62	21–44
Experience (yrs)			
Mean (SD)	15.35 (11.28)	18.69 (10.86)	6.10 (6.28)
Min – Max	0.17 – 38	0.17 – 38	0.17 – 16
Type of commitment (#)			
Career-volunteer	31 (63.27%)	26 (72.22%)	5 (38.46%)
Volunteer	15 (30.61%)	9 (25.00%)	6 (46.15%)
Trainee	2 (4.08%)	0 (0.00%)	2 (15.39%)
Other	1 (2.04%)	1 (2.78%)[a]	0 (0.00%)

[a]Assistant chief responsible for the brigade.

3.2 Purchasing

When asked if the turnout gear was specifically purchased for an individual, the responses of female participants were significantly different from their male counterparts. Twenty-six male participants (72.22%) answered that their turnout coat was specifically purchased for them and only 2 female participants (15.38%) answered the same. Responses of turnout pants were similar as 27 (75.00%) of the male participants answered that their turnout pants were specifically purchased for them and only 1 (7.69%) female participant answered affirmatively.

Although the fire brigade has been progressively investing in specifically tailored turnout gear[11], career firefighters have priority over volunteers, as they use their equipment more frequently. Usually, volunteer personnel is provided with turnout gear already used by former firefighters.

3.3 Size Selection

Correct sizing is particularly important in protective clothing, as the performance of the clothing depends on the correct fit [15]. When participants were asked if they experienced any difficulties in selecting their turnout coat size, 46.15% (n = 6) of female respondents answered «yes» while only 16.67% (n = 6) of male participants answered the question affirmatively. Difficulties experienced in selecting their turnout pants size were similar. Female participants' responses were significantly different than male responses, as 61.54% (n = 8) of female participants expressed difficulties in selecting their turnout pants, while only 16.67% (n = 6) of male answered «yes».

[11] For this, the manufacturer provides a sample set of sizes and adjust to their individual measurements. According to the study participants, modifications were usually made on the coat sleeve length and on the pants leg length.

Difficulties mentioned by female participants in selecting their turnout gear were similar for both the coats and pants, including the fit, sizing system, and the availability of sizes in the brigade. Examples of difficulties mentioned are illustrated in Table 2.

Table 2. Female participants difficulties in selecting the turnout gear size (type of commitment)

SIZING	COAT	"the smaller size was too small, and the size above was too big [for me]" (volunteer)
	PANTS	"the size above was too big and the smaller size didn't fit on the hips" (volunteer)
		"I was in doubt between L and XL" (volunteer)
FIT	COAT	"the S fits great on the armhole, but it is too tight on the hips" (career-volunteer)
		"I believe that, as they are Unisex, sometimes they fit on the arms but don't fit on the torso… other times, they fit on the torso, but not on the arms" (career-volunteer)
	PANTS	"[turnout pants] are a bit bulky" (volunteer)
		"it's the same as the coat… if they fit in one region, they don't fit in another" (career-volunteer)
AVAILABILITY	COAT	"there is a lack of available sizes [in the brigade]" (volunteer)
		"I've got the available size [in the station]… you know… but it should be a M" (volunteer)
		"I haven't picked it [the size]… I've got the smallest size available at that time" (career-volunteer)
	PANTS	"there were not many sizes [available]" (trainee)
		"I haven't chosen the size… they were just assigned [to me]" (career-volunteer)
		"they just provided me those [pants]" (career-volunteer)

As recommended by Shuster [12], the availability of PPE in sizes that fit women can remediate the problems faced by female firefighters. However, a more adequate sizing system remains a challenge. As male and female anthropometrics are sufficiently different, turnout gear needs to be designed differently [11].

3.4 Protection Level

Concerning the protection level, responses from female participants were slightly different from male participants. According to 69.23% (n = 9) of the female respondents, they feel «very protected» by their turnout coat and according to 30.77% (n = 4) of female participants they feel «somewhat protected». Male participants answered as follows for their turnout coat: 77.78% (n = 28) feel «very protected», 19.44% (n = 7) feel «somewhat protected» and 2.78% (n = 1) feel «very little protection».

A higher perception of protection level with turnout pants was also expressed among male participants (very protected: 80.56%, n = 29; somewhat protected: 16.67%, n = 6; very little protection: 2.78%, n = 1). Female participants expressed a lower evaluation concerning perceived protection of turnout pants: 61.54% (n = 8) answered that they feel «very protected» and 38.46% (n = 5) answered that they feel «somewhat protected».

These results are in accordance with the Hollerbach *et al.* study [14] that identified issues with ill-fitting gear as one of the biggest threats to safety for female firefighters.

4 Final Considerations

The level of protection is an important feature to consider when selecting personal protective equipment. In the case of firefighting, comfort is also of paramount relevance. According to recent studies, female firefighters are more subjected to ill-fitting PPE, usually designed for male anthropometrics. The preliminary results presented in this paper corroborate such findings, as female participants expressed more difficulties in selecting their protective clothing than male participants. The availability of sizes and the sizing system was also discussed. In addition, the level of protection experienced was also evaluated as being lower by the female participants. Although the number of participants was modest, the findings of this pilot study provided valuable insights to better understand the main issues experienced by the Portuguese female firefighters regarding their PPE.

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Rethinking Sketching Role in Nowadays Design Process

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Abstract. Since everybody is typing on computers and tablets, should we maybe focus upon typing rather than writing? Questions like these make explicit not only a change in culture but also how to deal with new technologies in a rapidly changing society. The question entails much more than typing versus handwriting. Learning how to write is learning how to organize and form thoughts and ideas on a sheet of paper, through a brain process. Handwriting connects thinking and doing which is an inherent part of mankind. We can raise similar questions regarding freehand drawing within design education. Once, physical drawing and sketching ruled all design curricula, because at that time there was no alternative. However, nowadays, with the several options new technologies can offer, we must reconsider the several functions of hand drawing within the design process. Designers conceive and develop solutions for problems that are of different nature. Sketching can be an operative support for problem solving and critical analyses during the design conceptual process. This research intends to investigate if the nowadays wide use of the new technologies does not invalidate the important role played by sketching as a stimulating instrument for generate new ideas and as a critical verification of the several hypotheses. Sketching survival facing new technologies is a main issue we want to discuss and investigate.

Keywords: Educational design · Drawing · New technologies · Design process

1 Introduction

The conceptual process of most designers is usually based on sketches. There is a deep relationship between design and sketching. The essential question of determining if sketches can be the key of the design process constitutes the starting point for a postdoctoral research project about the relevance of the use of hand drawing in the design practice. In this paper, we present the first stages of this research.

Given that sketching has been traditionally used over the centuries is sometimes seen as an outdated method for design. Tradition is often presumed to be ancient, unalterable; sketching is sometimes considered in this sense, but in reality, its use has evolved and expanded. Nowadays is widely used by various areas of knowledge and

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professional practice, surpassing the previous and restricted use only by areas linked to the fine arts and the project such as architecture, engineering and design.

This research aims to stimulate reflection and bring new perspectives on the nowadays use of sketching, underlining sketching survival and relevance facing the new technologies growing importance.

2 Sketching

The word Sketch, deriving from the Italian Schizzo, has its origin from the Latin Schedium, which derives from the Greek Skhedios, both meaning done extempore: done without preparation, improvised [1].

According to the Oxford English Dictionary [2], the word Sketch means: "a rough or unfinished version of any creative work" and to the Cambridge English Dictionary: "a simple, quickly-made drawing that does not have many details".

Therefore, the word Sketch describes a quickly made drawing and its intention is to give a general overview or the guidelines of something, in relation to the intended final shape or figure, a rough drawing representing the chief features of an object and often made as a preliminary study.

People have been sketching for a long time, but, with the advent of digital drawing tools, Hayden Mills [3] tries to answer why some people still prefer to sketch with a pen, or a pencil on a paper. He concludes that, in the first place, sketching gives a place to start: many creative professionals begin with a pen and paper. The process of thinking through sketching helps them getting their creativity flowing. Besides, it helps everyone to document the process. Early design process ideas come and go, sketching forces to shift the ideas into paper, helping to document those ideas in real-time as they arise in few seconds (Figs. 1 and 2).

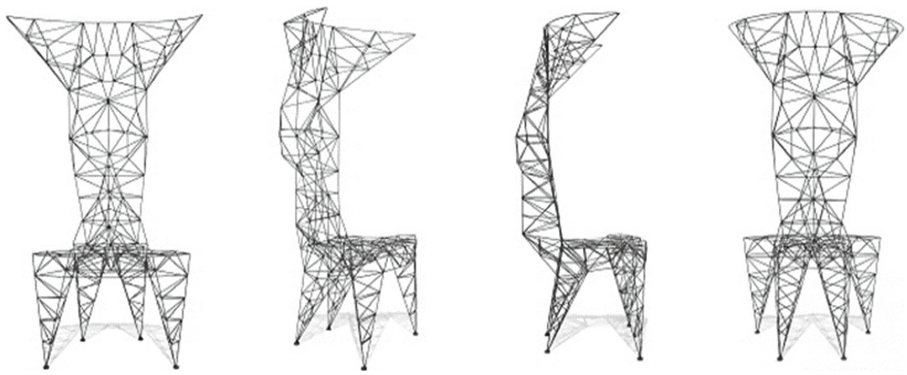

Fig. 1. Tom Dixon's Pylon chair sketches (1995). Source: [https://www.switchmodern.com/product/tom-dixon-pylon-chair/]

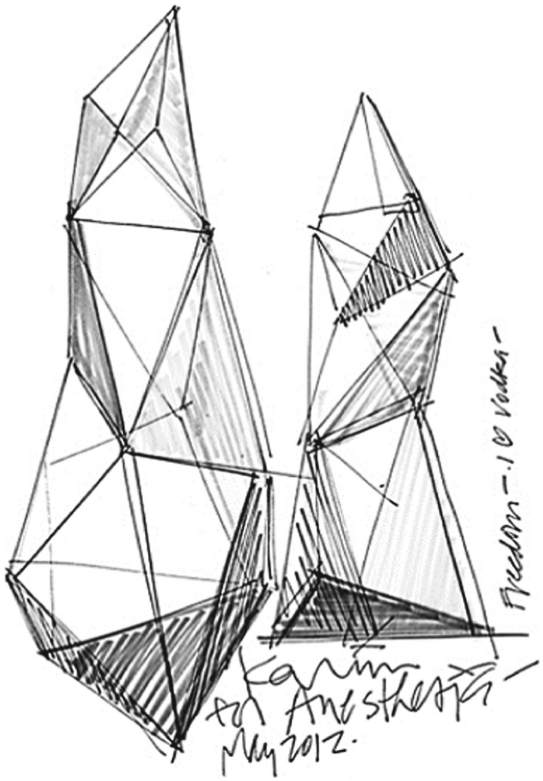

Fig. 2. First conceptual sketches for a vodka bottle by Karim Rashid (2012). Source: [https://www.dezeen.com/2013/10/18/vodka-bottle-by-karim-rashid-for-anestasia/].

Several authors' statements about the relevance of sketching consider it as an essential tool in design creative processes.

Gabriela Goldschmidt's studies [4] point out to drawing as an integral and inseparable part of design thinking. The author argues that the act of sketching is broader than a technique or phase, representing the way designers reflect through visual exploration. This way of facing drawing as reflective practice is similar to Donald Schön's arguments [5].

According to Van Der Lugt [6], sketching is a valuable tool in creative teams, validating brainstorming, materializing concepts, externalizing the various ideas that float in different work teams. It acquired a more comprehensive and broad meaning, but one of its basic principles remains: to communicate and to develop ideas. For this author, the visual language triggered by sketching is part of the designer's communication process and can be defined in four guidelines: investigate, explore, explain and persuade.

As Kevin Henry argues, sketching continues to be the most direct and quick method for designers to explain and explore ideas [7] (Fig. 3).

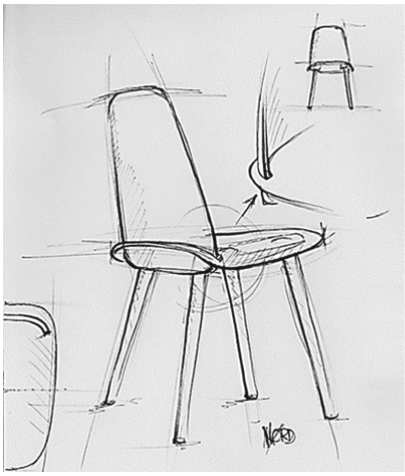

Fig. 3. *Nørd* wood chair first study sketches by David Geckeler for *Muuto* (2012). Source: [https://www.dezeen.com/2012/nord-by-david-geckeler-for-muuto]

For Nigel Cross [8], sketching is a key instrument for design. During the process early stages, sketches are a way for the designer to communicate with himself, a sort of thinking aloud, and concludes that the design conceiving process is based on the development of ideas through their visible expression in sketches.

Sketching goes far beyond the elementary representation of ideas. It represents the development of self-criticism from the initial sketches to achieve the design solutions therefore a medium for the reflection in action as Donald Schön argues [5].

We can conclude that sketches can be an operative support for the problem solving and the critical analyses during the designers conceiving process (Fig. 4).

Fig. 4. Sketches done by Nike designer Tinker Hatfield reveals what he had in mind (1994) Source: [https://www.google.com/search?q=tinker+hatfield+sketches]

Bill Buxton argues that it is a precious strategy in the design process, indicating what sketching should be as the correct way to project in design [9].

As the designer must face a complex process from beginning to end, from the first ideas for something new until its materialization, he can use sketches. Sketching can constitute a useful means for the development of his ideas, as an operational support during the creative process.

The search for solutions implies that the designer must study in detail each phase of the process, evaluating if the solutions he conceive are the best ones or that are possible to materialize. During this process, sketches can be essential. Any trace or scribble can contribute to the idea development.

For a designer, the sketchbook (Fig. 5) is a place to order his thoughts, to gather information through the images he draws and to develop each phase for a design solution. The sketchbook represents a way of thinking through drawn lines in a creative process, revealing the important role that sketching can play within the development of any project.

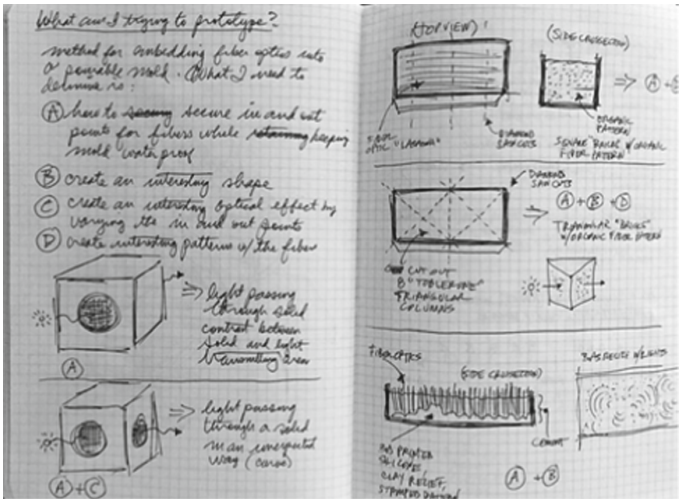

Fig. 5. Thinking through the drawn lines and some notes written on a sketchbook Source: [https://www.fastcompany.com/3056991/16-famous-designers-show-us-their-favorite-notebooks]

Sketching allows that reasoning can be expressed and decoded through the drawn lines. We face our ideas represented in the paper space. There is a direct link between the thoughts and the hand that executes the drawing. Since sketching is performed by the hand used as an extension of the brain, it meets the concept of drawing is mental activity.

In *The Inexorable Rise of Drawing*, an article that analyses contemporary thinking about drawing, Annabel Tilley [10] identifies the reasons why, nowadays, the theme of hand drawing has become so relevant. According to Tilley, the interdisciplinary capacity of drawing was finally recognized, and the importance of the easiness with

which hand drawing can explain and describe the intangible. In this article, Tilley concludes that this development in the form we face drawing might be considered at the heart of a change in the perception of the drawings growing relevance, and why by 2000, drawing had become to the new millennium what digital media was to the nineties – an exciting and innovative force widely acknowledged for its infinite possibilities. Nowadays, we are still trying to define what drawing really is, and, imagine what it might become in the future.

For Hamilton [11], through the process of sketching we can continuously express and create, linking together new ideas with technical expertise, increased by the assistance and interaction with new technologies.

Domingos [12], in his book, *The Master Algorithm* writes about the great advances of Artificial Intelligence and its promising future, but he argues that Artificial Intelligence is not yet capable of creating something real new which is the unique and extraordinary capacity of Human Creativity.

Automatic Learning based on Artificial Intelligence can increase our data and generate numerous learning components and, therefore, can be very useful to generate creativity through knowledge; however, creativity is a special skill that, for now, it is a unique and intrinsic part of the Human Being. Machine Learning, however, can help to find more accurate foundations and research findings for the creative work [13].

For Mike Rohde [14] the use of sketches during the first stages of the design process is an excellent way to increase creativity, adding in the final stages of the project the useful application of software and hardware tools (Fig. 6).

Fig. 6. Cey Adams pencil sketches for a Google Doodle. (2017) Source: [https://www.businessinsider.com/new-google-doodle-honors-hip-hops-history-2017]

At Google, despite being a high technology company, artists typically use sketches to create a new Google Doodle.

Roome [15] states that the cross-pollination between traditional and digital platforms is extremely beneficial.

For Joshua Brewer, senior designer at Twitter and UX designer, the real value of sketching is that it allows exploring and refining ideas in a quick, iterative and visual

manner. Rapid ideation flow and interact, layout and hierarchy can be quickly established, rearranged or discarded, all of this without ever touching a computer [3].

3 Conclusions

This study demonstrates that sketching has been undergoing mutations, changing the vision and concept about the use of sketches, opening doors to rethinking sketching role in nowadays design process.

We can conclude that it is possible to combine the two main roles performed by sketching forming a more intertwined relationship. One perspective is 'visual thinking' about the reflection that the designer makes during the conversation with his own sketches. Another perspective is 'visual communication', exploring sketching as a means of communication with others during the creative process.

In creative teams, sketching is a valuable tool, validating brainstorming, materializing concepts, externalizing the various ideas that float in different work teams.

One of the main features of sketching is the speed and easiness of communication combined with its universality. Hand drawing is fast and easy, it gives freedom to explore ideas as quickly as they arise, it helps problem solving faster.

Sketching is a visual thinking tool and is a common language that can bring clarity to an idea. We all know that a simple drawing can be more clarifying than an explanation in words.

Nowadays, the wide use of sketches by designers during their creative process clearly shows the continuous importance of hand drawing, particularly in times dominated by new technologies.

We can also conclude that new technologies can be very useful for designers, saving much time, facilitating practice tasks, even becoming indispensable in some design process phases. However, they do not replace sketching, especially in the initial stage of recording the first ideas and during their subsequent development by incorporating a critical dimension in design's creative process.

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An Investigation of the Garment Pressure for Developing Yoga Sports Bras in Ergonomic Design

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Abstract. This study was designed to develop yoga sports bras by investigating women's preferences in the sports bra types and garment pressures during yoga practice. The participants responded to a set of questionnaires, pertaining to satisfaction of the current sports bra types. In an experiment, five women evaluated garment pressures in five different types of sports bras during yoga practice. The result shows that compression sports bra type was the most favorable design feature. However, it was identified as the least comfortable type due to high garment pressure on the body. The greater garment pressure was identified at the shoulder straps, the bottom side seams, and the scapula. Skin irritation and feeling of discomfort from the garment pressure were reported from the experiment.

Keywords: Sports bras · Yoga · Garment pressure · Fit

1 Introduction

Yoga has been popular in the United States as it improves mental and physical strength, flexibility, balance, agility, and endurance. According to Yoga in America Study [1], the number of yoga practitioners has increased to 36 million in 2016, from 20.4 million in 2012, and 72% of the practitioners are women. With growing interest in yoga and fitness wear, the sporting goods industry in particular has rapidly grown in recent years [2]. Sports bras are necessary for women practicing yoga or any fitness exercises. Several previous studies [3, 4] have investigated functionality of sports bras on breast support during running performance. For sports bra design, garment pressure (kpg) is necessary to support breast. Lee and Kim (2012) have identified garment pressure under bras [5]. An improper garment pressure might cause negative effects such as fatigue and discomfort feeling [6–8]. However, there have been insufficient studies on sports bra garment pressure during static yoga poses. Thus, the aim of this study is to investigate women's satisfaction of yoga sports bras and its garment pressure during static yoga poses.

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2 Methodology

A total of 206 women (ages 25 to 34) responded to a set of questionnaires. The survey consisted of 16 questionnaires pertaining to sports bra function during yoga, satisfaction of the sports bra types, fit and discomfort issues due to sports bra garment pressure. Descriptive statistics and Chi-square test with Likelihood ratio were used to assess the association of sports bra types and self-reported discomfort (e.g. breast movement, bra shifting, skin irritation, bra garment pressure).

In an experiment, after the first set of survey, five women (29 ± 2.5 years of age, 160.2 ± 1.2 cm height, 52.65 ± 0.85 kg body mass) who regularly practiced yoga and wore average A-cup bra size (84.75 ± 1.25 cm bust, 75 ± 1.6 cm under bust) were recruited for evaluating sports bra garment pressure related to sports bra types. Participants were asked to try on five different types of sports bras: Compression sports bra with racerback strap (Type A), Compression sports bra with tank top strap (Type B), Compression & Encapsulation sports bra with tank top strap (Type C), Encapsulation sports bra with racerback strap (Type D), and Compression & Encapsulation sports bra with racerback strap (Type E) (Fig. 1).

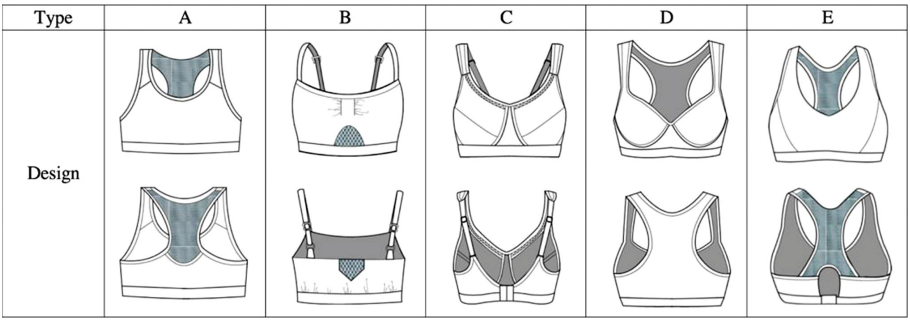

Fig. 1. Five types of sports bras

For sports bra garment pressure evaluation, a garment pressure measurement method [7, 8] was used in this study. Garment pressure was measured using a 10 mm calibrated garment pressure sensor (0.5 to 24 kPa range, 50 Hz) placed under each sports bra at the eight interface garment pressure points, including a center front point at the bottom, a quarter of front point at the bottom, a quarter of back point at the bottom (scapula), a center back point at the bottom, a side seam point at the bottom, a side seam point at the top, a shoulder strap point, and a front armhole point (Fig. 2).

The sensors were secured with micropore surgical tape. Each sports bra garment pressure (kPa) was measured while the participants stood static sitting and standing with arms straight up positions from side to front in 90°, 135°, 180°, and bend over positions forward in 45° and 90°. F-test and Duncan post hoc analyses were used to identify if there were any significant effects of sports bra types on garment pressure outcome variables.

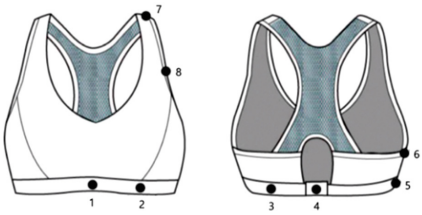

Fig. 2. The eight interface garment pressure points

3 Result

In the survey, 46.6% of the 206 participants answered that they wear sports bras during yoga practicing. They used to wear compression sports bra type (44.7%), compression & encapsulation sports bra with racerback strap type (30.1%), and encapsulation sports bra with tank top strap type (25.2%) (Table 1).

Table 1. The preference of sports bra types

	Type	N(%)
Sports bras	Compression sports bra	92(44.7)
	Encapsulation sports bra	52(25.2)
	Compression & Encapsulation sports bra	62(30.1)
	Total	206(100)

Compared to the encapsulation sports bra shifting satisfaction score (2.42 ± 0.99), the compression sports bra satisfaction scores ($p < 0.001$) were greater in functional design such as the less breast movement (3.62 ± 1.12) and less bra shifting (3.35 ± 1.10). However, the compression sports bra's proper amount of garment pressure satisfaction score ($p < 0.001$, 2.5 ± 1.2) was significantly less than the encapsulation sports bra's (3.61 ± 1.35). Although the compression type was the most preferred by 44.7% of the participants because of its functional feature, the compression caused discomfort caused by tightness and undesirable garment pressure on certain sections of the body (Table 2).

In the experiment, it was found that compression sports bra Type A (1.5 ± 0.87 kPa) and Type B (1.3 ± 0.84 kPa) displayed greater garment pressure than the encapsulation sports bra Type C (0.88 ± 0.74 kPa), Type D (0.78 ± 0.82 kPa), and Type E (0.77 ± 0.35 kPa). Participants expressed feeling of discomfort with the compression sports bra from garment pressure of the side seams at the bottom in Type A and B (3.11 ± 0.30 kPa; 2.13 ± 0.08 kPa) and undesirable tightness of tank top straps in Type B compression (2.68 ± 0.14 kPa) (Table 3).

Table 2. Satisfaction by sports bra types. N = 206

	Mean(SD)			F-value
	Compression (n = 92)	Encapsulation (n = 52)	Compression & Encapsulation (n = 62)	
Breast movement	3.62(1.12) A	2.74(1.23) B	2.32(1.13) C	18.51***
Sports bra shifting	3.35(1.10) A	2.77(1.14) B	2.42(0.99) B	14.61***
Skin irritation by the seams	3.54(1.11) A	2.81(1.23) B	2.81(1.16) B	10.44***
Discomfort tightness	2.50(1.20) B	3.27(1.21) A	3.61(1.35) A	16.03***
Design	2.74(1.18) B	2.62(1.23) B	3.55(1.28) A	10.81***
Bust shape appearance	2.26(1.14) C	3.42(1.33) B	3.87(1.02) A	40.05***

***p < 0.001, A > B > C: Duncan multiple range test

Table 3. The garment pressure by interface points. Unit: kpa

	Mean(SD)					F-value
	Type A	Type B	Type C	Type D	Type E	
A center front point at the bottom	1.80(0.14) A	1.26(0.11) B	0.92(0.21) BC	0.91(0.13) BC	0.75(0.08) C	17.10**
A quarter of front point at the bottom	1.57(0.15) A	1.14(0.07) BC	0.83(0.18) CD	1.17(0.13) B	0.73(0.06) D	13.58**
A side seam point at the bottom	3.11(0.30) A	2.13(0.08) B	2.55(0.25) B	2.50(0.06) B	1.19(0.08) C	30.80**
A side seam point at the top	1.12(0.05) A	0.60(0.06) B	0.32(0.01) C	0.12(0.06) D	0.31(0.08) C	101.08***
A front armhole point	0.98(0.23) A	0.73(0.14) AB	0.45(0.12) BC	0.13(0.00) C	0.64(0.00) AB	11.54*
A shoulder strap point	0.87(0.06) B	2.68(0.14) A	0.66(0.19) BC	0.84(0.02) B	0.43(0.09) C	119.36***
A quarter of back point at the bottom (scapula)	2.21(0.26) A	1.71(0.22) AB	1.11(0.27) BC	0.62(0.25) C	1.35(0.21) B	12.02**
A center back point at the bottom	0.37(0.39) AB	0.14(0.17) AB	0.25(0.07) AB	−.03(0.01) B	0.75(0.33) A	2.92
Mean (SD)	1.50(0.87)	1.30(0.84)	0.88(0.74)	0.78(0.82)	0.77(0.35)	

*p < 0.05, **p < 0.01, ***p < 0.001, A > B > C: Duncan multiple range test

Table 4. The garment pressure by yoga postures (Sitting position). Unit: kpa

		Type A		Type B		Type C		Type D		Type E	
		M(SD)	F	M(SD)	F	M(SD)	F	M(SD)	F	M(SD)	F
The bottom side seam											
Sitting		4.50 (0.24) A	7.97*	2.80 (0.01) A	11.07**	2.52 (0.03) B	3.84*	2.69 (0.35)	3.14	1.75 (0.28)	2.85
Arms straight up	Front	3.08 (0.41) B		2.16 (0.17) B		2.71 (0.29) AB		2.36 (0.20)		1.15 (0.24)	
	Side	3.02 (0.39) B		1.97 (0.10) B		2.50 (0.38) B		2.49 (0.17)		1.13 (0.32)	
Bend over		3.54 (0.44) B		2.21 (0.28) B		3.14 (0.24) A		2.84 (0.39)		1.28 (0.26)	
The scapula											
Sitting		2.54 (0.03) AB	6.03***	2.24 (0.00) A	17.71***	0.91 (0.01) C	13.26***	0.81 (0.12) B	14.10***	2.13 (0.29) A	4.86*
Arms straight up	Front	1.95 (0.69) B		1.53 (0.12) C		1.10 (0.29) BC		0.71 (0.03) C		1.17 (0.26) C	
	Side	2.13 (0.57) B		1.83 (0.21) B		1.29 (0.17) B		0.81 (0.04) B		1.42 (0.43) BC	
Bend over		3.35 (0.08) A		2.22 (0.16) A		1.81 (0.01) A		0.90 (0.04) A		1.82 (0.40) AB	

*p < 0.05, **p < 0.01, ***p < 0.001, A > B > C: Duncan multiple range test

When the compression sports bra garment pressure was analyzed in various static sitting and standing poses, the garment pressure was dramatically changed in static sitting poses. Compared to standing poses, overall, static sitting poses displayed higher garment pressure at the eight interface garment pressure points. In the static sitting posture ($p < 0.001$), Type A compression garment pressure of the bottom side seam was significantly increased (4.5 ± 0.24 kPa). In sitting bend over posture, the compression sports bra garment pressure was greater at the following interface points: the scapular (3.35 ± 0.08 kPa) and the bottom side seam (3.54 ± 0.44 kPa) (Table 4). Also, in standing, the bend over posture resulted in greater interface garment pressures at the bottom of side seams (3.47 ± 0.24 kPa) and the scapula (2.70 ± 0.20 kPa) in the compression sports bra Type A and Type B. The shoulder strap in Type B was shown greater sports bra garment pressure in standing with arms straight up and front ($p < 0.001$) (Table 5).

Table 5. The garment pressure by yoga postures (Standing position). Unit: kpa

		Type A		Type B		Type C		Type D		Type E	
		M(SD)	F	M(SD)	F	M(SD)	F	M(SD)	F	M(SD)	F
The bottom side seam											
Standing		2.50(0.42) C	11.20***	2.05(0.27) B	5.24*	2.01(0.14) B	2.14	2.01(0.04)	1.78	0.81(0.31)	0.50
Arms straight up	Front	2.97(0.18) B		1.98(0.06) B		2.44(0.23) AB		2.44(0.44)		1.24(0.52)	
	Side	2.60(0.29) BC		1.94(0.28) B		2.19(0.59) AB		2.36(0.54)		1.13(0.46)	
Bend over		3.47(0.24) A		2.39(0.07) A		2.73(0.21) A		2.86(0.42)		1.12(0.21)	
The scapula											
Standing		1.27(0.28) C	10.61**	1.26(0.16) B	7.94**	0.66(0.28)	0.52	0.09(0.01) B	4.11*	0.78(0.28)	0.80
Arms straight up	Front	2.20(0.38) AB		1.41(0.11) B		0.95(0.31)		0.46(0.15) A		1.20(0.49)	
	Side	1.65(0.41) BC		1.70(0.19) A		0.98(0.42)		0.42(0.20) A		1.23(0.50)	
Bend over		2.70(0.20) A		1.69(0.09) A		0.93(0.08)		0.61(0.19) A		1.36(0.22)	

*p < 0.05, **p < 0.01, ***p < 0.001, A > B > C: Duncan multiple range test

4 Conclusion

High interface garment pressure has been found from the compression sports bra. Although the compression sports bra type has reported as the most favorable design by consumers, it was identified as the least comfort due to high garment pressure on the body during static yoga poses. Similarly, in our experiment, the greater garment pressure has been identified at the shoulder straps, the bottom side seams and the scapula. The undesirable garment pressure causes skin irritation, tightness, and feeling of discomfort during static poses. Considering long hours of static poses in yoga, the garment pressure might be a critical issue. Results from this study bring insights of the garment pressures in relation to the type of activity and suggest yoga sports bras in ergonomic design. Further studies should be done for developing yoga sports bras that would reduce unnecessary garment pressure and strap tension during still poses.

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Study on the Design of Asymmetric Breast Correction Product

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Abstract. Women with asymmetric breasts need the help of correction products in their daily life, but the products on the market are in a single form and lack of such theoretical research. Therefore, this study aims to propose a design method that can provide women with appropriate correction products and improve women's confidence in life. Methods on the basis of literature research, firstly, the behavior analysis of brassiere wearing for women with asymmetric breasts was carried out to explore the pain points affecting the target users. Secondly, the mirror theory was used to translate the pain points, and the core requirements were obtained, and the design method of asymmetric breast correction products was proposed. Results asymmetric breasts were divided into three categories, and brassiere suitable for the target group was proposed. Conclusion it can provide reference for the innovative model of asymmetric breast correction products.

Keywords: Breast · Asymmetry · Behavior analysis · Product design

1 Introduction

With the development of economy, modern women pay more and more attention to the pursuit of beauty. Breast, as one of the second sexual characteristics of women, has been transformed from the former reproductive organ into the key part to show the beauty of women, which increasingly highlights its side as an aesthetic standard. The aesthetics of breast shape has gradually attracted the attention of researchers, among which breast symmetry is one of the important indexes to evaluate the beauty of breast shape [1]. However, there is a certain degree of asymmetry in the symmetrical sexual organs of the human body, and there is a general asymmetry in the breasts of mature women. This situation will cause women to pay attention to their body shape and physical and mental health, resulting in negative emotions such as inferiority, sensitivity, etc., which makes the demand of beauty loving women for chest correction increasingly urgent. However, the existing correction products on the market are in a single form (Fig. 1), which can not be targeted to match the diverse breast shape of women. In academia, there is a lack of theoretical reference for the design of asymmetric breast correction products. Therefore, this study extracts pain points through user behavior, and then transforms the pain points into expectations, proposes

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a classification method of asymmetric breast, improves the theory of asymmetric breast field, and applies it to the design of corrective brassiere to help women obtain symmetrical breast appearance.

Fig. 1. Pictures of existing products

2 Correction of Asymmetric Breast

The asymmetry of breast shape is shown by the difference of breast height, breast outline and breast volume [2]. The two most widely used methods to correct the shape of the breast are breast plastic surgery and adjustable bra.

Breast plastic surgery is to repair and reconstruct the breast appearance of women who are not satisfied with their own chest shape by means of surgery. The general procedure is to use visual inspection, 3D scanning and other methods before operation, classify the patients' breasts according to the classification standard of surgery, and then adopt the operation methods such as mastectomy and breast filling according to different types, and observe and adjust after operation. In theory, breast plastic surgery can relatively accurately and customized solve the problem of asymmetric appearance of women's breasts, but because invasive surgery will have the risk of disease and there will still be a certain proportion of asymmetry after the operation, the doctor's own clinical experience is required to be high, which is not selected by most women.

Adjustable bra is defined as a kind of bra that can adjust the female's chest type. It can be interpreted as the purpose of using the optimized material and structure to protect and fix the chest in order to correct the appearance of the chest. The design of the adjustable bra follows the principles of functionality, comfort and beauty, and carries out the cup structure design based on the analysis of the female chest shape. But for women with asymmetric breasts, the adjustable brassiere designed according to the same shape of both breasts is obviously not suitable for their left and right breasts of different sizes. There are two reasons for unsuitable: first, there is no suitable chest shape, second, there is no suitable cup structure.

Combined with the advantages of medical procedures and the design principles of adjustable bra, the design reference of correction products adapted to asymmetric breast was sorted out.

3 Asymmetric Breast Product Design Method

3.1 Analysis of Brassiere Wearing Behavior of Target Users

When users interact with the product, they will perceive the appearance, material and touch of the product through their senses, and emerge the use function and operation sequence of the product [3], forming a good interactive experience. User behavior analysis can help designers to restore user scenarios more deeply, and understand user motivation and needs. Therefore, based on the observation and literature integration in the local brassiere stores, the behavior and pain points of women with asymmetric breasts are roughly sorted out as follows: before wearing brassiere, during wearing brassiere and after wearing brassiere.

1. Measurement of chest size: no obvious pain point
2. Determine breast type: the shape of the smaller side of the chest is ignored.
3. Choose brassiere suitable for breast shape: Based on the fit between the breast on the larger side and the cup
4. Wearing brassiere: no obvious pain points
5. Placement of fillings into one side of the small chest: the fillings have poor fitness; the correction effect is not obvious
6. Adjust shoulder belt: no obvious pain point
7. Take off brassiere: no obvious pain point.

3.2 Construction of Core Requirements of Target Users

It is very important for designers to have a clear understanding of the needs of customers. By analyzing the pain points of users' behaviors, the core pain points of women with asymmetric breasts in (2), (3), (5) and (7) are sorted out, and the valuable design directions for the target users are put forward. In this study, we use the mirror theory [4] to translate the pain points generated in the user's behavior analysis into "complaints", and then turn "complaints" into "wishes" (Table 1). We can get two core requirements: 1. We hope that both breasts will be treated differently; 2. We hope to get a symmetrical chest appearance.

Table 1. The model of mirror theory analysis

Activities	Complains	Wish model
2. Determine breast type	The evaluation criteria of bilateral breast morphological characteristics are the same	Different evaluation criteria of bilateral breast morphological characteristics
3. Choose brassiere suitable for breast shape		
5. Placement of fillings into one side of the small chest	Asymmetric appearance of chest	Symmetrical chest appearance

3.3 Product Design Method of Target Users

According to the core needs of users, users expect to improve from human factors engineering (breast shape) and product design (design elements). Based on the core requirements of the target users, this study divides the asymmetric breast into three categories from the perspective of product design, and proposes a design method of asymmetric breast correction products (Fig. 2). This design method can provide theoretical reference for the design of chest correction products, enrich the knowledge of related fields, and make the products better serve people.

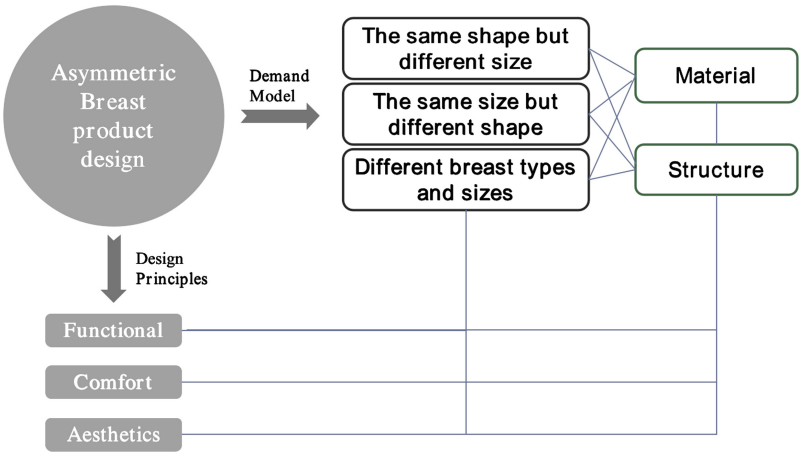

Fig. 2. Asymmetric breast product design method

4 Brassiere Design Scheme

Based on the analysis of asymmetric breast type and the basic theory of brassiere [5] design, a new structural design of adjustable brassiere is proposed (Fig. 3). Structure name and corresponding functions are shown in Table 2. Users should first confirm

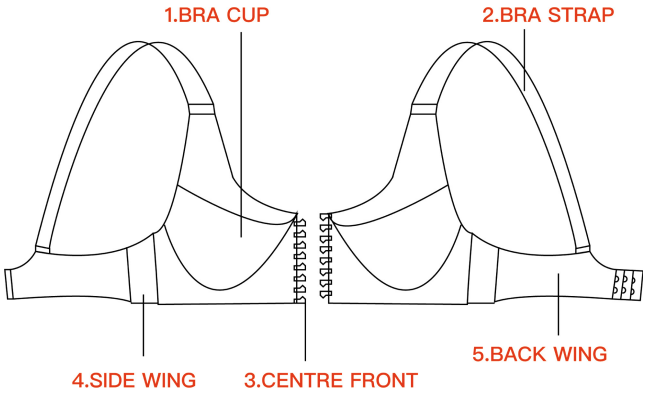

Fig. 3. The structure of the bras

their own breast type, then select the corresponding cup according to the different breast shape on the left and right, then use the zipper to connect the two different cups, adjust the ratio of shoulder belt and back, and finish wearing.

Table 2. The function of brassiere

Items	Function
1. Bra up	Wrap, secure, protect breasts
2. Bra strap	To adapt to the shoulder thickness difference of different users
3. Center front	Used to stabilize bra structure and connect left and right cups
4. Side wing	Wrap up the accessory breast and back fat
5. Back wing	It is used to adapt to the difference of lower chest circumference of different users

5 Conclusion

This study provides a reference for the design and development of asymmetric breast correction products by exploring the behaviors and needs of women with asymmetric breasts. In addition, based on the literature review, this study puts forward suggestions for the classification of asymmetric breasts, and future research will verify the correction results by measuring the human body data when users wear bras.

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A Study on the Functional Dimensions of Chinese People for Workspace Design

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Abstract. This study makes statistics and analysis on the body size for the working space of different gender and different age groups by using the regression formulas in GB/T 13547-1992 and the newly collected data of height and weight obtained in the national adult body size survey. The data obtained can be used for the design and ergonomic evaluation of various working spaces related to human body size, such as operation, maintenance, safety protection, etc.

Keywords: Functional dimensions · Chinese people · Workspace

1 Introduction

People's basic postures are generally standing, sitting, kneeling, lying, climbing and so on. In general, the measurement of human body size will be based on the two postures of standing and sitting. Due to the long time and complex measurement, it is difficult to carry out a large number of sampling measurements for position of kneeling, lying and climbing. Therefore the indirect way of linear regression could be taken on the basis of Chinese adult body size measurement.

According to the cluster analysis of the correlation coefficient of human body size, the items of human body size can be roughly divided into two categories. One is the size items reflecting the length of human body, such as height and upper limb length; the other is the items reflecting the horizontal size of human body, such as chest circumference, weight and chest thickness. Moreover, the size items reflecting the length of human body are all proportional to the height (closely related), and the items reflecting the horizontal size of human body are closely related to the weight or chest circumference. Considering that chest circumference is inconvenient to measure, height and weight are the most basic size items in human body size, which are easy to measure and ensure accuracy, therefore, height and weight can be selected as independent variables of regression equation. The linear regression equations between human body size items and basic human body size items (height, weight) were established in GB/T 13547:1992 [1]. By substituting the basic body size item data involved in the established regression equations, the corresponding workspace body size item values can be obtained.

In 2013–2018, China Institute of standardization sampled and measured the body size data of more than 26000 samples in different regions, ages and genders. The collected data did not include the workspace size data such as kneeling, lying and

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climbing positions. According to the newly collected data of height and weight of the national adult body size, using the regression formulas in GB/T 13547:1992, this study makes statistics and analysis on the body size of the workspace for different gender and different age groups.

2 Sample Distribution

In this survey, stratified multi-level cluster sampling is adopted. According to the difference of Chinese people's body shape, the whole country is divided into six regions: North China, central and Western China, the middle reaches of the Yangtze River, the lower reaches of the Yangtze River, Guangdong, Guangxi and Fujian, YunGuichuan. Each region selected 3–6 cities, and 32 cities were selected from the whole country. The sample number of each region is determined according to the population proportion of the 2010 national census data. The total number of people sampled is more than 26000, of which the ratio of men and women is basically 1:1.

3 Measurement Method

This nationwide body size measurement adopted the method of combining 3D body scanning with manual measurement. Height and weight were measured by hand. Height was measured by Martin's ruler and weight was measured by weight meter.

4 Data Analysis

4.1 Size of Human Body in Working Space of Different People

Using the regression formulas in GB/T 13547-1992, the P50 data of newly collected height and weight data for men and women are substituted into the regression formulas to get the body size of workspace for different gender groups, as shown in Table 1.

Table 1. Body size of workspace for different gender groups (mm)

Gender	Kneeling length	Kneeling height	Prone position length	Prone position height	Crawling position length	Crawling position height
Male	628	1265	2138	378	1321	801
Female	590	1197	1984	374	1239	738

It can be seen from the data that the P50 percentile values of the six data items of men are greater than those of women.

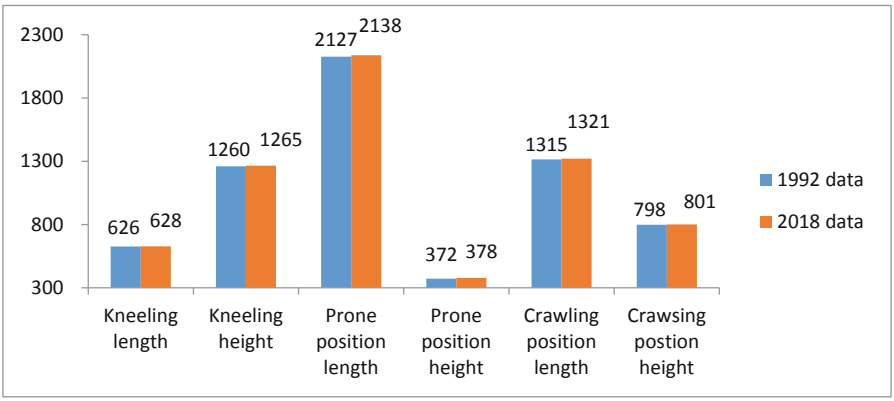

Fig. 1. Comparison of the data for males

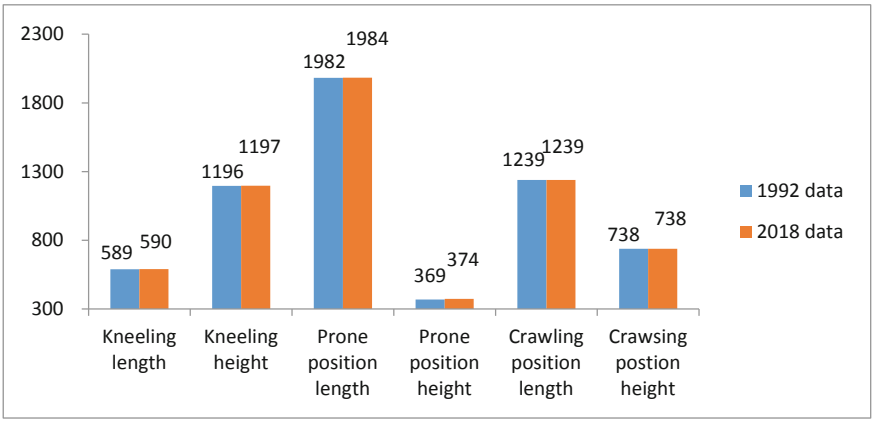

Fig. 2. Comparison of the data for females

Compared with the data in GB/T 13547-1992, the histogram is shown in Fig. 1 and Fig. 2.

It can be seen from Fig. 1 and Fig. 2 that the six dimensions of men's have increased from 0.32% to 1.61%, among which the largest increase is proposed position height. For women, besides crawling position length and crawling position height, the other four items also increased by 0.08%–1.36%, proposition height is also the largest increase data. On the whole, the increase of men is larger than that of women.

5 Body Size of Workspace for Different Age Groups

Table 2 and Table 3 show the body size of workspace for different age groups.

From Table 2 and Table 3, it can be seen that the size of human body in the working space is different for different age groups due to their different height and

Table 2. Body size of working space for male of different ages (mm)

Gender	Kneeling length	Kneeling height	Prone position length	Prone position height	Crawling position length	Crawling position height
18–25	641	1290	2184	375	1345	814
26–35	635	1279	2164	379	1334	808
36–60	623	1254	2118	379	1310	795

Table 3. Body size of working space for female of different ages (mm)

Gender	Kneeling length	Kneeling height	Prone position length	Prone position height	Crawling position length	Crawling position height
18–25	600	1216	2021	369	1258	752
26–35	596	1208	2005	372	1250	746
36–60	587	1192	1974	376	1235	735

weight. Among them, kneeling posture length, kneeling posture height, prone posture length, climbing posture length and climbing posture height are related to human height, and their values decrease with the increase of age. Body height in prone position is related to body weight and decreases with age.

6 Conclusions

In general, the measurement of human body size will be based on the two postures of standing and sitting. Due to the long time and complexity of measurement, large-scale measurement is not generally carried out the positions such as lying and climbing. But these kinds of data are important parameters in the design of working space such as maintenance and safety protection. According to the latest data of height and weight of national adult body size, this study uses the regression formulas in GB/T 13547-1992 to make statistics and analysis on the body size of the working space for different gender and age groups, and obtains the basic static body size data of Chinese adults related to the working space.

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Reference

1. GB/T 13547-1992 Human dimensions in workspaces

Experimental Study on Tightening Torque of Bottle Cap

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Abstract. Too much tightening torque of the bottle cap can cause the user difficulty in opening the bottle. The purpose of this paper was to explore factors affecting the tightening torque of the bottle cap. The test scenario of tightening operation of bottle cap was established. The tightening torques of sixteen young subjects (8 male/8 female) were measured at four operating distances, two working postures and three types of bottle cap diameters (30 mm, 36 mm and 60 mm). The results showed the larger the bottle cap diameter, the greater the tightening torque required of bottle cap. Gender, height, weight and hand length had significant influence on the tightening torque, and the tightening torque of men was larger than that of women when opening the bottle cap. However, the working posture and distance had no significant impact on the tightening torque. The research results could have some practical reference value for the ergonomic design and evaluation of manual knob torque.

Keywords: Tightening torque · Correlation · Ergonomics

1 Introduction

In daily work and life, manual rotating operation is often used, such as opening the drink bottle cap. The performance of manual rotating operation may be affected by such factors as torsional force/torque, gender, human body size (height, weight, hand length and hand width, etc.), size of rotating parts (diameter, height, length and width, etc.), material of contact surface, operation with gloves or not, operating distance, working posture and height [1–7].The aim of this study was to investigate the daily tightening operation of the bottle cap, especially the tightening operation of closing the cap after use. As such, the tightening torque of the bottle cap was to be measured, and the main influential factors of the tightening torque of the bottle cap were to be analyzed.

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2 Methods

2.1 Subjects

Sixteen young people (8 men/8 women) were recruited to take part in the tightening torque test of the bottle cap. The subjects were required to be in good health and free from quadriplegia. Prior to this experiment, the subjects were introduced to the experiment contents, specifications and action posture. The basic information of subjects was shown in Table 1.

Table 1. Basic information of subjects

Factor	Male (Mean ± SD)	Female (Mean ± SD)
Age	21.8 ± 0.7	21.4 ± 0.5
Height (mm)	1759.6 ± 43.8	1618.6 ± 37.2
Weight (kg)	63.0 ± 6.5	56.0 ± 4.8
Arm length (mm)	616.3 ± 36.0	577.9 ± 25.4
Hand length (mm)	184.4 ± 7.7	173.6 ± 6.3
Hand width (mm)	97.5 ± 5.6	90.7 ± 3.3

2.2 Experimental Set-up

The Marker10 dynamometer (Fig. 1) can accurately capture the torque peak value when rotating by using the high-speed 7000 Hz sampling rate. Its clamp size can be adjusted to meet the measurement of the rotating force/torque of various shapes of containers. The maximum torque measurement range is 11.5 N.m.

Through the investigation of diameters of drink bottle caps in the market, three commonly used round caps (30 mm, 36 mm and 60 mm) were selected as the test objects (Fig. 2).

Fig. 1. Marker 10 dynamometer

Fig. 2. Three sizes of bottle caps

2.3 Experimental Specification

Operating Distance: Considering the individual difference of arm length of subjects for controlling the arm posture (the same angle between the upper and the lower arms), the required tightening torques were measured when tightening the bottle cap at the straight arm, 4/5 arm, 3/4 arm and 2/3 arm positions, respectively to compare the torsional torque of men and women in the same arm posture.

Working Posture: considering that the tightening torque may be different due to different working postures, subjects were required to measure comfortable tightening torque (acceptable tightening torque) and maximum tightening torque under sitting/standing postures.

Hand Posture: Hold the bottle cap with the right hand, tighten the bottle cap clockwise, and keep the body posture unchanged during the test.

2.4 Experimental Procedures

The test scenario was shown in Fig. 3. The specific steps were as follows:

1) The bottle with the cap diameter of 30 mm was fixed on the dynamometer, whereby the subjects adjusted the front and rear positions of the seat and the dynamometer independently to ensure that they could hold the cap in a straight arm position.
2) The subjects mimicked the operation of tightening the bottle cap. The comfortable tightening torque and the maximum tightening torque were measured (measured 3 times respectively, taking the average value).
3) Keep the above sitting posture and bottle cap size unchanged, then complete the tightening torque measurement of the bottle cap at the positions of 4/5 arm length, 3/4 arm length and 2/3 arm length.
4) Measure the comfortable tightening torque and the maximum tightening torque of 36 mm and 60 mm bottle cap diameter with the same steps.
5) In a comfortable standing posture, the subjects replicated the operation of tightening the bottle cap. The comfortable tightening torque and the maximum tightening torque at the positions of 4/5 arm length and 3/4 arm length were measured.

Note: after each measurement, the subjects rested for 1–3 min to prevent measurement error caused by operation fatigue.

Fig. 3. Test scenario

2.5 Data Analysis

In this study, IBM SPSS 23 statistical software was used to analyze the correlations between working posture, operating distance, bottle cap diameter, gender, human body size (height, weight, hand length and hand width) and tightening torque. The differences of tightening torque between men and women in sitting/standing posture, different operating distance and three bottle cap diameters were statistically analyzed.

3 Results

3.1 Tightening Torque

The maximum tightening torque of women was about 55% less than that of men, and the comfortable tightening torque of women was about 57% less than men. Through independent sample t-test analysis, the results showed that the tightening torque of men was significantly greater than that of women (Fig. 4).

Sixty-nine percent (69%) of the subjects in comfortable position (4/5 arm length, 3/4 arm length and 2/3 arm length) had the maximum tightening torque greater than those in uncomfortable position (straight arm); 75% of the subjects in comfortable position had the maximum tightening torque greater than those in uncomfortable position. The maximum tightening torque was at 4/5 arm length position, and the minimum tightening torque was at the straight arm position (Fig. 4).

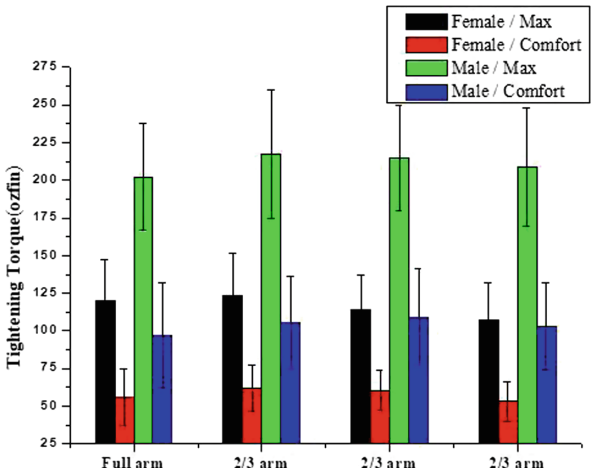

Fig. 4. Tightening torque for men/women at four operating distances (cap diameter 30 mm/sitting).

The maximum tightening torque in standing posture was less than the maximum tightening torque in sitting posture, which was approximately 87% of the maximum tightening torque in sitting posture. The comfortable tightening torque in standing posture was also less than the tightening torque in sitting posture, which was about 84% of the comfortable tightening torque in sitting posture (Fig. 5).

Comfortable tightening torque to maximum tightening torque ratio was about 0.5.

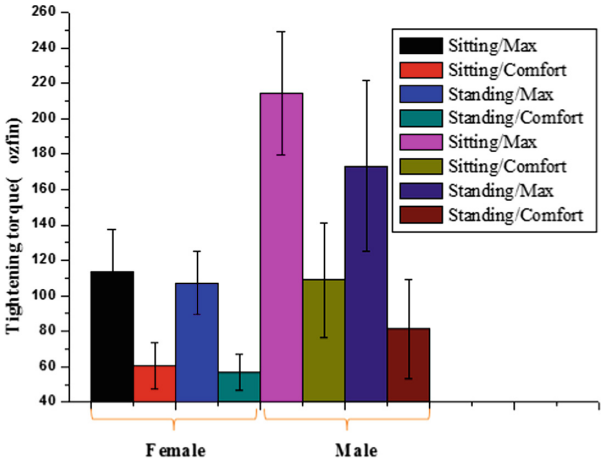

Fig. 5. Tightening torque for men and women in sitting/standing position (3/4 arm length)

The tightening comfort torque and maximum torque of the three types of bottle cap diameter were shown in Fig. 6, indicating the larger the bottle cap diameter, the greater the comfort tightening torque and maximum tightening torque.

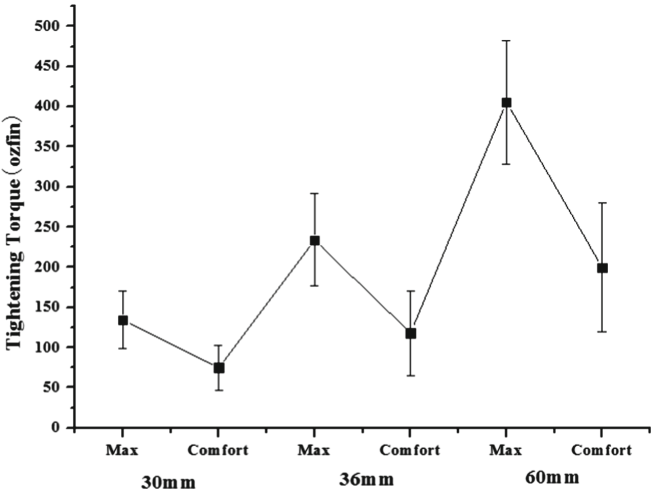

Fig. 6. Tightening torque of different cap diameters (n = 14)

3.2 Correlations

The correlation between human factors (gender, height, weight, hand length and hand width), operating distance, working posture, bottle cap size and tightening torque was shown in Table 2.

1) Gender was significantly related to the tightening torque of the bottle cap.
2) Height and weight were significantly related to the tightening torque of bottle cap.
3) Hand length had a significant effect on tightening torque, while hand width had no significant effect on tightening torque.
4) The operating distance and working posture were not related to the tightening torque.
5) The diameter of the bottle cap significantly contributed to the tightening torque.

Table 2. Correlation between various factors and tightening torque

Factor	Maximum tightening torque		Comfortable tightening torque	
	r	p	r	p
Gender	0.856**	0.000	0.713**	0.002
Height	0.791**	0.000	0.717**	0.002
Weight	0.728**	0.001	0.783**	0.000
Hand length	0.668**	0.005	0.571*	0.021
Hand width	0.291	0.274	0.496	0.051
Operating distance	−0.029	0.818	0.032	0.802
Working posture	−0.198	0.117	−0.215	0.088
Diameter	0.880**	0.000	0.676**	0.000

**$p < 0.01$ *$p < 0.05$

4 Discussion

The tightening torque of the bottle cap was positively related to the bottle cap diameter (Fig. 6), which was consistent with the conclusion of the literature reviews [5–7]. There were certain differences in the tightening torques required for different working positions (sitting/standing), with the tightening torques in sitting position being larger than those in standing position (Fig. 5). These differences were due to the rotating operation in sitting position being easier to exert force than those in standing position when the subjects were required to operate with one hand. Also, the tightening torques in bottle cap operation for males were larger than females, which were consistent with the fact that male strength was generally larger female.

The tightening torque was significantly related to gender, height, weight, hand length and hand width. The tightening operation of the bottle cap can be extended to the general single hand rotating operation such as the manual knob operation. The rotating torque characteristics of the manual operation can be referred to the methods and results in this study.

This study was an experiment on the tightening torque of the bottle cap of sixteen young subjects in sitting/standing position. The results were limited as follows: First, the sample size was small, and the subjects operated with only the right hand. Second, the influence of the operating height of the bottle cap in sitting/standing position was not being factored in this study. Third, although four operating distances were given, the difference between them was not statistically significant except for the full arm, whereby the distance difference of the other three was very small (4/5 arm length, 3/4 arm length and 2/3 arm length). Finally, the research results were limited to the above three kinds of cap diameters.

5 Conclusions

The tightening torques of sitting/standing position, four operating distances and three bottle cap diameters were measured, and the following results were obtained.

1) The maximum tightening torque and comfortable tightening torque of men were significantly larger than those of women.
2) Height, weight and hand length of subjects had significant effects on the tightening torque. However, the working posture and operating distance had no significant effect on the tightening torque.
3) diameter of the bottle cap was significantly related to the tightening torque, showing a positive relationship between the bottle cap diameter and the tightening torque.

Acknowledgments. This research was supported by the Beijing Natural Science Foundation Project [kz201811417048], National Quality Infrastructure (2017NQI) project (2017YFF0 206603) and President Foundation of China National Institute of Standardization (project number 522018Y-5984).

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Ergonomic Characteristics and Usage Habits of aAdult Backpack

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Abstract. As the most commonly used storage tool, backpack is one of the daily necessities for adults. The long-term incorrect bearing way and bearing behavior habit can cause harm to the adult's neck, shoulder and other body parts. In this paper, adults are taken as research objects. Through questionnaires and in-depth interviews, characteristics and usage habits of adult backpacks are obtained, and the ergonomic experiment scenario of backpacks is determined. It lays the foundation for further experiments.

Keywords: Adult backpack · Behavioral habits · Ergonomics

1 Introduction

With the development of human society, health is the basis of human production and life, but it is often easily neglected. In the 21st century, backpack has become one of the indispensable tools in people's daily life. Teenagers are the main group of people who use backpack. Many scholars have devoted themselves to studying the impact of backpack on human body.

At present, scholars' researches on the influence of backpacks on balance, body posture and gait of teenagers mainly focus on the influence of different loads on backpacks, while there are relatively few studies on the influence of different load positions and different backpacks on balance, body posture and gait of teenagers [1]. According to relevant studies [2–4], it can be inferred that back loading will increase the overall weight of the body and shift the human mass center (center of mass, COM) of the whole body upward, which will reduce the effectiveness of posture control and increase posture sway, thus reducing the balance ability of the body. When the body is in balance, the stress center of the body (center of pressure, COP) is fixed in a relatively stable position. However, when the external body is given a certain amount of weight, the COP will increase the displacement of the front and back and left and right directions, and the posture will increase, thus reducing the balance ability of the body. Grimmer et al. [5] analyzed the influence of backpacks of three different weights (3%, 5%, 10% BW, body weight) on standing posture of 250 adolescents aged 12–18 years, and showed that the forward displacement of all anatomical points (head, neck, shoulders, hips, thighs, knees, and ankles) increased linearly with the increase of

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backpacks. Hong, Brueggemann et al. [6] studied the changes in gait of a 10-year-old boy when carrying a backpack (0%, 10%, 15% and 20% BW). The results showed that, compared with 0% BW, the trunk significantly leaned forward when carrying 20% BW. Wang min et al. [7] found that backpack weight and backpack mode can affect the spine morphology of adolescents.

So far, most research on the effects of backpacks on the human body has focused on teenagers, with only a handful of researchers studying the effects of adult backpacks. Charteris [8] selected 45 young male subjects to carry 20%, 30%, 40%, 50% and 60% BW respectively and walk 40 m on the flat ground. The results showed that with the increase of backpack load, the double support time increased significantly, the stride length decreased, and the joint Angle of lower limbs also changed accordingly.

In this paper, adults of different ages were selected. Through questionnaires and in-depth interviews, the characteristics, use habits and purchase preferences of adult backpacks were extensively investigated to obtain the characteristics and use habits of adult backpacks, laying a foundation for the subsequent experiments.

2 Research Methods

This paper mainly uses questionnaire survey and interview to explore the use habits of adult backpack and the impact of backpack on it.

2.1 Questionnaire Survey

Using the self-compiled "The questionnaire of the burdened products", through WeChat, QQ to many provinces and cities throughout the country (including the first, second, third and fourth tier cities), questionnaires were sent to non-specific objects. A total of 111 valid questionnaires were received. Respondents ranged in age from 18 to 60, with 34.23% of men and 65.77% of women.

The questionnaire mainly includes the basic situation of the backpack, the bearing situation, the impact on the body, and the selection of the backpack.In the preliminary work, sufficient literature review was carried out to analyze the length and width of backpacks that affect the comfort of backpacks, the external shape of backpacks and the layout of backpacks; strap width, spacing, thickness, etc.; hardness-softness and comfortable pressure of backpacks and straps; relevant factors such as the layout of the function modules and the size of the structure were analyzed, which laid a good foundation for compiling the questionnaire. In the process of compilation, the results of literature review, related assessment tools and open survey results were taken into overall consideration. The items of the questionnaire were all derived from the results of open questionnaire, literature review and related assessment tools at home and abroad. Prior to the initial test, relevant experts (including professors of psychology and education and PHDS of psychology and ergonomics) were asked to review and revise the items of the pre-test questionnaire. Before the formal investigation, some adults were asked to fill in the questionnaire to make it easy to understand, applicable and consistent with theoretical assumptions. These measures ensure that the questionnaire has a good content validity.

2.2 Interview Method

The interview outline of this paper is designed based on the data analysis results of the questionnaire to explore the health needs and use habits of adults for backpacks. The interview selected 30 subjects. The subjects were interviewed according to the outline, communicated with and interviewed in a relaxed and comfortable atmosphere, and their backpacks were photographed under different conditions (standing, walking, running, climbing and descending).Through the question and answer on the number and replacement frequency of the respondents' existing backpacks, we can understand their demand for backpacks. In view of the problems of backpack material, style, structure design, price, etc., the use needs and purchase preferences of adults for backpack can be further understood. By talking about the suitability and comfort of a backpack, the parts or positions that make carrying a backpack uncomfortable for adults can be learned clearly.

3 Survey Results and Analysis

3.1 The Weight of Backpacks

In the investigation of the bearing situation, 36.94% of adult backpack is about 2 to 4 kg, while 35.14% students backpack is about 0 to 2 kg. The reason may be that the subject group is the most concentrated between 18 to 35 years old. This age group mainly are college students, graduate students and office workers, so their backpacks mainly contain items such as computer, books, paper towels glass and other daily necessities. Moreover, the time and distance of using the backpack are closely related to the schedule of courses and working hours.

3.2 The Frequency of Changing Backpacks

The survey found that most people change their backpacks in more than six months. Among the reasons for changing backpacks, damaged backpacks, outdated backpacks and tired or uncomfortable backpacks rank among the top three, as shown in Fig. 1. Therefore, it is not hard to see that the quality and comfort of backpacks are the most concerned parts of adults.

3.3 The Buying Preferences of Backpacks

The results showed that most adults ranked "carrying comfort" as the top concern when buying a backpack, followed by other factors such as style, price and function. Therefore, it can be found that when people choose a backpack, comfort has become the first choice of people, and the last is the material of the backpack. Few people consider whether the material of the backpack is environmentally friendly.

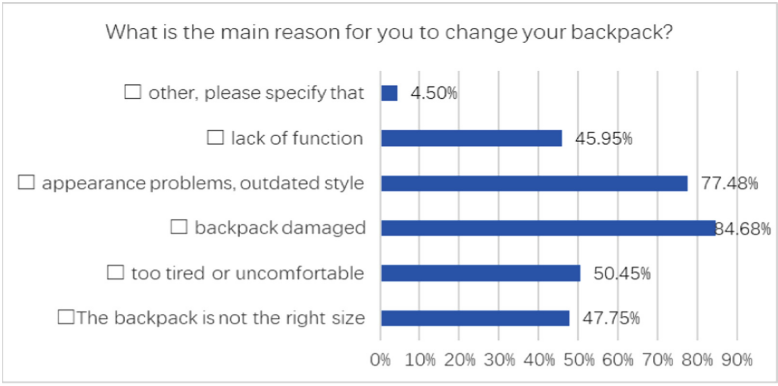

Fig. 1. The reason for changing the backpack

3.4 The Physical Effects

During the questionnaire survey, the subjects generally paid more attention to the impact of backpacks on human health, and they talked about their terrible feelings when carrying backpacks, mainly including: shoulder strap slipping; the length of the shoulder straps on both sides is different, which leads to the imbalance of the backpack; when walking or running, the things in the backpack fall back; the backpack does not fit with the body, etc. As shown in Fig. 2.

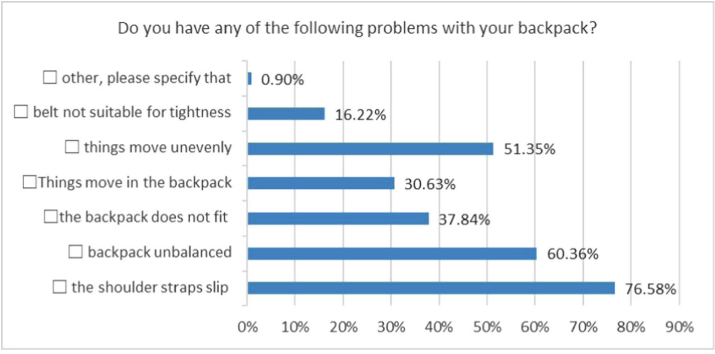

Fig. 2. The problems of carrying the backpack

In these undesirable situations, shoulder strap slipping is the first. The reasons are as follows. Firstly, it is related to shoulder strap material. Aglet slide shoulder may be related to the material. Now on the market a lot of manufacturers design fine heavy chains such as plastic to make it good-looking. Although this kind of material will make backpack become fashionable, but it is not practical. Because of less friction, it's easy to slip from shoulders. Secondly, it is related to the size of the shoulder strap. In addition to the wide and thick shoulder straps of student backpacks and mountain bags,

many backpacks use narrow shoulder straps for aesthetic reasons, and some have even become cylindrical. As a result, the straps easily swim over the shoulders, causing them to slip. Thirdly, it is related to the length of shoulder strap. Because the length is not adjusted well, the length of the shoulder strap is adjusted too loose, which is easy to slip from shoulders. Finally, the incorrect posture of the backpack is also one of the causes of shoulder slip.

The second problem is backpack imbalance. This phenomenon is mainly caused by the following three reasons. The first reason is that the length of shoulder straps on both sides is different. The second reason is that the imbalance of the items in the backpack causes the imbalance of the backpack even though the backpack is very upright. The last reason is that due to the phenomenon of high and low shoulders, the backpack is unbalanced.

The third problem is backpack unsuitability. When walking or running, backpacks don't fit. Ergonomically, backpacks fit the back, it can disperse the weight of the backpack from the shoulder to the back to the hip, effectively reducing the load on the shoulders. The reason why the backpack does not fit with the back is that the length of the shoulder strap is too long. So, the gap between the backpack and the back can be alleviated by adjusting the length of the shoulder strap.

The last problem is bearing friction. The friction between the backpack and the shoulder is relatively large, mainly because the backpack does not fit with the back. It makes the shoulders bear the weight of the whole backpack, thus resulting in the large friction between the backpack and the shoulders. Secondly, due to the fierce market competition, many manufacturers leave out the cushion in order to reduce the cost of production. It makes the backpack and the back of the body directly contact, causing greater friction and making the human body feel uncomfortable. The friction between backpack and waist cannot be ignored. Now in the market, few consider the backpack's influence on the human body. Thus, a lot of backpacks don't have belt. This makes the great weight of the backpack borne by the waist. The friction between bag and the waist is very big, so it causes great damage to human body.

During the interview, the subjects generally reported that after carrying the backpack for a long time, they would suffer from shoulder pain, neck pain, back pain, back pain and other physical discomfort. The reason for this kind of physical discomfort may be that the design of the backpack itself does not conform to ergonomics. For example, the shoulder strap of the backpack is too thin; the material of the backpack is too hard and so on. Secondly, people use the wrong way of backpack, such as putting the shoulder strap too long, so that the weight of the backpack cannot contact with the back of the body. The weight of the shoulder is too large, resulting in a sense of painfulness after carrying the backpack. Some people carry the backpack on one side, so that the pressure on one side is too heavy, thus causing high and low shoulder.

4 Conclusion

With the development of the society, people's requirements for backpacks have gradually changed. They have higher requirements for the comfort and health of backpacks. Therefore, in order to meet people's needs to the greatest extent and

improve the comfort of backpacks, backpack manufacturers should make adaptions. On the one hand, the manufacturer can increase the thickness and width of the shoulder strap. Therefore, the weight of the backpack can be dispersed in the shoulder. In this way, it can relieve the pain of the shoulder. In addition, backpack manufactures can add a belt on the backpack. Therefore, when the backpack is overweight, the belt can relieve the stress of the shoulders and pass it to the back of the human body. Moreover, it can alleviate the friction of shoulder and reduce the fatigue of human body. Besides, it can make a cushion for the back, in which the contact between the human and backpack becomes more comfortable. On the other hand, backpack manufacturers should make backpack instructions, instructing the correct backpack posture. In this way, it can make full use of the backpack and finally make the backpacker feel comfortable and healthy.

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Physical Design Assessment of the Nintendo Switch Controller Configurations

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Abstract. The Nintendo Switch is a popular hybrid portable gaming console that employs a novel modular design, enabling it to be played in multiple controller configurations: Handheld mode, left and right JoyCon Sticks, and the JoyCon Grip. However, issues with physical discomfort have been noted among its user base, especially after extended periods of use. This could be the cause for user injury after prolonged use and poor gaming experience. To assess the design of the different configurations, the dimensions of the Switch console, its trigger and non-trigger buttons, and relative distances between parts were measured and compared to anthropometric guidelines provided by different literatures. A total of 16 Filipino participants, classified as either novice or expert users based on familiarity with the Switch or other gaming consoles and their functionalities, were asked to perform a predetermined set of tasks, including playing a game on the platform across different controller orientations. User perceptions on comfortability and satisfaction after using the platform were measured through a 5-point Likert comfortability scale (5 being most comfortable) survey and post-task surveys, respectively, and were analyzed in conjunction with user remarks while performing working on tasks. Results show that while some dimensions of the Switch does not conform to anthropometric guidelines from literature, user ratings for comfortability were high for both sets of users for the Handheld (4.13 for experts and 4.06 for novices) and JoyCon Grip (4.69 for experts and 4.81 for novices) configurations, and relatively low for JoyCon Stick modes (2.78 for experts and 3.38 for novices). Additionally, post-task survey results mirrored in-task remarks of discomfort and navigation issues while using the JoyCon stick configurations, with it receiving 72% of negative complaints during and after use. Recommendations to physical dimensions were made based on existing literature, with the aim of decreasing the risk of user injury with prolonged usage and improving overall user satisfaction, which could be the basis of future studies on redesigning the Switch and the effects of its controller configurations on gaming experience satisfaction.

Keywords: Nintendo Switch · Anthropometric assessment · Controller configuration · Gaming experience

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1 Background of the Study

The Nintendo Switch, a portable gaming console released in 2017, is a hybrid console whose novel design is aimed at a wide demographic through its multiple modes of use: (1) docked TV mode, (2) Handheld, and (3) tabletop. It also has four main orientations of controller usage: (1) Handheld mode, (2) left JoyCon Sidestick, (3) right JoyCon Sidestick, and the JoyCon grip.

A 2019 study on casual users of the Nintendo Switch show that average consecutive use of the console was 2 hours per game, and 6–8 hours per week [1], which was noted to be the cause for missed activities and adverse health effects such as insomnia, fatigue, carpal tunnel syndrome, and muscle soreness [2, 3]. Grip strength issues have been observed among Switch users after prolonged usage, often yielding hand cramps in using the Handheld mode [4]. Additionally, complaints about the JoyCon sidesticks being too small for hands to hold have necessitated third-party grip extensions to enjoy playing properly [5, 6].

However, studies focusing on the dimensional aspects of the design of the Switch is scarce at present, especially for Southeast Asian users of the console system. This study was undertaken to provide an assessment of the Nintendo Switch based on existing anthropometric guidelines [7], to provide recommendations for future iterations, and lessen the risk of potential user injury noted with its current design.

2 Methodology

In order to verify if claims of potential injury could be alluded to the Switch design, an assessment of the console's features was conducted. In particular, dimensional measurements were compared with existing anthropometric standards [7], and correlated with varying users' concerns on discomfort and needing third-party grips to beneficially supplement gaming experience [6]. Participants were employed to rate comfortability in using the console across different controller configurations.

2.1 Participants

Sixteen participants, from the Switch's most common user demographic age (19–34) [8], were first made to answer a pre-test questionnaire in order to determine their familiarity with (1) any video game console, and (2) with the Nintendo Switch, through a 4-point Likert scale. Participants was labeled as an "*Expert*" if he/she fit either of the following conditions: (1) if a participant was found to have an average of higher than 2 for both questions, or (2) if the participant has a score of 3 or higher for the 2nd question. Otherwise, the participant was labeled as "*Novice*".

2.2 Measurement of Nintendo Switch Dimensions and Benchmarking

Researchers measured the dimensions of the different buttons and features of the Switch console and compared those with existing standards. All necessary measurements of and between these features were measured using standard rulers and Vernier calipers.

Corresponding standard measurements were obtained from Tilley's *The Measure of Man and Woman*, which is composed of recommended measurements designed for the 98th percentile of the 1993 US population [7]. These measurements take into account appropriate finger widths, as well as specifications in location coding needed for distances between features based on productivity tool design principles.

Buttons were analyzed depending on whether they were trigger or non-trigger buttons, and were measured against recommended button dimensions and distances from each other, according to the classification scheme by the same source.

2.3 User Comfortability Assessment

User comfortability with using different Nintendo Switch controller configurations was assessed by making participants play Mario Kart Deluxe 8, a track racing game owned by a majority of Switch users [9].

Participants were tasked to finish one lap each using the four main orientations of the Switch console controllers, and then asked to complete three set tasks in-game using an assigned orientation. All settings, including vehicle used, items available, opponent difficulty, and circuit location were kept controlled for every participant. After each lap, the respondents were interviewed for insights on using their assigned controller orientation and to rate separately the comfort of each orientation on a 5-point Likert scale.

Afterwards, each participant was assigned a specific orientation to successfully play one full race (3 laps) of a Grand Prix game, or a full race. They were given a list of tasks which encompassed using the controls of the Switch and navigating the game. The same factors were controlled as the initial test. After completing the race, each respondent was asked to rate their perceived intuitiveness of the assigned orientation.

2.4 Data Analysis

The obtained measurements from the dimensional analysis of the Switch features was compared to the recommended measurement standards [7], on a pass-or-fail basis, depending on whether such dimensions were within prescribed ranges. All standard measurements taken were of the 95th percentile. Comfort ratings and general comments from participants were also used to supplement the analysis.

3 Results and Discussion

Non-Trigger Buttons Measures. The results of non-trigger button assessment can be seen in Table 1. The non-trigger buttons are accessible to both thumbs and index fingers, but ideally are only pressed by the thumbs in normal gameplay. The ideal measurements for these buttons are supposedly between 13–25 mm [7].

Most buttons measured failed the anthropometric assessment, having not reached the lower limit of the range. This result could be due to game console developers deliberately making these diameters smaller to provide easier transitions when switching buttons controls with fingers [10].

Table 1. Non-trigger buttons measures

Button	Diameter (mm)	Ideal diameter	Result
XYAB buttons	7.235	13–25 mm	Fail
Directional buttons	7.235		Fail
(+) Button	5.220		Fail
(−) Button	1.475		Fail
Print screen button	6.025		Fail
Home button	7.900		Fail
Detach buttons	4.455		Fail
Joystick	15.305		**Pass**
Power button	4.455		Fail

Trigger Buttons. The results of trigger button assessment can be seen in Table 2. Trigger buttons are often placed at the edges of a device, to be pushed down as if pulling a trigger of a gun. On the Switch, these are situated at the top parts of their respective orientations, where index fingers naturally rest when holding the controller.

Table 2. Trigger buttons

Button	Width (mm)	Ideal width	Result
L/R buttons	29.115	6–13 mm	Fail
LZ/RZ buttons	25.245		Fail
SL/SR buttons	8.345		**Pass**
SL/SR bumper	14.315		Fail

Only the SL/SR buttons were found to be within ideal width, with the failure in the rest being due to its large size. Trigger widths should not be too large as a full finger grip is often needed; the finger should wrap around the button and press it with force, like in guns or other hand tools. The difference between the L/R, LZ/RZ, and SL/SR bumpers is that the wrapping of the fingers is not needed. Index fingers do not need to move as much as the thumbs in-game, hence why enlarged buttons were created.

Button Distances. The results of button distance assessment can be seen in Table 3. Smaller distances may be problematic for larger-sized fingers, as they might find themselves unable to press or switch to certain buttons properly without accidentally pressing other buttons. Sufficient distance is needed between buttons for entirely separate actions in-game. For example, Joysticks are used to move a player, an entity, or scroll through menus, while XYAB buttons are used for specific in-game actions like selecting an option or completing an action.

Only 3 out of 5 distances measured passed this anthropometric standard. The XYAB and Directional buttons were found to be too close to one another. This might be a reason for pressing wrong buttons in-game, which would be a valid concern for players especially in fast-paced in-game situations.

Table 3. Button distances

Buttons compared	Distance (mm)	Ideal distance	Result
XYAB/Directional Buttons (Perpendicular)	8.640	>13 mm	Fail
XYAB/Directional Buttons (Adjacent)	3.795		Fail
B button/Up Button to Edge of Joystick	9.415		Fail
Right JoyCon (Center of Joystick to Home Screen Buttons)	20.570		Pass
Left JoyCon (Center of Directional Buttons to Print Screen Buttons)	19.280		Pass

Comparison to Comfort Ratings and Game Experience. Comfort ratings for Experts and Novices can be seen in Table 4.

Table 4. Comfort Ratings

Orientation	Expert	Novice
Handheld Mode	4.13	4.06
Left JoyCon Sidestick	2.44	3.38
Right JoyCon Sidestick	3.13	3.38
JoyCon Grip	4.69	4.81

In the four orientations tested, the Handheld Mode and JoyCon Grip were rated relatively high for both Experts and Novices, getting ratings above 4 for both Expert and Novice users. Game experience was noted to mostly involve pressing XYAB buttons, leaning the Joystick, and occasionally using trigger buttons for secondary actions, most of which had failed the anthropometric assessment.

However, despite the results of the anthropometric test, the Switch was rated to be comfortable for most users, as seen in the generally positive ratings at least for the Handheld mode and JoyCon Grip. Users did not actively complain on the size and distance of and between buttons while playing Mario Kart. Participants favored the JoyCon Grip the most, seeing that it was easier to press trigger buttons and hold the controller in general. This is notable because it is designed to look like other more common controllers like Playstation's Dualshock controllers and the various Xbox controllers. Perhaps a similar design helped Novices acclimatize to using the orientation easier, even with limited prior exposure to gaming consoles.

Conversely, the Left and Right JoyCon Sidestick orientations received mixed comfort ratings. User comments were on the increased difficulty in holding the controller and pressing buttons as intently as with previous orientations. Some users had difficulty in using the JoyCons due to button size. With each XYAB/Directional Button being less than 1 cm in diameter, pressing them in-game might pose some challenges in the Sidestick modes, as the rest of the hand has less to grip on than in other modes.

Controller grip is important for players as it allows the other fingers to move faster freely, since the entire JoyCon is only 102 mm in width and 32.5 mm in length. With this, the result of the anthropometric standards comes into question; the SL/SR buttons might have passed the assessment, but are not comfortable to use due to its small size. Fingers and hands can also feel cramped or stretched due to how the player grips the Sidestick. This discomfort can lead to overall dissatisfaction and frustration while playing games in the Switch.

Other comments were directed towards button placement. The small sizes for Non-Trigger Buttons and enlarged sizes for Trigger Buttons were thought to be a deliberate intention by the Switch developers, as to allow for easier usage in-game; the main buttons were made smaller and closer to each other for easier switching without the need for the player's sight while playing games, while larger sizes for the triggers meant that players did not need to move index fingers as much either. Likewise, the button distances were thought to be shortened as to help players arrive at certain buttons easier while using the Switch – the speed of human-computer interaction in console gaming is immensely swift, and thus might be prioritized while developing controller designs.

Design Recommendations. In order to decrease the risk of injury with prolonged used, the following design changes are recommended, specified in Table 5.

Table 5. Proposed changes to Nintendo Switch button dimensions

Button	Current diameter (mm)	Proposed diameter (mm)	Other proposed changes
XYAB buttons	7.235	10.235	
Directional buttons	7.235	10.235	
(+) Button	5.220	6.220	
(−) Button	1.475	2.475	
Print screen button	6.025	9.025	Move down by 1.5 mm
Home button	7.900	10.900	Move down by 1.5 mm
Detach buttons	4.455	6.455	
SL/SR button	8.345	9.345	

It is important to note that these changes were made under the assumption that no changes are made to the width of the entire JoyCon or the console. Adjusting these widths might affect the console's portability as well as the grip, satisfaction, and game experience of users. Although these will not make all buttons fit within the baseline anthropometric standards [7] due to lack of space on the console, they should bring the buttons closer to the recommended measurements, and should lead to an overall increase in user comfort and safety.

Although face button recommendations failed to satisfy the baseline standards, it was found that they are within other standards [11], which states that standard diameter for push button designed for military use is 10 mm-25 mm. This might be a more appropriate standard for comparison, for investigation in future studies.

4 Conclusion

This study assessed the physical dimensions of the Nintendo Switch by comparing them against existing anthropometric guidelines and its effects on user comfortability for Novice and Expert users. Upon comparing Switch measurements, namely with anthropometric standards for the 95th percentile, it was determined that only five (5) out of eighteen (18) measurements passed standards. Several vital parts of the controllers were not ergonomic in design.

Despite the relative failure in the anthropometric grading, the Switch received mixed to positive comfort ratings; Handheld and JoyCon grip modes in particular received relatively high user comfort rating scores. However, the lower comfort ratings using the Sidestick orientations do point out small button sizing and uncomfortable placement as factors on these orientations, which is also reflected in the anthropometric assessment of this study, and were the basis for design recommendations for future iterations of the console.

The general disconnect between anthropometric results and comfort ratings suggest that Handheld devices like the Switch may need a different set of anthropometric standards in order to be better classified in an ergonomic sense, which could form the basis for future studies.

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Pressure Comfort Design Elements for Backpacks

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Abstract. Backpack pressure comfort is an important comfort indicator for backpack. In recent years, there have appeared many functional design on backpack products such as burden reduction, pressure relief, and protection of the spine. This paper studies the effect of functional design elements by comparing two different backpacks with one functional backpack and one non-functional backpack. And it discusses the effects from three indexes including the maximum pressure on the shoulders, the balance of the pressure on the shoulders and the pressure dispersion. The results show that functional backpack is not better than non-functional backpack for these three indicators. In addition, an experiment was carried out to test whether the one-piece shoulder belt plays a substantial role in the pressure balance of shoulders. Through the test, we found that the effective link of the shoulder belt can significantly improve the ability of the shoulder balance. Therefore, this paper considers that the backpack is a whole system, a single design element may be conducive to improving the pressure comfort, but the synthesis of multiple design elements may not have the effect.

Keywords: Pressure comfort · Design · Backpacks

1 Introduction

With the great satisfaction of functional requirements, consumers are increasingly demanding for the comfort of products, and backpacks are typical ones of them. Users of backpacks are everywhere in life, students, travelers and mountaineers. A reasonable backpack design can reduce the pressure on people's shoulders, relieve fatigue, improve backpack posture, and effectively reduce damage of the body bone deformation and muscle to minimize the negative impact of carrying behavior on human body.

Current research indicates that the lightweight design of travelling bags will become the mainstream trend in the future. Its lightweight design is mainly considered from multiple perspectives such as fabric performance, carrying structure and backpack accessories [1]. The traditional backpack concentrated the main weight of the backpack on the shoulders, so that the weight on the shoulders is too much while the other parts

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of the body share little weight. The lightweight design not only chooses lightweight materials, but also focuses on distributing the weight of the backpack to the body.

Relevant scholars have developed a backboard by analyzing the pressure distribution ratio of the human waist and back, and improved the weight ratio 6:1:3 (the shoulder:back:waist) of the ordinary backpack to 3:3:4, which effectively distributed the weight of the backpack's load to various parts of the body [2]. In recent years, there are many functional design elements on the backpack products, such as load reduction, pressure relief, spine protection, etc. The "5 belts and 3 devices" is the typical functional design adding to the backpack structure system, that is, shoulder belts, chest belts, waist belts, shoulder load belts, bottom load belts, support devices, ventilation devices and adjustment devices. The design of the 5 belts plays an important role in the comfort of the carrying system. The design of functional backpacks is based on the structure of the human body and focuses on the design of assistive devices. Good support, such as thickened shoulder pads, scapula pads, waist pads, chest straps and waist belts, and shoulder assistive devices are mainly used to assist the force and stabilize the center of gravity.

The unreasonable backpack design will have a great impact on the human body. Scholars have found that the impact of backpacks on adolescents is mainly concentrated on body balance, body posture, and gait, to different degrees on blood oxygen saturation, heart rate, respiratory rate, and oxygen consumption [3]. However, there is few paper shown that functional design elements can obviously improve the pressure comfort. So this paper studies the effect of functional design elements by comparing two different backpacks.

The selected backpacks have obvious differences in functions. One is a functional backpack with different functional design elements such as pressure reduction of back plate, shoulder belt, and chest buckle, spine protection function, waist protection function. And the other is an ordinary backpack without functional design elements. An experiment was carried out to explore the differences effect of the two backpacks under the same weight (3 kg). And this paper discusses the effects from three indexes including the maximum pressure on the shoulders, the balance of the pressure on the shoulders and the pressure dispersion. The design elements' effect between two bags were discussed after.

2 Experiment

2.1 Experimental Material

To explore the effect of functional elements, a functional backpack (with Backplane lightening, Shoulder strap, Chest buckle, Spinal function, Waist support) and a non-functional backpack were chose. The back of these backpacks are shown in the following Fig. 1 and Fig. 2.

Fig. 1. Back of functional backpack

Fig. 2. Back of non-functional backpack

2.2 Participants

Ten adults (5 males and 5 females), aged from 19 to 24 (22 ± 1.3 yrs), weight 59 ± 10.8 kg were chose to be participants. The participants' height was selected as the 50 percentiles for adult men and women from the GB 10000-88 standard "Human dimensions of Chinese adults", which is 164.8 ± 3.2 cm.

2.3 Procedures

According the literature, the most stressful contact parts of the backpack and body are the shoulders, backs on both sides, and hips on both sides. The proportion of pressure on them varies while the style of the backpack differs.

Each backpack was packed with loads to achieve a total weight of 3 kg. 10 participants carried each backpack in an upright position and adjusted to the most comfortable and balanced state. Using the Pliance pressure test system, pressure data was collected about one minute for each part on the subjects' body.

2.4 Analysis of Pressure

a) Maximum pressure on shoulders

The pressure on the shoulders is an important indicator that directly reflects the design of the backpack. Comparing the peak pressure and mean pressure of the left and right shoulders for each backpack and we will take the biggest pressure value to discuss the design of the two backpacks.

b) Shoulder pressure balance

The shoulder pressure balance means the difference between the peak pressure and the mean pressure of the left and right shoulders. By calculating the difference between the peak pressure and the mean pressure of the left and right shoulders, and we can get the difference of the shoulder pressure balance of the two backpacks.

c) Pressure dispersion

Pressure dispersion refers to the percentage distribution of total pressure in various parts of the body. The peak pressure and mean pressure ratio of each part are calculated, and the difference in pressure dispersion between the two backpacks is tested.

2.5 Data Analysis

2.5.1 Maximum Pressure on Shoulders

The difference between the maximum pressure shoulders of the two backpacks was analyzed with a paired T-test, and the following results were obtained: there was no significant difference in peak pressure between the two back packs ($P_{PeakPressure} = 0.177 > 0.05$). At the same time, there is no significant difference in the mean pressure ($P_{MeanPressure} = 0.067 > 0.05$). But the average peak and mean pressure of the functional backpack are larger than that of the non-functional backpack.

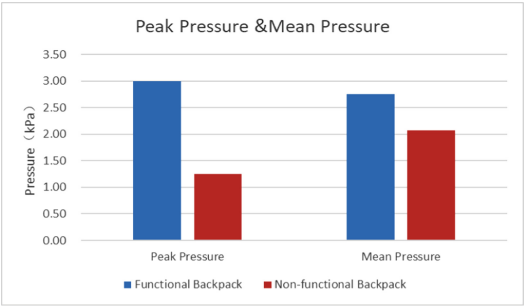

Fig. 3. Peak pressure and Mean pressure on shoulders of two backpacks

2.5.2 Shoulder Pressure Balance

The paired T-test was performed separately to the peak and mean pressure of shoulders for each backpacks. It found that there is no significant difference in the shoulder pressure balance between the two backpacks ($P_{PeakPressure} = 0.151 > 0.05$), At the same time, there is no significant difference in the mean pressure ($P_{MeanPressure} = 0.708 > 0.05$). The peak pressure difference between the left and right shoulders of the functional backpack is critically significant ($P_{PeakPressure} = 0.056$). But the non-functional backpack has no significant ($P_{PeakPressure} = 0.657$). The average difference of peak and mean pressure of functional backpack are larger than that of the non-functional backpack.

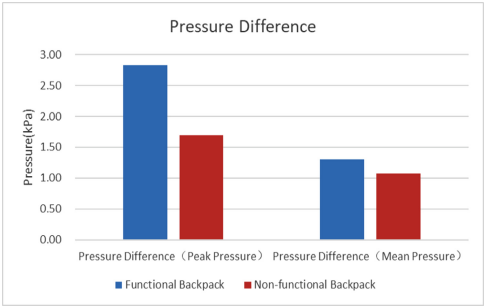

Fig. 4. Pressure difference on shoulders of two backpacks

2.5.3 Pressure Dispersion

Most of the peak pressure and mean pressure are concentrated on the shoulders for the functional backpack. But to the non-functional backpack, the forces are evenly distributed. There is a similar percentage of pressure distribution on the shoulders and hips. But there is no pressure on the backs for two backpacks (Fig. 6).

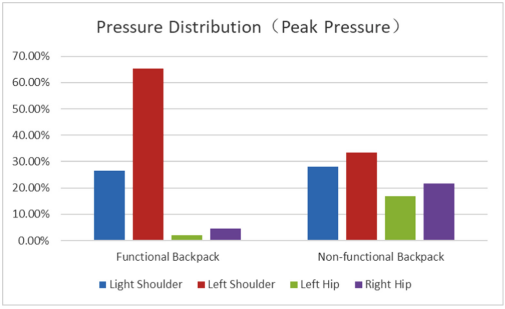

Fig. 5. Pressure distribution (peak pressure) of two backpacks

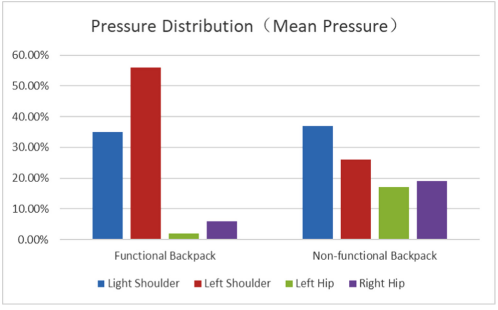

Fig. 6. Pressure distribution (Mean pressure) of two backpacks

2.5.4 Results

From above, although the Maximum-pressure-on-shoulders and Shoulders-pressure-balance of the functional backpack and the non-functional backpack have no significant difference, the average peak and mean value of the functional backpack is larger than that of the non-functional backpack. And the balance of non-functional backpack is better than the functional backpack. At the same time, most pressure of the functional backpack is concentrated on the shoulders, while the ordinary backpack is stressed in other parts of the body. So, the pressure comfort of a functional backpack is no better than that of a non-functional backpack.

3 Improved Shoulder Pressure Balance

Shoulder pressure balance is an important indicator to improve the comfort of shoulder. There are many backpacks with One-Piece-Shoulder-Strap on the market (see Fig. 3), which claim to have the ability to improve shoulder balance. Therefore, a test of the shoulder strap connection was added on the previous experiment with shoulder belt accessories connected to the functional backpack to simulate the One-Piece-Shoulder-Strap (see Fig. 4). Loading the backpack to a total weight to 4 kg (in order to increase shoulder pressure) and the experiment was executed as before (Figs. 7 and 8).

Fig. 7. One-Piece-Shoulder-Strap backpack on market

Fig. 8. Shoulder belt accessories

3.1 Data Analysis

When there is no shoulder strap connection, it has a significant difference of the peak pressure between the left and right shoulders ($p = 0.000 < 0.05$), and the pressure ratio of the left and right shoulder is 0.37. When the shoulder strap is connected, there shows no significant difference between the pressures on the left and right shoulder ($p = 0.085 > 0.05$), The pressure ratio of the left and right shoulder is approximately 1, which means that the force on the left and right shoulder are basically equal.

It can be seen from the Fig. 5 that when the shoulder strap is not connected, the pressure on the right shoulder is significantly higher than the pressure on the left shoulder. When the shoulder strap is connected, the pressure on the left and right shoulder pressure is basically the same.

So, a result can be draw that the connection of the shoulder strap can obviously improve the shoulder pressure balance (Fig. 9).

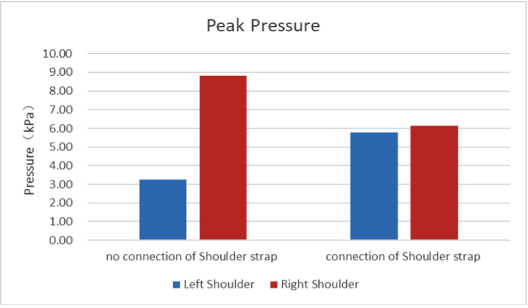

Fig. 9. Peak Pressure on shoulders before and after the connection

4 Discussion and Conclusion

From above, we could draw a conclusion that the pressure comfort of functional backpack is not better than that of the non-functional backpack. The functional designs do not play a practical and effective function, which may be due to the fact that there are too many functional elements lead to the mutual cancellation of functions.

In addition, this paper used the shoulder belt accessories to link the shoulder belt of the backpack to simulate the One-Piece-Shoulder-Strap backpack on the market. And we found that the effective link of the shoulder belt can significantly improve the shoulder balance.

This article also found that both backpacks have no contact on the back, indicating that neither backpack has a clear fit to the back of each subject. This may be related to the shapes of the back panel of the two backpacks and the internal structures of the backpacks. With unstable internal structure, the gravity center may be pulled backwards with the contents of the backpack. In addition, this article only focuses on a 3 kg load, and maybe the results will be different under other weights. And the number of participants wasn't large enough too, although the test results showed a certain trend. We will consider increasing the sample size in the future to improve the reliability of the results.

Therefore, this paper considers that the backpack is a whole system, a single design element may be conducive to improve the pressure comfort, but the synthesis of multiple design elements may not have the effect. When designing the functional elements of the backpack, it should be considered as a whole, and the simple and random function superposition may be unavailing.

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Editorial and Typographic Studies

Graphic-Semantic Expressions Map: An Methodological Tool

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Abstract. This paper aims to demonstrate the results of applying the Graphic-Semantic Expression Map, a methodological tool in design teaching, that help students on the brand mark creation. The proposed map tries to overcome the difficulty that the students have in understanding how they can remove and cross-check the information they gather during the research phase with the concept of the projects and intends to help in the intersection and interpretation of the images that the students collect, leading in the end to guidelines for the brand mark creation, in terms of their graphic representation (color, typography and shape). In the end it is intended to assess whether or not this tool helps students in this process of logo creations without limiting they creativity. This investigation is a part of the post-doctoral research.

Keywords: Design teaching · Teaching methodologies · Graphic design · Semantics map

1 Introduction

In design teaching the problem is systematic, students have a hard time understanding how they can remove and cross-check the information they gather during the research phase with the concept of the projects. During this phase students often use social media, Instagram is one of the most used as a tool where they can collect images that inspire them visually. However, seems that is not enough because, in the end, the works presented by student's don't reflect all of these work that they have in the early stages of project and students present projects without any relation with the investigation phase.

On design field, is common to use moodboards as a way to visualize ideas, concepts or even references and inspiration elements for the realization of projects. Moodboards are a type of a visual language, consisting of a collage of images, text and/or samples of objects that inspire a design. That design can take the form of a logo, for graphic design, product, interior design, etc. This kind of resource are particularly useful for design student whose analytical and creative skills are rapidly developing. They can be one of the most valuable tools in the whole design process because they are potentially fast and they can provide direction and insight into which the time-consuming stages of design development are founded (Garner and McDonagh-Philp 2002).

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Visual thinking is an essential tool because it helps clarify ideas or viewing images that represents concepts help in the interpretation of the problems and triggers ideas associations. In this way, the images are treated as information, so that, from them, innovative ideas are created.

In this context, concept maps are a widely used tool in design teaching to help students visualize and unify concepts. During the development of a design project, we need to articulate abstract concepts or are metaphorical through images, in order to give meaning to visual concepts. The semantic panel provides a visual form capable of stimulating and inspiring the process of design projects. It is a technique that helps the active method, which aims to represent meanings through the visualization of images, that is, a technique that translates verbal language into visual signals (Rijo 2020).

The methodological tool proposed tries to overcome this difficulty and intends to help in the intersection and interpretation of the images that the students collect, leading in the end to guidelines for the brand mak creation, in terms of their graphic representation (color, typography and shape).

2 Graphic-Semantic Expression Map (GSEM)

In order to find alternatives to educational models centered in the classroom, along with research on teaching practices and design research, a proposal was developed for a methodical tool to be used with students. The design methodology and practice that reinforce the principles of a designer's training lead to defend the methodological proposal presented here: founded and integrated in the real context with the methodological principles present in the teaching of design. The intention is to integrate the practice as an instrument for the research and action project, considering the practice-based and practice-oriented methodology as an operational tool.

Among the recurring themes in the design universe is the concern for shapes, meanings and functions. It is, therefore, from the hybridization of these three aspects-syntactic, semantic and pragmatic relationships - and the fulfillment of their aesthetic, symbolic and practical functions, that design products seek to respond or meet human demands.

In Design, the semantic dimension is the dimension of the object itself and the meaning of the thing, it is the meaning of the product created, be it an artifact or a graphic expression, and that has attributions of meaning and communication through the expression visual.

As shown in a previous study (Rijo 2019), the GSEM is based on the traditional conceptual panel, a map of graphic-semantic expression that aims to make the relationship between the various evaluable elements more understandable is presented. This map proposes to cross the collection made in the research phase, the design concept and the elements of inspiration with typography, color and form. It is a methodological map that help the process of synthesizing the expressive code and reinforce the relationship between graphic expression and semantics in the practice of design. This type of semantic panel offers a visual and sensorial channel of communication and inspiration for design research and development, which could be

considered more logical and empathic within a context design than traditional verb-centric approaches.

GESM is a tool that facilitates the acquisition, transmission, mobilization and implementation of the essential stages of a project in the area of graphic design (Fig.1). This tool proposes to cross the collection made in the research phase, the conceptual design and the elements of inspiration with typography, color and form (Rijo 2020).

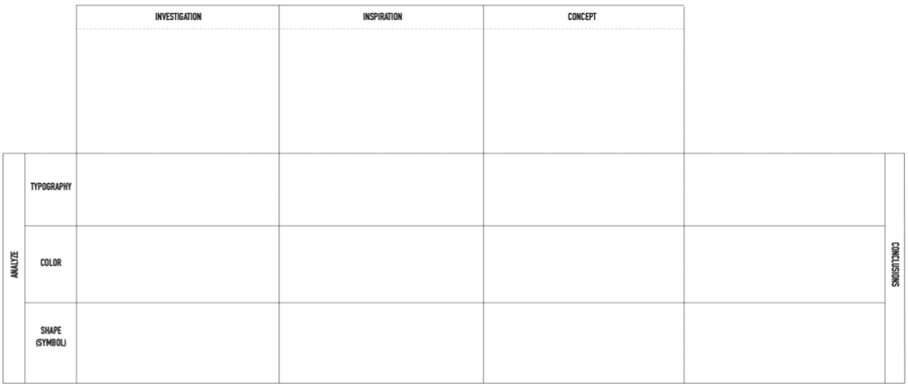

Fig. 1. Graphic-semantic expression map. Author's image. Author's image.

3 Workshop

In order to test the efficiency of the GSEM, a set of workshops to be taught in Higher Education Institutions was conceived. In the present article we will analyze the results obtained from the workshop in the 1st year and 1st semester in the degree in design on the University of Navarra in Pamplona.

The Workshop entitled "From concept to project - Graphic-Semantic Expression Map" took place on University of Navarra facilities on October 19th of 2019 with the duration of 5 h and was attended by 72 students, aged between 19 and 25 years old.

Because was impossible to had time to develop individual work with these number of students, was establish since the beginning that the students will split in small groups of 6 persons each, given a total of 12 groups.

The workshop was structured in three distinct moments: the first moment characterized by a more expository and exemplifying part (1 h), the second time characterized by the individual work of the students (3 h) and the last one was the presentation of results (1 h).

The first moment was structured in four parts: (1) Exposition of the workshop goals; (2) Contextualization of the research, its goals and presentation of relevant information on the subject to be addressed; (3) Presentation of the GSEM as tools in the practice of graphic design; (4) Presentation, with an example, to better explain the problem and the correct use of the methodological tool presented.

The second moment was characterized by the work of the students, trying to fill the GSEM according to the briefing.

The third and last moment, each group had 5 min to present the results.

3.1 Briefing

The briefing was given by the Lisbon Polytechnic and intended to create a graphic brand for the "International Week of the Lisbon Polytechnic".

The "International Week" is an event that takes place every year, between April and May at the Polytechnic Institute of Lisbon and brings together around 100 employees (teachers and non-teachers) from European institutions of higher education, in the context of international mobility Erasmus + program. For a week, the participants, in addition to knowing the mission, organization and structure of the Polytechnic Institute of Lisbon, will exchange experiences and work practices. It is intended that participants enjoy moments of leisure and conviviality while providing the opportunity to get to know the city of Lisbon.

The "Lisbon International Week" program includes visits to the organic units of the Lisbon Polytechnic, participant presentations, thematic workshops, socialization activities and a visit to the city of Lisbon. Participants in this event come from several countries, including the Czech Republic, Poland, Turkey, Spain, Romania, Lithuania, Italy, Slovenia, Finland (Rijo 2020).

The goal was to create the brand mark that represented this event for the 2019 edition and future editions, since in 2019 the eighth edition would take place and this event did not have a brand that identified it.

The principal concerns were the creation of a brand that represent Lisbon and that was easy recognizable to the people that will attend to the event.

On this workshop the students didn't had to create the brand, the task was applying the GSEM, evaluate the conclusions and give the guidelines for the brand mark creation.

It was given to the students, in paper, the GSEM for they complete, and, because of the time, it was given the topic "concept" already completed with information. In that way the students only need to do the "research" and the "inspiration" topics.

3.2 Results of the Workshop

Because was impossible to show in this article all the results of the GSEM that the twelve groups develop, it was chosen one work to illustrate better what kind of work was develop in the workshop (Fig. 2).

Like previously mentioned the topic concept was equal for all groups because was given by us at the beginning of the workshop. On Fig. 2 is visible the investigation that the group did about other brands and the images of reference that the students use for the inspiration of the brand mark creation.

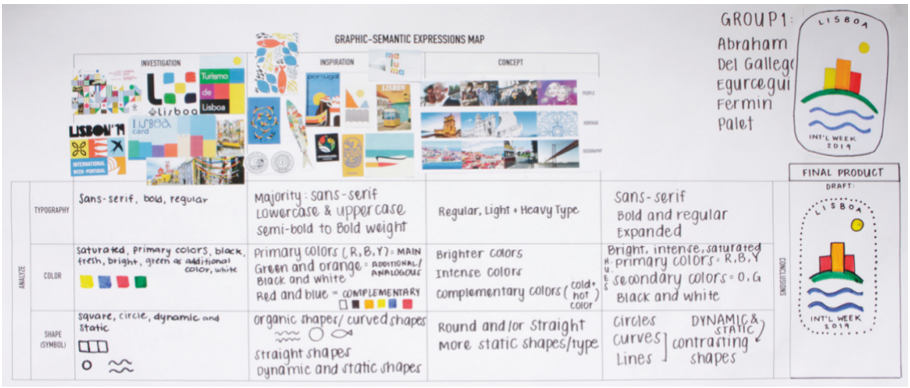

Fig. 2. Graphic-Semantic Expressions Map of group 1, compose by the students Abraham, De Gallego, Egurcegui, Fermin and Palet. Author's photo.

Wen analyzed the results of all groups of the application of the GSEM (Fig. 3) we can conclude that this gave rise to a set of very useful guidelines for the creation of brands marks. It is interesting to note that some students felt the necessity of show how could be applied the results of the GMES in a low prototype of what the brand mark will look like.

Taking in consideration that the topic "concept" was the same for all of the groups and that the topic of investigation was very similar to, what make the difference on the final results was the inspirations that the students choose.

Analyzing the topic of colors is visible that the colors that appear most are the blue and the yellow. The students even don't knowing Lisbon were fascinates with photos that they saw int the internet: the blue of the river and the yellow light of the sun or of the night lights were the things that they noticed more. The other main color is the red, yellow and green because are the colors that appears several times, since they are the colors of Portuguese flag.

On the inspiration topic, the students named Portuguese tiles, Lisbon toponymy, the tram and the relationship with the sea as the elements that stood out the most and that could be used in the representation of the brand mark. For that reason, the guidelines for the construction of the symbol are between the straight and the curved, the static and the dynamic composition.

Another interesting aspect is the fact that the students who wanted to create a draft of the brand mark, identify themselves in the brands that they created, these being a reflection of a certain style already adopted by the students. In this way, the tool used was not an inhibition element of the student's creativity or their own style.

From the feedback received by the students, the GSEM helped fundamentally in the choice of colors and typography, these being the elements causing most difficulty for students on a creation of a brand mark.

GROUP OF STUDENTS	CONCLUSIONS OF GRAPHIC SEMANTIC-EXPRESSION MAP			LOGO CREATED AND VARIATIONS
	TYPE	COLORS	FORMS	
GROUP 1	SANS SERIFE TYPE BOLD AND REGULAR EXPANDED		CIRCLES/ CURVES LINES DYNAMIC AND STATIC	
GROUP 2	REGULAR OR LIGTH TYPE WITH SERIF		ROUND/STRAIGHT LINES ESTATIC COMPOSITION	
GROUP 3	HUMANIST SANS-SERIF TYPE LIGTH OR BOLD		ROUND SHAPES STATIC CURVE LINES	
GROUP 4	HUMANIS SAN-SERIF HEAVY WITH LIGTH TYPE		STRAIGHTAND CURVE LINES ORGANIC SHAPES	
GROUP 5	GILL SANS SAN SERIF BOLD		ROUND SHAPES SKYLINE	
GROUP 6	SERIF FONT LIGHT AND BOLD		STRAIGHT LINES SATIC SHAPE	———
GROUP 7	GEOMETRIC SAN SERIF FONT		STRAIGHT LINES SATIC SHAPE	———
GROUP 8	HUMANIST SANS-SERIF TYPE LIGTH OR BOLD		CURVED SHAPES WAVES MOVEMENT	———
GROUP 9	FONT SANS SERIF STRAIGTH STEM REGULAR		STRAIGHT FORMS GEOMETRIC FORMS CIRCLES	———
GROUP 10	FONT SANS SERIF STRAIGTH STEM REGULAR AND BOLD		ROUND AND OVAL SHAPES STRAIGHT WITH CURVES LINES	———
GROUP 11	SANS SERIF TYPE STRAIGHT STEM LIGTH AND REGULAR		CURVED FORMS MOVEMENT DINAMIC	———

Fig. 3. Resume of the results of the GSEM of the groups that participated in the workshop. Author's image.

4 Conclusions

We propose the investigation of active methodologies that contribute to research, creative development and better results in topics related to graphic design. In design teaching there are many exploratory tools that help students in the research phase and that help to achieve the several design phases. In the early stages of a project - the research stage, the definition of a problem, the definition of a concept - students obtain a lot of visual information through images, for this reason, visual thinking is an essential tool because it helps clarify ideas.

The graphic semantic expression map help students in the early stages of a project to understand the meaning and concepts on the graphic design field.

This map was tested and evaluated as an methodological tool to facilitate the creation and development of brand marks.

After the evaluation of results obtained in MEGS, it can be concluded that it gave rise to a set of very useful guidelines for the brand creation, giving valid guidelines that helps the students with the different graphic elements (typography, colors and symbol).

From the comments received by the student who worked on this project, MEGS has essentially helped with the choice of colors and typography, which are generally the most difficult elements that students have when building a graphic brand.

This demonstrates what was initially intended: a tool that helps in research, analysis and systematization of information, which leads to guidelines for possible forms of action.

In design there are no recipes, the results that the GSEM gives are only guidelines, these guidelines are a summary of the different steps inherent in the creation of a project in the field of graphic design. With these guidelines, the possibilities are endless, without compromising the creativity or uniqueness of the project (Rijo 2020).

In the end, we conclude that the association of semantic elements with graphic elements promotes the convergence between the objectives of the project and the synthesis of expressive codes, while facilitating the interpretation and creation of new graphic products.

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Inclusive Readability: Recommended Typographic Criteria for Improved Reading in Students with Learning Disabilities

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Abstract. This paper considers the hypothesis that typographic shape and criteria may positively or negatively influence the reading performance of children with Specific Reading Disorders. We focus on children between the ages of 5 and 13 with Dyslexia and Visuospatial Difficulties or other similar disorders. We propose a theoretical approach, with a non-interventionist methodology of qualitative research, in which, through a literary review, we clarify what are Specific Learning Disorders, such as Dyslexia, Dysorthography, Dysgraphia, and Dyscalculia, and what is their interference in the reading process. Typography, psychology, and knowledge on neurologic development were used to characterise the neurological functioning of the reading process, both in fluent and dyslexic readers, who show sub-activity in the posterior brain systems (Phonological Deficit Theory). The aim is to understand how legibility and readability are processed in children with Specific Reading Learning Disorders. We analysed multiple typographic recommendations for Inclusive Education and found problems; the objective of this research is to improve reading skills in students with learning disabilities by developing typographic criteria specifically for this purpose. We present typographical recommendations and criteria to complement and improve existing decrees and regulations for inclusive education and conclude accepting our recommendations would be beneficial to students with learning disabilities. We present these typographic recommendations for use in the English and Portuguese languages.

Keywords: Communication design · Reading disability · Inclusive learning · Typography · Legibility

1 Introduction

This paper aims to analyze the timeliness of typographical recommendations within an ergonomic approach of Inclusive Education, as a means to optimize text legibility and readability for children with reading disabilities.

This study emerges in sequence of previous investigations conducted on the Decree-Law that regulates inclusive education in the Portuguese Legislation. From that analysis, we concluded that the Decree-Law still lacks conceptual and theoretical development in typographical terms. Inclusive Education has long been debated and

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applied in many countries, albeit with its due differences; however, the shortcomings in the typographical recommendations used in this type of education, concerning children with a reading deficit, have been—in some aspects—universal.

As such, we propose to structure a set of recommendations, not just the ones of typographical nature, but also micro-typographical, as a way to potentiate the learning performance of these children through the optimization of legibility—the reading of a word—and through readability—the reading of a continuous text—of didactic material, as opposed to existing "dyslexia friendly" typefaces, mostly focused on the first.

This study correlates typography with the domains of neurology, semiotics, psychology, metalinguistic and ergonomics, according to the principles of user-centered Communication Design.

2 Reading Disabilities

Regarding Reading Disabilities, we focus our study on the Specific Reading Learning Disorder (SRLD), defined in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) as a neurodevelopmental disorder with implications on reading, rendering this process difficult and, as a consequence, also the learning. It manifests itself mostly in childhood, with schooling, accompanying the individual through life [1, 2]. Within the SRLD are disorder subtypes; in this paper, we focus on *Dyslexia* and *Visuospatial Difficulties*.

The term Dyslexia is related to a phonological disorder of hereditary origin, caused by a grouping of chromosomes with corrupted or missing DNA, whose discrepancy between cognitive and learning abilities is obvious. It does not correspond to intellectual incapacity, and may even manifest itself in deeply gifted children. It is a disorder without gender nor language prevalence [3]. Similar phonemes such as **v/f**, **ch/j**, **b/p**, **d/t**, **q/g**, **pre/per**, are easily mixed up, in this case in the Portuguese language.

Visuospatial Difficulties, in turn, are the result of undefined laterality (of cerebral hemisphere dominance) with implications in the reading capacity. These implications occur mostly when the concept of Form Constancy is applied by these individuals to letters/characters, making it not possible for them to decipher the characters' spatial position as being determinant for their meaning. Similar graphemes that are easily mixed up, by rotation and reflection, are **p**, **d**, **b**, **q**.

The term Dyslexia has become trivial, having often—mistakenly—all difficulties of reading and writing being attributed to it. To correctly intervene in the problem it is necessary to understand the borders of each disorder and define its symptomatologic limits. This should be done even when facing comorbidity, when there is a factor of common risk in neurodevelopment disorders, and these tend to mutually aggravate.

The same can be verified with a variation of language. Much has been debated on the existence of different types of Dyslexia according to different languages; however, recent studies have proved that even though Dyslexia manifests in distinct ways in different languages—due to the linguistic characteristics of each one, like phonetics, visual, lexical, orthographic, structural or even graphical, at the level of ascenders,

descenders, accentuation, etc.—the neurology is the same. In sum, there is only one type of Dyslexia, universal, independent of gender, language, socioeconomic status; while there are other types of "Dys" (from the Greek *difficulty*) of the same group: *Dysphasia*, *Dysorthography*, *Dyscalculia*, and *Dyspraxia* [4].

Even though Language is not a determining factor for the existence of Dyslexia, this disorder renders the learning of certain languages more difficult than others, due to their linguistic and phonetic complexity. The Language to which most difficulty indices are associated is the English Language, being also the most widely taught and studies Language worldwide. For that reason, we will direct our study and our proposal of new structuring rules for both the English Language and the Portuguese Language, considering their linguistic particularities. Thusly, we bring new points of interest to the research, which makes us reflect on linguistic flexibilities and connections [4].

3 Relevance of the Study for Inclusive Education

Education, as we know it, is based on linguistic codes, in which reading is completely indispensable. As such, children with reading learning difficulties, as is the case of Dyslexia, are left in a profound disadvantage in relation to their peers, being in constant pursuit of equality rather than excellence. Considering that about 10 to 20% of the world population and 9 to 12% of the European population is in the spectrum of Dyslexia, the problem has a considerably large expression [3].

When the diagnosis is not made well and early on, i.e., when schools do not duly accompany dyslexic children, many end up experiencing underachievement and/or absenteeism. This can potentiate psychological/mental health factors, such as lack of confidence, low self-esteem, anxiety, and depression. Many dyslexic children, when not well accompanied in their learning processes, will experience a strong negative impact in their childhood life, with repercussions in adult life, and many never reach their intellectual potential in professional terms. Furthermore, there is a strong correlation between poverty levels and Dyslexia, due to the fact that the support for these children is often inadequate or privatized, leading dyslexic people of lesser economic means to never reach exceedance, and leading mostly to school abandonment.

Despite scientific advancements in this area, this disorder continues to be seen mostly with a lack of understanding and with prejudice, as a disadvantage for society in economic terms [5].

The *European Dyslexia Association* analyses diverse studies that support statistically the strong correlation between Dyslexia and other neurodevelopment disorders:

- 20–40% of the persons with dyslexia also have dyscalculia;
- 20–55% of persons with developmental language disorder are dyslexic;
- 10–20% of persons with dyslexia have an anxiety disorder;
- 2–14% of persons with dyslexia have depression;
- 8–18% of persons with dyslexia have an attention deficit and/or hyperactivity disorder [5].

4 Possible Neurological Functioning of the Reading Process

Since long have researchers studied neuroplasticity and questioned its possible intervention in the case of overcoming difficulties in dyslexic readers. fMRI technology has allowed researchers to demonstrate Dyslexia from the biological perspective. Moreover, it has also confirmed the fact that the neuroplasticity of the dyslexic reader's brain allows for stimulation of areas not predestined for reading, as well as the creation of new neurological pathways, as a way to compensate a cerebral sub-activity in the posterior left side of the brain.

Sally Shaywitz and her team can thus substantiate that different cerebral activity patterns exist in dyslexic and non-dyslexic readers. Patterns of a fluent reader are constant throughout life, whereas those of a dyslexic reader show alterations, stimulating areas not in detriment of others but as a compensatory pathway that was developed, resulting from exceedance. Although not so quick nor automatic, it is an efficient process and it allows the dyslexic reader to gradually improve his/her reading skills through life, as well as other activities that depend on that area of the brain, now more stimulated. We can, therefore, confirm that the brain's anatomy of both readers is the same, while there is a neurological difference. Unfortunately, many schools and companies do not recognize the importance and advantages of neurodiversity, which allows for different perspectives and chains of reasoning to occur [6].

5 "Dyslexia Friendly" Typographic Recommendations Around the World

The analysis that was developed in previous research on the use of the **Arial** typeface, particularly in the Portuguese case, as expressed in the legal diploma, allowed us to conclude that the norms prescribed by the law need to be improved concerning font type and the specification of its use.

There are three typefaces consistently recommended as being "dyslexia friendly": **Arial**, **Times New Roman**, and **Comic Sans**—in addition to legal specifications for educational uses of each country, European or American. A first analysis leads us to believe that there is no criteria nor scientific and methodological support behind the choice of these typefaces, beyond the fact that they are well-known and well-established in the market; otherwise, they do not share many common aspects.

In addition to these recommendations, there are a few typefaces specifically designed for dyslexic individuals and for those with other types of learning difficulties, such as **Dyslexie** (by Christian Boer), **OpenDyslexic** (by Abelardo Gonzalez), **Sassoon** (by Rosemary Sassoon), and **FS ME** (by Jason Smith). While most have been relatively disseminated and tested, up until now they have failed to achieve satisfactory proven results.

By analyzing the typeface **Dyslexie**, we can see that it is based on the gravitational principle applied to the letters. It assumes that, by increasing the thickness on the lower part of the letters, as well as the differences between these and the ascenders and descenders, the rotations these children create during reading will be reduced. In this

study, we concluded that the shapes become too unusual and compromise the principle of familiarity by adding details/elements to the letters that, in their origin, do not belong to them, thereby deviating from the calligraphic principles that originated typography. There is a clear focus on readability and on Visuospatial Difficulties, given that the characters, as a collection of continuous text, present diverse problems (particularly tracking and kerning), similar to what happens with the **OpenDyslexic** typeface [7, 8].

It is important to highlight that when we mention individuals with a reading deficit, be it a result of Dyslexia or Visuospatial Difficulties, we refer to readers that often abandon the set, that is, the content of the text, and focus on shape, similar to what happens with novice readers. Such a phenomenon results in a slower and more tiresome reading, more prone to reading mistakes and to textual comprehension and interpretation errors. If the space between letters and words is exaggerated, then it tends to worsen. Only when we combine letters do we reach/produce a text that carries meaning, and only when these are combined do they become a type [9].

The typeface **Sassoon**, and especially the typeface **FS ME**, are closer to our goals and premise. From our analysis of case studies we concluded that the absence of serifs can help the understanding of the letter as individual elements, but not as part of a set [10].

The **FS Me**, as a project, aims for total inclusion through the universality/breath of its use, intending thusly to become the typographic font used by all students, with and without learning difficulties, in schools [11]. Our study also aims to reach inclusion through typography; however, it approaches inclusion from a distinct point of view, thus modifying its end goal and allowing everyone, within their differences, to reach equality of opportunities. For that to be possible, the typography in question must be as structured as possible, so that it can respond strictly to the specific needs of the types or subtypes of disorders under discussion. That way, it would allow children to be leveled as much as possible with their peers, thusly reducing the existing discrepancy between cognitive capabilities and school achievement, as well as reducing the negative impact that the lack of educational achievement and maladjustment may have. It, therefore, promotes not only school inclusion, but also social inclusion, in the sense that the continuation of education can promote a better integration in the job market. This is partly due to the overcoming of difficulties and to the acquired communication skills, including learning foreign languages, which can have advantages that are personal but also global in socioeconomic terms.

6 Proposal for New Recommendations

As an alternative to the "dyslexia friendly" recommendations—while these have been revealed effective in an isolated word the same cannot be said for a text, on which our tests revealed a low performance—we propose the use of a typeface with specific characteristics. Specifically, we propose a typeface that: is *open-source*; based on *calligraphic principles*; has *very visible serifs*; has an *oblique axis* resulting in *asymmetrical arches*; and is adequate and susceptible to be *applied in the Portuguese and English Languages*—since these are the languages on which we focus our study, because they are the most difficult to learn by dyslexics, but also because they are the sixth and third most widely spoken native language in the world, respectively.

After analyzing eight candidate typefaces through a set of criteria, such as essential characteristics for legibility and readability, we are now able to advance a new typographical proposal with its respective composition. We propose the use of the font **Alegreya** with a *size of* 14 pt; *line spacing of* 21 pt; *paragraph spacing of* 30 pt; *margins of* 45 mm all around; *non-justified* and *non-hyphenated* text; 90% *black* on off white/yellow-tinted paper, to avoid too much shine or vibration, therefore reducing the tiredness during reading from the added time to complete the reading task by children with peal (for example, with recycled paper); and *maximum screen zoom in of* 150%.

We consider this font to be adequate for a SRLD condition because it respects all the requisites previously presented; its design is suited for text reading, having as main focus the optimization of the reading rhythm—therefore entering the field of phonetics and consequently responding to the needs produced by Dyslexia and not just Visuospatial Difficulties—; it is a Latin-script font; it has a wide range of glyphs; and it has an extensive font family, with true italics [12].

However, there are other peculiarities which deserve our special attention, such as metrics, in particular those of **Literata** – a Google font designed by *TypeTogether* –, resulting in a significant space between letters. Teachers find this trait very important for children with SRLD to be able to recognize and understand the shapes of letters without compromising the unity of the word [13].

7 Conclusion

With this study, we conclude that, even though medicine and scientific studies on the matters under discussion have proven the reality and urgency of the topic, the solutions that have been proposed are not a part of these advancements. They have been shown to lack effectiveness, leading to the subsistence of the negative consequences of these disorders.

As such, we believe that while a typographical font is not developed with all these characteristics—among which neurologic, physiologic, psych-linguistic, and structural —, the open-source font **Alegreya** and the specifications determined by its use are a solution we consider to be more adequate than those currently in force in the various manuals and Decrees.

As future investigations, we aim to explore the linguistic factor in-depth, which we believe to be crucial in the typographical and micro-typographical intervention so that structuring rules/norms are specific not only to the problem but also to all its surrounding factors/constraints. We also intend to validate/test the present study through two sample groups (composed of 6 to 8 children with SRLD, a group of children who speak Portuguese and another with English as a native language) and focus groups (composed of a panel of specialists in the fields of neurology, psychology, education, linguistics, ergonomics, communication design, and typography).

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Modularity and Grids in Letterforms Across Calligraphy, Conventional Type and Geometric Type Teaching

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Abstract. This paper deconstructs the inherent modular nature of the Latin alphabet, more specifically its structure and anatomy. Letterforms are often rendered into grids and occasionally through the usage of geometric shapes and/or other reusable shapes, a practice which has been useful for either letterform design teaching purposes or actual longform text setting by calligraphic methods.

We propose a theoretical approach, with a non-interventionist methodology of qualitative research, through literary review in which we evaluate the state of the art. Authors across the academic and historic spectrum are reviewed: ranging from the humanistic Dürer – with his *Underweysung der Messung* treatise – to the mathematically-inclined Hofstadter – with his *Letter Spirit* project –, but also including specialists such as Johnston, Gill, Tschichold, Albers, Schrofer, Crouwel, Noordzij, Briem, Frutiger and Knuth – with their extensive theoretical treatises supported by constant professional practice. Our main objective is that an integrated understanding of the multiple systems of typographic modularity will become a valuable theoretical framework for teaching graduate and post-graduate graphic design, graphic communication and type design courses. Modular and geometric type design practice, applied in practical teaching/learning exercises, can structure the students' view and understanding of the alphabet as a visual code of communication, allowing for an improved process and, therefore, improved results. We conclude that teaching a modular theoretical view, in conjunction with practical exercises, structures students' understanding of typography beyond traditional modular typography, as well as the composing elements of both calligraphy and conventional type design. This method makes the process of learning and understanding typographic anatomy easier, a factor which allows for improved courses in type design.

Keywords: Calligraphy · Typography · Type design · Modularity · Alphabet · Grids · Geometry · Teaching

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1 Introduction

The Latin alphabet, whether rendered into its original monumental roman square capital (MRSC) incarnation, the later Caroline/antiqua/foundational hand (FH) minuscule development and its stylistic descendants, or the italic script (IS) is, by its very nature and regardless of the tools and techniques used for its physical reproduction, a set of intrinsically modular structures, simplifiable into geometrical shapes, which may be rendered atop grids either way. These techniques can be used both for letterform analysis [1], teaching [2] and construction [3], and the latter can be done manually or digitally, and devised either by human brains [4] or algorithmically, via parametrization [5] or artificial intelligence [6, 7].

It naturally follows that when teaching calligraphy and/or type design, whether conventional or geometric, said factor and techniques should be approached as part of that process from the very beginning, instead of taking a strictly superficial and prescriptive outlook on letterforms.

2 Grids: Their Evolution, Function, and Typologies

When approaching the usage of grids in typography, it is important to note just how pervasive these are in all forms of verbal records – by the very nature of their flow of information and of the usually flat, physical media upon which they are expressed – and also in many other forms of visual communication – such as art –, as a framework for structuring and/or giving meaning to content on a larger scale. While we will be focusing mostly in microtypography and character-level structural grids, some grander historical, aesthetic and technical notions should also be considered.

Among these are the grid's centripetal or centrifugal nature [8], its various point-, line- or field-based typologies and its evolution from being a carrier of meaning, during Medieval times, to becoming a tool of reality mapping, in a Renaissance and Cartesian spirit, and finally a modern field-based framework for structuring information and post-modern ingredient for new forms of expression [9].

Also relevant are its different geometric typologies, such as the different number of axes and its respective angles, which can then combine into recurrent constructions, such as orthogonal – typical in conventional type design, such as that of the Roman du Roi, calligraphy and in vanguard lettering projects –, isometric, slanted and others – such as those still based on an orthogonal framework but leaning on circles, diagonals and proportion ratios –, and the presence or absence of gutters.

3 Letterform Theories and Teaching Across the Ages

The written word has, since its inception, served the permanent recording of information and its transmission to others, sometimes as a means of building and asserting authority [10]. Its rendering, whether in epigraphic, painted lettering or calligraphic form, has been, for centuries, the purview of dedicated craftspeople who transmitted their knowledge from master to pupil. When it comes to the Latin alphabet, not many

detailed records of said craft processes were created or spread until the invention of the printing press and the democratization of knowledge it brought upon the Western world.

Once that crucial milestone was achieved, multiple calligraphy and lettering manuals were published in quick succession by several authors, mostly in but not limited to Italy, such as: **Arrighi**, who wrote, in 1522 [11], the first manual on the IS, based on the Papal Chancery style [12–14] and with an inherently modular construction [15]; **Tagliente**, in 1524, with several calligraphic styles and alphabets [16], including an orthogonal grid- and circle-based (OGC) construction of a blackletter/textura (B/T) style; **Palatino**, in 1540, also with a strong emphasis on the IS [17]; **Pacioli**, in 1509, with an OGC system for the design of MRSC [14, 18]; **Fanti**, in 1514 [19], with OGC constructions of a FH style, a B/T and MRSC; **Dürer**, in 1525 [20], with an OGC construction of MRSC and what is likely the first modular square-based construction of a B/T; and **Tory**, in 1529 [21], with a mystically-inclined work [14] including MRSC constructed on a 10 × 10 unit square-based grid (SG).

The next milestone in standardization was undertaken in France, from 1693 onwards, by the **Académie des Sciences**, supported by the research of Truchet, Jaugeon and G. F. des Billettes. The final product, designed by **Philippe Grandjean** for the Imprimerie Royale, would become the **Romain du Roi** typeface [22, 23], an entire system – including MRSC and lowercase characters – of geometric construction, based on a 8 × 8 SG, further subdivided into 6 × 6 sub-grids, for a total of 2,304 squares, an approach that neatly predicted digital type design strategies, especially in its slanted variant [23], and would influence authors such as Knuth [5, 24].

A further detachment from the calligraphic origins of the FH archetype ensued, resulting in the modern Didone typefaces, which Morris and Walker considered an example of "false perfection" and a "degeneration under industrialization" [23]. It is in this context that **Edward Johnston** almost singlehandedly revived the teaching of calligraphy [25], by studying early manuscripts at the British Museum and publishing his calligraphy treatise *Writing & Illuminating & Lettering* (1906) [26]. This extensive, eclectic but prescriptive exercise would lead to a posthumous magnum opus, ***Formal Penmanship*** (1971) [27], in which the author describes the writing tools – namely the broad nib –, the traditions – i.e. the several different styles reproducible with the former – and the definition, "by the thing" – a manifesto of sorts –, of Formal Penmanship. Johnston succinctly demonstrates, with a FH style, a series of parameters defining of any handwritten, namely: skeleton forms – i.e. the linear paths followed by the nib in each character; nib angle – providing the stress to the characters; weight – i.e. the nib-width-to-character-height ratio; shape – given by the appearance of curved strokes and finishings; number, order and pen-direction of strokes; and speed of writing.

In the same context, **Eric Gill**, who worked with Johnston and drew inspiration from the latter's London Underground Railways humanist sans serif font (also known as **Johnston**) for the eponymous **Gill Sans** family, and also designed the serif faces Perpetua and Joanna, would go on to write *An essay on Typography* (1931) [28], in which the he presents us with his ideology – influenced by the Arts & Crafts movement but more accommodating and even predictive of modernist design –, shows his deep understanding of type design principles and anticipates the debate over the essence of a letter in several decades.

Almost simultaneously, **Jan Tschichold** would author *Schriftschreiben für Setzer* (Formal writing for compositors) (1931), in which the author teaches his theories – i.e. the usage, for FH archetypes, of skeletal forms, broad-nib pens and the grid in a fluid manner, as a "guideline for the vertical axis", the horizontal proportions obeying the rhythm and "the flow of the writing tool" [29]. By contrast, his ***Leicht und schnell konstruierbare Schrift*** (Quick and easy font building) (1930) method is, like **DIN 1451** [30], strictly grid-bound, but includes adjusting letter-spacing so as to preserve word rhythm. Before returning to humanistic principles and conventional type design, Tschichold also developed a monolinear font for *Noch eine neue Schrift* (Another new script) (1930), an unpublished Schablonenschrift/stencil (SchS) typeface for Stempel and **Transito**, also a SchS font [29].

Other SchS fonts were developed in the Bauhaus, namely the recently digitized **Joschmi** [31] – a font based on three modules and a square-based grid with vertical gutters (SGVG), by **Joost Schmidt**, and the fonts presented in ***Zur Schablonenschrift*** (On stencil typeface) (1926) – based on a freer approach, very similar to Transito – and ***Kombinationsschrift "3"*** (Combination script "3") (1931) – a more rigid font, also based on three modules and a SGVG, but offering parametric variants –, by **Josef Albers** [32]. The latter would publish *Zur Ökonomie der Schriftform* (On the economy of typeface) (1926), where he argues for the material savings, standardization and presumed legibility improvements of said typefaces at long distances. Other typefaces, such as **Herbert Bayer**'s **Universal** font, would go the geometrical, OGC route [29], in a monolinear expression devoid of finishings.

On the Netherlands, vanguard designer **Hendrik Wijdeveld** also designed modular SchS on SGVG variants [33], and **Jurriaan Schrofer** revisited the archetype in 1963 with his **Sans Serious** font, expanded upon it with horizontal gutters and different shapes, and also experimented with various grid configurations or construction techniques, and the limits of modularity or even abstraction and its consequences – in the form of non-alphabetic, meaningless characters–, as explained in his ***Letters op Maat*** (Letters made to measure) (1987) essay [3]. On a related note, **Wim Crouwel** would ostensibly commit to legibility research, proposing his parametrically variable **New Alphabet** system as viable, while also referencing Francesco Griffo's **Bembo** with the typeface for the Fodor catalogs [34].

In a similar vein to that of Johnston, **Gerrit Noordzij** authored *Das Kind und die Schrift* (The child and the writing) (1985) [35], several writings for ATypI compiled in *Letterletter* (2000) [36], and *The stroke: theory of writing* (2005) [37], laying out his theories, including old concepts, namely speed, rhythm and the importance of negative vs. positive shapes, and novel ones such as: *wortbild* (word image); the "second dimension of the stroke" and "third dimension of movement", traits lost due to the introduction of, respectively, flexible and pointed nibs, and cursive, uninterrupted script, scathingly critiquing the Renaissance theorists; the counterpoint; and the translation, rotation and expansion models, summed up in his **parametric three-axis, cubic system**.

Also relevant is **Gunnlaugur S. E. Briem** [15], who authored the **Icelandic Method**, an integrated approach to calligraphy teaching, specifically of IS and admittedly and strongly influenced by Arrighi's own. In it, Briem suggests the usage of grids for training and exposes the aforementioned modularity of IS.

Adrian Frutiger would present his type designer and semiotics scholar's take, adding, to a general history of writing and calligraphic principles, his four morphological tables of reductionist experiments on 2 × 2 unit SG – the last two of which with the addition of ±45° bisecting lines and a ⌀2-unit contained circle – and his "theory of reduced hand movements" in letter building, numbered as follows: "1, simple crossing; 2, right-angle change of direction; 3, curved change of direction; 4, welding in middle of stroke; 5, welding of two stroke endings; 6, welding at one end of stroke; 7, meeting of stroke beginning and ending" [1].

Douglas Hofstadter's ***Letter Spirit*** project, developed at the Fluid Analogies Research group/Center for Research on Concepts and Cognition of the Indiana University, would use a very similar grid to Frutiger's, with the addition of two levels for ascenders and descenders – making it a 2 × 4 unit SG with a 2-unit x-height – and ±45° lines on all squares, and, in a yet more radical fashion, also simplify and group **parts** and **junctions** of letter anatomy respectively into the more general and abstract concepts of **"roles"** and **"r-roles"**. Its main purpose was producing AI-generated fonts in order to explore the concepts of "letter" – or, more specifically, the essence of each letter individually – and "spirit" – which, in a traditional type design conception, could be translated as the internal familial coherence of a font as a whole [6].

Donald Knuth would also create, in conjunction with the TeX typesetting system, his own algorithmically-based system for font generation, ***METAFONT*** [5]. Unlike Hofstadter's, this is a fully-fledged, human-controlled and parametrical, conventional type-bound affair, as evidenced by the author's aforementioned historical influences and care with the most minute of details, such as the design of the letter S [38].

4 Integrated Teaching of Calligraphy and Type Design

Based on all the aforementioned references, and with the additional support of an iPad application [39, 40] and its ancillary, premade calligraphy grids [41], as well as type specimens [42–45] and research on modularity [24], letterpress and potential interactive enhancements thereto [46], a theoretical framework of our own emerged. It has been tested, at various stages of its development, in several extra-curricular calligraphy and combined calligraphy and type design workshops developed at the Faculty of Architecture of the University of Lisbon, attracting a total of 118 students from undergraduate, graduate and postgraduate levels since the 2012/13 school year, as well as at a curricular level, in the MA in Contemporary Editorial and Typographic Practices, jointly coordinated by the Faculties of Architecture and Fine Arts of the same institution, since the 2014/15 school year, encompassing a total of four classes and 63 students.

5 Conclusions

The results of the aforementioned experience have, so far, pointed towards an increasingly positive influence of said integrated approach – including elements of typographic history and theory, calligraphic practice exercises, geometric modularity

and conventional type design. This research in teaching is, however, ongoing and still lacking in external validation. As such, our main goal will be elevating it to a formal project at the postgraduate research level, with recourse to the standardization of said theoretical framework into toolkits and of the exercises to be administered, in turn, to experimental and control groups, the final results being evaluated by an external panels of experts and, thus, analyzed.

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A Critical Overview of Modular and Geometric Type Design Categorization in Typographic Taxonomy Systems

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Abstract. This paper identifies inherent limitations of current and popular typographic taxonomy systems regarding the categorization of modular and geometric type. These taxonomy systems commonly focus on historical sources and strictly aesthetical or structurally generic factors. We believe that even ones which offer a greater degree of detail still fail to extend to the level of attention regarding the full range of idiosyncrasies of modular and geometric type design.

We thus propose a theoretical approach, making use of a non-interventionist methodology of qualitative research, through literary review and observation, and we evaluate the state of the art regarding current and historical typographic taxonomy systems and works from Childers, Griscti et al.; Kupferschmid; Baines & Haslam; Johnston; and Dixon, with a special focus on the latter's own classification system and its potential for expansion. Our main objective is that a critical understanding of the multiple systems of typographic taxonomy, combined with our first-hand professional experience and theoretical research in modular type design may facilitate the production, categorization, promotion and commercial distribution of modular fonts and font systems, as well as the teaching of the history and techniques specific to this creative field. Modular and geometric type design production is a field of activity in its own right, with a rich and diverse history and ongoing vitality, and should thus be validated on its aesthetic, technical, commercial and pedagogic merits, regardless of its limited practical applications on our demanding modern visual communication.

We conclude by introducing the early guidelines for a revised and expanded taxonomy system, as well as some practical applications, which can include improved learning exercises both for beginners and seasoned professionals, as well as enhanced categorization and filtering tools both for online font stores and font managing software.

Keywords: Typeface classification · Typeface taxonomy · Typography · Type design · Modularity · Modular fonts · Geometry · Font distribution · Teaching

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1 Introduction

Typographic taxonomy, while not as ancient as typography itself, is a field of study with a long [1], controversial [2, 3] and increasingly tortuous history, on account of the not-so-recent phenomenon of revivalism [4] and the accelerating explosion of experimental "new and novel typefaces" [1]. Among the latter, we must include modular and geometric type design, a niche of self-declared revolutionary [5–7], experimental [8], research-oriented [7] and/or ornamental [9] specimens.

Although they were designed contemporarily with most of the popular and current typographic taxonomy systems, these typefaces were unfortunately not referenced at all by name in said systems, let alone afforded a bespoke system that takes into account their rich diversity and type design specificities. This state of affairs is due mostly to the normal delay from scholars in their reaction to new phenomena, but also partly to the niche status of these typefaces, as well as to the dearth of first-hand accounts on their design process and of efforts from their authors towards their effective promotion as off-the-shelf, commercially viable products.

Their popularity – both commercially and as a teaching tool – is, however, on the rise [10–12], along with that of other more conventionally designed digital display typefaces. As our main objective we will, thus, set out to evaluate the extant typographic taxonomy systems in order to ascertain which is the most suitable for adaptation and expansion, so as to better fit and describe these modular and geometric typefaces, and will then proceed to set out some early guidelines for said expansion.

2 Typographic Taxonomy Overview

Typographic taxonomy systems, while themselves fairly diverse, can be grouped into two different super-families: **container-like**, with major classes and sometimes subclasses not unlike those set forth by Linnaeus when categorizing biodiversity; and **database-like**, with ever-expanding tags which can be freely combined so as to ideally fit and describe any typeface – past, present and future – conceivable.

Both kinds of systems feature their own advantages, but also present some limitations and/or challenges in their potential usage, after proper adaptation, for categorizing modular and geometric typography; as such and in the name of openness towards alternative solutions, tentative expansion approaches will be suggested even for those deemed less suitable for this purpose.

2.1 Container-Like Typographic Taxonomy Systems

Taking Childers, Griscti & Leben's thorough study, complete with graphic visualizations, on 25 typographic taxonomy systems [3], as a starting point, we can immediately identify an obvious genealogy and several common trends.

Regarding lineage and structure, **Vox**'s original system (1954) was adapted wholesale by the British Standards Institution to form the **BS 2961:1967** system (1967) and, according to Dixon, the latter's "top down approach to categorisation" seems to have informed or to reflect the way other taxonomy systems developed [13].

Thibaudeau's system (1921), upon which Vox's was based [3, 14], is one of the simpler examples, as are those developed by **Bringhurst** (1992), **Lupton** (2004), **Craig** (1961), **Fontfont**, **Linotype** and **Letraset**. These systems do not commonly try to group what Childers et al. call "Topical typefaces" [3], or even cover them at all (see Footnote 1), and only in Lupton's case are the remaining text typefaces grouped into Sans and Serif super-categories.

Vox's later system, as adopted and modified by **ATypI** (1962), influenced its contemporary by **Nettlehorst** (1957), and was used as the basis for other more complex systems, such as **DIN 16518** (1964), which in turn was barely expanded and/or otherwise modified by the likes of **McLean** (1980), **Lawson** (1990), **Solomon** (1986), **Strizver** (2001), and even **Dixon**'s own initial container-like system (1995) [3]. All these systems feature a tripartite combination of Serif, Sans Serif and Topical super-categories, sometimes accompanied by isolated Topical categories, with a varying emphasis on subclassification of either Blackletter or Display fonts.

At the opposite end of the complexity spectrum, some outliers are notable: **Haley**'s system (1995), a hybrid system that separates both Serif and Sans Serif fonts in great detail, unfortunately doesn't afford Topical typefaces the same treatment; **Paratype**'s system, which is considerably more "balanced" – especially in its treatment of Topical typefaces – but also "redundant" [3]; **Adobe**'s system, which doesn't properly separate Sans Serif fonts but dedicates significant more detail to Topical typefaces than most others; **Bevington & Chong**'s as-of-yet unpublished and rightly considered by Childers et al. to be a novel system [3], with its two main functional halves, Text and Display, which are divided into three super-categories each, in turn subdivided into three further sub-categories, into which fonts are placed according to their position "within a scatterplot field along two distinctive dimensions for each sub-category" and, in the Topicals' case, according to how they reference a **style**, an **era** or a **place**; and, finally, **Childers et al.**'s own "Resolved" system [3], also a tripartite affair, with all Sans Serif categories as top-level, on the Serif family Slab Serif and Old Style as super-categories as well as Modern and Transitional as top-level isolated ones, and on the Topical family Blackletter and Script as super-categories and **Graphic** as the single outlier.

When it comes to trends, this last choice of concept and name, similar to that used in BS 2961:1967, is telling of a running theme which Childers et al. had trouble in dealing with in a systematic fashion[1]: the act of lumping together all outlier typefaces into a **"catch-all category"** [3], by various definitions, which Baines & Haslam had also colorfully considered "a dumping ground for misfits" when referring precisely to British Standards Institution's approach and its choice of that very name [1].

[1] While the authors' concern with the fragmentation of sub-categories, the usage of generic categories, and the way both impair memorability and usability, is commendable, their acceptance of the opposite, radical approach of ignoring Topical typefaces altogether is incoherent and troublesome, as it perpetuates a stigma which affects the latter and their designers [13].

2.2 Database-Like Typographic Taxonomy Systems

On the other side of the conceptual divide, some authors propose systems which allow for a typeface to belong in more than one category, as was **Vox**'s intention with his original system (1954) [14], later subverted in **BS 2961:1967** and its offspring [13].

Updike's system (1922), while not strictly database-like, presents itself as a hybrid, with its multiple and differentiated **era-based** sub-systems for each **geographic region** [3], in a detailed acknowledgement of diversity, rare before or since its inception.

More interestingly, **Kupferschmid**'s system (2003) follows a **form model**, based on Noordzij's three-axis theory of writing [15] at what the author calls the **bones level**, further complimented by the **flesh level**, comprising the expression of each parameter set forth by said theory and the presence or absence of serifs and other finishings, and the **skin level**, comprising the finer details of said finishings and which finally introduces us to the possibility of using "a collection of **tags**" [emphasis ours] to describe a typeface in fine detail [14, 16]. Furthermore, Kupferschmid suggests yet another level of **micro-classification**, also by using potentially more generic and abstract, user-generated tags in an interactive environment [14].

Devised nearly a century before its brethren, **Johnston**'s system (1906), intended for the analysis of what he calls "**models of lettering**", is the last component in a scribe's work process, which could describe any kind of specimen regardless of medium [17] and consists of a hierarchic, numbered list comprising all relevant structural and decorative details. This system could not only be used for typography, but also seems to mimic other authors such as Dürer [18], and anticipate some of Albers' [19] or Schrofer's [8] concerns with measurements, Dixon's own analysis framework and modern digital type design naming conventions such as "components".

Dixon's later system (2002) acknowledges the complexity and futility of trying to categorize the ever-expanding body of type design work with the increasingly ineffective "top-down" systems, proposing an approach decidedly more advanced than that of Vox's original system. Instead of a simple combination of preexisting container-like categories or simple tags, Dixon's framework separates categorization parameters into **sources** – "the generic influences informing a typeform" –, **formal attributes** – "the basic individual units of description that refer to a typeface's design and construction" – and **patterns** – "the most common recurrent configurations" of both former parameters [13]. Furthermore, Dixon recognizes that while her system is internally coherent as is, it can be subject to an also admittedly welcome expansion, and rightly argues that said expansibility, by default and by design, is what sets it apart from the rest.

2.3 Where Are Modular and Geometric Categories/Tags? A Common Trend

All the former systems having been considered, the aforementioned trend (see Footnote 1) becomes increasingly acute when it comes to modular and geometric type design, regardless of the kind of taxonomic system. These fonts are never named as such, as the only mentions to "Geometric" type pertain to geometric Sans Serif faces, such as Futura, and never to fonts designed exclusively with geometric shapes, such as

Kombinationsschrift "3" [19] or Sans Serious [9], and all Latin lettering being, in a sense, inherently modular [20–23], it is also understandable – if not entirely acceptable – that no "Modular" category was defined for specimens built up out of more rigid modules.

When it comes to "Geometric" and "Modular" tags and/or parameters in database-like systems, however, there is no technical reason for their apparent absence, other than a lack of knowledge and/or interest from those that make use of them – an issue Kupferschmid already noted in general terms [14] – or themselves being an eternal work-in-progress – which Dixon also readily acknowledged [13].

3 On Improving Modular and Geometric Type Taxonomy

When it comes to the most popular systems, still either container-like or simpler tag-based affairs, the promotion of entire modular- and geometric-oriented sub-systems with the same trappings and categories of a conventional system – not unlike the approach Updike proposed for specific regions – could be a valid approach for the former, as would be, for the latter, the addition of "Modular", "Geometric", "Grid-based", "Additive" tags, among others, and possibly even sub-tags to each of them.

As for more complex systems, which should not be forced "on everyone if it may not even be helpful to them" [14], we do believe that they may be useful for advanced users looking for modular and geometric fonts. Bearing that in mind, Kupferschmid's focus on Noordzij's theory is also observed in the field of modular and geometric type design [24–27], and said theory's parameters are certainly compatible with Dixon's system [4, 13]; thus, taking the latter and expanding it in order to accommodate additional modular- and geometric-specific parameters seems to be the best course of action.

As such, we propose the following headings and submenus: **Grid**, and the corresponding **Kind** – orthogonal/isometric/other, continuous/with single- or multi-axial gutters, centrifugal/centripetal (Fig. 1) – **Module Snapping** – line-snapping/cell-snapping – and **Character Snapping** – monospaced/grid-spaced/fractionally-spaced/freely-spaced; **Modules**, and the corresponding **Number** – of total different module designs –, **Shape(s)**, **Position** – in relation to the grid – and **Permissible Transformations** – translation/rotation/shearing/scaling; **Macro-proportion** – the height-to-width ratio of relevant characters; **Micro-proportion** – the ratio between black/positive and white/negative shapes, following Johnston's [20] and Noordzij's [15] theories; **Skeleton Shapes** – as defined by Johnston [20], Noordzij [15], Majoor [28] or even Schrofer [8], namely how they snap to the grid lines and/or its cells. As for the existing headings, some common, modular- and geometric-specific submenus, based on conventional type design paradigms, will make an appearance, namely **monolinear**, **formal** or **hybrid**.

From the combination of these formal attributes and recurrent references we can already identify a few already existent modular- and geometric-specific patterns, such as the "vanguardism-referencing, interrupted stencil construction, from square or rectangle shapes and quarter-circles" [24] seen on examples such as **Joschmi** [29], the aforementioned **Kombinationsschrift "3"** [19] and **Sans Serious** [9], **Arte e Género**

[30] or **Cappucino** [24, 31]. In a similar vein to the one advanced at the beginning of this chapter, these formal attributes do not preclude modular fonts from adhering to conventional references and, thus, from belonging to conventional patterns as well, as is the case of the font **Equilatera** in its **Textura Quadrata** variant [24, 32].

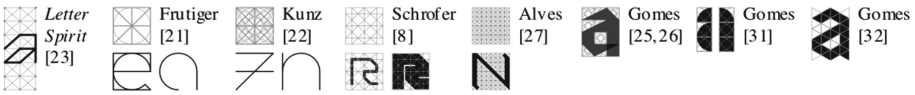

Fig. 1. Representative typologies of grids

4 Conclusions

Besides the obvious, noble goal of better categorizing existing modular and geometric typefaces for its own sake and under a scholarly premise, in order to make sense of the inherent complexity born out of the constant reinterpretation of the Latin alphabet archetypes, some practical benefits may arise from the dissemination and day-to-day usage of all or any of the stated approaches towards an improved taxonomy system.

The first benefit pertains to the teaching of the history, principles and techniques of not just modular and geometric typography and its design, but of those of conventional typography itself, as many of those subjects can be better explained and demonstrated by teachers and experienced first-hand by students in a simpler, modular and geometric setting [11]. It stands to reason that the greater the knowledge on this subject is, the better the preparation of its teachers and the quality of their didactic materials will be. This being an area in which the authors of this paper operate on a professional capacity, said vector of dissemination, along with academic communication, is all but assured.

The second obvious benefit would be the ease in finding modular and geometric typefaces, both at the buying stage and during daily use. Kupferschmid alluded to the issues affecting the usage of complex systems in commercial settings [14], but we see no impediment to offering a light version of such a system, or offering it as an extra tool for seasoned professionals already attuned to its conventions after exposure to it – which would naturally follow from the former point, whether directly or indirectly.

The pioneers' efforts, albeit outdated, are still commendable, as is Griscti et al.'s exercise in analyzing them and attempting to derive an improved system under the same conceptual framework. We are evidently biased towards Kupferschmid's and Dixon's approaches, as they take into account future developments by default, are firmly rooted in professional experience and backed by actual on-the-field testing.

Along with further refinements and structuring, this latter hurdle is the last one yet to be cleared by our own system extension; we are cautiously optimistic that it, too, will soon reach a mature state and be properly validated in all but guaranteed academic and commercial settings of our own initiative and, hopefully, of third-parties' as well.

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Design for Behavior Change

Expected Architects Acceptance of a BIM Tool to Optimize the Building Energetic Performance

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Abstract. This paper presents an evaluation of the architect's acceptance of new proposal toll, that will be integrated in a BIM environment, to be used to optimize in the space organization in function of the energetic performance of a building, in comparison to the traditional solutions alternatives. This evaluation used the social psychology to evaluate the architects expected acceptance of this tool. One hundred two architects participated in this study, the main results showed that only 61.8% of the sample agree that this BIN solution can help their performance in project. This result can be justified by the values of effort expectation that 79,8% believe that they need to have a high effort to be able to use this application. The need to a good usability and user experience to improve the interaction with this application, is a very important aspect to change those results and to improve the use of BIM solution in their work tasks.

Keywords: User acceptance · BIM tool · Energetic performance · Architects

1 Introduction

This paper outlines part of a research project, Ren4EEnIEQ, funded under the Portuguese Foundation for Science and Technology (FCT) and European Regional Development Fund (FEDER), which involves the assessment of acceptability and intention to use a new tool for architects. The project objective aims to develop a comprehensive tool for deep building renovation, which comprises the building survey, design generation, building geometry optimization, and energy system and constructive system optimization in single BIM add-on tool for architects. The goal is to help the architect looking for the best building renovation solution that minimizes energy consumption and maximizes indoor environmental quality in a cost-effective manner.

The evaluation of the user acceptance was done according to the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2): performance expectancy; effort expectancy; social influence; facilitating conditions; hedonic motivation; and behavioral intention to use the BIM tool.

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Unified Theory of Acceptance and Use of Technology (UTAUT)
UTAUT is used in technology acceptance studies to predict system use and to make decisions about technology adoption and use. The model incorporates eight other models that foresee the adoption, acceptance and use of technology, bringing coherence to the technology acceptance literature and providing a unified view of technology [1, 2].

The first UTAUT presented by Venkatesh, Morris, Davis, & Davis [3] has four constructs that influence behavioral intention to use a technology (performance expectancy, effort expectancy, social influence, and facilitating conditions). These authors have defined performance expectancy as the degree to which the user believes that using the tech will help him achieve performance gains; effort expectancy explains the degree of ease associated with the use of technology; social influence indicates the degree to which the user perceived that others (e.g., friends, colleagues and family) believe he should use the technology; and facilitating conditions define the degree to which the user perceives the existence of an infrastructure that supports the use of technology.

Later, Venkatesh, Thong and Xu [4] adapt UTAUT and introduce UTAUT2, including three more constructs (hedonic motivation, price value, and habit) and new connections between all variables and the behavioral intention to use. They also include individual variables: gender; age; and experience. Ignoring the voluntariness, present in original UTAUT.

Reviewing other studies, we understand that it is possible to involve other variables within this theory, example is the case of Shuhaiber and Mashal [5], investigated how then involved the personal characteristics of users (trust, awareness and pleasure/fun) with the intention of using a system. Chintalapati, Srinivas, and Daruri [6] puts the Perceived usefulness sub-variable of Performance expectancy, the Perceived Ease of Use sub-variable of Effort expectancy and User Attitude as variables responsible for intent to use (Behavioral Intention). Manis and Choi [7] study intention to use through Perceived Usefulness, Perceived Ease of Use, Perceived Enjoyment and Attitude toward using. Recently Yang and Wang [8] present a more simplified study model where they test the direct relationship between Perceived Usefulness and Perceived Ease of Use with Intention to Use. This flexibility of adding and removing variables shows us that it's possible to select the most appropriate constructs for each case study.

1.1 Objectives

This study focused on expected user acceptance of a BIM add-on tool for architects. In this context, the main objective is to evaluate the acceptance of a concept showing an interface and explain what they can do with it.

2 Methodology

The online survey was conducted to capture the users' expectations regarding the use of such systems. The questions were designed to get subjective evaluations of the following parameters of UTAUT2: performance expectancy, effort expectancy, social

influence, facilitating conditions hedonic motivation, and behavioral intention to use. A video has been created with a scenario that enables the comprehension of a potential use of the program before answering the questions.

2.1 Survey Structure

The survey by questionnaire, consisted in three parts: (1) the informed consent, (2) the video about the tool, (3) the questions related to the tool and personal variables.

About part 3, the questions were inspired by Venkatesh et al. [4] research and adapted to assess the acceptance of Portuguese and Brazilian architects and architecture students. They were invited to participate by email or contact via social network LinkedIn.

Adapting the questions according to the study theme, we selected eighteen items to evaluate the parameters present in the UTAUT2. All these items were measured using a seven-point Likert-scale from 1 (completely disagree) to 7 (completely agree). Three questions were collected regarding each construct except price value and habit. The price value and the habit are not suitable constructs for study, because the tool will not bring a direct cost to an employee in his studio, for example. It cannot become a habit when it doesn't exist.

With the performance expectancy we want to know if the architect believes that the tool is useful for his daily life, he would perform well, and would help him get his work done quickly. At effort expectancy let's evaluate if the user feels able to use the program without difficulty and could become skillful. The variable social influence will indicate whether colleagues and the organization can influence program use. The facilitating conditions are related to the support, he has the necessary knowledge, if he knows how to use it and if he could overcome his difficulties. With the hedonic motivation we analyze if using the tool can be enjoyable or fun. Lastly, behavioral Intention, we ask directly if the user has the intention to use the tool in the future.

2.2 Video Scenario

To engage the participants in the fill of the questionnaire, a video was created to explain the tool. To simplify understanding in the video, we use a simple story where we use the BIM tool in a context. In a previous study we had already presented a video to test a concept, this technique proved to be useful and well accepted by the participants [9]. A team of experts wrote the script, filmed the scenes and edited the video. When finished, it was uploaded to embed in part 2 of the survey (https://youtu.be/NR4-YyQIaeg).

The BIM tool appears as a functional prototype, was developed respecting usability heuristics. The simulation was run on Adobe XD and captured the video screen bringing a more realistic interaction, introducing files, pressing buttons and observing graphics. An audio was introduced in the edition, explaining what is being done at the same time.

In the first scene an architect is working in his studio, focused on his project. There are many sketches, materials and the environment seem disorganized. In this environment he can't work and is frustrated.

The second scene begins as a dream and a prototype of the program is presented.

In the last scene the architect returns to his first studio where he is alone and calls to get the program. In a perfect studio a work team uses the program and discusses the ideas of the projects they are working on.

2.3 Data Analysis

After exporting the data, they were inserted into the IBM SPSS (Statistical Package for Social Sciences) software to perform the statistical analysis.

With the Likert 1–7 scale we will extract the percentages of responses, mean, median and standard deviation from the constructs. This analysis will show the response tendencies of the architects.

Cronbach's alpha assesses whether the designed test measures the variable of interest. It's interesting test the reliability of the Likert Scale multiple question survey. Cronbach's alpha greater than 0.7 suggests an acceptable internal consistency.

With the factorial analysis we reduce many variables into fewer numbers of factors. Factors represent the relationships between the various constructs of the survey. This grouping will help us to assemble the model for acceptance of the BIM tool.

2.4 Sample

In total, 102 questionnaires were collected for analysis. The gender ratio corresponds to 57 men (55.9%) to 45 women (44.1%). The minimum age was 21 years and the maximum age was 59 years, the mean was 33.8, with a median of 32.0 and a standard deviation of 8.2 years. The sample included 97 architects (95.1%) and 5 architecture students (4.9%). In the nationality factor we observe that 92 people are Portuguese (90.2%) and 10 Brazilians (9.8%).

3 Results and Discussion

We present Table 1, shows the distribution of scores by participants for each question (N = 102). The results are grouped by the cumulative percentage. Percentages are cumulated with response 1, 2 and 3 on the Likert scale (1 completely disagree – 7 completely agree) as the negative tendency, response 4 is the neutral response that does not agree or disagree with the sentence, and responses 5, 6 and 7 are considered as positive tendency.

Table 1. Distribution of scores for each question.

Constructs	Code	Percentage of responses 1, 2 and 3	Percentage of response 4	Percentage of responses 5, 6 and 7
Performance Expectancy	PE1	16,7%	12,7%	70,6%
	PE2	25,5%	15,7%	58,8%
	PE3	22,5%	18,6%	58,9%
Effort Expectancy	EE1	6,9%	16,7%	76,4%
	EE2	5,9%	19,6%	74,5%
	EE3	7,8%	22,5%	69,7%
Social Influence	SI1	21,6%	22,5%	55,9%
	SI2	11,8%	16,7%	71,5%
	SI3	16,7%	14,7%	68,6%
Facilitating Conditions	FC1	12,7%	26,5%	60,8%
	FC2	16,7%	17,6%	65,7%
	FC3	22,5%	28,4%	49,1%
Hedonic Motivation	HM1	20,6%	36,3%	43,1%
	HM2	17,6%	32,4%	50,0%
	HM3	18,6%	32,4%	49,0%
Behavioral Intention	BI1	13,7%	21,6%	64,7%
	BI2	14,7%	19,6%	65,7%
	BI3	20,6%	22,5%	56,9%

Analyzing Table 1 we can see a tendency to the right, that is, the answers 5, 6 and 7. Recalling our main objective of this study, we want to know if the BIM tool will be accepted by architects. The Behavioral Intention construct shows us that there is a mean between 4, 7 and 5 in the questions, although it's a positive response, it doesn't indicate the best intention to use the tool. We also noted a lower agreement on the questions of variable Hedonic Motivation, we want to know if the use could be fun, enjoyable or exciting. The neutral answer may be because they never used the tool and can't understand with the video or because the tool presented doesn't seem very different from others, they already use it in work. The tool should be used in a serious work situation, architects don't see it as something with so much fun. We also observed the coded question FC3, comparing with the other questions of the construct Facilitating Conditions this presented a lower mean and a lower positive trend. Most people think have the necessary knowledge to use the tool (FC1) and the tool is compatible with other technologies they use (FC2), but most of them don't believe that other people would help them if they had difficulty using the tool (FC3).

To measure reliability or internal consistency, Cronbach's alpha was applied to verify if the questionnaire measures what it should, in our case the acceptability of the tool by the architects. In our case Cronbach's alpha is 0.933, higher than 0.9, indicates an excellent internal consistency. A high level of consistency for this specific sample shows that the questionnaire is reliable and accurately measures the variable of interest.

A factorial analysis was performed to identify the minimum number of factors that represent the relationships between the various items of the questionnaire.

The Keyser-Meyer-Olkin test had a value of 0.888 revealing that the analysis of the main components is good. Table 2 shows the factor matrix after varimax rotation. Factor extraction determined three factors.

Table 2. Factor matrix after Varimax rotation

Constructs		Rotated component matrix		
		Factor 1	Factor 2	Factor 3
Performance Expectancy	PE1	**0,802**		
	PE2	**0,804**		
	PE3	**0,754**		
Effort Expectancy	EE1		**0,847**	
	EE2		**0,881**	
	EE3		**0,825**	
Social Influence	SI1			**0,795**
	SI2			**0,787**
	SI3	0,408		**0,683**
Facilitating Conditions	FC1		**0,770**	
	FC2	0,407	**0,553**	
	FC3	0,414	**0,623**	
Hedonic Motivation	HM1	**0,832**		
	HM2	**0,825**		
	HM3	**0,891**		
Behavioral Intention	BI1	**0,878**		
	BI2	**0,897**		
	BI3	**0,893**		

The first factor is responsible for 49.4% of the variance and consists of Performance Expectancy, Hedonic Motivation and Behavioral Intention. These variables indicate the intended use of the tool. The nature of the variables in this factor will be called Tool Use. The second factor, responsible for 14.4% of variance, is Effort Expectancy and Facilitating Conditions. These variables are related to the ease/effort perspective and conditions for using the application. This factor will be called Conditions of Use.

The third and last factor, responsible for 9.4% of the variance, is Social Influence. As this factor consists of one variable, we will keep its name Social Influence.

This factor labeling can be subjective and is presented as a suggestion analyzing the variables contained in each group. These factors are associated with user acceptance of the tool.

4 Conclusions

The study reported results of accepting the use of a BIM add-on tool, using a video with a program usage scenario. The identification of the acceptance of this software at an early stage of the development of the Ren4EEnIEQ project will justify the costs

involved in the application development. For our sample, AutoCad is the most popular tool and should be considered in design solutions. We identified an agreement with the Behavioral Intention sentences: "I would like to use this tool in the future." with 64.7%; "I would like to use the tool in my work." with 65.7%; and "I would like to use the tool often." with 56.9%. However, we still have the remaining percentage of disagreement (between 13.7% and 20.6%) and with no preference (between 19.6% and 22.5%).

For future work we recommend the inclusion of other professionals, such as engineers working with BIM tools. Perhaps adding more information about the tool's functionalities would be an added value for the perception of use. We are also concerned with adding a variable for years of professional inexperience and not only if the participants are students or architects. It would be interesting to know if the architect works as a freelancer, and if he has worked in another country. We believe that considering these factors can affect the results positively.

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Designers and Repertoire: Considerations on the Importance of Expanding Design Students' Knowledge Base

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Abstract. This work substantiates the importance of discussing the design students' repertoire as the basis for developing projects with quality and identity, considering the sociocultural background of where they live. We highlight the Brazilian education system's singularity—students from both public and private schools can study in federal universities. An academic graphic design project was used as an example for the next studies. Semiotic elements were applied to the reading criteria in the regional, national, and universal contexts, which were analyzed through syntax dimensions. It was identified that the repertoire's effects on the project's quality have to be assessed with greater depth, and the results will effectively influence the way design courses are planned and managed.

Keywords: Design · Repertoire · Heuristic · Cultural identity

1 Introduction

Design as a recognized professional practice came up in each country based on their peculiarities and idiosyncrasies. We are based on the principle that designers have always existed. However, due to space and time restrictions, our references are focused on the 20th century. For example, we simplify that the Italian design originated from arts and architecture; the North American design, from large-scale production's workmanship; and in Germany, from the Bauhaus and the Ulm School of Design. In Brazil, the design practice began in the Modernism, in the 1950s. In the following decade, this prolific period to all artistic segments enabled the implementation of the

This topic was covered in the article Reflexões sobre a origem da beleza no design: uma apreciação através dos avanços tecnológicos que contribuíram para fundamentar a forma dos produtos de design no século XX (Reflections on the origin of beauty in design: An appraisal of the technological advances that contributed to fostering the shape of design products in the 20th century). Ready for publication.

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first design school, ESDI. The technical education of the School of Arts and Crafts of São Paulo, implemented in 1873, had a substantial influence. Our point of view is based on the fact that every product result from a universal cultural information base we called "repertoire." Flusser argues that "Design, like any other cultural aspect, is the way shapes appear."

The dynamics in which we live the present was optimized by information technology. The global market today demands products with quality and identity. As it is well-grounded in the book A estetização do mundo: Viver na era do capitalismo artista:

> "In the consumer industry, design, fashion, advertising, decoration, cinema, and show business create mass seductive products that convey emotions and sensitivity, shaping a proliferating aesthetic universe that is heterogenous due to its eclecticism of styles. With the economy's aestheticization, we live in a world marked by an abundance of styles, designs, images, narratives, landscapes, shows, songs, cosmetic products, tourist destinations, museums, and exhibitions" [1].

The aesthetic approaches developed by designers permeate the numerous technological possibilities and cultural expressions, recoding the concepts of beauty associated with usability. Scruton [2] sustains that "The sense of beauty guides the emotions and desires of its bearer. It can show their pleasure or taste, but it is a pleasure in what they value and a taste for their true ideals."

In this article, our analysis is on the importance of the understanding basis that foster the development of new products. We assume that each person has their own cognitive ability that, associated with sensory perception, diversely interacts with the surrounding world. At first, the objective is to understand to which extent the repertoire base is essential in the creation of a new design product—that is, how students can use information from their daily life.

Wherever they are and whatever their culture is, designers will always be based on the cultural values of a global market, peculiarities of their country of origin, and belief and value references of the region where they live. These three sources of learning and education will base the identity of the developed projects. A project developed in the Design course of UFMA is presented as a case study.

2 Development

The pedagogical methods applied in education in Brazil foster interdisciplinary and transdisciplinary knowledge. However, both elementary and high school often have distinct realities of infrastructure and education quality between public and private schools. Private schools have better facilities and better qualified teachers. This reality is reversed when we compare higher education institutions. This is due to the fact that public universities have resources to train teachers and infrastructure through research projects. Another relevant factor is the student's quality of life, particularly their living conditions, transportation, food, and opportunities of cultural contact with developed countries. We understand it reflects on the developed projects' results, as illustrated by the neurologist Dean Burnett [3], "Strong evidence shows that almost all of our experiences are somehow stored in the short-term memory." Therefore, it is part of our repertoire. He also assures that:

> "The brain also acknowledges connections and trends based on information stored in the memory. Our experiences base our points of view and what makes sense. However, our first experiences occur in childhood and contain a lot of information that we carry for life" [3].

Therefore, when students begin their design studies, their references are already formed and will contribute to a better understanding of the curriculum content.

Figure 1 schematically shows the repertoire base structure used by a designer to create products with identity. To understand the global market's demand, knowledge is absorbed by universal cultural references, namely music, theater, literature, poetry, visual arts, cinema, current affairs, and personal experiences. Knowledge is expanded on a continuum of experiences and information. Data are processed by references of collective value to each country until it occurs in an individual way. Preferences and interests in some of the numerous artistic expressions that synaptically mediate the existing patterns draw the grounds for creating a new product. The fascination of this self-nurturing dynamic lies in the shift of classification according to where we live. For example, in music, for a foreigner, samba is universal culture; for a native of Rio de Janeiro, it is regional; and for us who live in São Luís, it is between national and regional culture, being present in all artistic expressions.

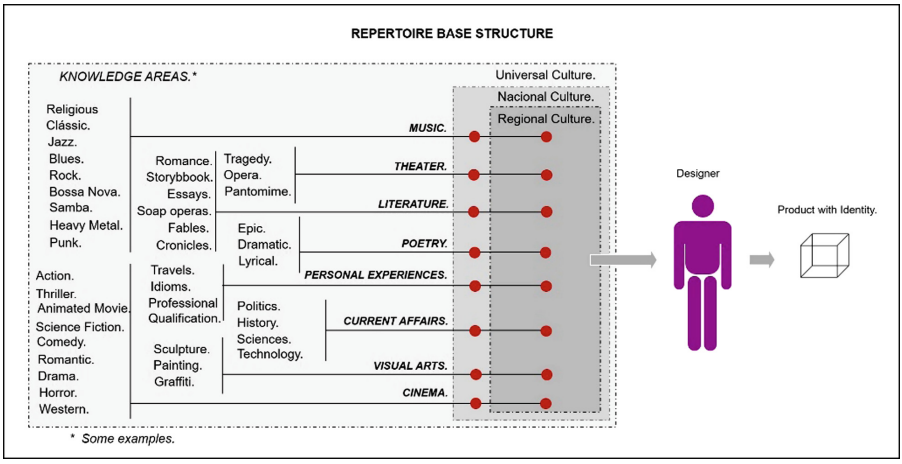

Fig. 1. Repertoire base structure. Source: Created by the author.

Donald Norman [4] endorses that "The human brain is ready for language. Its architecture, i.e., the way its different components are structured and interact enforces the very nature of language." Statements like this attest our certainties that products are communication channels. Understanding is processed through shape and content, form and function, or syntax and semantics. When a designer develops a technically sound project, they ensure it is properly applied and used—this is a premise of success.

The designers' production is a fine, bordering line between art and design, which can be subdivided into two subtle units: Beauty and pragmatics. They constantly alternate. Preceding shape and content, the intellection is processed according to the

cultural background, both of the designer and the user. As Scruton [2] states, "[…] works of art communicate something, even to the extent that each of them—or, who knows, any and all kinds of works of art—has a specific content that we should understand so that we can appreciate it and acknowledge its value." This explains, at least in part, the importance of the artistic production in all its variants associated to the experienced moment as a principle and basis of intellectual production activities that aim at defining something as a practical purpose of use. Sudjic [5] comments that, "Just like art often speaks of itself, design is now becoming so venerable that developed its own long narrative to speak of what interests it."

"Trained mind" refers to a person who has initiated a certain knowledge area and is encouraged to know increasingly more about their own culture and the universal culture. A trained mind has increasingly cultivated their sensory perception with time, being able to find the beauty's subtlety in their surroundings.

> "Works of art express things, and even abstractions, such as instrumental music or abstract painting, and can be an adequate environment for expression. […] Several artists realized their works' meaning through criticism, such as T. S. Eliot's reply to Helen Gardner's book about his poetry: 'At least now I know what it means'" [5].

One of the fascinations of the works of renowned authors is the ability to arouse specific emotions in each person. These peculiar interpretations, common in so many authors, were often not premeditated. However, as Scruton [2] says, "Art moves us because it is beautiful, and part of its beauty is due to the fact that it means something." Therefore, they foment the imagination of anonymous people who are sensitive to the interaction but not favored by "nature" with the gift of creation.

Scientific and technologies advances provided a quality of life that enabled us to experience "beauty" in our everyday life. Lipovetsky [1] ponders, "We are in the strategic and mercantile stage of the world's aestheticization. After the art for the gods, the art for the princes, and the art for the art, it now triumphs the art for the market."

3 Project Example

This work was developed by the students Fabio Pinheiro and Adriano Santana in the discipline Project VI. According to the briefing, they should submit a branding for an exhibition of design products developed in São Luís. The exhibition was going to be held at the Artistic and Historic Museum.

Figure 2 are project sheets and explain their creation process: From the rhetoric on which they were based to the elements that comprise the entire work. This classroom result is specifically presented as an example of the numerous possibilities of analysis of a design work. The spontaneous ontico is referred here as the perception of regional cultures that are permeated through other cultures of broader interpretation, colors and shapes, movement and dynamics of intercontextualized collective values.

In Fig. 3, the interpretive model is simplified with only three signs: The star, the flag's wave, and the colors. In the Brazilian state of Maranhão's flag, colors red, black, and white symbolize the mixture of races that built it. In the upper left corner, there is a blue square representing the sky and a white five-pointed star that symbolizes the state

Fig. 2. Project sheets and explain their creation process. Source: Fabio Pinheiro e Adriano Santana.

as part of the federation. The flag waving was associated to the movement of the folk dances Bumba Meu Boi and Tambor de Crioula. The star, which is often used on the ox's forehead, is the central element of the colors in stripes associated to the performers' ribbons and skirts, inserted into the dynamics of information in which the

informed, intellectual, and developed world exists. This graphic language (form) is present in the contemporary design.

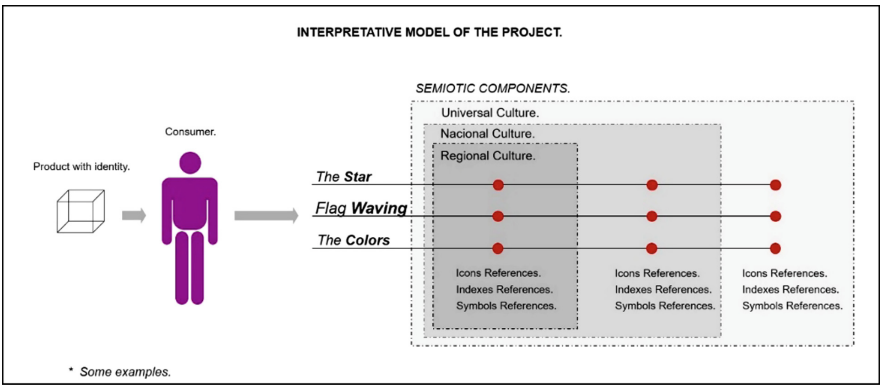

Fig. 3. Interpretative model of the project. Source: Created by the author.

The product interacts with the identity and the audience through each person's interpretive ability: The repertoire. Regardless of where they live, icons references (color similarity), indexes references (raw material and technology), and symbols references (cultural clues) are essential to understand and recognize the values, so that only then, with the principles of composition, proportion, and balance, beauty is found.

In the future, people will interpret this result of explored elements as belonging to a past decade. As defined by Rancière [6], "There is no episode, description, or sentence that does not carry the work of art's power. Because there is nothing that does not carry the power of language. Everything is equivalent, equally important, equally significant." We should all be aware of this permanent interaction, especially design professionals, because it is in this nearly palpable instant that lies the certainty that something "new" will occur.

4 Final Remarks

It is practically impossible to quantify the volume of information and knowledge on social media. Nevertheless, the consumer market is stratified by identifiable behavior profiles, such as purchasing power and social class. Even though in many cases mapping techniques or technologies interpret data with complex analysis programs, semiotics principles enable us to understand the dynamics in which we are inserted.

Based on the context we live in and aware of the markets and values of other cultures, our personal experiences can be the starting point in the interaction with larger centers. The study elements of signs in design provide a comprehensible classification that can be quantified.

São Luís is an average sized city with a market niche for easily identifiable exclusive design products. It also has an expressive folk tradition well-known in Brazil and overseas. Due to this peculiar characteristic, it can be compared with other cities for specific information.

Even covering parts of the project process, some questions still need to be discussed. How much universal cultural information does it have? What is its knowledge of arts? To which extent does the teacher in charge of the discipline interfere in the final result? Can a preference for a certain style result in a work? To which extent did the disciplines taken contribute to education? To which extent did unusual experiences while traveling contribute to determining the form or function of a product? All the presented factors influence, in different levels, the project process and need to be thought and discussed.

The studies developed so far show that philosophy's areas and approaches can draw consistent theoretical design basis, and that the semiotic elements are a possibility of collecting data and reaching a conclusion through language studies.

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Design Education a Strategy to Change the Perceptions of Students Case Study of Ciudad Juárez

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Abstract. Effective design can be use as a tool for reduction of crime. This suggests that graphic design interventions that seek to change perceptions could have the potential to reduce violent crime. The inquiry expects the students to work with real problems, obtaining reasons and enriching their ideas to face their social role and responsibility as professional citizens. The objective of this research is to measure the change with respect to the attitudes and discover about effective design in contemporary society.

Keywords: Design education · Social responsibility · Change perception

1 Introduction

Currently, crime is a problem that affects all societies and seems to be on the increase everywhere in the world. In Latin America the growth of deaths and injuries caused by violence is alarming. Violence persists across cultures, social class, education, incomes, ethnicity and age in every country. In Central America the increase in deaths and injuries caused by violence is alarming. Police figures indicate that while actual crimes are not dissimilar across México, some states have particular characteristics. During the 1990s, Ciudad Juárez became relevant, even at the international level, for an infamous event: since 1993 there were continually cases of murdered women, hundreds of cases, so many that there was talk of the dead of Juarez. A tragic phenomenon, which showed a significant deterioration in the social fabric around the maquiladora model, was especially due to the massive hiring of female and young labor. The State, for its part, showed its weaknesses and a very high level of impunity against these femicides [1].

In fifteen years, things have not been different for Ciudad Juárez, even today the record of homicides as October 2019, is 1,167 registering more than one hundred homicides per month according to "Fideicomiso para la Competitividad y Seguridad Ciudadana" (FICOSEC) it is a trust, run by a group of businessmen from the State of Chihuahua, nonprofit [2].

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2 Literature

According to Ekblom, crime prevention seeks to reduce the risk of criminal events and related misbehavior by intervening in their causes [3]. Violent crime and the fear of violent crime are costly to both individuals and communities. When crime escalates, the quality of life declines and neighborhoods become war zones in which residents are prisoners and, all too often, casualties. The damage from violent crime, once done, can never be repaired. The importance of efforts to prevent crime and violence may be less clear. Yet crime prevention efforts that seek to expand opportunities and incentives for personal responsibility. Prevention has been accepted as a key component of the human response to crime. However like many fast-growing efforts at this level, the crime prevention strategy is experiencing a number of growing pains that limit its effectiveness and could even threaten its survival. 'Bolted-on' crime prevention solutions don't work. Razor wire, for example it might reduce the fear of crime on one side of crime on side of wall, but increase it on the other side [4].

A different approach to crime reduction and prevention could be through Design. The design of everyday products, services, vehicles and architecture has an impact on crime and the fear of crime. Design can work as a proactive; for example the using well-published research can become a major commercial issue, such an example is that of car security. New methods of preventing crime are constantly under developments, for example, alarms, locks, detectors, glass breakers and perimeter. As a result less car crimes have been committed. Communities and businesses can benefit from proposals to reduce crime. Design Against Crime (DAC) is a new concept to consider in design and where design can play a very important role preventing and reduce crime. Design against crime, posses many challenges for designers particularly when design looks to persuade the audience of some change. Nowadays we live in a changing world this implies that some change will be required in design itself. According to Clark, design against crime is about making all these products resistant to misappropriation, mistreatment, misuse, mishandling or misbehaviour. In Clarke's words "It involves a mix of replication and innovation - creatively resolving conflicting and competing requirements and constraints to produce something that is fit for the purpose without neglecting the human dimension" [5].

While there is passing reference to the role of graphic design, there is no detailed consideration of the graphic designers role as a mediator in crime reduction. This suggests an opportunity to consider in detail, a currently unexplored area of research. While there are particular changes in addressing violent crime (as opposed to say, mobile phone theft) it shares with all other crimes an inherently rational nature. A study of violent crime in Australia noted that those coerced by violence are those most vulnerable to criminal violence and the exploitation of physical advantage [6].

This suggests that graphic design interventions that seek to change perceptions of reward and punishment could have the potential to reduce violent crime. There is, however, potential for anticipating criminal behaviour by paying better attention to prevention of criminal acts in the first place. Recently, there has been a broad change of focus among criminologists, from interest in the offender to interest in the circumstances of the offence. Prevention can cover a huge group of activities such as from

environmental design through pre-school programmes, social control, and criminal justice system institutions.

In social campaigns the power of design can act as a social tool and their role will be informative but also educative. According to Frascara, the aim of persuasive message is to change the conduct of the target group through motivation and encouragement to make the audience think, judge and develop by them [7]. Design is a rapidly changing discipline, evolving to meet the changing needs of users and embracing developing technologies. While the necessary knowledge base for design against crime has yet to be established, indications are that if it is approached in the right manner with the necessary incentives, designers will engage with design against crime. Networks between key stakeholders are required to allow an effective flow of knowledge and information, for design against crime to be effectively incorporated into everyday design thinking.

3 Methodology

The qualitative approach, founded on inductive processes, is based on the gathering of data obtained from the perspective and point of view of the participants (their emotions, experiences, meanings). The experiences of the participants are fundamental in the collection of information from the researcher. This approach can be defined as a set of interpretive experiences. Also, it is important to mention the use of observation as a support technique, since it is a visual record of what happens around us, it is important gathering of empirical evidence. It should be considered: a good planning, in order to meet the requirements of validity and reliability. The observer it requires having the systematic ability to record events differentiating those details that could be significant from those that are not relevant.

Qualitative research methods will be used to explore attitudes, social behaviour and visual information developed by a group of graphic design students will also be evaluated using this method. Furthermore, questionnaires and interviews will permit quantitative work to be obtained with a closer evaluation. The use of questionnaires can present many advantages such as uniformity: each respondent receives identical set of questions. It can also address a large number of issues and questions of concern in a relatively large number of respondents. On the other hand questionnaires also have disadvantages for example it may be difficult to obtain a good response rate. Questionnaires are complex instruments and, if badly designed, can be misleading. For this project the structure of the questionnaire was divided into four categories, including six questions in each one: Personal details (identity), Their role as a designer (cognition), Visual media information in the local area (perception) and Attitudes towards violence against women (behaviour). The questionnaires was designed, with the key aim of allow the students to express honest answers and without any pressure to provide anticipated responses. However, some respondents found it difficult to explain their point of view concerning important issues, (identity, behaviour, violence, cognition). Due to the personal nature of the issues to be investigated in the questionnaires it may be found difficult to express on a blank space of paper. In order to be accurate in measuring the attitudes and perceptions in the group of students this research will use a

method of Cultural Probes; This is an experimental research method, used for the purpose of information gathering for design and in this project it will be used as a part of a strategy of working experimental design, to provide a better understanding of local culture and the perception that the students have and their role as designers in that particular area.

This research focuses in the visual thinking culture that introduces a methodology as well as awareness. Thus, this will try to understand some of the aspects of the social attitudes and the levels of influence of visual media information on the individual. In addition this method will attempt to reinforce the designer's creative process of work with images from a particular point of view at the time, as the student explores the social problems in his/her environment. Students should work based on social problems in their locality, following a methodological process and doing a close research on the subject. As well as defining the user with whom they should focus their work, the proposal should seek to be evaluated through measurable methods.

4 Discussions

Encouraging designers to take the potential of crime as a dominant issue in the design process. An initial evaluation of the first exercise provides a positive indication. The exercise has been well received by the students. After the questionnaire was undertaken, at the end of the first section of the project, a number of interesting points were detected.

There is not a clear definition for the design students in higher education about which are the aims and the responsibilities of graphic design. Also they remain unclear about their level of commitment to society as a profession. This has been shown in the questionnaires responses. The opinion of the other students in subjects such as sociology, engineering even industrial design indicate that in general the students do not have a clear idea about the role of the graphic design. (This was showed in an early interview, with a group of intermediate level of graphic design). Another interesting observation is the power of the media and the information that surrounds them. The influence of the consumerism is really strong, however part of the work of graphic design has been involved with marketing, publicity, etc. yet the alarming problem is the graphic design students even imaging that design can work as a social instrument. Moreover, there is a concern about the attitudes shown towards violence and problems in the City: students made a list about their most common perception. The apathy they presented when confronted with these issues was seem as insurmountable, the problems are many and they never think that design could help to solve them. We discussed how graphic design could help in each case. After several classes the perception in the students started to change. In the beginning they visualized that design can solve problems, however that is not the idea: to solve them such issues you have to use more than a magic stick. Graphic design can contribute to society by developing correct information, didactic materials or using animation for public information, yet, these are just tools. The project proposed to change the approach and not just changing the point of view of how you analyze the problems. For example, a couple of students were interesting in the powerful impact of the campaign Vodka Absolute. The idea in the

beginning was just to analyze the concepts of the publicity and the associated campaigns. But other issues such as, what happen developing the promotional materials of this alcoholic beverage for a specific group, yet for this product there is more than one target group. The students in Ciudad Juárez showed that the majority of potential consumers of this product were teenagers. The question here is could design be responsible, and if it is, to what level, and what can we (as graphic designers) do in order to be the conscience of our responsible society.

Another example is the political campaigns in México. They produce an immense visual pollution and the impact on the environment is irreversible. A group of students pretend to persuade people to give advice using another campaign: this means the creation of more visual pollution. We are responsible for this. What can we do as a designers to effect change? Probably we can convince our clients that we need to clean the city after each political event. Who needs to be responsible for this? These are a couple of examples that the designer can in a different ways be responsible for how they perceive a design. Some students became more convinced about the important of graphic design using as a tool to reduce crime.

5 Preliminary Conclusions

Seeking a design with conscience becomes a contemporary challenge; consumerism, struggling to survive in a globalize market, the influence of competitiveness of the labour force, as well as a scarce knowledge of what is the social commitment of the Graphic Designer towards society, are some of the main issues that Design faces these days. A design that has aesthetic potential but it is not clear about what is its concept; that is constantly seeking to sell and to be part of a competitive market, forgetting its social and community commitment. This is the design, which students are always searching for. Ways to be updated on trendy software, hope to find jobs in top agencies, fighting to get VIP clients, which usually are those who promote selling tobacco, alcoholic beverages, trendy prototypes of ideal lifestyle (such as anti-aging creams, credit cards, diets, cell phones). It is truly amazing to see how advertising campaigns are able to impose purchasing needs on people, being the image that society has about the purpose of Graphic design is one that promotes consumerism.

The strength and impact that designs have on people, backed up by an overwhelming amount of advertising true mass media, is the spark that triggers the need to buy on potential consumers. Considering that we live in an environment in which violence, lack of security and corruption are everyday events of daily scenery turn into a passive and indifferent society. Living in the border between Mexico and the US is a major challenge. Ciudad Juárez is the largest border city with US and their closeness promotes a constant comparison of life styles. Daily broadcast of data regarding products and trade marks from US, locate Juárez as a bicultural society that struggles everyday to find a graphic identity, confronting our University's (UACJ) graphic design students and putting them on the spot.

The classroom is the place where we build our professionals that will join work force in the future. The Universidad Autónoma de Ciudad Juárez (UACJ) is participating in the development of a case study in which main goal is to promote a change in

student's perception of their role and commitment to this society as professionals. Such proposals intend to involve student with real issues, in which they can use several methods to evaluate and credit a proposed product, with the intention to research deeply and to become aware by them of all the possibilities of participation that graphic design has in searching for ways to contribute in solving issues. This is a design with conscience and responsibility. Group proposals to date have been diverse, starting from didactic material for elementary schools and as manuals, campaigns, info-design and signs, in order to develop topics such as: Children's rights; oral violence, unwanted pregnancies, traffic chaos, alcohol issues, just to name a few.

Important advances have been posted up to date in this search of awakening interest among students to establish that graphic design can work as a tool in crime reduction and prevention. The change of the students was focused on trying to solve a social problem through design, based on a method. With this process, the student is convinced that establishing a methodology will allow a better order of ideas, search the needs of the problem and evaluated; that allows to narrow the margin of error, beyond the needs of the client are the needs of the study group.

One of the most representative changes, was the satisfaction of the students of understand the worth of your profession in the social field. These first groups of students who used this method allowed contributing in a positive way with its society, thus changing an attitude towards the use and application that was given to design.

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Color and Emotion: A Literature Review to Apply in Virtual Reality Environments

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Abstract. Within ergonomic design research, virtual reality (VR) is increasingly taking up more space, but studies relating color to emotions within virtual reality environments are still scarce. In this sense, we conducted a systematic literature review of studies that relate emotion and color in order to understand which are the most pertinent characteristics of the color-emotion relationship to be studied in future virtual reality environments. This paper tries to identify if there are any emotional responses to colors under virtual reality environments, providing an overview of the methodologies that are being used and are relevant to answer this question.

Keywords: Color · Virtual reality · Emotion · Literature review

1 Introduction

We can find studies about color theory dating from the ancient times going through the Middle Ages to nowadays [1, 2]. This variable has a considerable impact in our lives, notably on behavior and emotions [3]. Within ergonomic design research, virtual reality (VR) is increasingly taking up more space [4], but studies relating color to emotions within virtual reality environments are still scarce.

Kaiser [5] conducted a critical literature review in 1984 to find out the productions about physiological responses to colors. He reviewed studies that considered the physiological measures taken by electroencephalograms (EEG), galvanic skin response (GSR), blood pressure, oximetry, and heartbeat and respiration rate. He reported that, according the literature review, the color affects the human behavior and there are physiological responses to it. Wilson [6] discovered that the red was more exciting than the green color, followed by the yellow, and the blue, that has the less activation during a test with the galvanic skin response. Nourse and Welch [7] confronted the discovery made by Wilson, and found out, in the first tests, that the galvanic skin response for the violet was higher than the green ones. The literature review conducted by Elliot and Maier [8] demonstrated that the color can have an impact on people's affection, cognition, and behavior.

With the increasingly use of VR as interaction environments for many types of applications, from games, teaching, architectural and project design, to fundamental

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and applied research [9–12], it is of paramount importance to understand the effect of color on users' while interaction with virtual environments. Although the literature on color research is wide, little has been done considering VR applications and are spread in different fields of study. In this context, the main purpose of this paper is to perform a systematic literature review that focus not only on colors, but also on the variables of emotion and virtual reality.

2 Methodology

From the following research question: "Is there any emotional response to colors under virtual reality environments?" a systematic literature review was carried out considering two bibliographic databases: Scopus [13] and Web of Science [14]. Those databases were chosen as they are internationally credible and accepted in the academic sphere for their quality and peer review.

2.1 Search Strategy

To searched for relevant publications considering color, emotions, and VR, the software "Publish or Perish" [15] was used. This software was chosen because besides searching in pre-defined database (chosen by the operator), it also organizes the results in rankings, as recommended by Haddaway, Collins, Coughlin and Kirk [16], in a form of a list that can be later exported in several formats. In this software, the research can be done considering authors name, publication name, title words, and keywords. A temporal range can also be defined.

For this literature review, only Scopus and Web of Science databases were considered. A first round of search was carried out, and as the scope was to identify all empirical evidence with the exactly terms "color OR colour AND virtual reality AND emotion", these keywords were used. A time period was not determined.

A second round of search was also carried out considering as keywords "color OR colour AND virtual environment AND emotion". The time period, again, was not determined.

2.2 Inclusion and Exclusion Criteria

For this literature review, only peer reviewed publications in indexed databases were considered. At the end of the searches on each basis, a first screening was made and duplicate references were deleted.

The inclusion and exclusion criteria of this literature review are in agreement with purpose of the study of reviewing studies that relate variables of color and emotion using virtual reality or virtual environments. Thus, a second screening was performed. In this screening, content from the title and abstracts were read and their pertinence considering the searched keywords was evaluated by an expert who decided which of the papers should be or not included for a more detailed review.

2.3 Study Selection

The first round of searches in the software gave as result for the Web of Science database 23 papers, among journals and proceedings. The search on Scopus database had 62 results contained articles, chapters of books, conference papers and conference reviews. The results were dated from 1999 to 2019. At the end of the searches on each basis, duplicate references were deleted, leaving 68 results.

After that, the second round of search for the Web of Science database yielded 24 results contained articles, proceedings paper, and review; and in Scopus database, 40 results, among articles, proceedings, conference papers, and conference reviews, were found. The results were dated from 1999 to 2019 in Web of Science, and 2001 to 2018 in Scopus. The duplicate references between the first search and the second were deleted, leaving 04 results.

Thus, after this first screening considering the inclusion/exclusion criteria, 75 results remained.

Following, a second screening was performed from the title and abstracts of each one of the 75 remained papers, mainly considering the relevance to studies about color and virtual reality, color and emotion, and all together; accordingly, after that, the literature review was developed to answer the main question of this paper. Table 1 shows the process followed to identify the pertinent papers according to the main research question.

Table 1. Process of the literature review.

Step	Process	Period	Remaining articles
1	Scopus search using software "Publish or Perish" for the keywords "color OR colour AND virtual reality AND emotion"	1999–2019	62
2	Web of Science search using software "Publish or Perish" "color OR colour AND virtual reality AND emotion"	1999–2019	23
3	Eliminate duplicate results	–	68
4	Scopus search using software "Publish or Perish" for the keywords "color OR colour AND virtual environment AND emotion"	2001–2008	40
5	Web of Science search using software "Publish or Perish" for the keywords "color OR colour AND virtual environment AND emotion"	1999–2019	24
6	Eliminate duplicate results	–	75
7	Using title and abstract to identify results not relevant to the variables color and emotion using virtual reality or virtual environments	–	04

3 Results

Considering the research question "Is there any emotional response to colors under virtual reality environments?", the search process yielded four papers that fulfill all the inclusion/exclusion criteria. Following they will be discussed in the light of this question.

The study conducted by Siamionava, Slevitch and Tomas [3] tried to understand the role of color in the guest's perceptions of a hotel room using the VR with the head-mounted display (HMD) as a technique to provide a deep immersion of the participants. Through a quasi-experience, they collected the data of 139 participants, using the PAD model, about the impact of color attributes of the walls of a hotel room on the emotions. They had the measures of saturation, brightness, and hue as an independent variable, and the pleasure, arousal, and dominance as a dependent variable. They developed a virtual model of a typical Best Western hotel rooms, and they manipulated the hue values of the walls for red and blue with high and low levels of saturation and brightness. As results, they discovered that red hotel rooms were associated with the highest arousal and dominance levels, but the participants preferred to stay more in the blue rooms than in the red ones, because they were considered more relaxing. Another important finding was that feelings of pleasure and dominance were impacted by personal color preferences.

Geslin, Jégou and Beaudoin [17] believed that the intensity, the brightness and the saturation of the chromatic stimuli in the video games environments produce an emotional effect on players, so they made a study to understand how the colors properties can be used to elicit those effects. Were selected four images for each six different categories of video games, and they calculated the RGB value of each still images from video games for add up values of red, green, and blue. They used an online questionnaire to cover the largest number of participants and ensure greater diversity. Thus, they were not able to control the quality of color reproduction on the screens, but they argue that they are good enough nowadays. The semantic subjective questionnaire scales used in IAPS [18] was used to measure emotional impact of games selected images. They recruited just participants who play video games for more than two hours per week, and the 85 subjects observed 24 video games pictures randomly presented and answered the questionnaire. The results showed that exist a link between feelings of joy/sadness with the environment properties. How greater is the color brightness and saturation, more positive is the valence of these feelings; however, when the video game environments are less saturated, the feeling of fear and the negative valence are higher. They also observed that a high color diversity produces a positive sense of joy. From these results, they proposed an experimental circumplex model for colors design that could allow for the generation of positive and negative emotions, and also high and low arousal. This tool helps the game designers to manipulate the chromatic diversity according the emotional experiences they want to provoke in the players.

Hsiao and Hsiao [19] made a study to investigate the influence of the colors on humans inside a virtual environment. They developed a virtual reality space by computer simulation with six wall colors (black, white, red, yellow, green, and blue) to

investigate the interactions and correlation between them and five emotional adjectives (pleasant, romantic, comfortable, monotonic, and ice cold). They also took the heartbeat variability and blood pressure measures, before and after the experiment, to compare the physical variations of the participants. To conduct the experiment, the participants were set down in front of a computer with a HMD and a virtual environment. They asked to them to answer a questionnaire for assessing the measures of people's subjective perception of the colors of the environment. As results, they discovered that the word "pleasant" extended the significance level for the walls colors in red, green, and yellow; and "monotonic" had this level for the blue, white, and black wall colors. For the physical measures, the results indicated that the walls with red, green, and yellow walls reduced the activity of the sympathetic nervous system and improved the activity of the parasympathetic one to achieve a relaxed mental state.

Zhang, Kim, Shih, Koo, and Cha [20] used an immersive virtual environment as a tool for studying the colors of interior office environments. They just changed the colors of the walls in the experiment, and the participants needed to make some tasks in front of the different wall colors. The best performance was detected in the white offices comparing with the other three colors. Secondly, the tasks in the red office had better results than in the green and blue offices. This study had an important contribution because their discovery indicates that the immersive virtual environments can be used in color researches.

4 Discussion and Conclusions

The main focus of this literature review was to find and systemize information about research in color, emotions and VR/VE. The software used for the search on the scientific database showed a high consistence with a search made using the same keywords in the databases' websites, but with the advantage of ranking the results. The adopted method was also very helpful in focusing the search.

Considering the papers that fully fulfil the inclusion/exclusion criteria, the literature review suggested that we could have many benefits between the correlation of the virtual reality technology with colors or emotions. According to them, using VR as interaction environment, colors could evoke positive/negative emotions in users, allowing those responsible for designing and planning to manipulate environmental colors according to their needs. So, professionals like designers or architects can, for example, prototype their projects, and simulate the characteristics in VR according with the emotions that they want to convey. Studies also shows VR as suitable tool that can might be used for the evaluation of human emotion and physiological responses to colors. As the literature is scarce in the relation of color and emotions inside virtual reality environments, more studies are needed.

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Research on the Design of Smart Waste Classification and Collection Service System

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Abstract. This paper aims to explore the combination of the unmanned logistics system and the waste classification and collection in a prospective view, as well as the design strategy of the smart waste collection system which is more efficient and pays more attention to the service experience. Through case study, the change of residents' awareness, the update of smart community services, and the development opportunities of urban waste classification and collection in China are investigated. Based on the development of the terminal unmanned logistics, the correlation and the combination of the reverse unmanned logistics and the waste collection are discussed. According to the thinking of product-service system design, the conceptual design of smart waste classification and collection system by constructing the intelligent two-way unmanned logistics vehicle system, combining the forward and reverse logistics, and perfecting the credit mechanism is put forward.

Keywords: Smart technology · Unmanned logistics vehicles · Reverse logistics · Service system design · Waste classification and collection

1 Introduction

The waste problem is the manifestation of ecological environment crisis, which is related to human survival. Although the development of science and technology has created some new methods for waste disposal and new environmentally friendly materials are gradually being put into use, these end treatment methods can only relieve the problem and cannot cure the problem. This problem must be solved from the source, which means that everyone in the community has to participate in the waste classification operation and experience a lifestyle change [1].

At present, most cities in China still adopt the model of mixed collection of waste. The classification standard is not clear enough, and the knowledge of residents' waste classification is scarce, the diversification of residents' composition makes it difficult to coordinate waste classification, the breadth and depth of enterprises and social organizations participating in waste classification are not enough, and the waste classification services provided to community residents need to be explored.

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2 Waste Classification - A Change in Lifestyle

2.1 Pain-Points of Domestic Urban Waste Classification

Constructing a waste classification and collection service system is a complex social project, which cannot be done overnight. The huge output of urban domestic waste has put a lot of pressure on the stages of collection, transfer and treatment. The market mechanism has not yet been established, and the waste classification industrial chain has yet to be improved [2]. Based on the collation of recent literature and field investigations and interviews, the main problems faced when designing a city community waste classification and collection service system are as follows:

a. The classification criteria are not clear enough, and the residents' waste classification knowledge is lacking [3].
b. The diversity of residents makes it difficult to coordinate waste classification [4].
c. The breadth and depth of the participation of enterprises and social organizations in the classification of domestic waste is insufficient [5].
d. The services experience provided to residents are yet to be explored.

2.2 On-site Waste Collection Service

Like take-out, when waste classification and collection becomes an indispensable part of urban life, under the pressure of fast-paced life and work, "On-site waste collection service" came into being. One of the most important problems that is now bothering us is the convenience of waste collection. The on-site collection mode provides a new way to promote the classification of waste, which facilitates the resident's life, caters to the market demand, presents a win-win situation, and also reflects the change of the resident's awareness of waste payment. To some extent, this kind of online booking service makes waste collection easier and convenient for users and makes it more practical and effective [6].

2.3 Exploration of IOT + Waste Classification and Collection

The innovative model of IOT + waste classification and collection has been encouraged to be popularized in China, that is, to encourage enterprises to use modern information technologies and means such as the Internet of things and big data analytics to establish or integrate renewable resource information service platforms [7]. Encourage Internet companies to achieve an organic combination of online and offline waste collection.

The emergence of the Intelligent waste classification and collection system and the involvement of the relevant enterprises can create a stress relief effect on the government departments by saving manpower, material and financial resources. The lifestyle transformation of waste classification requires both institutional development and technological innovation to solve the difficulties of existing model and open up an effective new path for the domestic waste classification and collection [8] (Table 1).

Table 1. "IOT + waste classification and collection" cases

Company	Implementation Plan	Methods Summary
小黄狗DOG 环境守卫者	Set up intelligent collection machines with positioning function in the community. Users can find nearby collection machines through DOG App.	*a.* AI intelligent collection terminal *b.* Big data operation platform
aobag.com	Introduce the methods of 14-way classification, full bags for empty bags, drop points concentration and market price cashback. Aim at reducing the overall cost of collection and standardizing the process of recycling.	*c.* Real-name system *d.* QR code collection bags *e.* Market price cashback
虎哥HUGE	All-round scientific management of recycling, warehousing and logistics team to ensure that recycled waste materials can be treated safely, environment-friendly and scientifically. The accumulated points that users get from waste collection can be exchanged for commodities.	*f.* Self-built logistics management system *g.* Efficient on-site service *h.* Exchangeable accumulated points
闲豆回收 XIANDOU RECYCLING	Cooperate with well-known domestic retail and e-commerce enterprises. Through O2O, that is, combine the offline logistics and warehousing with the online technology and operation to realize online interaction and offline service, so as to improve the efficiency of recycling and user experience.	*i.* Business-to-Business *j.* All-round recovery network
心起分类	According to the idea of economy, high efficiency and sustainable development, the integration of the online platform of the waste classification and recovery system and the offline logistics entity is established,	*k.* Waste classification net + classified collection net + IOT

3 Cooperation Between Terminal Unmanned Logistics and Waste Classification and Collection

3.1 Characteristics of Domestic Urban Waste Collection Logistics

Reverse Logistics. Reverse logistics emphasizes more on the process of transferring raw materials, semi-finished products, produced products and related information from the consumer to the original production side. Urban domestic waste collection logistics can be classified as reverse logistics that collects waste from consumers for transportation and eventually flows to enterprises or treatment facilities.

Passivity, Complexity and Uncertainty. Compared with online shopping returns, users are often less active in waste collection. Urban waste has complex compositions and multiple management departments are involved in the process of urban waste

collection. The quantity and composition of urban solid waste are affected by various factors, which increases the uncertainty and difficulty in collection urban solid waste.

3.2 The Rapid Popularity of Terminal Unmanned Logistics Vehicles

Although fully automated driving technology will not arrive soon, unmanned vehicles in some special scenarios are expected to be commercialized earlier. For example, terminal delivery vehicles and waste trucks that with slow speed and simple route. The demand for "last kilometer" delivery is high and the anticipated security risks are low. More and more domestic companies including Ali Cainiao, JD.com, and Suning have begun to invest in unmanned logistics projects after the technology of AGV warehousing and classification has been implemented (Table 2).

Table 2. Comparative analysis of terminal unmanned logistics

	Forward logistics	Reverse logistics	
		Enterprise reverse logistics	Reverse logistics for waste recovery
Target	Take-out, online shopping, etc.	Shopping returns, maintenance and so on	Urban waste
Carrier	Smart equipment and operating facilities for delivery and receipt	Intelligent equipment and operation facilities for door-to-door pick-up and transportation	Intelligent equipment and transshipment facilities for domestic waste collection and transportation
Direction	Express transfer station → Customer	Customer → Express transfer station	User → Waste transfer station
Process	Delivery, signature	Pick-up, transport	Classification, collection, transport

3.3 The Combined Value of Unmanned Logistics and Waste Collection

Intelligent unmanned logistics system is a good fit for the small batch and multi-frequency transportation. The unmanned delivery and collection logistics service system can improve the efficiency and flexibility of the service, reduce operating costs and the dependence on human resources, and achieve personalized value-added services [9]. The combination of unmanned logistics and waste classification and collection can streamline the links of current collection and transportation of urban waste, significantly shrink the collection time and improve the aging efficiency. It can also help solve the problem of labor shortage.

4 Conceptual Design of Smart Waste Classification and Collection System

4.1 PSS Applied to Waste Classification and Collection System

It would be difficult for enterprises to establish differences and gain benefits by relying solely on high-tech intelligent products. More unique services are required. Product-service system (PSS) design tools like system map and story board work well in promoting the transformation from product to product-service, exploring integrated sustainable solutions of waste classification and collection, and guiding new consumption concepts [10]. Based on the existing warehousing logistics robot technology, the smart unmanned logistics waste classification and collection system "Hauler" aims at solving the waste problems from a prospective view, and building an unmanned delivery and collection ecosystem in smart community. From the aspects of system thinking, the whole system tries to provide users with a more efficient, convenient and feasible way of waste classification and collection with more better user experience (Fig. 1).

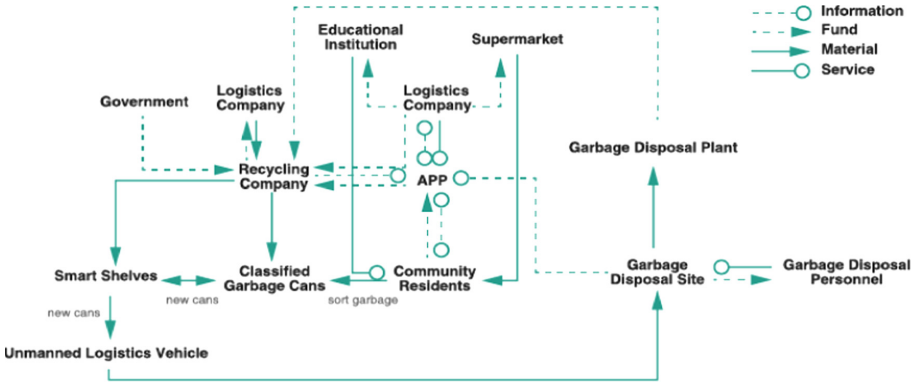

Fig. 1. Smart waste classification and collection system map

The standardized bins are marked with colors, and users can place the bins on smart shelves outside the door after filling them up. The shelves is provided with color recognition sensors to identify the classification color of the bins and transfer them to the centralized processing spots of each classification (Fig. 2).

Fig. 2. The design of smart bin, shelf, and unmanned vehicle

Internet of things make it possible for Haulers to connect with elevators, smart shelves, garbage bins, recycling sites and other contact points. Thus Haulers are able to take the elevator and deliver goods and recycle garbage to the door. The smart shelf can be folded and can detect the classified waste bins. After the unmanned vehicle connected with the smart shelf accurately, the tracks will drive the full waste bin into the unmanned vehicle and the empty bin will be put back to the shelf.

4.2 The Improvement of User Experience

The user experience can be improved a lot in the smart waste classification and collection system, which can guarantee the effect of source waste classification. After the users sign up for registration, they can get smart bins and smart shelf installed outside their doors, and get classification knowledge, understand the credit reward rules, and the usage instructions of the system from the App. Besides, users can freely distribute the bins in their own rooms, and get answers from the app when they encounter wast classification questions. After the bins are filled, the user only needs to place the bins on the smart self, and wait for the unmanned Haulers to collect and replace the bins (Fig. 3).

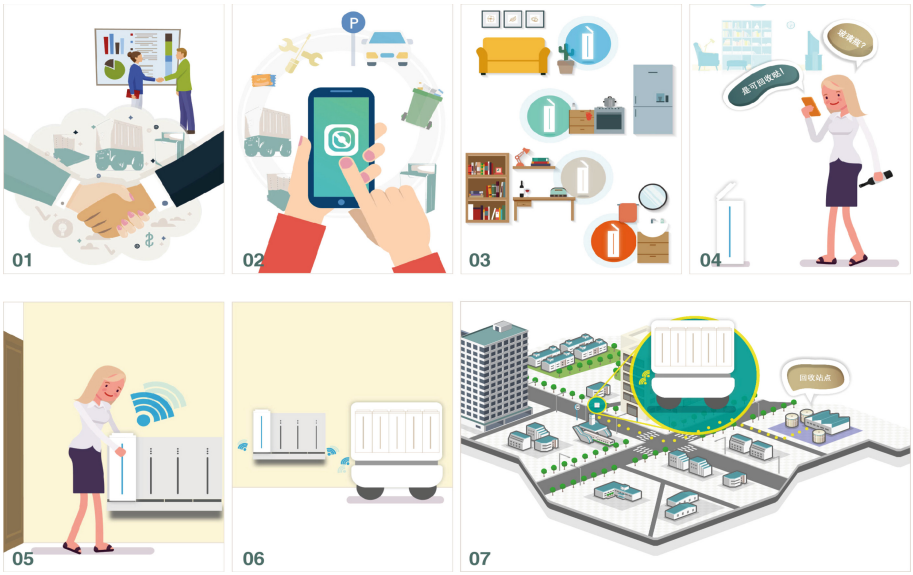

Fig. 3. Storyboard of "Hauler" service system

5 Conclusion

As the most important link of waste processing, source classification and collection urgently needs a systematic and effective implementation mode. The smart waste classification and collection system based on Internet of things and unmanned logistics responds to the government's policy call for waste classification, which can provide an exploration direction for urban community waste classification and collection from a prospective design view, combines with the frontier smart products, guide residents to consciously participate in waste classification links, and provide high-quality services to users while solving the waste problem and creates intelligent unmanned delivery and collection community ecology.

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Research on User Experience of Garbage Tricycle Based on Logic of Behaviors and Operation Characteristics of Village Cleaners

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Abstract. This paper selects waste classification and working process and behaviors of village cleaner in three villages around the Changsha City in south China as the research objects by using field survey method and task analysis method. This paper aims to clarify and visualize the local model of the waste classification system, and to explore the behavior of cleaner and find the pain points of it. Based on this research, a design process of garbage tricycle in village is established to guide the design and innovation process. Redefine participants, locate motivation of behaviors, plan processes of behaviors, seek new means, and create new scenarios and environments. It has certain significance to improve the work efficiency and promote the happiness and safety of village cleaner.

Keywords: Logic of behaviors · User experience · Waste classification · Village cleaners

1 Introduction

With the development of ergonomics, the focus of research has changed from "machine-adapted man" to "human-adapted machine", and then to human-computer interaction [1]. People have always been the core research theme. Three elements of ergonomics are human, machine, and environment. The research focus is not simply on the characteristics of each element, but the relationship in them. The interaction and interdependence of the three elements in the system determine the overall performance of the system. User experience design is actually a process of improving user satisfaction by improving and optimizing the user-product interaction process. Function-oriented industrial design lacks considerations of HCI and UX. Based on user-centered design, the product is no longer an independent entity, and design is no longer limited to the physical attributes of the of product, but requires more consideration of emotion. Norman proposed that "emotion design" considers that people's emotional processing of products is divided into three levels from low to high through brain activity: instinct, behavior and reflection [2]. Professor Xin believes "logic of behaviors" is based on rational organization behavior and regarded human behavior as the design object [3].

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Therefore, based on the pattern of waste classification in the countryside, the ecological environment and the logic of behaviors, this paper explores the interaction process between cleaners and garbage tricycle, analyzes the cleaner's operation behavior, and innovates the process of tricycle design.

2 Theory

2.1 Logic of Behaviors

Professor Xin proposed that in the traditional sense, design is generally understood as creation, while interaction design is different, it is creating "behavior". It also needs items, but only uses them as a medium to achieve behavior. The "action" and the corresponding "feedback" can form a round of interactive behavior. People, actions, tools or media, purpose and scene are the five elements of interaction design. Taking reasonable organization behavior as the basis for decision-making is called logic of behaviors. In the process of interactive behavior, tools or media, including software and hardware, are just the media, to implement the behavior. Interaction designers focus more on a designed and reasonable user experience than on simple product physical attributes [3].

2.2 "User-Centered" User Experience Design

According to Jesse James Garrett, user experience does not refer to how a product itself works. It refers to how a product connects and functions with outside world, that is, how people access and use it. The user experience is always subtle but important. User-centered design is a way to create an engaging and efficient user experience. The design process is built from the bottom of the strategy - the scope – the structure – the framework - the performance [4].

Designers need to clarify user needs at the level of strategy, segment target users, conduct in-depth research on users, understand their behaviors in daily life, and break down the steps of users to complete tasks. Interaction design which in structure layer defines how the system cooperates and responds to user behaviors.

User experience design is a process of gradually improving user satisfaction. Through the improvement of product usability and accessibility, it improves the emotional satisfaction of the user-product interaction process. The research on user experience is to improve user experience and user satisfaction. The improvement and design in complex systems is complex, and it needs a long time.

2.3 Research Methods

The pattern of waste classification in different regions leads to differences features. Compared with urban, the pattern in countryside has a late start and a weak foundation. Various regions are gradually exploring pattern suited for local. Changsha County is one of pilot counties. During the period, it has explored the pattern suited for itself and

offers to other villages to refer to. Therefore, the on-site survey and task analysis are used to investigate the cleaner's work process and how they interactive with tricycle.

Through interviews and observations to understand the operation behavior of the cleaners in their work situation. Break down the behaviors of cleaners. Draw a map of user experience and transform the needs of pain points to guide innovative practices. This survey passed a field inspection of 3 villages in Chunhua Town, Changsha County, and referred to the "Research Report on Rural Domestic Waste Reduction Work in Changsha, Hunan Province [5]" to comprehensively obtain the pattern of waste classification, factors of environment, interaction between the operators and related tools.

3 Factors of Environment and Behaviors

3.1 Pattern of Waste Classification in the Countryside

Discussing the pattern in the country is not only exploring the material flow, information flow, human flow, money flow of the system, but also the factors of environment in the cleaner - tricycle - environment system. According to the system map, the cleaner and tricycle play a vital role in the system. Environment includes pedestrians, roads, and vehicles. Roads are narrow in Chinese country. The size of tricycle should be considered to be flexible. The density of population is lower. Traffic conditions are relatively simple, so the safety of cleaners is higher. Taking Changsha County as an example, classification in the village, collection in town is the mainly pattern. Cleaner is responsible for cleaning an area. Their main work is to collect the garbage bins of every resident, collect the garbage bins in public areas, and clean the main roads in public areas. The main tools of the cleaners are vehicles. Other tools such as brooms, are carried by the vehicle (Fig. 1).

3.2 Garbage Tricycle

There are many types of garbage tricycles on the market. Functions are various. The garbage tricycle mentioned in this paper refers to the short-distance connection tools used by cleaners to collect and transport garbage.

A survey of Chunhuashan Village, Jiumu Village, and Jinding Community in Chunhua Town found that there are currently two types of garbage tricycle used by most cleaners. One type is the electric three-wheeled vehicle with a lid for storage, and the other type is the electric three-wheeled vehicle without a lid for storage. Both of them are modified from motor tricycles. The structure is divided into two parts, one is the cockpit and the other is the garbage storage space. The overall degree of automation is low, and a variety of tools need to be used in combination to implement the function (Fig. 2).

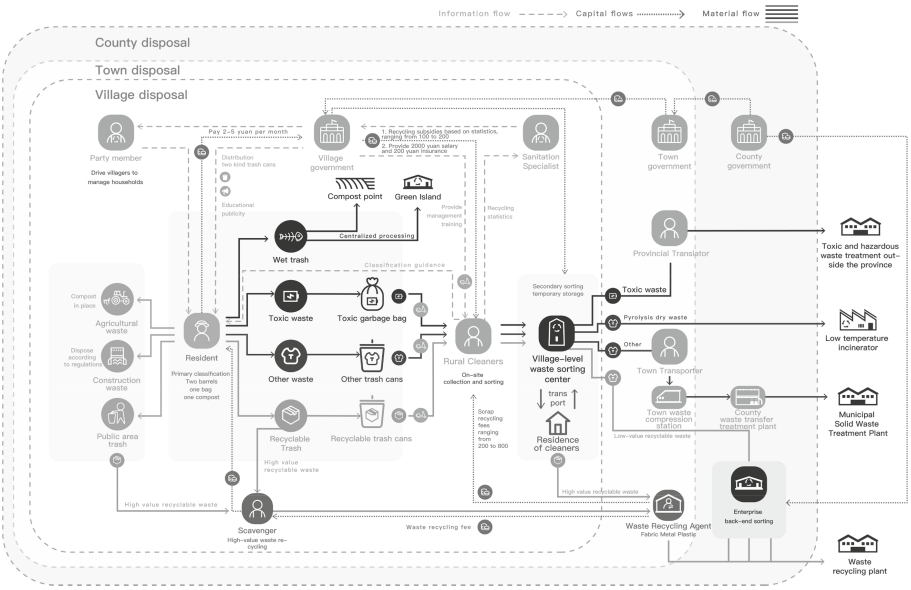

Fig. 1. Waste classification system model in Changsha countryside

Fig. 2. Two type of garbage tricycle in Chunhua Village

3.3 Operating Process of Cleaners

Taking Chunhua shan Village as an example, there are three work scenes of cleaners. It is to clean roads in public areas, to sort out and transport garbage in public areas bins, and to enter each household to sort out and transport garbage in garbage bins. Their working hours are long and work processes are complex. They need to constantly change their operating behavior. The process is summarized as wearing work equipment and bringing personal items-driving-parking-opening the back cover of the vehicle and taking out tools-handling large pieces of garbage/cleaning garbage on the road/collecting trash bin-put the garbage in the vehicle-cover the back cover of the vehicle-drive to the sorting center/home-secondary sorting. The complicated operation behavior is concentrated in the process of cleaning. The corresponding user experience map was drawn through interviews and observations, describing the "unspecified" needs of the cleaners (Fig. 3).

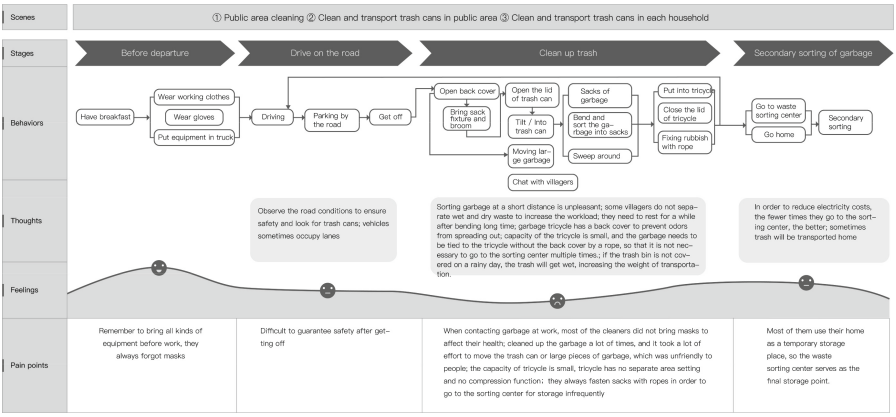

Fig. 3. Operating behavior of cleaners

3.4 Use Behavior Analysis

Summarize the usage behavior of the cleaners according to the four elements of the product usage: behavior's operation state, operation procedures, operation content, and operation time [6].

Operation State: Behavior refers to the necessary action experienced by users when using the product. Each action must ensure the consistency of the actions to conform to the users. The two phases of driving on the road and cleaning up the garbage are clearly divided, and cleaners must get off the vehicle to perform the next stage. The cleaners must not only clean up the garbage in the public areas, but also clean up the trash bins of the villagers. For three different scenarios, the cleaners always distribute the work according to the situation of the area and their own working habits. Most cleaners divide their working hours according to the content, usually not complete all the work in a single process. Due to parking in the road, the vehicle does not have obvious signs, which may cause problems such as traffic congestion and the personal safety of crisis cleaners. Therefore, it should have related signs in the vehicle design.

Operation Procedures: When designing behaviors, it ensures that the design conforms to the user's habits, so it should research on operating procedures. The operation procedures of the cleaners are cumbersome, especially in the process of cleaning up garbage. During the cleaning process, they must not only empty the trash can, but also coarsely sort the garbage to avoid inefficient work caused by mixed transportation. Meanwhile, classified and transparent transportation process is necessary for residents. During the design process, the vehicle can cooperate with the actions of the cleaners and perform secondary sorting during the collection process. The vehicle transportation capacity is limited. Although the cleaners bundled with ropes ensures the continuity of their work, it is not the optimal solution. Therefore, the garbage tricycle itself or the corresponding system needs to be able to guarantee the most continuous work for the cleaners. For instance, it offers route reference or spam compression.

Operation Content: The information that the product feedback to people when operating is an important element of the operation content. Feedback includes information of some mechanical parts and interactive information of interface parts. The vehicles driven by the cleaners are mechanically strong. The vehicles provide power and mileage feedback, and the lights play a role in lighting. They have less feedback on the tools such as fixtures and brooms. The manual operation of the cleaners in the process of cleaning and secondary sorting has a large proportion. On the whole, the lack of feedback between the cleaners and the tricycle is in a state of weak interaction. When the cleaners return to the sorting center, the garbage carried will be sorted and weighed again and included in the performance of the cleaners. When collecting garbage in the households of the residents, the cleaners and tricycle did not provide relevant information to the residents. Residents don not know whether they are correctly classified and how much garbage the cleaner has collected. It causes the residents' awareness of classification to dilute.

Operation Time: During the operation, different parts of the product or different functions use different times, and the functions are optimized according to the time used. The longest use of the cleaners during the operation is the rear compartment, followed by the cockpit. The two independent spaces are friendly to the cleaners' physical and mental health, but the information in the two spaces is independent. When cleaners are driving in the cockpit, they don't know the condition of the rear compartment. Secondly, the cleaners often get out of the tricycle and use the broom fixture to clean the road, which can reflect how arduous of cleaners' work. It is dominated by human operation.

4 Product Design and Innovation

4.1 Design Process of Garbage Tricycle

Combining the human-centered design methods and three factors of human-machine system, refining the design process. At first, analyze the system environment, user behavior. Based on the pattern of waste classification to clearly ensure the needs of cleaners and define the function of tricycle. Secondly, define the requirement of cleaner, and define the function of product. Then regard the user behaviors as the design object to design the working process of cleaner. Then define the form, color, materials required by the product. Then brainstorming, and evaluates the plan, and making prototypes and usability tests after evaluating iterations (Fig. 4).

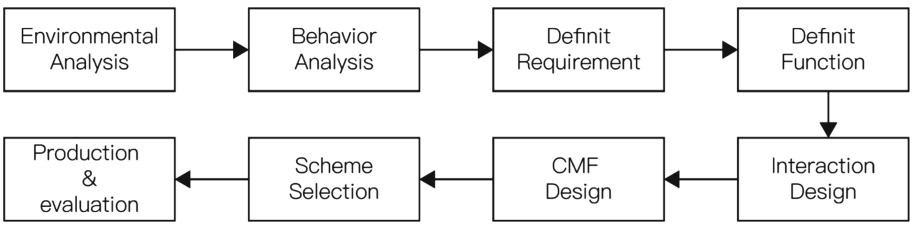

Fig. 4. Design process of garbage tricycle

4.2 Operation Requirements of Cleaners

Cleaners often need to work in the bad weather, they also need to bring personal items such as kettles, umbrellas, etc. In actual investigation, the cleaners often hang their work clothes on the rearview mirror of the vehicle, and the garbage tricycle is lacking space for storing items. Vehicles need not only space for storing tools, but also space for storing personal items.

When patrolling on the highway for cleaning, the cleaners are driving slowly. The appearance of the vehicle needs to remind pedestrians and passing vehicles of slow down to ensure the safety of the cleaners. With the maturity of automatic driving and image recognition technology, the functions remind the cleaners that there are trash cans could be realized, and work safety and efficiency of cleaners can be improved.

At present, the way of cleaning trash cans is cleaning by hand. In the case of reduced technical costs, mechanized methods can be used for cleaning. However, the terrain of the village is complex, and residents have scattered living. It is more feasible to improve the efficiency through institutional settings. Residents are allowed to empty garbage regularly, and residents receive feedback on the correct rate of their own, garbage weight and other information after they are dumped, and they are counted in the residential system. Cleaner can reject unqualified garbage. The cleaners only need to manually clean the trash cans in the public areas.

Garbage needs to be classified for recycling, the county's garbage bins are divided into recyclable garbage bins and other garbage bins. Harmful garbage is put in garbage bags. Due to the need to improve the accuracy of residents' classification practices, vehicles need to be provided with space for classified garbage storage. It has certain flexibility to facilitate the secondary sorting by the cleaners.

During the recycling process, cleaner needs to bend over to sort and bag the garbage in trash bin, which is not in line with ergonomics. Even if the residents are allowed to empty the trash bin regularly through the system setting, the existing recycling bin is too high for storage. Cleaner touch the bottom of the trash can. Residents also have psychological resistance. Therefore, the location and force of garbage collection must be considered.

The cleaner's work route needs to be flexible arranged according to the load of the trash cans in the residents' homes and the load of the trash cans in public areas. The existing work has a large collection volume and there are many repeated routes. Causing cleaners return home to store garbage temporarily. Therefore, the vehicle needs to have the function of compressing garbage. When the space is still insufficient after compression, it will go to the sorting center for garbage storage.

The cleaners need to clean the trash cans, but also clean the roads in public areas. In the setting of functions, the vehicles perform multi-functional integration to improve the work efficiency of cleaners.

4.3 Function Definition

The garbage tricycle is main tool for cleaners. Product definition is not just a short-distance vehicle. It should also improve work efficiency, safety, residents' classification awareness and correct rate of practice, and the sustainability of system.

The following lists the functions of this product: storage space design, including storage of personal items, storage of working tools. Through image recognition, the trash can on the side of the road is identified and feedback to the cleaner. The ability to compress garbage. A function to clean the road. The body has a sign to remind pedestrian and passing vehicle to passing slowly. The rear compartment of the tricycle is divided into different areas, one area is for the trash can to be scanned and weighed, and the other area for garbage sorting. Pouring down the rear compartment by controlling in cockpit for secondary sorting in the sorting center.

Fine-tune the existing pattern of system, collect other trash bins and recyclable trash bins at fixed times each week. The vehicle drives to the residents' yard to stay for the corresponding time. Residents take the trash bin to the garbage tricycle and the vehicle collects garbage. The bucket uses image recognition technology to scan the residents' garbage, and feedbacks the correct rate of garbage classification to the residents. The correct rate is higher than 80% and the corresponding points are obtained. The correct rate is too low to deduct the points. The points can be exchanged for corresponding gifts. At the residents' end, those with a higher cumulative ranking of all residents in the area received corresponding rewards.

4.4 Interaction Design

Wear Work Equipment and Bring Personal Items. In order to ensure safety, cleaners must wear work clothes and masks to perform work. When starting the vehicle, the system prompts the cleaners to equip related work equipment by sound. The cockpit is designed with a corresponding storage area to store the personal belongings of cleaners.

Driving. With the maturity of driving technology, head-up display technology, and navigation technology, it is a trend that provide the best working route for the cleaners in a day, integrate the cleaning content of public roads, and collect garbage bins at households and public areas. After collecting trash cans in households will no longer return to the area. At the same time, public roads will be cleaned on the road. It can be cleaned automatically after recognition. Reducing the distraction of users can also improve the user experience. The cleaner is reminded after the trash can is identified by the vehicle system on the road. The cleaner does not need to search for the trash can while driving.

Sweeping Road Garbage. After the adjustment of the existing pattern of classification, there are relatively few manual sweeps. Alleys and roads with rough roads that are unreachable by vehicles still need to be manually cleaned. A storage space for broom and broom fixtures is required in the rear area of the vehicle. Road garbage needs to be

stored in a separate area, which can be opened manually, is convenient for the cleaners to store the garbage after manual cleaning.

Collecting Trash Bin. The original mode of cleaning garbage bins manually by the cleaners will be changed into residents put trash bin in the corresponding position of the vehicle by themselves. It can reduce the manual work time of the cleaners. The cleaners only need to clean the trash can in the public areas. All processes can be digitized, eliminating the need for manual measurement, more accurate and reliable, reducing the behavior of the cleaners can improve their experience, and the product provides corresponding feedback to make residents feel the interactive fun of throwing garbage. Residents' behavior has increased but with the establishment of garbage classification awareness, the awareness of people's cooperation will gradually increase.

Secondary Sorting. The secondary sorting is a necessary process. Partially sorting can be performed during driving, but most of them still need to be transported to the sorting center for manual sorting. Although mechanical and intelligent technology has developed rapidly, but manual sorting is still required. The feedback of the rate of correct classification for the residents through the system can also improve the efficiency of secondary sorting.

5 Summary

The above theoretical research on logic of behaviors and user experience design, explores the relationship between logic of behaviors and logic of physical things, the priority of two decision logics in the design process, and the design process in user experience thinking. This paper explores the environmental factors and behavior factors in the HCI system with the cleaner-tricycle as the core in waste classification system in the countryside. A design process that embodies user experience and logic of behaviors is proposed, and it leads to the user experience design and innovation of short-distance vehicle. The design process and related theories still have room to improve in the application and practice process. For example, there are many elderly people in rural areas. The main force of littering may be elderly people and women.

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Research on Social Innovation and S.PSS Apply to Waste Sorting and Recycling System Design in Plateau Area

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Abstract. The Everest mountaineering industry is becoming more and more commercialized. The concurrent phenomena of garbage amount increase, land pollution, ecological deterioration, lack of resilience in policy design and localcc endogenous service system, etc. all involved in the condition of mountaineering and tourism resources decline. Through case studies, literature studies, structured interviews and dynamic route analysis of relevant factors, the policies, social and industrial context of the local mountaineering industry were discussed. Afterwards, the Everest mountaineering team members, local managers, herders and other stakeholders was taken as the member of participatory design, which was aimed to conceive the fundamental system of waste recycling and the related subsystems of manure disposal based on Everest base camp. In this design case, multiple design actions were taken to explore the possibility of multi-method and multi-dimensional design participation. The concept try to mitigate status of soil pollution in the Everest region, respond the demands of stakeholders, activate the endogenous forces, and systematically optimize the sustainability of the Everest mountaineering industry and self-organized system. This systematic design is based on the study of relatively exclusive self-organizing systems in the local area, and using design and social research method to sort out the interdisciplinary complexity, integrating interdisciplinary systems such as plateau ecology, mountaineering, regional revenue distribution, and cultural reconstruction, providing available research and design cases for system design and social innovation in communities in remote areas.

Keywords: Waste sorting and recycling system · Social innovation · S.PSS · Co-creation · BoP design method · Poverty alleviation

1 Introduction

Mount Everest (Qomolangma in Tibetan, means mother of Earth), located at the junction of Tibet and Nepal in China, has brought considerable economic and social benefits to the Everest National Park in Nepal and the Qomolangma Nature Conservation in China due to the development of mountaineering tourism economy.

While bringing extensive socio-economic benefits to the surrounding areas, Everest also faces the problem of constantly intensifying contradictions between economy development and ecological environmental protection.

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The Commercialization Process of Everest Mountaineering. Since the first summit of Mount Everest by Edmond Hillary in 1953, the rise of Mount Everest commercial climbing has led to a continuous increase in the number of climbers. In 2014 and 2015, affected by the avalanche of the South Slope and the earthquake in Nepal, the number of people who climbed Everest has decreased; by 2016; in the spring season of 2017, a total of 373 people Climbers have been granted permission to climb Everest from the South Face, the most since 1953 [1]. From the perspective of the mountaineering industrial, the commercialization process of Mount Everest has maintained a stable growth trend (Fig. 1).

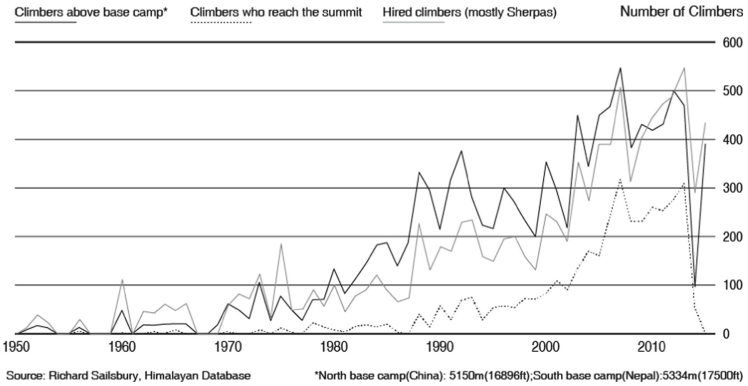

Fig. 1. Number of ascents of Everest by year (1950–2015)

Seasonal Weak-Load of Environment. There are large seasonal differences in the climbing of Mount Everest. Mountaineering and tourism activities mainly focus on the climate stability and suitable spring and autumn season, in this period (April to October), the water environment, land ecological and environment carrying capacity of the Qomolangma Nature Conservation is relatively small [2]. The environmental carrying capacity of the Qomolangma Nature Conservation is generally in a weak state.

Ecological Fragility of the Plateau. Before climbing, the alpine collaborators will transport tents, oxygen, water, and food for mountain climbing to camps at 7028, 7790, and 8300 meters above sea level. After the mountaineering activities, they will be transported away. According to surveys, when organizing a medium-scale mountaineering event, logistics materials can sometimes reach tens of tons or even hundreds of tons, and most of these materials are used only once [3]. For the Qinghai-Tibet Plateau with weak recovery capacity, once the natural environment is damaged or polluted, the consequences will be potential, profound and long-term [4].

Waste Issue of Everest. Due to the lack of environmental consciousness of climbers, environmental restrictions and lagging policies and regulations, a large amount of domestic waste represented by consumption/equipment and special waste represented by corpses and feces were generated above the Everest Snow Line. The lack of manpower and material resources for relevant treatment under severe environmental

conditions, and the lack of systematic management methods have led to the ever-increasing amount of Everest garbage [3]. The waste situation in conservation areas is equally worrying. According to rough statistics, the total number of tourists entering and leaving Everest Base Camp on the south slope is between 70,000 and 100,000 each year. As world-famous mountaineer Messner said, the once holy Mount Everest "is becoming the highest dump on earth."

2 Purpose of Research and Design

2.1 Sustainable Development Dilemma in Qomolangma Nature Conservation

From the comprehensive perspective of environmental benefits, economic development and social and cultural values, the sustainable development of the Everest mountaineering industry is facing difficulties.

The current model focuses on sacrificing environmental benefits, brings economic development to the mountaineering industry, and is relatively lacking in social and cultural value.

Environmental Impact. Everest's waste problem has caused many secondary environmental problems. Such as secondary problems such as land pollution, ecological degradation and environmental carrying capacity decline. Most high-altitude recyclers are professional climbers who have been trained for a long time, and the labor cost of waste recycling is high (Fig. 2).

Fig. 2. Documentary on Everest mountaineering environmental protection activities. In the process of climbing, most climbers have no energy to consider garbage collection and can only produce as little garbage as possible.

Development of the Mountaineering Industry. The existing "centralized" mountaineering system of the Everest Nature Reserve cannot effectively respond to a series of issues that Everest is facing and the demands of stakeholders. Traditional mountaineering is often regarded as professional behavior, with complex standards and

established specifications, and emerging design ideas and methods have not yet effectively participated in the optimization of mountaineering practices.

Comprehensive Social Benefits. The tourism income distribution in Tingri County wasn't good enough, resulting in the under-developed of the Everest Mountaineering Industry and local people's living standards. At the same time, the influx of a large number of dominant foreign capital and industries has also caused the local endogenous economic and cultural to gradually weaken.

2.2 Purpose of Research and Design

Plateau permafrost is an area where design is less involved. As the representative of Everest, the permafrost area around the world accounts for about 20–25% of the total land area. Permafrost protected areas are facing environmental and social challenges that are quite different from other geographical environments. In design practice perspective, this paper can give systematic understanding to the self-organized system and demand of stakeholders in this less-focused area, and giving multiple deliberate concepts and suggestions which were beneficial to creatively identify alternatives aiming at existing issues through design-oriented approach.

3 Literature Research

Stakeholder Identification. The stakeholders of waste management systems in developing areas were identified and prioritized in previous research. The main stakeholders included the local authority, and private contractors providing services which set up policies. Other important stakeholders are the service users such as: households, civil organizations, commercial and industrial sector. Farmers, media, donor organizations etc. are less mentioned and still have a potential. The informal stakeholders include waste pickers collecting door to door, at the street or in the disposal site, itinerant waste buyers, junk shop owners and street sweepers [5].

Income Distribution Mechanism. Zhaxi Zong township is located in the south of Tingri County, 67 km away from the county seat. According to statistics, the tourism income of 30 administrative villages in Zhaxi Zong township accounts for more than 50% of the gross national product. Tourism is the main source of income in the region. Studies have pointed out that the industrial income of the Everest Reserve has not played a good role in improving the living standards of local people [6]. Figure 3 shows the distribution of mountaineering tourism industry income in Zhaxi Zong township in the Everest Nature Reserve.

Sustainable Product Service System. In the mid-to-late 1990s, the United Nations Environment Programme proposed the concept of a Product Service System (PSS). The key idea is that the product provides the consumer with the function or result of the product. [7] After 20 years of development, the connotation of S.PSS has been expanded. The more common definition is "an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand (to

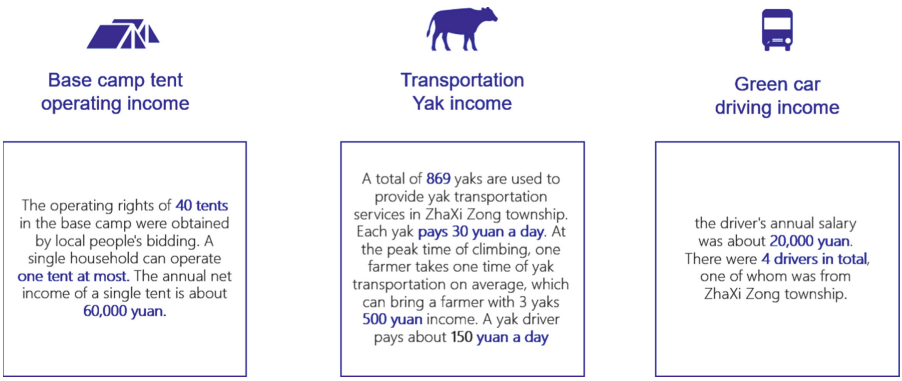

Fig. 3. Distribution of Everest Mountaineering Service income in Zha Xi Zong township.

deliver a 'unit of satisfaction'), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the economic and competitive interest of the providers continuously seeks environmentally and socio-ethically beneficial new solutions" [8].

In recent studies, the potential application prospects of S.PSS in low- and middle-income contexts have also been widely found., "S.PSSs are expected to be especially beneficial for low and middle-income contexts because they can cut the access costs to useful goods and services, the customer is neither required to buy the product, nor threatened by the maintenance and the repair costs." [8].

4 Stakeholder Analysis in Qomolangma Nature Conservation

Commercial Mountaineering Organization. Refers to the mountaineering customer paying a fee to the adventure company, and the adventure company is responsible for the services on the mountain. Generally speaking, the services of Everest Commercial Mountaineering include: personal assistance of guides, oxygen supply, camp service, adaptation training, material transportation, safety guarantee of dangerous routes, medical assistance and so on. Mountaineering activities are mainly undertaken by the government and qualified companies. This commercial climbing method determines that mountaineering customers rely mainly on the guidance and services of adventure companies when climbing.

Other Stakeholders. ShengShan Mountaineering Services is a major supplier of commercial mountaineering. China Mountaineering Association is the main management and supervision organization. All mountaineering activities must be approved by China Mountaineering Association. NGOs pay more attention to environmental protection and organize regular environmental protection actions. Non-governmental and student mountaineering association usually organize corresponding environmental protection actions during mountaineering. The local villagers are the mainstay of

Everest food and accommodation service, and they are also part of Everest's conventional environmental protection forces (Fig. 4).

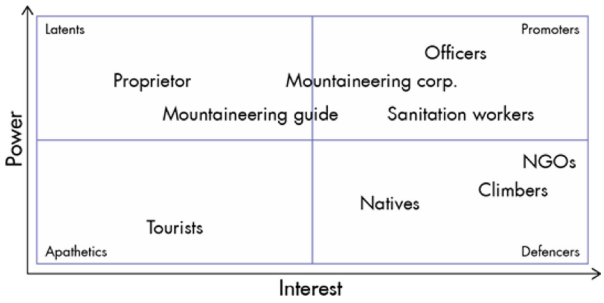

Fig. 4. Everest Environmental Protection Stakeholder matrix.

Stakeholders In-depth Interviewing. Interviews were conducted with the managers of commercial mountaineering companies and travel service companies, tourists who have been to Everest Base Camp, and university mountaineering teams, and the identification of stakeholders was reconfirmed through the interviews. Through interviews, we learned that the base camp has weak infrastructure, lack of relevant signs, weak environmental awareness among tourists, and relevant departments have not formulated environmental protection systems for tourists.

5 Dynamic Line Analysis

This article selects the typical commercial climbing of the North Col route on the north Face of Mount Everest for dynamic line analysis, based on the study of the summit process of Mount Everest [9], documentary data of Mount Everest summit image [10] The collation of the climbing team interviews, sorting out the key stages in the climbing process, time information and geographic information. Sort out the key user journeys, service touchpoints and environmental elements in the Everest Mountaineering Service System.

Just like Fig. 5 showing, the commercial mountaineering expedition is divided into five stages, namely, the preparatory, the adaptive training, the material transferring, the summitting and the downhill stage. The timing of these phases is relatively flexible and one stage may be repeated multiple times to ensure feasibility. The climbing plan is flexibly arranged according to the weather conditions, materials, personnel arrangement, Etc.

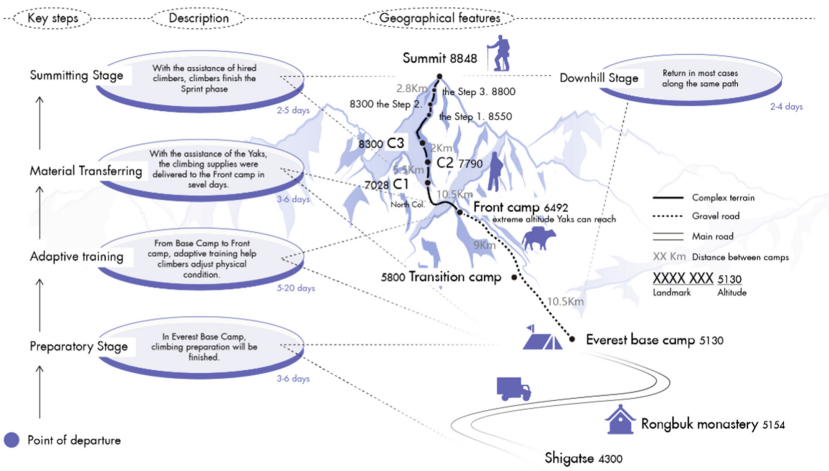

Fig. 5. Dynamic line analysis for a typical commercial mountaineering expedition

6 Design Opportunities

Based on five Phases in Integrated Sustainable Waste Management (ISWM) (Including: generation and separation; collection, transfer and transport; Treatment; Recycling; Final disposal.) [5]. And previous stakeholder analysis, a systematic exploration of innovation opportunity points for the existing system is shown, as shown in Fig. 6.

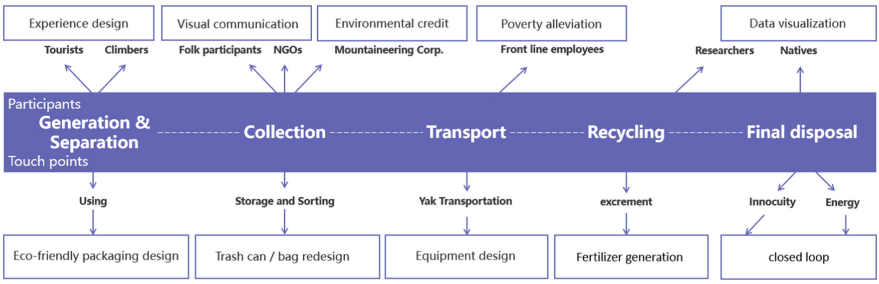

Fig. 6. S.PSS design opportunities in ISWM.

Visual communication helps climbers and tourists understand the necessity and urgency of Everest environmental protection, and also helps to revitalize the local cultural industry; from the perspective of user experience, the combination of commercial mountaineering service system and waste disposal system. It is also include the design of the mountaineering service front desk (such as the yak team), the design of the mountaineering environment credit system, and the design of the tourist experience.

7 S.PSS Design for Qomolangma Nature Conservation

Based on the above research, This paper has established the "Eco-Qomolangma Integrated service system" with Everest Base Camp as its core. The system contains multiple levels, from the outer mountain climbing and tourism service system, the main system for waste separation and recycling, to the manure Recycling and other related subsystems. This systematic design practice and research is based on a relatively closed self-organizing system, using design as a medium to sort out interdisciplinary complexity, and integrates interdisciplinary complexity such as plateau area ecology, mountain climbing systems, regional revenue redistribution, and cultural regeneration system. Provides research and design cases for the practice of system design in remote communities (Figs. 7 and 8).

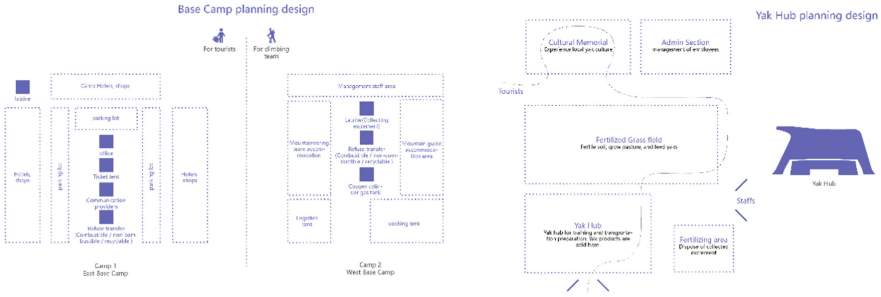

Fig. 7. Design for base camp and Qomolangma Nature Reserve Comprehensive Tourism Distribution Center.

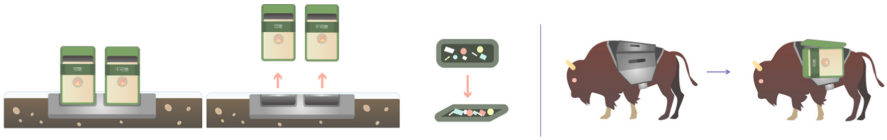

Fig. 8. Mountaineering trash can redesign.

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Design of a Mobile Support Application for Teenagers Suffering from Depression in Zapopan, México

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Abstract. Suicide is the second cause of death in the world in people aged 15 to 29 years. Depression is a psychological disorder that affects more than 300 million people worldwide. This disorder is caused by different factors, whether biological, psychosocial, personality, or genetic. It is characterized by having a low state of mind, loss of interest, feelings of guilt, restlessness, sleep disturbances, decreased appetite, accompanied by feelings of sadness, which physically and mentally affects the way of feeling and thinking, arriving in extreme cases to cases of suicides or attempts of him. Nowadays, there are several types of depression, such as major depression, dysthymia, adaptive disorder, depressive episode, recurrent depressive disorder, bipolar depression, psychotic depression, atypical depression, seasonal affective disorder, each one has its own characteristics, as well as symptomatology.

Keywords: Depression · Tennagers · Product & service design · Innovation

1 Introduction

Suicide is the second cause of death in the world in people aged 15 to 29 years. Depression is a psychological disorder that affects more than 300 million people worldwide. This disorder is caused by different factors, whether biological, psychosocial, personality, or genetic. It is characterized by having a low state of mind, loss of interest, feelings of guilt, restlessness, sleep disturbances, deconcentration, decreased appetite, accompanied by feelings of sadness, which physically and mentally affects the way of feeling and thinking, arriving in extreme cases to cases of suicides or attempts of him. There are several treatments for depression, but it depends a lot on what the patient in particular needs, since each one has different needs. Among the treatments are psychological treatment, which consists of different types of therapies with an expert; the biological treatment, which are different drugs that exist in the market to address the situation and the specific needs of the patient; as well as alternative treatment, which through certain activities, foods or aromas help during the recovery process [1]. The world health organization predicts that by the year 2020, depression will be the second cause of disability in the world and the first in Mexico. In America,

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almost 7 out of 10 people with depression do not receive the treatment they need, and in Mexico, [2] there are more than 10 million people with this condition and in the state of Jalisco have reported the highest rates of depression among young people between 10–19 years of age [3], so the objective of this research will be young people between 15 and 18 years old in the Municipality of Jalisco Zapopan. For this disorder, at present, there are not many innovative products that are tangible or services with which the patient can be helped since each individual has different needs, and it is challenging to find non-medical options, initiatives, recommendations in the style of life or natural treatments. However, the seriousness of the matter is increasingly recognized. Organizations such as Jalisco Civil Hospital have organized different campaigns to disseminate information to the population about the disorder, to prevent and inform and thus have the ability to identify it at an early stage and not reach any serious situation, as well as encourages and supports patients to ask for help, motivating them to continue with their treatment and be able to overcome that stage of their life. Depression is a problem that has been increasing over the years and is definitely causing an impact in Mexican society, that is why you need to be well informed in order to act properly, and thus help people who need it. At present, there are different types of depression, such as major depression; Depressive symptoms are intense and appear in the form of episodes (weeks or months). Dysthymia; Depressive symptoms are less intense but are very disabling because they are chronic (they last at least two years). Adaptive disorder and depressive symptoms are mild, are present for a short period, and are due to some problem (acute stressor) that the patient has suffered. A depressive episode, recurrent depressive disorder, bipolar depression, psychotic depression, atypical depression, seasonal affective disorder, each one has its characteristics, as well as symptomatology [4].

2 Background

There are several treatments for depression, but it depends a lot on what the patient in particular needs, since each one has different needs. Among the treatments are psychological treatment, which consists of different types of therapy, such as interpersonal therapy, cognitive therapy and behavioral activation with an expert, with the objectives of treating the symptoms and in case there are behavioral patterns that predispose the appearance of depressive episodes to modify that type of personality, in addition to providing the tools to be able to face the disease; the biological treatment, which is divided into pharmacological treatment and electroconvulsive treatment. The pharmacological treatment is different drugs that exist in the market to address the situation and the specific needs of the patient. Currently, three types are used: antidepressants, mood stabilizers, and anxiolytics. And the electroconvulsive treatment, which is used in the most severe cases of major depression, in this treatment is carried out inadequate sanitary conditions by means of an electrical energy device that sends impulses to the brain, where it causes a brief convulsion to the brain (which it lasts between 30 s and 2 min). During these treatments, the patient is given general anesthesia, so it is

only recommended for the most acute cases of depression, as well as an alternative treatment, which through certain activities, such as physical exercise; Food, some examples are: citrus fruits, pulses, and nuts; aromas, such as rose oil, lavender, and sage, which help during the recovery process. The World Health Organization predicts that by the year 2020, depression will be the second cause of disability in the world and the first in Mexico. In America, almost 7 out of 10 people with depression do not receive the treatment they need. In Mexico, there are more than 10 million people with this condition and in the state of Jalisco have reported the highest rates of depression in young people between 10–19 years of age, so the objective of this research will be young people between 15 and 18 years old in the Municipality of Zapopan [5].

Some factors that foment this disease in Mexico are the consumption of toxic substances, the environment, socioeconomic conditions, high labor demands, intrafamily violence, insecurity, among others. For this disorder, at present, there are not many innovative products that are tangible or services with which the patient can be helped, since each individual has different needs and it is difficult to find non-medical options, initiatives, recommendations in the style of life or natural treatments. Depression is a problem that has been increasing over the years, and is definitely causing an impact in Mexican society, that is why you need to be well informed in order to act properly, and thus help people who need it. And unfortunately, in Mexico, the importance that is due is not taken into account, and there are very few resources for this disease.

3 Methodology

In this research, different methodologies were used, such as Design thinking, because in this project the most important thing is the user and the problems he faces, so his needs are the priority, and this methodology is characterized by generating ideas that focus on understanding to solve the needs of the users. Emotional design, where "Emotions have a vital role in human's ability to understand and create meaning of the world. Chapman [6] and Norman [7] pointed out that emotional design can be the solution to build a strong emotional attachment and empathy between people and products which can also influence people's life - the way people think, feel, and act. Norman [8] concluded that a successful design excels in three levels of emotional design – visceral level (appearance and pleasure to see), behavioural level (usability and performance), and reflective level (the meaning, self-image, and message of a product). Since our subject has a lot to do with the user's emotions, and when creating a design that is pleasing to the eye, some positive emotion or some sense of belonging

could achieve the desired effect; Total design, which is defined as is the systematic activity necessary, from the identification of the market/user, need to the selling of the successful product to satisfy that need - an activity that encompasses product, process, people and organization.- Stuart Pugh, because depression is a sensitive issue, it is necessary that the product or service be introduced to the market in an appropriate manner for being successful.

4 Procedure

Three surveys were carried out to different actors to know a little more about the diverse needs and problems with which the user, family members, and experts face each other. The first survey is aimed at experts (psychologists) to reaffirm the information researched and obtaining new information that will help as a basis to develop a product/service. The second survey is aimed at young people, with the aim of knowing a little more about their true needs and knowing how much information is available about depression. Finally, the third survey is aimed at relatives or friends of young people with depression, to know if they have the necessary knowledge to help their relatives or friends and also find solutions to their needs.

5 Results

For this project, it was decided to implement service design as a complement to the design proposal for the problem. The service design that is proposed is the development of a mobile application, which will be a support network for young people suffering from depression, within it users can find tips and activities that can be done at the time of feeling a certain way, You can write how you feel and have the option of sharing it with the same application community, and if necessary, you will also have the option of contacting an expert near your user, in the development of this application you will not be looking for just the benefit of users, if not also seeks to help psychologists, because when the user decides to contact an expert, psychologists will be contacted near their area which can give some tip, however, to give and have a follow-up psychologist can offer their services and schedule appointments with users, in order to provide more support. The mobile app is called “páusate” (Take a break) and will be available for iOS and Android platforms (Fig. 1, 2).

Fig. 1. Examples of the mobile application screens

Fig. 2. Examples of the mobile application screens

6 Conclusions

Based on the results obtained, we were able to see the real needs of our users, and we were able to conclude. We decided to create a helpful infographic with which the young people can identify themselves, in which they are motivated to see things. Positive and given a few words of encouragement, in the same way, they are offered support by inviting them to download the mobile application in which they can find different forms of support.

The manufacture of the infographic consisted of designing the graphic elements that integrate it, as well as the history and the message that is wanted to transmit. First, the idea of what was to be transmitted was clearly established, the layout of the story and the graphic elements were designed. Then the colors, size, and materials were defined. Finally, the final design was turned into a digital version, printed and framed to give a better finish and image. These infographics will be placed in spaces where young people develop, such as schools (Fig. 1). Our proposal follows the stipulations of the Official Mexican Standard. The necessary and chosen material for the infographic is durable, and with an impression of quality is opaline paper. Because the product will be exposed, its wear can be much greater if it is left alone, that is why it is recommended to reinforce it by marking or plasticizing it.

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Education and Gamification

Design of an Intuitive Control Concept for Lifting Operations Using the Example of Forklifts

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Abstract. Because of their flexibility, forklifts are still one of the most popular transport vehicles used in intralogistics. In practice, the lack of knowledge in handling forklifts leads to a high safety risk and lower handling performance. The paper presents a new control paradigm, which reduces the training period for new employees and the occurrence of user errors. The described paradigm designs a control, which reacts in accordance with the operator's expectations. A survey was conducted to compare the different motion designs in the categories of ergonomics, intuitiveness and controllability. The test persons perceived the new control paradigms as more intuitive than a state-of-the-art control. The results do not show any significant difference with regard to the order of the test sequences or previous experience in handling forklifts. Subsequently, inexperienced and experienced forklift operators benefit from the new control paradigm.

Keywords: Ergonomics design · Intuitiveness · Intuitive control · Case study · Forklift control

1 Introduction

The shortage of skilled personnel is constantly growing in intralogistics. In a survey of logistics companies, 75% of respondents said that they have difficulties filling vacancies adequately [1]. Especially in small and medium-sized enterprises, where employees carry out a large number of different tasks, this results in a reduction in experience. In such companies, due to the low investment costs and high flexibility, forklifts carry out the material flow. However, the industrial truck fleet usually consists of different forklift types. These have numerous manufacturer-specific operating concepts for the control system. The operating concepts usually consist of several hand or finger levers for each degree of control of the forklift. In practice, the different control concepts and the lack of knowledge in handling forklifts leads to a high safety risk and lower handling performance. In particular, inexperienced employees require training to operate these controls intuitively and safely. Otherwise, the behavior of the forklift differs from the behavior expected by the operator, and the risk of operating errors rises [2]. For this reason, it is necessary to develop a new intuitive control system for forklifts.

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2 Background

2.1 Intuitiveness in Control Design

A technical system is intuitively usable if it enables the user to experience fast, generally accurate and often non-conscious interaction based on prior knowledge. Operating an intuitively usable technical system does not require high cognitive effort and the system is therefore easy to use. Interaction with new technical systems, which requires novel association, leads to a high working memory load and a slow processing speed. On the other hand, a direct perception of the interaction results in an easy and fast experience [3–5]. To reach this level of intuitiveness, there are already recommendations in place regarding the design of controls. The control task is intuitive if it corresponds to the user's expectations from the context of use, and to generally recognized conventions. This conformance to expectations is mainly determined by the compatibility of the interaction with all information available to the user. Compatibility is therefore the amount of necessary recoding between different pieces of information in reality, displays, actuators or internal models by the operator. In terms of controlling a machine, the highest compatibility and thus intuitiveness is achieved by matching the motion of the operating element and the desired movement of the actuator. This means that the actuator and the internal image coincide, and no additional display or internal conversion of information by the operator is required [6, 7].

In the related research field, the development of intuitive control concepts is increasing. In many fields of application, such as the handling of heavy weights, there are attempts to reduce the strain on individuals [5, 8–11]. For working machines such as hydraulic diggers, researchers are testing haptic feedback as a way of increasing the intuitiveness of use. For forklifts, the replacement of the steering wheel with a joystick control is part of academic exploration [12, 13]. However, there has been no consideration in terms of increasing the intuitiveness of a forklift's mast control.

2.2 State of the Art in Forklift Controls

The current state of the art in forklift controls consists of manufacturer-specific concepts. In addition to the conventional controls through separate hand or finger levers for each movement of the mast (Fig. 1 – two leftmost images) new controls are being developed, and combine several movements of the mast via one or two joysticks (Fig. 1 – two rightmost images).

Fig. 1. State-of-the-art controls for forklift masts [14, 15]

The main functions of the mast system are lifting, the lateral movement of the forks and the tilting of the lift mast (Fig. 2). Since the lifting of the forks takes place in the z-axis, the direction of motion of the control element due to the expectation conformity should be identical. Furthermore, operators control the lifting and lateral movement of the fork by rotary motion, despite the actuator movements being linear. In summary, there is currently no control concept that meets the requirements of conformity with expectations. This initial situation is also present in other areas of application for machines with lifting functions and with a fixed workplace for the operator.

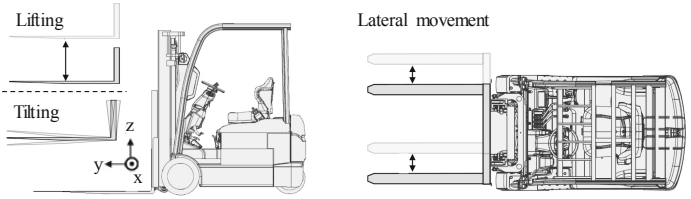

Fig. 2. Functions of the forklift mast

From these considerations, the basic question is whether the existing rotary motion or instead a linear motion of the operating element is ideal for a linear movement of the actuator. A further aspect is whether there is an ideal form of operating element for lifting operations, which strictly follows the rules of expectation conformity, or whether the design must involve compromises in favor of ergonomics and controllability.

3 Study Design

3.1 Developed Forms of Motion and Control Concepts

Based on the first derived question, the following mechanical systems are used to compare the concepts of linear and rotatory motion (Fig. 3 – two leftmost images).

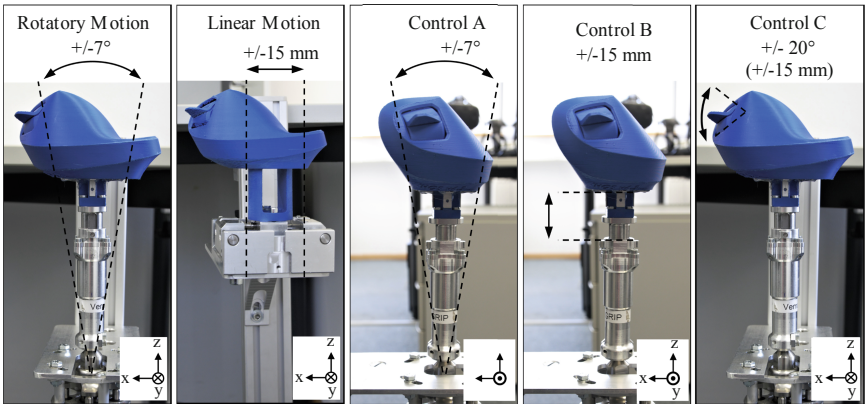

Fig. 3. Tested mechanical systems for rotatory and linear motion (two leftmost images) and for lifting operations (three rightmost images)

For the lateral movement of the forks one mechanism allows a rotary motion of ±7°, the other a linear motion of ±15 mm. To compare the control concepts developed for lifting operations, there are three mechanics. Control A represents the state of the art. A forward/backward motion of the joystick in the y-direction lowers or raises the forks. With control B, the lifting or lowering of the forks is controlled by an upwards or downwards motion. This control was derived from the principles of expectation conformity. The movement of the operating element strictly reproduces the motion of the control unit. Control C represents an additional approach of increasing the expectation conformity by a motion in the z-direction, which is similar to the movement of the actuator.

3.2 Hypothesis and Design of the Survey

Based on the described problems and mechanical systems, a self-developed survey aims to clarify the following hypotheses:

(1) There is no difference in the evaluation of rotatory and linear motion for the lateral movement of the fork in the categories of ergonomics (E), intuitiveness (I) and controllability (C).
(2) There is no difference in the evaluation of the three tested controls for the fork lifting in the categories of ergonomics, intuitiveness and controllability.

In addition, for both hypotheses, statistic tests examine whether there is a difference in the evaluation of test persons with differing experience in handling a forklift. The survey is made up of the following statements:

(1) I find the use of the system to be physically effortless. (E, positive)
(2) I find the control of the movement in this system to be prone to error. (C, negative)
(3) I find the system to be very intuitive to operate. (I, positive)
(4) I think that with this system I can precisely control the movement. (C, positive)
(5) It took me a long time to understand the operation of the system. (I, negative)
(6) Over a longer period, I find the motion exhausting. (E, negative)

Thereby, two of the statements form a pair to clarify each category. One of the statements is formulated positively and the other negatively in order to counteract a question-contextual effect. The test persons respond to the statements according to the Likert scale, on an index from one (strongly disagree) to five (strongly agree). In addition, the test persons provide demographic data (age, sex, existing user experience).

3.3 Survey

For the test, 30 subjects responded to the survey. The group of test subjects consists of 24 men and 6 women. Eleven test subjects have a forklift-driving experience. On average, the subjects are 29.6 years old (SD 8.8 years).

Part 1 of the test compares the concepts of linear and rotatory motion. Before the test, the subjects are randomly divided into two groups and the sequence of the task is

randomized. After explaining the associated movement (lateral movement of the fork in x-direction) to the test subject, he or she can test the control system. Then the test subjects completed the survey. After explaining the associated movement of the forks with the three developed controls to the test persons in part 2, they tried the controls in randomized order and responded to the same survey.

4 Results and Discussion

4.1 Comparison of Linear and Rotatory Motion

Figure 4 shows the evaluation of the linear and rotatory motion in the categories of ergonomics, intuitiveness and controllability for the lateral movement of the fork.

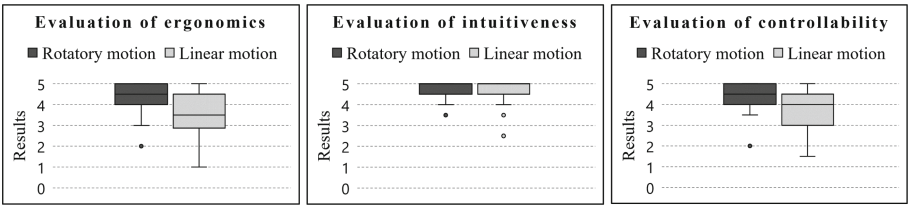

Fig. 4. Results of the evaluation of the linear and rotatory motion

Since the survey results are distribution-free, ordinal-scaled data of two dependent samples, the Wilcoxon signed-rank test as a non-parametric statistical hypothesis test gives following results ($\alpha = 0.05$). The evaluation of the ergonomics and the controllability of the two motions shows a significant difference (asymptotic significance ergonomics = 0.0003, controllability = 0.0025). In both categories, the test persons rate the rotatory motion significantly higher than the linear motion. The reason given by the test persons is the greater range of motion from the forearm and the resulting higher load and worse controllability via linear motion. The test subjects even rate the intuitiveness of the rotatory movement equally, although it does not represent expectation conformity for a translatory task (asymptotic significance intuitiveness = 0.2895).

Furthermore, a Mann-Whitney *U* test for the distribution-free, ordinal-scaled data of two independent samples examines the influence of the test sequence and of previous experience in forklift driving. No significant difference in the results was found. This means that control via rotary motion is more ergonomic and easier to control for both inexperienced and experienced forklift truck drivers.

4.2 Comparison of the Motion Modes for Controlling Lifting Operations

Figure 5 shows the evaluation of the different controls for the lifting operation in the categories of ergonomics, intuitiveness and controllability.

The results for the comparison of the controls are distribution-free, ordinal-scaled data of three dependent samples. Therefore, a Friedman test proved that the results for the controls differ significantly ($\alpha = 0.05$). Thus, a post hoc analysis (Dunn Bonferroni test) compares the differences between the controls individually by pair (Table 1).

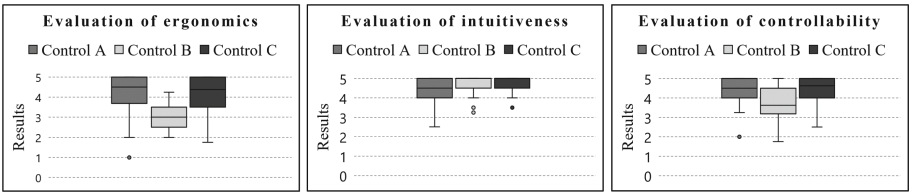

Fig. 5. Results of the evaluation of the different controls for the lifting operation

The comparison of control A and control B shows that the test persons perceive control A as more ergonomic and easier to control than control B, although there is no significant difference in the evaluation of intuitiveness. Compared to control C, there is only a difference in the evaluation of intuitiveness. The test persons perceive control C to be more intuitive than control A. The evaluation of the ergonomics and controllability of control B and control C shows significant differences. The test participants rated control C significantly better than control B.

Table 1. Corrected significance of the post hoc analysis (Dunn Bonferroni test)

Compared controls	Ergonomics	Intuitiveness	Controllability
A - B	0.0001	0,1584	0,0244
A - C	1.0000	0,0355	0,8175
B - C	0.0001	1,0000	0,0005

In summary, the test persons rate the control C equally or better in all selected categories than the state of the art (control A) and the control with the highest theoretical expectation conformity (control B). Furthermore, a Mann-Whitney *U* test shows no differences in the evaluation of the controls depending of the previous experience in forklift truck driving. Equally, a Kruskal-Wallis test for the six independent samples of the different test sequences shows no differences in the results.

5 Conclusion

The paper compares two general approaches to the design of a control device: on the one hand a linear motion of the control element, and on the other hand a rotatory motion. For that reason, test persons responded to a survey to compare the different designs of motion in the categories of ergonomics, intuitiveness and controllability. Although, the operator controls a linear movement, the test operators perceived a

rotatory motion of the control element to be equally intuitive. However, the test subjects conceived a rotatory motion as more ergonomic and controllable. Furthermore, the paper compares three alternative control elements for the lifting functions. The test operators perceived the developed controls for the lifting operation as more intuitive than a state-of-the-art control system. In particular, thumb-based control with a rotatory motion in the z-axis received high ratings from the subjects. The results do not show any significant difference in terms of the order of the test sequences or previous forklift experience. Subsequently, both inexperienced and experienced forklift operators benefit from the new control paradigm.

As next steps, haptic feedback such as vibrations will be integrated into the concept. This feedback simplifies the task and makes it direct perceptible for the driver. Furthermore, the implementation in a forklift, along with testing, should provide evidence of the differences between the new control concept and the state of the art.

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Return to Manual Control After Monitoring Automated Systems: Effects of Different Levels of Reliability

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Abstract. Automated systems changed the role of the human operator from active controller to supervisor of automated system. This new role comes with several human factors issues, as monitoring inefficiency. Some authors showed that it is possible to mitigate this monitoring performance drop using adaptive automation. Here, we assessed the consequences of a return to manual control with four different levels of automation reliability on eighty students. We compared the effect of the introduction of two manual sessions to exclusively automated sessions (total duration 90 min) using the MATB-II (i.e., intermittent vs permanent automation). Results showed that participants spend more time looking at the automated task in the 0% level reliability compared to 100% level of reliability over the time whatever the automation type. Manuals sessions in intermittent automation group had an impact on the time spend looking at the automated monitoring task.

Keywords: Automation · Reliability · Task allocation · Manual control · Monitoring

1 Introduction

It has been long known that automated system can both be beneficial and prejudicial to human performance [1]. The implantation of automated system changed the role of the human operator from an active controller of the system to a passive monitoring supervisor of this one [2]. Previous studies showed the negatives consequences induced by this new role as automation related to complacency [3] or loss of situation awareness [4]. For this reason, the benefits of automation use is sometimes questioned because of the repercussion in case of imperfect automation (i.e., not perfectly reliable), as a decrease of performance [5] or an inadequate visual resources allocation [6].

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According to some studies [5, 7] the impacts of imperfect automation are more prejudicial with a constant reliability automation than a variable reliability automation. Moreover, it has been showed than different levels of reliability impacted the performance or the time spend looking at the automated task [6]. Some authors put forth the idea than return to manual control after monitoring automated allows to reduce these impacts [8, 9]. They highlighted the use of adaptive and adaptable automations that provided more flexibility in function allocation [4]. In their studies, the authors confronted the participants to the MATB-II [10], a multitask environment in which one task is automated but not perfectly reliable (56.25% of reliability). Participants performed three tasks simultaneous. They showed that a return to manual control during 10-min enhanced monitoring behavior and reduced the decline in performance. In the current study, we investigate the presence or not of two repeated manual sessions when participants performed multiples tasks simultaneously on the performance and visual attention allocation of participants. According to previous studies that suggest that different levels of reliability influenced the performance of the participants, we used four levels of reliability (0%; 56.25%; 87.5% or 100%) for test the return or not of manuals sessions with multiple levels of reliability. We hypothesized that the return to manual sessions would improve the monitoring with an increase of performance and fixation time of the participants after the manuals session. We thought that an increase of the level of reliability would lead to a decrement in visual resources allocation and detection rate of the participants.

2 Method

2.1 Participants

Eighty students from 18 to 28 years (62 women and 18 men, $M = 19.9$ years, $SD = 2.2$) from the Institut National Universitaire Jean François Champollion in Albi (FR) participated in the experiment. They had no visual acuity problems.

2.2 Apparatus and Materials

The Multi Attribute Task Battery. The MATB [10] is a micro-world composed of five simultaneous tasks. A modified version named OpenMATB [11] was used in this study with three of the five tasks: a monitoring task that consisting of four vertical gauges with a cursor fluctuating in each gauge. Sometimes, the cursor was blocked in the lower or the upper part of one of the gauges (indicating system malfunction) and the "warning" light changed to red. The participants must detect the system malfunctions. The other two tasks consisted of a tracking task in which the participants had to keep a cursor in a target area and a resource management task in which participants had to control a system of pumps to maintain two tanks (A and B) that were continually depleting at 2500 L.

The tasks were performed on a standard computer with a 23″ monitor (1920 × 1080 pixels). A joystick was used for the tracking task and a keyboard for the monitoring and the resource management tasks. Eye movements were recorded using a RED 500 system (SensoMotoric Instruments).

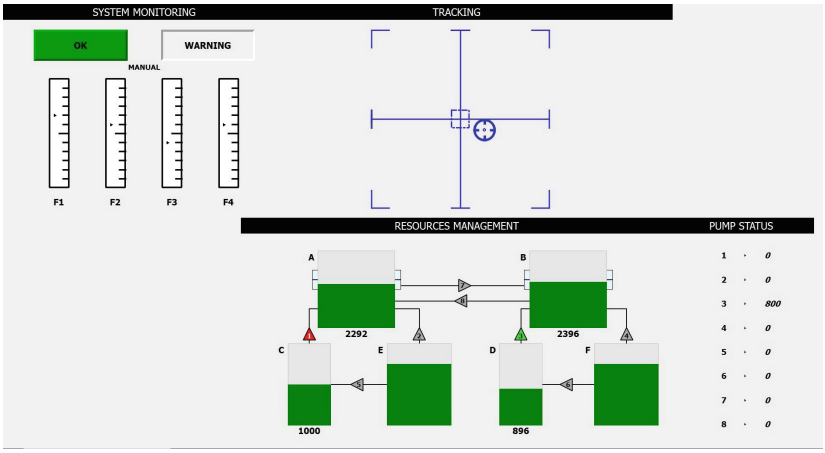

Fig. 1. Screenshot of the OpenMatb.

Monitoring Automation. In this study, monitoring task was automated as follows: when a malfunction occurred (the cursor was blocked on the upper or lower of a gauge), the warning light turn on red color and the cursor was automatically unblocked. However, in case of failures of automation, the warning light didn't turn on and the cursor was not unblocked automatically. In this situation, the participant had to detect himself the malfunction and press the corresponding keys (F1, F2, F3 or F4) to unfreeze the cursor.

Experimental Design. A between-subjects 4 (automation reliability level: 0%; 56.25%; 87.5% or 100%) by 2 (automation presence: permanent or intermittent) design was used. Ten participants were assigned to the eight experimental conditions. Each 10-min session included 16 systems malfunctions. Under intermittent automation, session 4 and 7 had to be perform manually. Participants were informed with the word "MANUAL" placed above the monitoring task during all sessions 4 and 7 duration (Fig. 1); when automation was available again "AUTO ON" was displayed. Under permanent automation, session 4 and 7 were still under automation according to the reliability of the experimental condition.

2.3 Procedure

First, participants signed a consent document. Then, the different tasks of the MATB were explained to the participants. After a calibration of the eye tracker, they performed a training in which they performed manually each of the three MATB tasks individually for two minutes (2 min × 3 tasks). After that, they were informed about the functioning of the automated task and confronted to the three simultaneous tasks. They were also informed about the potential failures of the automation.

The experimental sessions consisted in 90 min of nine 10-min sessions. Depending on their condition, participants completed two sessions manuals (intermittent automation) or not (permanent automation). The monitoring task was automated with

one of the four level of reliability. After the third,sixth session and ninth, participants completed the NASA TLX and two questions about their trust into automation and self-confidence to achieve the monitoring task.

2.4 Measures

We computed the relative fixation time that correspond as the sum of the recorded fixation durations [6]. Three Areas of Interest (AOI) was defined and corresponded to the three MATB tasks.

Concerning the subjective measures, participants had to complete a computerized version of the NASA-TLX [12] and were asked to evaluate their trust into automation and their self-confidence by responding to both questions "How high was your self-confidence to perform the monitoring task?" and "How much did you trust the automation of the monitoring task to detect the system malfunction?" [13] on a scale from 0 (completely disagree) to 10 (completely agree). Participants complete the subjective measures at the end of the third, the sixth and the ninth sessions.

For the performance, concerning the monitoring task, the detection rate (number of malfunctions corrected) was recorded. Performance was normalized between 0 (no malfunctions detected) and 1 (all malfunctions detected). For the tracking task, the performance was assessed through the proportion of time that the cursor spent inside the target area. For the resources management task, the mean distance to the target level was computed for the two depleting tanks (A and B), and the two distances were averaged.

3 Results

3.1 Gaze Behaviors

For the monitoring task, we conducted *t*-tests comparisons on the relative fixation time between session 1 and 9 for all level of reliability. Participants spend more time looking at the monitoring task in the session 9 ($M = 101.26$ s, $SE = 10.07$) than in session 1 ($M = 60.31$, $SE = 10.61$) in the 0% level of reliability and permanent automation group, $t(9) = -2.669$, $p < .05$, $r = .44$). On the contrary, for the 100% level of reliability and permanent group, participants spend less time on monitoring task in session 9 ($M = 22.48$ s, $SE = 5.46$) than session 1 ($M = 77.02$ s, $SE = 16.76$), $t(9) = 3.667$, $p < .01$, $r = .60$. We didn't find a difference between session 1 and 9 for the level 56.25% and 87.5%, $p > .05$.

Concerning the intermittent automation group, participants spend more time on session 1 ($M = 76.12$ s, $SE = 36.32$) than session 9 ($M = 36.32$ s, $SE = 10.43$). We didn't find a difference between session 1 and 9 for the level 0%, 56.25% and 87.5%, $p > .05$.

3.2 Performance

For the monitoring task, we conducted *t*-tests comparisons on the performance between session 1 and 9 for all level of reliability. A 100% level was not included because no detection was required by participants in this level. In the 0% reliability level and

permanent automation group, the detection rate increased in session 9 (M = 0.94, SE = 0.06) compared to session 1 (M = 0.55, SE = 0.13), ($t(9) = -3.124$, $p < .05$, $r = .52$). We didn't find a difference between session 1 and 9 for the level 56.25% and 87.5%, $p > .05$. With intermittent automation, we didn't found a difference between session 1 and session 9 for all three reliability levels, $p > .05$.

3.3 Subjective Measures

A mixed ANOVA (within-subject: session factor; inter-subject: type of automation and level of reliability) showed a mean effect of the session factor on the self-confidence ($F(2, 135) = 7.532$, $p < .001$) and an interaction between the session factor and automation reliability ($F(6, 136) = 2.494$, $p < .05$, $n^2 = .094$). Post-hoc analyses indicated that self-confidence in session 3 (M = 4.2, SE = 0.49) was smaller than in session 6 (M = 5.9, SE = 0.49) and 9 (M = 6.0, SE = 0.52) in the 100% level reliability.

For the trust into automation, no main effect of the session factor ($F(2,136) = 1.347$, $p = 0.263$) and no interaction between the session factor and automation reliability ($F(2, 136) = 1.556$, $p = 0.169$) were found. However, the ANOVA revealed a main effect of automation reliability ($F(3,72) = 1,437$, $p < .01$, $\eta_p^2 = .192$) and an interaction between the session factor and automation type ($F(2, 136) = 3.549$, $p < .05$, $\eta_p^2 = 0.047$). Concerning the main effect of automation reliability, post-hoc showed a significant difference between the level 0% (M = 4.28, SE = 0.53) and 87.5% (M = 6.53, SE = 0.43) as well as between the level 0% and 100% (M = 6.48, SE = 0.58). For the interaction between the session factor and automation type, no significant differences were revealed by post-hoc.

4 Discussion

The aim of this present study was to compare the effects of the presence of two types of automation (i.e., permanent and intermittent) and four levels of reliability (i.e., 0%; 56.25%; 87.5% or 100%) during 90 min of monitoring on performance and visual resources allocation of the participants.

The results showed that when participants monitored an automation during 90 min with a perfect automation (100% reliable), they spend less time on the automated task over time with both type of automation. According to other studies [8, 9], this trend seems to be slightly reduced with intermittent automation although the time spend on the monitoring task still decreased over the time. With intermittent automation and 0% level of reliability, the time spend on monitoring time tend to increase over the time although no significant different was recorded. However, in the permanent automation group and 0% of reliability, the participants increased significantly the time spend on the monitoring task between session 1 and session 9. This results showed a different visual behavior adopted by the participants that depend of the reliability level of automation [6].

Concerning the performance, participants had a better manual detection rate over time only in the 0% reliability level and permanent automation. However, we can note

the same tendency with intermittent automation even if the difference was not significant. This result suggested that performing the task manually allowed to enhance the performance over time.

According to the results of subjective measures, the participants trust less the automation in the 0% reliability than in the 87.5% and 100% reliability level. This result confirms that reliability of automation is involved in the trust in automation [14]. Moreover, participants had a better self-confidence over the time with a perfect automation. In conclusion, this study suggests that a perfectly reliable or a totally unreliable automation lead to different strategies of the participants in terms of visual allocation strategies Moreover, return to manuals sessions control after a long period of monitoring lead to a reallocation of visual attention to the automated task in the next following automated sessions during an amount of time.

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Augmented Reality and the Use of Alternative Communication for Children with Autism Spectrum Disorder: A Literature Review

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Abstract. The term Autistic Spectrum Disorder (ASD) has been increasingly studied by researchers and disseminated by scientific media. People with ASD exhibit peculiar social characteristics that often interferes in their communication with other people. Therefore the need to offer new possibilities to pursue better communication for these people trough assistive technologies. The present article aims to identify what national and international scientific productions, published between 2013 and 2018 have revealed about the use of augmented reality and alternative communication of people with ASD. The results shows that assistive technology contributes to increase or expand functional abilities of people with disabilities and therefore promotes independent life and inclusion. Otherwise it is observed that unknowing the disorder and lacking specified strategy for it may cause small impact upon the learning process of ASD population.

Keywords: Autism spectrum disorder · Augmented reality · Alternative communication · Assistive technology

1 Introduction

The Autistic Spectrum Disorders (ASD) which belongs to DSM-V and CD F-84.07 refers to a group of disorders characterized by a shared spectrum of qualitative losses in social interaction, in language, associated with repetitive behaviors and restricted interests [1]. These factors limit social interaction and child development placing diagnosed children in a particular world, with restrict connections [2].

In 2016 an estimative was released pointing out that near 1% of the global population lives with autism [3], corresponding to 70 millions of people in the world. Therefore in Brazil the percentage is equivalent to 2 million people in the spectrum [4].

These characteristics can lead to children isolation and that impoverishes even more the abilities of communication to which literature is unanimous in recommending early diagnosis and intervention [5]. Therefore, the school become a fundamental resource to enrich social experiences of children with ASD, providing interaction between pairs and contributing to the development of new learnings and behaviors.

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There is not a unique method to teach any topic to autistic people because each individual has specific needs and difficulties, being all different even when diagnosed at the same ASD level. However it is important to adopt a multidisciplinary approach with the assistance of different professionals such as psychologists, speech therapists and teachers specialized in inclusive education. The goal is to develop autistic people abilities and work so that difficulties affects their lives less and less.

Technology has been largely used in this area of knowledge, by using interactive table, alphabetization applications, simulators of daily life competences in virtual life, electronic puppets, and mainly for new forms of communication. The appeal of technological devices over autistic children is frequently mentioned by their parents and doctors. In technological determinism [6], considers that new technologies are seen as something that provides "conditions for social change and progress and are invented as if they were within an independent sphere from where new societies or new human conditions are created.

In recent years such fascination has been used by researchers to develop more effective communication and teaching techniques such as the use of videos, PDAs (mini computers) and augmented virtual reality. Considering the interaction between teacher and student or doctor and patient with special needs, alternative communication systems an effective way to ensure the inclusion of these individuals. That way, anyone prevented from speaking can communicate with other people and expose ideas, thoughts and feelings if they can use resources specially developed and adapted to the environment in which they are inserted.

Therefore, there are great discussions about the increase of this need, which raises a global alert, in different areas and social classes. It directly affects the way these individuals – and their network of affective partners communicate and interact with each other, also affecting ambivalences that guide ASD putting them in a quest for building or rebuilding ways by which they can help the development of artifacts that can actually contribute to their cognitive development.

2 Method

The literature review was carried out by an electronic search of articles, theses and dissertations published between 2013 and 2018 on the databases SciELO, LILACS, Blucher Design Proceedings, Researchgate, Google Scholar and Capes. The refinement of the research is made using key descriptors, including the terms autistic spectrum disorder, alternative communication, augmented reality and assistive technology. Only papers published full text, focusing on speech therapy were considered. In total 05 productions were analyzed.

3 Results and Discussion

Nowadays many products are widely developed to supply the needs of people who belonging to ASD but these users are not able to report their satisfaction or dissatisfaction with that artifact. Assistive technology is still a new term used to identify all the

arsenal of Research and Services that contributes to providing or expanding functional abilities of people with disabilities, promoting life independence and inclusion.

Alternative Communication (AC) is a category of assistive technology that is directly involved in helping and stimulating abilities so people with disabilities can communicate. The target audience of Alternative Communication are "[…] people who don't functionally speak or write or presenting non correspondent pace between their communicative need and ability to speak and/or write" [7].

The Augmented Reality (AR) has been widely used as a technological resource in educational environments. Several studies prove that its use brings contributions to the perception and motivation of users in various activities in the educational context, assisting in learning in different areas of knowledge [8, 9]. Augmented reality complements the real world with virtual components, making real physical objects and virtual objects coexist in the same space.

Augmented Reality on mobile devices has a great impact since it is easier to work with that type of device, opening the way for concrete possibilities of generating Augmented Reality relating images in real time, the user's geographic position and markers with information stored in Fombona [10]. Currently, platforms such as Vuforia. In this way, the user has more autonomy to create models. And the application knows how to do it better.

According to Milgram [11], Augmented Reality (AR) belongs to Mixed Reality and places itself somewhere in between the continuous virtual reality that connects a completely real environment to a completely virtual one. Observing the diagram, it is possible to say that Augmented Reality is somewhere within Mixed Reality where the real environment overlaps virtual elements.

Walking through Milgram Continuous, it is also possible to realize that AR approaches to Real just as Augmented Virtuality (AV) does to Virtual even though both belong to Mixed Reality, which mixes not only virtual elements but also real ones. According to Tori and Hounsell [12], Milgram Continuous should be updated because, for him, it is impossible to start from a real environment and arrive in a virtual one without exiting the first one. Suggested the use of two continuous, one starting from the non-virtualizable Real where AR could be found and another one starting from the virtualizable Real where VR could be found. Discussions about these concepts are frequent, as well as discrepancies related to their classification.

Freitas and Del Prette [13] analysed the variation in the directory of children's social abilities with different categories of special education needs. Among the analysed categories the study verified TEA as the ones who presented smaller frequency of social abilities, endorsing other mentioned authors. Therefore the study states that the joint action of psychologists, parents and teachers becomes fundamental in the organization of conditions to provide development to this group of subjects. Regarding the communication and language category, studies were related: [14, 15], with similar goals to the aforementioned authors.

Augmented Reality involves high-quality rendering, precise alignment of the "virtual world" inside the "real world", real-time interaction between the "real world" and the "virtual world". The augmented "environment" corresponds exactly to the real one, it is only filtered and has more than one sensory modality [16]. They all support AR technology as a unique opportunity for making a real difference changing lives and the treatment of autistic spectrum disorder.

It is important to emphasise that five of the selected articles presents expressive results of the use of assistive technology and augmented reality, presented in the chart below. Developed to improve cognition, communication, imagination and attention of children with TEA. In all selected articles, AR proved to be a satisfactory resource as a mechanism of attention engagement for the evaluated children, assisting the traditional methods already validated and the current treatments.

Chart 1. Researches with positive result.

Authors	Used resources of AR	Justification on the use of AR	Results	Numbers of participants
Soares et al. [16]	Environment where the image captured by a cell phone camera turns into a cartoon, similar to a comic book	Improving the face to face interaction between a child with ASD and her educational psychologist	*Positive*: The technology proved to be relevant for a better understanding of the activity that involves executive functions *Negative:* The technology do not present great impact when the child with ASD do not have major social interaction problems	4 children
Rosa, Silva and Aymone [17]	Communication board with application for smartphones AURASMA (images turned into real multimedia)	Improving the learning by adapting communication boards already used	*Positive:* Significant improvement of all participants *Negative:* Problems with animations distracted some of the children	11 children
Bai, Blackwell and Coulouris [18]	Interactive system that combines reality with virtual content using monitor and camera	Assisting the use of imagination of children with ASD	*Positive*: Increased frequency and duration of the games playing	12 children (4 to 7 years old)
Rincón et al. [19]	Using a cell phone or tablet camera to view 3D objects and sounds	Assisting the communication of children using AR and drawing attention with sounds	*Positive*: Significant improvement observed in the animal cards and 14% improvement on children's attention *Negative*: One of the children did not react well to the volume of the sounds	6 children (3 to 9 years old)
Escobedo et al. [20]	Identification system of mobile objects (AR): one AR mobile application	Exploring how AR can help redirect the attention of children with autism, connecting the physical and digital world	*Positive*: The use of the applications increased student's time spent on tasks by 20%. 24% improvement for positive emotions	12 children

The results showed in the chart above presented the main contents within our research area. In the first experiment, Soares et al. [16] monitored a weekly educational-psychological tracking where children were submitted to sessions to measure aspects related to cognition. The use of AR technology in this case aimed to increase face to face interaction with the educational psychologist. It built an AR environment based on Google Cardboard glasses. With the use of a filter, the image captured by the cell phone camera turned into a cartoon similar to a comic book. The result of the visualization of the facial processing through the proposed technology showed a better understanding of the learning activities involving executive functions.

In the second article, Rosa, Silva and Aymone [17] researched ways to upgrade communication boards with the AR resources, offering a new design to help communication with children with ASD. The free use of the application AURASMA were used respectively to develop 3D objects and develop AR actions more simply, turning images into real multimedia. The relevance of this offer supports the need pointed out by this work that shows the importance of exposing and continually insisting on the process of language acquisition of children with ASD.

In the third experiment, imagination was identified as a main symptom that constitutes the triad of characteristics of the condition of autistic spectrum along with social interaction and communication. Based on that, Bai, Blackwell and Coulouris [18], developed an interactive system that explores the potential of AR to visually conceptualize an open play environment aimed at children with ASD to explore the imagination of these children.

In the fourth experiment, Rincón et al. [19] developed a new perspective for therapy of children at the Neurohabilitar clinic with the use of AR. The clinic uses cards with pictures of animals, fruits and means of transportation waiting for the children's reaction when viewing and recognizing them. The team turn the images in the cards into 3D image, also adding sounds that could help the children's recognition. A significant improvement was observed especially in the 3D cards with animals. With the help of sounds the children began to recognize animals more easily.

In the fifth study, the authors Escobedo et al. [20] discover how AR can help redirect the attention of children with autism. For that they used an identification system for mobile objects (Mobis), a mobile application of AR that was developed to allow teachers to overlap digital content over physical objects. With the use of the application the time that students spent in the tasks increased 20%. The students attended therapy sessions more excited when wearing it "in motion" to discover objects in the environment.

4 Final Considerations

This article contributes to the analysis of current bibliographical literature, in order to find studies that present investigations on Assistive Technologies based on AR to assist the development of activities with autistic children. Here, the central issue was to discover "How and in what activities it is possible and most effective to use AR to develop Assistive Technologies that contribute to promoting activities with autistic children.

It is observed that although some articles somehow approached the training of subjects with ASD with the aid of augmented reality, few are those who used strategies directly related to validated therapies.

Some of the described studies in this article are about the promising effects and the collaborative work model, so it is still necessary to create research groups focused on this type of investigations in addition to a better interaction among researchers. In other words, an effective dialogue between institutions responsible for promoting actions that benefit education, demanding a better investment in productions that portray the apprentice, allowing them to acquire knowledge and develop learning.

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Human-Centered Design – The Importance of Usability Tests in the Development of Technological Objects

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Abstract. Playing, between parents and children, is a privileged form of interaction, which contributes to the strengthening of the bond between them. Technology is deeply rooted in contemporary society and is expected to continue in the future, therefore, it is pertinent to understand how technology can support the child's development, as well as family relationships, to promote social interaction. Optimize the quality of user interaction is one of the main objectives of this work. For that, a user-centered design approach was adopted. The collection of data through parent surveys allowed to understand the user and define the project requirements. The user experience with children was studied during the development process, through usability tests, which allowed to improve product usability and optimize the user experience. Through a design methodology, a product was developed by following the user's needs and preferences, able to promote meaningful and engaging playful experiences.

Keywords: Human-centered design · Usability tests · Children · Technological objects

1 Development of Technological Objects for Children

Children are born and grow in environments rich in technology and, in this sense, it is natural that they integrate it into playful recreation [1–3]. The involvement with new technologies, from an early age, influences the process of development and learning of the child and gives a new meaning to playful moments. The fact that playing has a decisive importance in the development of the child [4] leads to questions on how it is possible to apply technology to positively influence that development [5]. The importance placed on early learning - play as support for development and learning, and the belief that skills related to technologies are necessary for future employability, has fueled the market of educational and interactive toys, thus contributing to greater child involvement with technological playful products [6]. The new technologies

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triggered the emergence of hybrid playful products, which combine tangibility with technology. This category of products did not neglect the importance of the experience of physical interaction, which can be optimized/benefited by the integration of technological functionalities, thus giving rise to more involving and significant experiences [7].

Technology will continue to evolve and therefore new forms of interaction will emerge, which should be studied in terms of usability so that the quality of interactions (user-product) can be optimized. To do this, it is necessary to put users in the process of developing the product, to develop a product with good usability, by following the needs and preferences of users.

2 Usability Tests with Children

Designing a product for children is different from designing for adults. When designing (and testing) products for children, particular attention should be considered to the characteristics, skills, and limitations of the age group involved [8]. It is crucial to prepare usability tests with special care and sensitivity when it comes to children [9].

The literature on usability tests with children is scarce compared to the literature on usability tests with adults [10]. Although usability tests with children to resemble adult tests in many respects, there are some differences that necessary to consider in order to get the most out of the sessions [11].

It is necessary to understand the cognitive, physical and social development level for the children to be able to understand what is asked of and express themselves, as well as be prepared to deal with common issues/problems/possible challenges related to the concentration and motivation of children [11]. In this way, it is possible to adapt the tasks and select the methods to be used to gather as much useful information, always ensuring the well-being of the children [11].

Given the possible challenges related to the characteristics of the child, the test environment, test methods, the writing of the tasks and instructions of the test, the ethical practices during the test and the inconveniences imposed on parents (and often teachers) the preparation of the tests need to be carefully planned to reduce the effects these challenges may bring [10]. First of all, it is necessary to be prepared to adapt the methodology, language, the time spent and the timeframes, work with parents and make changes to the method of recruitment of participants and, eventually, test site [12]. In this context, it is important to follow certain guidelines, such as:

- Segment by age intervals and adapt the test accordingly;
- Use language appropriate to the age group;
- Use visual scales instead of numbers and words (e.g., smileyometer rating scale);
- Involve parents, in particular, ensure that the necessary consents are assigned before the test session (e.g., a consent form to test minor, consent and recording release form for minor, receipt form to compensate minor and release form to digitally record minor) [12]. With this in mind, it is imperative to define a sensible and wise strategy in advance before moving towards the test session itself.

3 The Methodology

Given the above, a design methodology will be applied to a case study (Fig. 1) to prove the effectiveness of the process in the development of a playful children's product, with tangible and intangible elements and promoting, therefore, the interaction between parents and children.

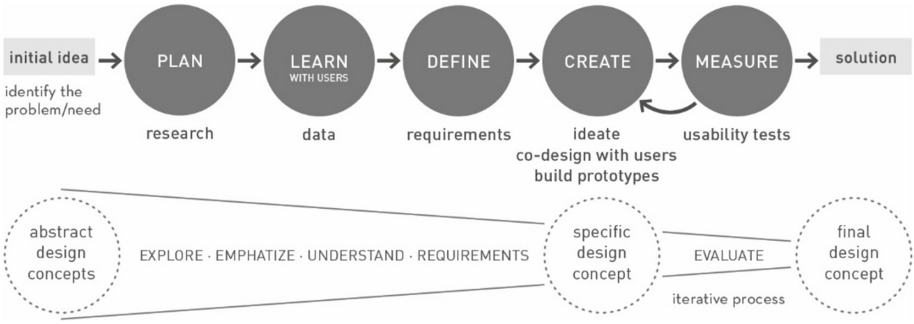

Fig. 1. Methodology applied to the case study.

According to the literature, the first phase of the user-centered design process comprises its planning [13–15]. Thus, after identifying the problem/need (i.e., opportunity), in which a high-level (i.e., abstract) concept is established, an in-depth study of what is intended to develop is followed, justifying its relevance and exploring the various possibilities involved. In this context, a careful analysis should be carried out on three central themes: child development, childhood today (with the growing presence of technology) and the children's play products industry.

The second phase consists of understanding and specifying the needs of users and the context of use [13]. A human-centered design methodology is a problem-solving approach that involves the active participation of users in the development of the solution, to ensure that it meets their needs and expectations [15]. In this sense, the participation of parents and children, through the completion of questionnaire surveys, is a valuable and indispensable source of information. With the data obtained it will be possible to identify the preferences, opinions, and habits of parents and children, which in turn may allow the definition of requirements and identify the constraints of the project.

The iterative design process involves the evaluation of possible solutions, namely through usability testing with users [15]. The emphasis focuses on the collection of behavioral data, regarding performance and satisfaction, through the evaluation of conceptual models and/or prototypes with real users [15]. Thus, three-dimensional models need to be constructed to allow the performance of several usability test sessions (evaluation and comparison) with users (parents and children). The iteration of design solutions takes place from the collection of new data through feedback from users throughout the development cycle [16]. This approach allows to proceed with

rapid product development, learn through empirical evidence, and shape the product according to the capabilities and expectations of users [15].

After a series of sessions, in which the current state of the product is evaluated, a new model can be developed and optimized, based on the information collected, and then performed final tests (validation test). Validation test results determine the final concept, the design solution that best meets users' needs.

4 Case Study

4.1 Plan, Learn and Define

The following case study was carried out in the context of the development of a children's play product (for parents and children). After analyzing the market of children's play products, a general and abstract concept was explored with parents. Data collection, through a questionnaire survey of parents (of children between 3 and 5 years of age), allowed to collect important information to establish parameters and define product requirements to obtain a more objective concept. Based on the results obtained, in which it is possible to identify the preferences, opinions, and habits of parents and children (since the toy was for both), the most promising concept was elected, which best met the established requirements. The product was intended to merge the material/physical and technological world, to provide more engaging and meaningful experiences (for children but with the participation of parents). Thus, the experience of physical interaction was expanded with the technological component, without resorting to the use of screens (the long-term effects of overuse of screen-based devices are not yet known).

4.2 Create and Measure

The use of three-dimensional physical models contributes to a better understanding of the product and is essential for performing usability tests. The goal was to test the interaction with two different models, each with two different button settings (Fig. 2).

Fig. 2. Model A with buttons 1 and model B with buttons 1 (left); model A with buttons 2 and model B with buttons 3 (center); model A and model B with the graphic representation of the real buttons (right).

First Cycle. Initially, a pilot test was carried out with a 4-year-old child, to validate the test plan, namely, to verify if it was in full condition to be applied to the selected sample (children of 4 and 5 years old).

Then, an evaluation and comparison test was carried out with 11 children of 4 and 5 years old of both genders, which allowed to evaluate the children's performance and satisfaction concerning both models.

In these tests, each child was asked to perform 11 tasks per model, while the observed events were recorded. Additionally, the "smileyometer" scale was used, with three options to choose from, as a way to collect and evaluate the children's opinions.

The data collected was organized by tasks. In this paper, it will be presented only the 1st task evaluated – to grab the product. In this task, the main issue was to investigate the location/area where the child grabbed the product, to understand if the geometry/volume was the most appropriate. In both models' different contact areas were identified, which did not always result in a comfortable interaction, due to the relationship between the child's hand size and the product volume. Thus, concerning dimensions, it was found that it was necessary to resize the volume of the product, to provide more comfort to the child. In model A, to reduce the dimensions of the "lower body" (length and width) and in model B of the "upper body" and the narrowest part (expected contact area). The size of both the physical buttons and the capacitive buttons is adequate, as well as their positioning. From the analysis of the results of this first test, it was concluded that model A (with the buttons arrangement 1) obtained better results than model B, both in terms of usability and in terms of children's preference. Thus, model A (buttons 1) was selected for the next phase.

Second Cycle. After the first usability test, which provided data about users (children) performance and preferences, allowing the identification of aspects that need improvement, the test with both parents and children follows to assess the parents' opinion about the product (concept and operation), namely with ease of use, comfort, aesthetic component and level of overall satisfaction. Parents, besides deciding about the purchase of a product, are also potential users of the product. This research also considered these two aspects. The test had 12 children aged 4 and 5 years old and their parents. It was conducted in pairs (father/mother and son/daughter). It was just used model A since it had better results in the first test. Initially, the project was contextualized, followed by the presentation of the concept of the toy, while the child interacted freely with the product and the father observed it. Then, the evaluator with the help of the child explained the functioning of the product, while the parent observed the interaction process between the child and the product. Finally, the parent was asked to complete a questionnaire about what he/she observed. As an example, only one of the questions asked to parents will be presented. When asked about their satisfaction with certain aspects related to the geometry and comfort of the product, most participants reported being satisfied or very satisfied with the shape, size, stability, and portability. The test with parents and children together allowed to verify that the product meets the requirements previously defined. However, given the considerable number of responses at the midpoint of the Likert scale, it is concluded that the product should be subject to improvements at the dimensional level, reinforcing the conclusions

of the first usability test. That said, the construction of a new model with smaller dimensions (length, height, and width) followed those of the initial model.

Third Cycle. With the new model, it was implemented the validation test, with the main objective to verify whether it was possible to correct the usability problems previously identified. It was intended to assess the general condition of the product and its acceptance by users. The test had 14 children of 4 and 5 years old of both genders. The test comprises only the model to be improved. Given that the intention was also to make a comparative analysis of the two models, the phases that make up this validation test are the same as those of the first cycle.

In the first interaction with the product (task 1 – to grab the product), most children (n = 11) grabbed the product in the expected area. The remaining children (n = 3) did it in another contact area, (in the middle of the "lower-body"). In this sense, it seems that there are two predominant contact areas, contrary to what was verified in the first test (four different contact areas) (Fig. 3). One can admit that this result is due to the resizing of the product dimensions.

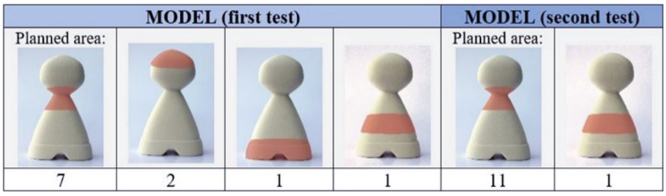

Fig. 3. Areas where the product was grabbed in the interaction.

Through the comparative analysis of the obtained results in the first and second usability tests, it was concluded that the main objectives were met, namely, the optimization of the user interaction process with the product. It was possible to overcome the most evident usability problems, identified initially on the first test with the first model. The results of the validation test indicate that the second model effectively provides better user experience (functioning and comfort) (Fig. 4).

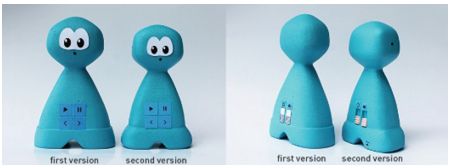

Fig. 4. First (left) and second/final model (right).

The various test sessions allowed to identify usability problems and understand the strengths and weaknesses of the models under study, to select the best option, both in terms of performance and in terms of user satisfaction.

5 Conclusions

The application of a methodology allows bringing the design process to a successful conclusion/result. In this case/project specifically, the purpose of the application was the optimization of user interaction with the product, which gives rise to a better experience of use, which in turn is directly related to the success of the product.

For that purpose, involving the users (children and parents), (i) at an early phase of exploration and comprehension, which resulted in the project specifications (to guide the project towards the defined objectives), (ii) to development phase where measuring design solutions were employed, allows to shape the product according to the capabilities and expectations of users.

Thus, it is concluded that the collection of data through feedback from users throughout the development cycle is a key point to ensure a good project.

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Efficacy of VR-Based Reminiscence Therapy in Improving Autobiographical Memory for Chinese Patients with AD

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Abstract. The goal of the study was to examine the efficacy of virtual reality (VR) for reminiscence therapy (RT) in improving autobiographical memory (AM) for Chinese patients with Alzheimer's disease (AD). We designed a virtual reminiscence room using 3D modeling and rendering technology to reproduce life scenes from the 1970s of China. Then we assigned subjects to the VR-based RT group, the Photo-based RT group and the Blank group for AM-stimulating efficacy test and acceptability assessment. AM was collected using the free narrative recall and scored by the TEMPau scale. Acceptability was assessed using three self-report questionnaires, including a motivation questionnaire, a presence questionnaire and a VR sickness questionnaire. The result showed that the total memory scores in both the VR and the Photo group were significantly higher than the Blank. Further, subjects showed significant pleasure for the VR than for the photos, and they reported high levels of presence as well as negligible sickness symptoms. This study gives a preliminary view that VR can be considered as an effective and acceptable tool for reminiscence therapy in AD patients.

Keywords: Virtual reality · Reminiscence therapy · Autobiographical memory · Alzheimer's disease

1 Introduction

Due to the risen average lifespan, we are witnessing a dramatic increase of the incidence of age-related disorders such as Alzheimer's disease (AD). On the cognitive level, one particularly devastating effect of AD is the loss of autobiographical memory (AM) [1–3]. AM, one of the essential components of human memory, is defined as a multifaceted concept which concerns experiences of one's personal life and provides the foundation for self-consciousness [4]. More specifically, AM is composed of two main components, an episodic component, containing personal specific events that occurred at a particular time and place, and a semantic one termed personal semantic memory [5].

To help AD patients restore inaccessible autobiographical memories, various interventions have been introduced. Reminiscence therapy (RT) has been the most widely studied non-pharmacological approach for AM recall in AD patients [4]. This therapy is described as an activity where participants are asked to recall memories of

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events and experiences from their past life. The current practice of RT often relies upon visual and audio aids, for example, photos have been considered to be useful tools by professionals [6]. In recent years, the multimedia information and communication technologies (ICT) have been widely employed to promote RT, including digital reminiscence games on Android tablet [7], personalized DVD displayed on smartphones [8], 3D graphic applications manipulated by large touchscreens [9], and networked photo and video sharing systems based on Web technology [10].

Besides, virtual reality (VR) has been gradually gaining in popularity as a promising tool to facilitate RT. Firstly, due to the ability to create three-dimensional objects and establish complex virtual environments which might be realistic, VR allows users to interact with objects which are difficult to obtain in the physical world (such as cultural heritages) or to experience places which are no longer exist anymore (such as historical scenes). Secondly, VR systems can vary in the degrees of immersion and interaction and further modulate the feeling of presence, defined as the feeling of "being there" [11], thus allowing users not only to view the scenes passively but also to roam actively in a more attractive experience of reminiscence [12].

However, few studies have been conducted so far to test the therapeutic effect of VR-based RT in AD patients. On the one hand, some studies have created highly realistic virtual environments to support RT, such as an old Scottish style public bar [13], a Chinese historic house scene [14], and an old country house with pet avatars [15]. Still, most of these studies only gave qualitative insights into the working of their prototypes. On the other hand, there were indeed some quantitative studies which proved that VR could stimulate autobiographical memory, but their research subjects were healthy older people rather than AD patients [16, 17].

In the present article, we focus on designing a virtual reality system that can support RT by reproducing life scenes from people's past life through 3D modeling and rendering technology [18]. Moreover, we conduct an efficacy study with VR-based RT on Chinese AD patients in order to find answers to the following main research questions:

- AM-stimulating efficacy: can VR effectively stimulate recollections of autobiographical memory in AD patients? If so, how does it compare to the traditional RT stimuli (take photos as an example)?
- Acceptability: can AD patients well accept VR? Specifically, will they report positive motivation, high sense of presence, and low (even ignorable) sickness symptoms to the VR experience?

2 Method

2.1 Participants

The inclusion criteria for subjects were as follows: (1) the subjects were diagnosed with Alzheimer's disease by their physicians and had no other psychiatric disorders, no migraine or epilepsy and no severe perceptual (visual or auditory) impairments [19]; (2) the subjects were able to sit alone and view the experimental materials (VR and photos) for the duration of the experiment; (3) the subjects were able to have normal

verbal communication with researchers. Thirty subjects satisfied the inclusion criteria. They were recruited from the Changsha Armar Dementia Care Center and the Dementia Department of Changsha Geriatric Rehabilitation Hospital. At the time of inclusion, the Mini Mental State Examination (MMSE) [20] was performed to confirm their AD stage.

Thirty participants were evenly and randomly assigned to the VR-based reminiscence therapy group (the VR group), the Photo-based reminiscence therapy group (the Photo group), and the Blank group. Three groups did not differ significantly in mean age, mean year in school, gender distribution, and mean MMSE score. The basic characteristics and group comparisons for subjects can be found in Table 1.

Table 1. Basic characteristics and group comparisons for subjects with AD.

	VR (N = 10)	Photo (N = 10)	Blank (N = 10)	p
Female, n	5	8	7	0.350
Age, mean ± SD	76.7 ± 5.5	79.4 ± 2.0	78.5 ± 3.4	0.305
Year in school, mean ± SD	10.4 ± 4.4	8.1 ± 3.7	9.7 ± 3.5	0.455
MMSE, mean ± SD	19.8 ± 3.8	18.0 ± 2.9	18.2 ± 2.6	0.390

2.2 The Virtual Reminiscence Room

The design of the stimulus used for the VR-based RT group, the virtual reminiscence room, went through three steps including user research, design and internal testing.

User Research. We first searched for lots of pictures of ordinary Chinese home environments in the 1970s through desktop research. We then recruited some older people to conduct user interviews and asked them to mark the old objects that impressed them most. The reason why we chose the 1970s as the social background was that studies have documented that the memories from the young adulthood of AD patients were preserved better than recent ones [21]. According to the user interview notes, we acquired a collection of reminiscence objects, we then started to implement the visual construction of the virtual reminiscence room.

Design. The environment of the virtual reminiscence room resembled a Chinese rural cottage in the 1970s with an area of 30 square meters. In the room, there were classic old objects from the past (such as a pedal sewing machine, an old-style electric fan, a black-and-white television and a handmade bamboo chair). Once-popular beverages (such as Gaolegao and Feichang Cola) and enameled cups were on the table. A poster of Chairman Mao and some vintage certificates were put on the walls. These objects represented the vivid folk culture of China in the 1970s and were almost rare to obtain now. We used 3DS Max software for 3D modeling and texture rendering and used Unity Engine software for system establishing. In the original prototype version, we used the Playmaker plugin to add simple gaze interaction in the VR system. For

example, when the user staring at the electric fan for 3 s, the electric fan would run; when the user staring at the posters on the wall, the posters would be enlarged.

Internal Testing. To initially test the usability of the prototype, we recruited some older people to conduct internal testing. The results showed that most participants were well tolerated to the VR system, but the duration of the stimulation should not exceed 2 min due to the eye strain. Participants also reported that the VR experience was enjoyable, but the gaze interaction seemed too complicated for them. Consequently, in the final version of the VR system, we removed the gaze interaction to ease the operational burden of elderly users. Screenshots of the virtual reminiscence room can be found in Fig. 1.

Fig. 1. Screenshots of the virtual reminiscence room used in the VR-based RT group.

2.3 Experimental Materials

In the VR group, the stimulus was displayed using HTC Vive Focus headset, an instant wireless platform with a display resolution of 1440 × 2000 per eye, inside-out 6DOF tracking, and 110-degree field of view. In the Photo group, we provided subjects with 20 color print photos (200 mm × 140 mm) in which the reminiscence objects were identical to those in the virtual reminiscence room. In the Blank group, there was no visual stimuli provided to subjects (see Fig. 2).

Fig. 2. The experimental materials of the study: (a) the Blank group (b) the VR-based RT group (c) the Photo-based RT group.

2.4 Procedure

General Procedure. The experiment was conducted in a quiet and familiar place (the reception hall of the care institutions). To avoid any risk of unsteadiness or falling, each subject sat in an armchair and accompanied by a caregiver. After performing MMSE and documenting demographic information, the AM-stimulating test officially began. We developed a repeated stimulating experimental method, collecting autobiographical memory for twice. We first provided stimuli (VR or photos) to each subject and asked them to view for 2 min freely. Subsequently, autobiographical memory was collected using the free narrative recall of life history, which have been demonstrated to be well suitable for AD patients [22]. Specifically, subjects had 5 min to talk in detail about a personal event related to the presented stimuli. Meanwhile, we implemented a structured verbal guidance plan: if subjects became confused and could not spontaneously recall a personal event, we provided them with cues (e.g., "what was the first event that came to mind when you view the scenes?"); if the memory was generic, we encouraged them to be specific (e.g., "do you remember a particular day when you saw this scene last time?") [23]. After three cueing or encouragement attempts, there came to the second round of stimulation where subjects were asked to view the stimuli again and to recall another event. In the Blank group, subjects were just verbally guided without any visual stimulation.

Self-report Questionnaires. Three self-report questionnaires were used to assess the acceptability in AD patients: (1) a motivation questionnaire (used in the VR and the Photo group) adapted from Benoit et al. [16] and Plechatá et al. [24], including items of interest, motivation, pleasantness, anxiety, security and fatigue, ranging from 1 (not at all) to 5 (extremely). (2) a presence questionnaire (used in the VR group) adapted from the Igroup Presence questionnaire [25], including four representative items corresponding to the following dimensions: experienced realism (REAL), involvement (INV) general presence (PRES) and spatial presence (SP), ranging from 1 (not at all) to 5 (extremely). (3) a VR sickness questionnaire (used in the VR group) developed by Kim et al. [26], including nine sickness symptoms such as headache and eyestrain, ranging from 0 (not at all) to 3 (extremely). For each questionnaire, we translated the items into Chinese everyday language that was easy for subjects to understand. If the subjects were unable to complete the scoring independently, the questionnaires would be filled out by researchers while the caregiver instructed the subjects to express their real feelings. The summary of the study procedure can be found in Fig. 3.

Measure of Autobiographical Memory. In the present study, we focused on the episodic component in AM and used of the TEMPau scale [27, 28] to assess the specificity of the subject's recollection. Each recalled event was scored on a four-point episodic scale: zero points for an absence of memory or only semantic response (e.g., "I know the sewing machine."); one point for a vague personal memory (e.g., "I used to see sewing machines very often, but I have rarely seen them recently."); two points for a personal but nonspecific event or a specific event but time and place not recalled (e.g., "I used to make shoes with sewing machine by myself. I would first make the soles and then the uppers."), and three points for a strictly episodic recall situated in time and

place (e.g., "In the 1980s, I had a sewing machine at home. At that time, my younger sister was impoverished, so I gave my sewing machine to her. Since then, she was able to make a living by making clothes."). Also, in line with Baddeley and Wilson [29], we rated whether the patient was able to produce the recollection spontaneously. A zero would be scored on if no personal event could be recalled, or if further guidance was required. If subjects recalled spontaneously after the stimulation without further guidance, it would be scored as one point.

The subject's verbal outputs were directly recorded directly during the experiment. Three quantitative scorings were computed: (1) a total recall score, taking into account all types of autobiographical memory (maximum = 6 points for each subject); (2) a strictly episodic recall score referring to the recall of a specific memory, situated in time and space (maximum = 6 points for each subject) and (3) a spontaneous recall score (maximum = 2 points for each subject).

Statistical Analysis. Statistical analysis of autobiographical memory scores and self-report questionnaire scores was carried out using SPSS 20.0 software with a significance level of 0.05. Mean comparisons between groups were performed using the repeated-measures ANOVA.

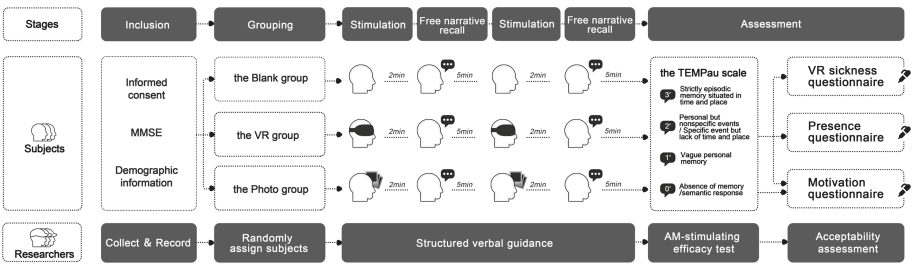

Fig. 3. Summary of the study procedure.

3 Result

3.1 Autobiographical Memory Scores

Figure 4 illustrates the result of the autobiographical memory scores. Firstly, for the total recall score, both the VR group ($M = 3.00$, $SD = 2.06$, $p = 0.008$) and Photo group ($M = 2.60$, $SD = 1.78$, $p = 0.027$) scored significantly higher than the Blank ($M = 0.90$, $SD = 0.74$), but there was no significant difference between the VR and the Photo in this dimension ($p > 0.05$). Secondly, the strictly episodic recall scores of three groups were all at relatively low levels, and no significant difference was found (Blank, $M = 0.30$, $SD = 0.95$; Photo, $M = 0.90$, $SD = 2.03$; VR, $M = 1.20$, $SD = 2.10$; all $p > 0.05$). Thirdly, the spontaneous recollection of three groups all reflected fairly low scores and did not differ significantly either (Blank, $M = 0.20$, $SD = 0.42$; Photo, $M = 0.40$, $SD = 0.70$; VR, $M = 0.50$, $SD = 0.84$; all $p > 0.05$).

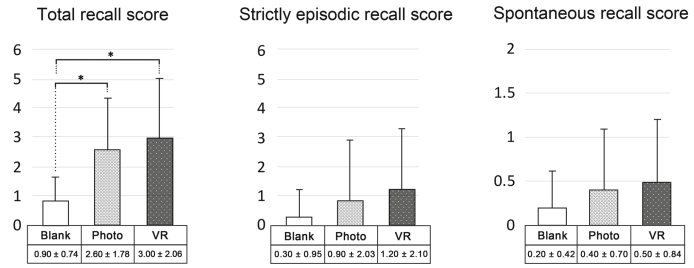

Fig. 4. Result of the autobiographical memory scores for the VR-based RT group, the Photo-based RT group and the Blank group. Stars indicate between group difference. *p < 0.05.

3.2 Self-report Questionnaire Scores

Figure 5 illustrates the result of the self-report questionnaire scores. Firstly, the results of the motivation questionnaire showed that, both the VR and the Photo group reported to be highly interested (Photo, M = 3.30, SD = 0.95; VR, M = 4.00, SD = 0.94), highly motivated (Photo, M = 3.00, SD = 1.25; VR, M = 4.00, SD = 1.05) and highly secure (Photo, M = 4.80, SD = 0.42; VR, M = 4.60, SD = 1.27). In particular, subjects reported to be significantly more pleasant for the VR than for the photos (Photo, M = 2.90, SD = 1.52; VR, M = 4.00, SD = 0.94; p = 0.04). Besides, both groups reported low levels of anxiety (Photo, M = 1.50, SD = 1.08; VR, M = 1.50, SD = 0.71) and fatigue (Photo, M = 1.70, SD = 1.25; VR, M = 2.00, SD = 1.05). Secondly, scores from the presence questionnaire were all at relatively high levels (REAL, M = 3.90, SD = 0.88; INV, M = 3.70, SD = 0.82; PRES, M = 3.10, SD = 1.10; SP, M = 3.00, SD = 1.25), indicating that VR system used in this study elicited high sense of presence in AD patients. Thirdly, scores form the items on the VR sickness questionnaire were all in the fairly low ranges (all M < 0.50).

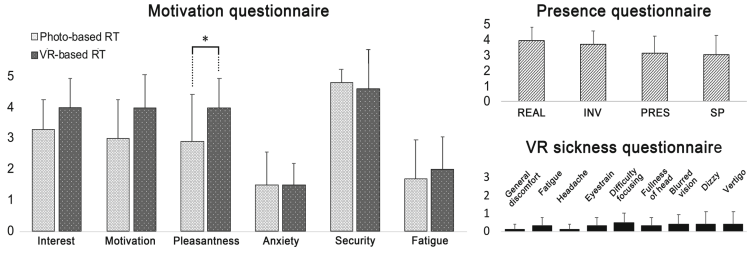

Fig. 5. Result of the motivation questionnaire scores, the presence questionnaire scores and the VR sickness questionnaire scores. Stars indicate between group difference. *p < 0.05.

4 Discussion

4.1 Autobiographical Memory Recall

The main objective of this study was to examine the efficacy of VR-based RT in stimulating autobiographical memory of AD patients. A major finding was that the total recall scores of the VR and the Photo group both improved significantly than the Blank group. However, the strictly episodic recall scores of the three groups were all at low levels and did not differ significantly. This finding demonstrates that the VR system used in this study can effectively stimulate AM of AD patients, but in essence, it can evoke more vague and nonspecific personal memory (1-point and 2-point memory) rather than strictly episodic memory situated in time and place (3-point memory). This result may be explained by previous studies which argued that AD patients generally have exaggeratedly more difficulty in retrieving specific events than generic information [30]. Therefore, more further studies should be conducted to verify whether VR can also effectively stimulate the strictly episodic memory in AD patients. Furthermore, we also found that the spontaneous recall scores of three groups were all fairly low, which indicates that AD patients are generally less likely to produce the recollection spontaneously regardless of the forms of stimuli. This confirms to some extent that the therapist-client interaction (such as the structured verbal guidance used in the study) is a key component of RT for AD patients besides the practical stimuli.

Additionally, it should be noted that the result of our study may not provide strong evidence to prove that the stimulating effect of VR is superior to the photos since no significant difference was found between the two groups. We speculate that the reason is that the stimulating efficacy of the VR have been constrained by certain factors: firstly, in terms of the inherent limitations of VR technology, the higher immersion may lead to a higher level of perceptual overload thus may distract subjects from the visual material. Makransky et al. have indicated a possible effect of higher levels of cognitive load related to immersive technology [31]; Secondly, from the perspective of design, the prototype we used in the study may have some defects, for example, we only established static objects without adding interaction for users, which may limit the activities available and result in less stimulating efficacy. Siriaraya et al. have suggested that increasing the level of interactivity properly in the VR system may be more helpful in augmenting past memories in people with dementia [12].

4.2 Acceptability

Results of the self-report questionnaires showed that AD patients in both the VR and the Photo group were highly interested and motivated to the provided intervention, and reported high feelings of security, and low anxiety and fatigue. Interestingly, subjects in the VR group showed significant pleasure more than the Photo group. Besides, scores from the presence questionnaire and the VR sickness questionnaire indicated that subjects experienced high level of presence and negligible discomfort symptoms during the VR experience. Additionally, through our observations, many subjects in the VR intervention showed surprised facial expressions, and some of them even stood up involuntarily, waving their hands in the air. These results emphatically prove the

acceptability of VR in AD patients and also suggest that VR can be promisingly employed to make reminiscence therapy happier for seniors with cognitive disorders.

5 Conclusion

In the presented study, we introduced our design of the virtual reminiscence room and tested the efficacy of VR-based RT in improving autobiographical memory for AD patients. We randomly assigned subjects to the VR-based RT group, the Photo-based RT group and the Blank group for AM-stimulating efficacy test and acceptability assessment. According to our results, VR can effectively stimulate the autobiographical memory in AD patients. Furthermore, VR can be well accepted in this population: it elicits high level of presence, provokes limited symptoms of VR sickness, and evokes pleasant feelings significantly more than photos. Therefore, we draw a reasonable conclusion that VR can be considered as an effective and acceptable tool for reminiscence therapy in AD patients and has the potential to surpass traditional RT stimuli such as photos. On the practical side, some methodological innovations developed in this study can also be reference for future researches on RT for AD patients, for example, the structured verbal guidance and the repeated stimulating method.

Despite these promising contributions, it is important to admit that the differences in AM performance observed in this study could have been influenced by other factors. On the one hand, some unexpected events occurred: although we tried to make the subject's recollection more comparable by providing structured verbal guidance, some subjects cannot understand exactly the guidance and talked too much about irrelevant matters, which made the process of extracting memory a bit more challenging. On the other hand, ethical implications regarding evaluative work with AD patients and the tight working schedule of institution caregivers made it difficult to recruit and test larger samples. Moreover, we only tested patients at the middle stage of AD in this study, which may come a limitation to the study contribution. So, in the future, we will conduct more controlled further experiments on larger samples to fix these vulnerabilities. Further, we are also working to investigate how older people with AD interact with the virtual environment and explore how virtual environment can be designed to create charming experiences with a specific therapeutic effect.

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Design Education. Human Factors at the Core of a Coworking Self-determined New Design Learning Approach

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Abstract. Designers, we have a problem! The ever-expanding field of design is causing turmoil in its practice and education. There is a growing concern originating from the profession now dealing with complex global problems requiring new skills, obscuring the once well-defined boundaries of design practice. Collaborating with other fields of knowledge is now an absolute necessity. Consequently, design education has become a ubiquitous track in design conferences and other academic events, with the most prominent design figures claiming for rapid changes in the way we teach our future designers. Our research is focused on how work, learn and leisure is melting into one single dimension, evidencing new self-determined learning modes. Accordingly, three case studies of new design learning models are presented using a four axes matrix – Coworking, Openness, Operation, Learning. This paper investigates how Coworking spaces can help shape new design learning strategies.

Keywords: Design education · Human factors · Coworking · Self-determined learning

1 Introduction

Many reports, papers, books, and presentations have been presented all over the world by the most prominent design figures, such as Ken Friedman [1] and many other important authors in the academic design field. One way or another, all claim for rapid and effective changes in the way we teach our future designers how to design in a constantly changing world, after the advent of new emerging technologies over the last thirty years.

In order to address this context, three case studies are presented and analysed, looking for evidence of self-determined design learning models and the way they borrow their settings from coworking spaces. A matrix is used to map the operating conditions of these learning projects, tentatively identifying new learning paradigms in which these educational systems develop.

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We named this graphic visualisation as COOL (Coworking/Openness/Operation/Learning). Questions were asked within the scope of each quadrant, and each respondent had to rate how much their educational project related to the topics presented:

- On the Coworking quadrant, we questioned each design school about how much the project is aligned with the Coworking movement and if it establishes a connection between work and learning.
- On Openness, we meant to understand how open and informal the projects are, and how they accommodate diversity and collaboration.
- Operation was about how the projects differ from other design education approaches and its relative position within the local/global design educational systems.
- Finally, about Learning we wanted to know about the core human factors of the projects, and how self-determined is their learning models.

The resulting matrix will tentatively shed some light on the way these alternative design learning projects are grounded on various forms of Coworking and self-determined learning methods. This paper investigates these themes by addressing the origins of the Coworking movement, and its self-determined modes of co-learning, through a brief history of the movement.

2 Coworking or Self-determined Work and Learn

2.1 A Brief History of Coworking

We will start by explaining why the term was coined as a new verb instead of keeping the common dash in co-working. Brad Neuberg coined the word Coworking in 2005 [2] after establishing a plan for his professional future, which he briefly described in three steps. Being a web developer, he would mostly and firstly work on open-source projects; he would write and communicate on these open-source projects; and finally, as he stated, he would create from scratch a new kind of space to support his workplace needs and the kind of professional community he was looking for, naming it: coworking. Until now, the term is still discussed. In 2018, APStyle decided to acknowledge Coworking as referring to a new kind of workspace shared by different people, not under the same company [3]. Instead of co-working, the new term coworking is about collaboration and sharing the same space, keeping one's individuality and independence but not working alone. It also implies a new kind of space based on diversity, probably the core value of the coworking movement, made of different people, from different knowledge areas, and different geographical origins.

Therefore, collaborating and sharing resources and knowledge in a hyper-connected world was the main reason why the coworking movement expanded so fast and globally. From the first spaces in the United States, back in 2005, the number of coworking facilities has been growing exponentially to a countless number.

2.2 Self-determined Learning

Although not an absolute novelty, self-determined learning [4] recently gained new relevance due to the distributed systems and networks where we all work, communicate, and learn, in collaborative and self-determined modes. In fact, given the fact that we all operate online using equal tools and technologies, it seems perfectly adequate, specifically for the new learners, to learn from peers, collaboratively, designing or hacking, as TNDS puts it in its signature, a singular dedicated way of learning. Moreover, we think any actual teacher or lecturer will agree that new generations of learners increasingly show less interest in being taught than in active/auto learning [5] anticipating new learner-centered learning models. In the beginning of the 21st century, Hase & Kenyon [6] announced self-determined (or Heutagogy) to be a "better and more natural" way of learning for new learners in a complex and technology-based world.

3 Three Cases of New Design Learning Models

Three case studies are presented and analysed in the way of a simple matrix. Two of these three educational projects in design were selected by their uniqueness in the Portuguese panorama, while the third one is led in a global way that is also unique in its approach. In common, they all propose new ways of teaching new design practitioners to keep up with the required skills demanded from a complex and hyper-connected world. Under those circumstances, a short description of each design school is presented below.

3.1 The New Digital School

The New Digital School (TNDS) is a privately owned design education project located in Oporto, Portugal. Starting from the basic assumption that design education must evolve to keep up with the pace of a new digital world, TNDS radically moves away from any formal academic learning model or curriculum. Henceforth, TNDS is an innovative digital design learning program that is student-centered, strongly connected to the industry, and community-based. Furthermore, students can choose to work on personal or real assignments from the industry. A major shift from other traditional approaches is that instead of a single teacher, students benefit from a pool of industry experts, professional mentors and a local team of facilitators [7].

3.2 The Global Studio

The Global Studio (TGS) was brought to life after the recognition of the profound changes in our societies, namely from the point of view of the "way that products are developed, produced, distributed and consumed" as their website informs. TGS shows a relevant concern on new societal paradigms emerging from global and hyper-connected organisations, thus asking for new approaches in design education.

Where other design learning projects focus more and more on collaboration at a local level, TGS does it in a more global manner, focusing on project-based learning assignments that require from the students the ability to develop new skills to respond to new levels of complexity. Together with this, a global approach to communication and collaboration is stimulated, bearing in mind new dematerialized and distributed design companies, organisations, and workplaces. Nevertheless, TGS is still rooted in Academia and its discipline-based model, ranging from design classical disciplines to the engineering and education fields. Students benefit from a mixed combination of online and offline learning moments, blending with a role-playing strategy practice in which they alternate as designers or clients to globally address complex design assignments [8].

3.3 Porto Design Factory

Similarly to the previous projects, Porto Design Factory (PDF) keeps a solid relationship with the local industry, specifically with the Portuguese Northern region companies. PDF is based on a problem-based learning pedagogical model, combining interdisciplinary work, applied research, and collaboration with industry stakeholders. This model has a strong focus on the very specific culture of Oporto and the surrounding region, decisively contributing to promoting an entrepreneurial mindset within the student's community. Additionally, PDF is a member of the Design Factory Global Network (DFGN), made of 20 global education institutions. Students can, therefore, collaborate, exchange and share knowledge with their peers from cities like Helsinki, Shanghai, Melbourne, Santiago do Chile, the Netherlands, Geneva or New York. Uniquely, PDF plays an important role in the local innovation ecosystem, boosting new ideas and solutions based on a collaborative and interdisciplinary dialogue with its stakeholders [9].

3.4 COOL – Coworking, Openness, Operation, Learning Matrix

The following graphic visualization is the resulting matrix from the collected data of three selected cases (Fig. 1). Project founders or representatives rated – from 1 to 5, being value 1 low accordance, and value 5 a high accordance – their project's accordance with the core factors of each of the four quadrants of this analysis.

An initial reading of the results immediately points out to two basic conclusions. While the three educational projects coincide in positioning themselves as differentiated approaches in design education, and to a certain degree see themselves as self-determined learning projects, they diverge when asked about their approach to Coworking and Openness. PDF has a weaker connection to Coworking while TGS and specially TNDS rate their projects as almost true coworking spaces, specially TNDS. Equally important is how openness is perceived by each project. Here, PDF states an almost total openness to informality, collaboration, and diversity probably justified by its strong connection to the local/regional economy and entrepreneurial ecosystem. Moreover, it is relevant to mention that the only independent and privately-owned project is TNDS, which is also the only one indicating a clear closeness to a Coworking environment in their learning strategy.

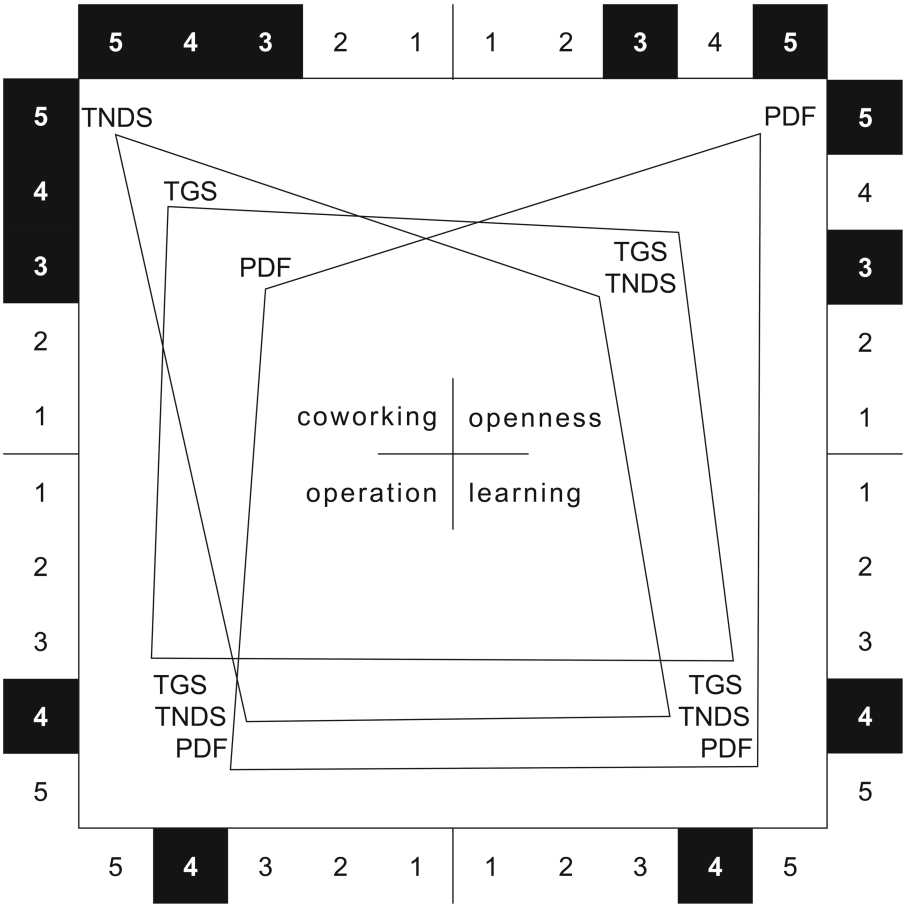

Fig. 1. COOL (Coworking, Openness, Operation, Learning) Matrix. TNDS = The New Digital School (Oporto, Portugal), TGS = The Global Studio (Japan, Korea, Australia, Taiwan, China, UK, and Canada), PDF = Porto Design Factory (Oporto, Portugal).

4 Conclusions

It seems reasonably safe to say that the immediate future of Design Education will have to learn from the new shared workplaces based on well-nourished communities, filled with a wide range of diversity made of different professionals and geographies, and increased levels of informality and openness. Ultimately, future design learning models will benefit from self-determined learning processes, distributing the responsibility of learning between new kinds of learners, new kinds of "teachers" like mentors, facilitators, community managers, and other learning enablers.

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Hierarchy of the Users Around the Birthing Bed, Analysis for Furniture Redesign

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Abstract. Analysis of hierarchical tasks in the hospital on the delivery phase, Users who interact with a delivery bed, to understand the usability of the object and the patterns of use, to identify possible improvements for the future bed design process. This paper argues that the use of the delivery bed requires further study of the number of users, their characteristics and hierarchy of use around the bed during labour, in order to consider the users who actually use the object for the improvement of the future design. A web study was conducted on 32 videos chosen for convenience, on Youtube, showing the birthing process. Each user was counted and characterized around the delivery bed, as well as the tasks they performed around the bed during the delivery phase. In the number of users the average was 6.8 Everyone was ranked according to who had the most interaction with the product.

Keywords: Medical device design · Birthing bed · Usability · Human factors · Human-systems integration · Systems engineering

1 Introduction

It is necessary to study and know the limitations, needs and capabilities of the users for a better understanding of the characteristics and specifications required by the products [1]. Agencies such as the FDA require that user needs be considered during the design process, so the usability of these products is crucial to improving both patient safety and quality of life [2]. The ISO standard that refers to user needs as a requirement for the design of new medical products, does not talk about the different types of users, by not classifying and prioritizing them for use, and in addition does not identify the relationship of user movement in the course of medical device use [3]. Ghulam and Robinson in a study conducted to identify types of users in medical devices conclude that there is no formal classification, however all types of users are important according to the stages in which they perform and must have detailed information of their needs, requirements, preferences and experiences, for success in product development [2].

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The goal in obstetrics and midwifery is to maintain the well-being of mother and child during birth [4]. The factors that influence a woman's degree of satisfaction have been rudimentary studied [4]. It has been found that the form of health care and the interaction between practitioners and patients with the environment and objects depends on the design of the bed. Therefore, considering that for most midwives the bed is still the best option for delivery, the design of the bed can influence women's experiences during delivery [5]. This paper argues that the use of the delivery table requires further study of the number of users, their characteristics and their hierarchy of use around the table during labour, in order to consider the users who actually use the object for the improvement of the design of future delivery tables. The Colliers state that film or video allows the researcher to deal with the 'what' as well as the 'how' of behavior because it can capture the 'sparkle and character' of an event [6] as well as being use to provide quantitive inforation to the observer [7]. Social networking sites (SNS) are being used as alternative channels of communication and information to ensure more humane and less violent obstetric care, based on scientific evidence [8]. The objective of the study is to analyze videos about births on the Youtube [9] platform in order to obtain characteristics of the users as well as their needs and limitations.

2 Methods

The information was collected by performing a search on the Youtube [9] platform using the terms "parto natural", "parto sin censura", "birth vlog", "vlog de parto". The aim of the search was to select 32 videos for analysis. The search yielded 3,077,000 videos of which 60 were analyzed, of these 28 were discarded because of the type of shots they had. The selected videos were from the United States (46,9%), Spain (31,3%), Mexico (6,3%), Argentina (6,3%), United Kingdom (6,3%) and Russia (3,1%) (Table 1).

Table 1. Example of analysis used for each video

Video screenshot and source	User	Hierarchy	Task description
Video 25.  United States	Mother	2	Leaning almost sitting, soles of feet supported
	Family	5	Accompaniment
	Specialist	1	Delivery, cleaning the baby
	Pediatrician	4	Delivery assistance, baby cleaning, mom cleaning
	Baby	3	Cleaning on the mother's belly

3 Analysis

Each of the videos was analyzed to obtain the following data;

Number of users: all the people who interacted with the birthing bed were taken into account. User type: Considering function, interactions, clothing, etc. users were classified in the following categories; mother, relative, specialist, baby, doctor, nurse and technician. Hierarchy: Considering the importance of use, a scale from 1 to 7 was used, taking 1 as the most important and 7 as the least. Description of the user's participation, observations on the stretcher and a general image. We also looked at the type of room, the mother's state of health.

4 Results

The results will be presented according to each of the aspects analyzed in the videos. In the number of users of the birthing bed the average was 6,8 with a maximum of 10, while the minimum was 5 having only the specialist, mother, relative, nurse and baby. The above-mentioned minimum users were those repeated in each case. In other cases, there was more than one family member (28.1%), a paediatrician (60%), technicians (31%) and more nurses (15%). In 44% of the videos observed, the patient was taken to a delivery room for the expulsion stage, in 56% of the cases, the patient had the three stages of delivery in the same room. Of the stretchers used 50% had leg holders, 31% had foot rests and 21.8% no accessories (Table 2).

Table 2. Appearance of users by video

User	Percentage	Number of videos
Specialist	100	32
Mother	100	32
Baby	100	32
Nurse	100	32
Family member	100	32
Pediatrician	59,4	22
Technician	31,3	10
2nd Nurse	15,6	5
2nd Family member	28,1	9
2nd Doctor	6,3	2
2nd Technician	3,1	1
3rd Nurse	3,1	1
3rd Family member	18,8	6
4th Family member	9,4	3

In the hierarchy of users, it was found that the user who had the most interaction with the stretcher is the specialist physician, who performs the entire process of delivery. The main patient and the one on the table is the mother, so she was placed in the number two position in the hierarchy. Subsequently, the assistant to the medical specialist was considered. This role can be played by another doctor or a nurse, who in most cases was positioned at the side of the bed during the delivery. Once the baby is born, the assistant was in charge of placing the baby on the mother to clean it. The baby, on the other hand, was placed at number four in the hierarchy, since he does not used the stretcher by himself, but it is his security at the time of the expulsion and the first care. Number 5 considered those who only use the stretcher for one activity at a specific time of delivery that does not involve carrying the baby; nurses to assist in cleaning the baby, pre-checking the mother, supporting the leg if necessary, providing medication, preparing the belly to place the baby on it and cutting the cord. Number 6 considered the family members who had contact with the stretcher only by supporting the mother and number 7 the users who were around the expulsion stretcher without having contact with her; family members with video recording, doctors in charge of the first care of the baby once outside the stretcher and nurses.

Fig. 1. Video 25. Use of foot rests

Fig. 2. Video 24. Use of leg holders

Regarding the interaction of the users with the bed, we can conclude that the users who should have more free access to the bed are the specialist doctors, since they carry out the most important task. To facilitate this, the position of the patient's legs must be taken into account. In 53% of the cases, these legs were held by family members, nurses or the patient herself. In 22% of the cases foot rests were used [10], which allow the patient to have greater support (Fig. 1.). In the case of leg holders [11], (31%) it was concluded that they do not provide the same support as foot rests during delivery but are useful for positioning the patient's legs after the baby is born, for cleaning purposes afterwards (Fig. 2.). In the Fig. 3. a top view of the different user accommodations observed in the videos is shown leaving the specialist on the bottom of the bed, the doctor or nurse assisting him/her and the other doctors, nurses or family members on the sides of the stretcher either for care, accompaniment or cleaning of the baby after birth.

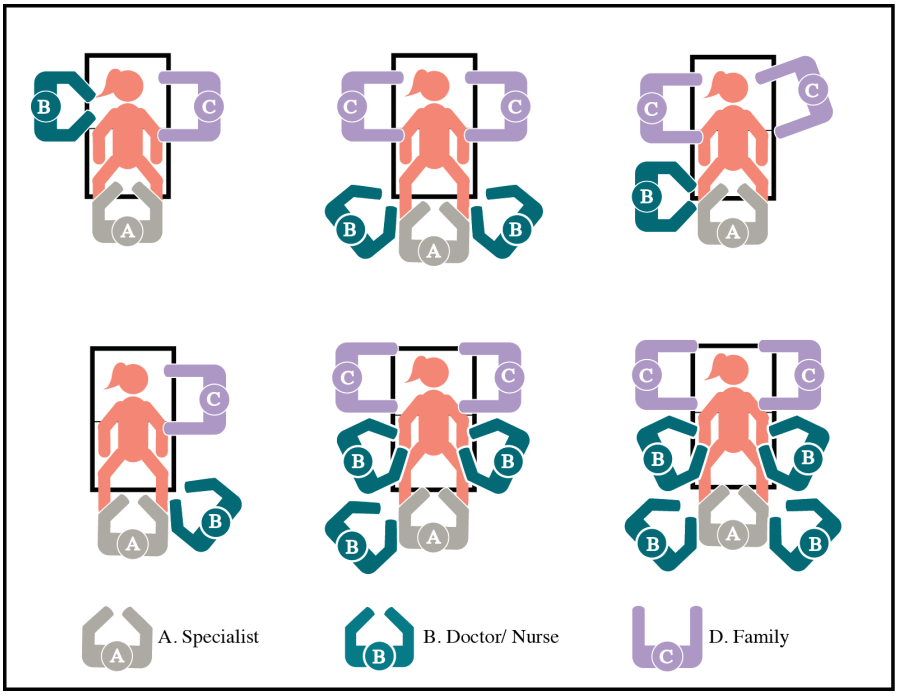

Fig. 3. User interaction with the birth bed during labor.

In the Fig. 4. The positions used by the mothers during the births analysed are shown, with the least used being 4 (3.1%), followed by 1 with 9.4% where the stretcher is completely straight, forcing the patient to make a greater effort to stay upright. The most used position was the second with 60% which allows nurses better access from the side of the bed giving them more space to perform their tasks.

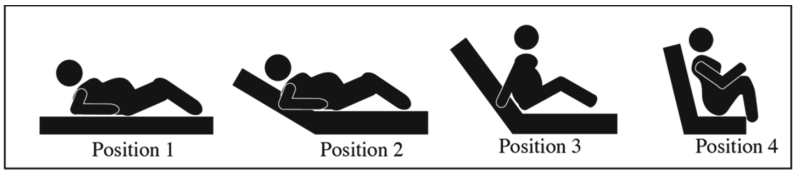

Fig. 4. Positions during labor.

5 Discussion and Conclusion

For a future redesign of the birth bed, the use of foot rests during the stage of expulsion is recommended, as well as leg holders during the last stage, since the use of these accessories can reduce the number of unnecessary people around the stretcher, optimizing space and improving the performance of the most important users tasks.

The design process of the birthing bed should consider further studies on the users who really play a role in the usability of the product, as well as their characteristics and their hierarchy around the birthing bed during the delivery phase, in order to identify patterns that allow the design of better tables to increase the satisfaction of all users involved.

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Fictional Worlds in Cinema and Games: Affinities in Their Conceptions, Creation, and Goals

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Abstract. Any cinematographic or videogame storytelling and narrative, real action, drawn or digital - imply developing replications of Man's life and existence, that will have to be unavoidably anchored in its fictional space. Only with those worlds the game or movie character's script and plot can make sense.

The player lives and experiences these fictions and their worlds, feeling himself a protagonist of the fiction and a co-builder of it.

Any linear cinematic narrative has a great amount of aspects that differ from its nature of being the strictly controlled narrative and representation of cinema or animation, compared to the player interaction with the fiction of a game.

It is this common ground and distinction between linear and interactive narratives – film and animation versus games - that this article tries to analyze, understand, and explore. Toward this aim, some paradigmatic films and games will be used as case studies.

Keywords: Games · Movies · Language · Fictional space · Viewer/player

1 Introduction

1.1 Viewer/Player Existential Experience of Fictional Worlds and Their Tales

The space of a fictional world is inseparably connected with the characters who inhabit in it and act on it, and with the action and narrative flowing from it: it is the support where happens all human experience. It is where he lives, acts, and interacts with the world and the others.

The cinematographic or videogame storytelling and narrative, real action, drawn or digital - imply developing replications of Man's life and existence, that will have to be unavoidably anchored in its fictional space. In these worlds the script and plot make sense to the game or movie characters: *"The atmospheric qualities of sets, places and environments are essential in establishing a mood and the deployment of an emotional feeling about the world around the movie"* [1].

Each space of a world is unavoidable linked with its inhabitants: worlds and characters, in their interaction, foresees action and narrative flowing from it. The

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Fictional Space is the support where happens all human experience of the plot, relating the World, their Characters and their Action and Plot.

Any narrative in a linear cinematic or game interaction environment simulating Man's life existence is necessarily anchored in its fictional space. Only with this space makes sense the game/movie narrative, being told as the script and plot unfolds.

A game player must plan and act in response to challenges that are posed to him. He lives and experiences these fictions and their worlds, feeling himself a protagonist of the fiction and a co-builder of it: narratives enable the viewer to apprehend, ok think and place himself before new challenging and never thought perspectives, ideas, values and concepts: *"the subjective experience that emerges from the interaction between game and player"* [2].

In a game tale storytelling and script, the cinematographic linearity should become theoretically in infinite lines of possible events and plots, with diverse endings, in which a narrative story line can diverges in multiple plots and outcomes. Also, this relationship between the gamer, the gameplay, narrative and fictional worlds imply a storyline and plot where the player can go through a infinite fictional space in a immersive and free path through the Fiction Space. So, space and plot are inseparable from the fiction narrative and storytelling.

This "freedom" appeals much to the player as also allows him a greater immersion in the game world, because it facilitates the projection of his imagination about this world and the events that he himself casts. In order to maintain a sense of freedom in the game, this control is done in a subtle and indirect way through various forms, called "indirect control" of the player, such as constraints, objectives, interfaces, visual design, characters and music [3].

1.2 Living Versus Interacting

In a game design or a film plot characters inhabit their world's existential space: the viewer/player is constrained to be aware of realities, spaces, events, and the other characters, and is bound to those, engaging and interacting with them. He is totally immersed - soul, senses, and body - and experiences these interactions with the fictional world in the first person: *"not only enters in the worlds games, as well he changes them and their elements"* [4].

To understand the full Storytelling of a Cinematic Fiction and to be interact with that fiction, in a game, requires to the viewer to look to it, but to be fully immersed and feeling a sense of "presence" in the Fiction World: *"is when the mental division between the player's real self and his in-game avatar softens, so events happening to the avatar become meaningful as though they were happening to the player himself"* [5].

This implies the player as the center of a fictional world, that surrounds him, feeling fully immersed in the fictional space and world. This is used in movies as in games and make the viewer/gamer feel he is in the world of the fiction and belongs to it and its living story. This degree of the player immersion can vary in depth: *"we can develop a set of design criteria that will enable us to judge a game's degree of impressiveness, engagement, and the degree of presence possible"* [6].

This living as the potential to make the viewer or player apprehend, think, and situate himself before new perspectives, ideas, values, quests, and concepts: *"the characters, events and architecture interact and designate each other"* [7].

In any linear cinematic narrative, of cinema or animation, a great amount of aspects differs in its nature, being a strictly controlled narrative and representation, compared to the player interaction with the fiction of a game.

In a linear narrative the viewer is guided, without any option, through successive spaces, events, premonitions, anticipations, fears, joys, expectations, and conclusions. Even the empathy or dislike he feels about characters and environments are not his choice, as he could thought, but it is the Art Director's one. Everything in a Visual Linear Cinematic Narrative is predefined and intended.

Much of the cinematic language and syntax of its grammar, particularly in relation to the fictional world space and content and its visual representation - production design - applies to games as to cinematographic linear narratives in a very close way: relation to camera behavior, light and color, composition, balance, emphasis, perception, directing and editing and also in the way the fictional space is built.

In a game there are aspects like fiction implicit and explicit rules, design of implicit constraints, phased goals, rewards and penalties, concepts of infinite - space with boundaries, structure, and dimensions clearly finite - that differs from the cinema linear visual and telling language.

2 Case Studies

In this article the goal is to infer some assumptions about the coordinated use of the several grammars, leading to the coherence and effectiveness of a game, and also to verify the conception and use of its fictional space as a support of the plot, actions and storytelling.

For this analysis, some popular and paradigmatic film and games will be used as case studies to look to, try to identify and relate:

- The grammar of game and movie languages: visual representation and composition, scripting, directing, editing, lighting and game specifics.
- The fictional worlds and spaces used and their concept.

2.1 Linear Narratives and Their Fictional Worlds and Places

Fig. 1. Blade Runner - Spaces of Power and Society Contrasts with Monumental Architecture

Blade Runner [8]
Blade Runner is a film that emphasizes power and world of pollution and harsh social contrasts, depicting cities inspired on Metropolis, multilevel, being the rich who inhabits in the highest levels (Fig. 1). Symbols of Power are all over the Film.

The Fictional Space is visual dominant in the film, full of signs about how is the people that inhabits in its very diverse spaces. The narrative and emotional role of its spaces and imagery is so important that the main telling is given by it (Fig. 2).

Fig. 2. The Fifth Element – City Multilayer alike with monumental and Eclectic Architecture

The Fifth Element [9]
In the line of Blade Runner but not so developed, this Film emulates and details, avoiding low key shots, the monumental, eclectic and multilevel nature of cities, at a urban and architectural level. The narrative role is not present, it consists more of a diversion background for the main story.

2.2 Games with Fictional Worlds as Parallel Telling Device

Fig. 3. Fictional World to place a non-related Music precision tap game

Dancing Line [10]
Dancing Line is a game where the player taps with the finger sync with the rhythm of popular songs (Fig. 3).

This would not have any relevance if they did not create:

- thematic spaces, filmed by a camera like in a film one
- It gives the player rich and imaginative worlds he travels along each song.
- Lines of rhythm become streets along detailed and cinematic spaces
- The Space metamorphoses along, synchronous with the progress of the player and the music.

2.3 Role Play Games – Interacting with Living Worlds

Fig. 4. Life is Strange: Game of Film Sequences unite by interaction stops

Life is Strange [11]
Life is Strange is the example how we can glue 3D shots, parts of the plot action, having between freeze shots were the player must decide what action he choose to take between a finite number presented. All the rules of cinema are present and applied with mastery (Fig. 4).

Fig. 5. RPG Toram Online – RPL with action in a supposed infinite world

RPG Toram Online [12]
Toram online is a RPG with an apparent infinite world where the player progresses through quests, interacting with other characters (Fig. 5). This Infinite world are quite finite!

2.4 Alter Ego Worlds – Alternative Worlds to Live

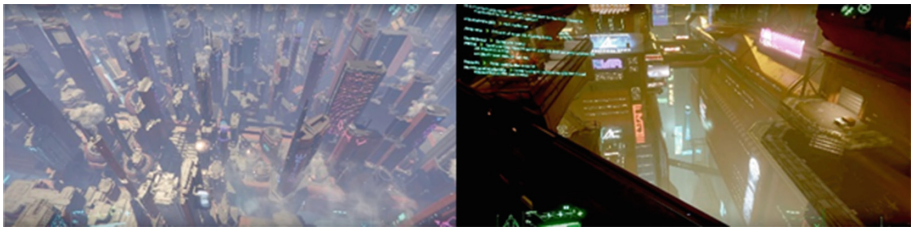

Fig. 6. Star Citizen – An IA Universe where the player can have an alternate life

Star Citizen [13]
Star Citizen is a new level of concept in game and Fictional Space (Fig. 6). It is an almost infinite and extremely detailed part of a univers, with stars, planets and moons, with all the dynamics of weather and vegetation, snow, sea, and physics laws. The most part is created by interactive IA that memorizes objects and places, having all-natural items natural movements, with the wind or when the player passes by.

Huge Cities and Industrial Complexes are full of transportations, detailed spaces with shops, offices, ships, dwellings, all usable and detailed.

In this hyperrealist Universe the player can be any profession he wants, can talk and collaborate with other online players (or their alter-egos avatars). The size and detail make this game infinite, for real!

3 Conclusions

The role of the Fictional World and Spaces in Films and Games is each time more important and storytelling, having a narrative fundamental role, framing completely the actions, emotions and ambience of the plot, characters, and players!

The visual representation, fictional spaces, lighting, framing, and camera angles is now the main tool in any 3D game or film.

But in this highly developed fictional spaces, characters and worlds, the actions and plots possible are now much more complex, parallel, and open ending!

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Tools, Equipment and Space Design

Design Strategies for a More Sustainable and Optimized Interaction

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Abstract. This paper reports a study based on the review of literature and case study, which is part of a product design research about children's furniture, including a high chair design project. The case study was developed with 10 models of evolutive high chairs, crossing information between research on design strategies for sustainability and other approaches to the selected models, namely a physical adaptability study, giving a more complete view of the application of these strategies for more sustainability in all phases of its life cycle, within the context of an optimized use of the object. The results revealed that two evolutive high chair models reflected the application of more design strategies for sustainability and also ranked higher in terms of physical adaptability. These approaches may represent good examples of design thinking and practice towards a more sustainable development, not overlooking the efficiency and optimization of the interaction with children's furniture.

Keywords: Design · Children's furniture · Sustainability · Human factors and ergonomics

1 Introduction

Sustainable development and a more circular economy are essential challenges to deal with, in present time. Sustainability means providing wealth, quality of life and preserved environment to present generations, without jeopardising the opportunity of future generations to meet the same needs [1]. For healthcare and production/consumption's goals [2], specific design strategies are vital to an evolution with balance and quality of life, also protecting the environment. Strategies such as Biomimicry; Cradle to Cradle®; Design for disassembly/deconstruction; Design for flexibility; Design for maintainability/reparability; Design for recoverability/recyclability; Design for the environment (eco-design); Green chemistry; Integrated design process; Life cycle thinking; Lifetime extension & durability; Regenerative design; Standardization; and Systems thinking [3]. In furniture development, Design for durability; Design for disassembly; Design for re-use and refurbishment; Design for recycling; and Design for safe disposal [4] were defined as specific strategies. Also, minimising and selecting low impact resources; optimizing and extending the product lifespan and facilitating disassembly, were defined as strategies for Life Cycle Design [5].

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This paper reports a study about design strategies for sustainability also crossing the data with a physical adaptability study [6], in order to have a more complete view on sustainability concerns in the context of an optimized interaction with the product. It is based on the review of literature and case study, which was part of a product design research about children's furniture, including a high chair design project. Its objective was to create solutions physically and psychologically more adapted to the child, from 6 months up to 7 years of age, whilst extending the product's life cycle and contributing to sustainability.

A high chair can be a socialization element at home as it brings families together at meals. It is inclusive to a child to be with his/her family at the table, so they can cohabit and interact with the same objects and equipment adapted to the users, without feeling discomfort. An evolutive high chair is a chair that follows child growth, adapting itself to children from several age groups with different anthropometric dimensions. It is a chair, which can be used for more than just a few years, as it is verified in the majority of the (non-evolutive) high chair models, available in the market. Parents make a long-term investment acquiring this type of equipment, which is generally expensive (the models featured in the case study may cost between 185 and 445 euro).

The case study featuring 10 models of children's high chairs with a wooden based structure, described by producers as evolutive, multifunctional and/or follower of child's growth, was developed. It seemed necessary to analyse the case study high chairs, also about its concerns on sustainability and compare its results with other approach that studied physical adaptability. These evolutive high chairs may present *a priori* an extended lifespan when comparing to non-evolutive high chairs but more information about the choice of materials, recyclability, re-utilization or multifunctionality was needed, to give further directions on this subject, to the high chair project.

2 The Study

2.1 Method and Aim

Through a methodology based on the review of literature and case study with 10 models of children's high chairs, this study searched for design strategies focusing on sustainability, which may have been applied in the development of the selected products, in a mainly qualitative based research, although with some quantitative analysis. Searching for good examples in this field is necessary for the development of the design strategies for sustainability proposal in the high chair project, which is the main objective of this research.

The broad scope of the case study included previously, observation and interview based studies with children [7], parents [8] and the author of two of the models featured in the case study (Tripp Trapp® and Nomi chairs) - Peter Opsvik.

The aim was also to cross the results about sustainability with the results gathered on a physical adaptability study [6], searching for a wider overall view of the models.

2.2 Case Study

The case study has been developed with 10 models of children's high chairs (Fig. 1) available in the international market. The models were described by producers as followers of child's growth from 6 months up to 6–12 years of age, and some of them as multifunctional products. The selection of these models was made with formal and functional diversity criteria, searching for different approaches and different adaptability solutions. All of these models have the choice of wood for its main structural material in common, although some of them have seat, back, footrest and other elements produced with other (non renewable source) materials, such as synthetic polymers.

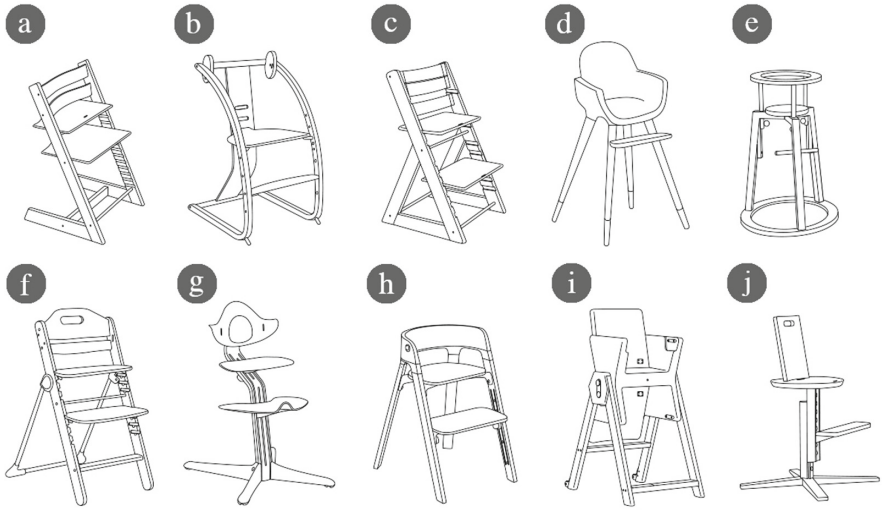

Fig. 1. Perspective views of the models of high chairs featured in the case study: a. Tripp Trapp® Chair; b. Bambini chair, c. Nórdica chair, d. Ovo chair, e. Rinki chair, f. Waffle highchair, g. Nomi Highchair; h. Stokke® Steps™ Chair; i. HiLo™ chair, j. Froc High Chair, digital illustration: Cristina Salvador.

The Tripp Trapp® chair (a) [9] produced by the norwegian company Stokke®, is the first and least recent model (1972) in this case study. This high chair is a best seller, with over 10 million units sold and was designed by Peter Opsvik [10]. Tripp Trapp® chair has a multi-position system with two plywood boards, which can be placed as seat and footrest, being adjusted to the child's growth. The seat has been considered as not very comfortable by children and parents; Opsvik considered the seat slippery, in a recent interview; it is heavy and difficult to change the seat and footrest position; its slides make it easy to stumble on it.

The Bambini chair (b) from japanese Sdi Fantasia [11], was developed by the late japanese designer Toshimitsu Sasaki and was re-launched in 2015. This chair adapts to the child by repositioning the seat and it is multifunctional, as it can be used as a

wooden rocking toy/horse when rotated. It is very expensive; heavy; and with no extra security system provided.

The next model in the study is the Nordica chair (c) from portuguese company Bebécar®/Trama® [12], released in 2014. This chair is made with pinewood, being the only model from the case study made with softwood, as it was analysed in previous studies [13]. Its concept is similar to the one applied in the Tripp Trapp® chair but with less possible positions and presenting similar problems concerning weight, comfort, maintenance, etc.

The Ovo chair (d) (2011) from spanish Micuna® [14], designed by design studio Culdesac™ [15] is also in the case study. With stackable feet, this chair can be used as a chair or as high chair with two different heights. It is a quite heavy and expensive chair.

From the finnish company Seimi®, the Rinki chair (e) [16], released in 2005, was designed by interior designer Hannu Peltonen. This is another multifunctional model as it can be used as a high chair and as a stool, changing the wooden ring's position. Although multifunctional, it doesn't seem to allow many positions do adapt to the child.

Waffle high-chair (f) (2015) from british company Cosatto® [17] is the sixth model from this case study. Although presenting the same feature of multi-position of the seat and footrest as the Tripp Trapp® chair, with less possible positions, this is a folding chair with metallic and synthetic polymer elements. It's the less expensive model; the maintenance is dificult and it requires specific tools; the paint scratches easily.

A more recent model from Peter Opsvik, the Nomi chair (g) (2013) from danish company Evomove® [18], presents a different formal approach with a middle stem in steam-bent veneer and adjustable back, seat and footrest in synthetic polymer with a sliding system, adjustable without the use of any tools. The base is wide and it's easy to stumble.

Still from Stokke® [19], there is the Stokke®Steps™ chair (h) (2014) designed by norwegian design studio Permafrost. Its footrest is adjustable by multi-position, the back/seat is produced with synthetic polymer and the chair's legs are made with solid wood. It allows fewer positions, comparing with the Tripp Trapp chair®.

HiLo™ chair (i) [20] from canadian studio Age design (2011), is also in this case study and adopts a different concept in adaptability. With a simple rotation of the double synthetic polymer's back/seat, it reduces the chair's height. It's the heaviest model (around 10 kg) and limits the child's movements.

The last model of the case study is the Froc high chair (j) (2014) from family company Froc [21]. This high chair was designed by slovenian studio Gigodesign [22] and has a middle stem made with solid european wood. It is adjustable to the child by multi-positioning the back, seat and footrest. It's heavy; has a not much comfortable seat; it's easy to stumble in its base; and provides no extra security system.

2.3 Results

There's a strong presence of non-evolutive high chairs in the market, which can be used only until 2–3 years of age. Once the child reaches that age, another chair is acquired or the child sits in a chair for adults, clearly unsuitable for children. Any evolutive high

chair has in its concept, a strategy of adaptability to achieve an extended product's lifespan, facing non-evolutive high chairs. All 10 models of evolutive high chairs have in common a concern for an extension of the product lifespan, as the chairs can be used from 6 months until 6, 10, 12 years of age and some until a teenage stage or even adulthood. In addition, other strategies for sustainability could be observed:

- Production using supplies of local raw material and/or renewable material (solid wood, plywood or laminated wood) - Tripp Trapp®, Bambini, Nórdica, Ovo, Rinki, Waffle high-chair, Nomi, Stokke®Steps™, Hilo™ and Froc;
- No harmful substances - Tripp Trapp®, Rinki, Nomi and Stokke®Steps™;
- Design for durability - Tripp Trapp®, Bambini, Nórdica, Ovo, Rinki, Waffle high-chair, Nomi, Stokke®Steps™, Hilo™ and Froc;
- Multifunctionality of product or package - Bambini, Ovo and Rinki;
- Design for disassembly/recyclability - Tripp Trapp®, Bambini, Nórdica, Ovo, Rinki, Waffle high-chair, Nomi, Stokke®Steps™ and Froc;
- Meeting international security standards - Tripp Trapp®, Rinki, Nomi, Stokke®-Steps™, Hilo™ and Froc;
- Flat packaging with recyclable cardboard - Tripp Trapp®, Bambini, Rinki, Waffle high-chair, Nomi and Stokke®Steps™.

Wood is a sustainable and renewable natural material [13]. All models have wood as the main structural material and five of them are made with certified wood from sustainably managed forests (FSC®). Five of the models' producers released information about local supply of raw material, which may lead to a reduced carbon footprint as transportation is minimized, lowering the environmental impact.

Four of the case study models declared the inexistence of harmful substances. Although the Tripp Trapp® chair is the model with more colour options, Stokke® refers using water based, non-toxic paint. Two models (Rinki and Bambini) were designed to be multifunctional, extending the utilization of the product and guaranteeing two functions in a single object. And the Ovo chair adds a function to its packaging as it can be used for toy storage.

The chair models also presented concerns about easy disassembling; revealed concern for recyclability; and spare parts are accessible for an easy repairability, for Stokke®'s models. Tripp Trapp®, Rinki, Nomi, Stokke®Steps™ and Bambini applied 5–6 design strategies for sustainability. The remaining models applied only 3–4 design strategies for sustainability.

A representation of the quantitative analysis of the results of the study about design strategies for sustainability (in units) is represented in Fig. 2, along with the results from the physical adaptability study (in percentage, rounded to the nearest tenth). When comparing results, the Tripp Trapp® and Nomi chairs stand out in both studies, with consistant and high scores, ensuring a longer interaction by extending its lifespan through specific design strategies for sustainability, but also through an anthropometric physical adaptability with multi-position and sliding systems.

Crossing information with previous studies, the problems these two models revealed, could not be overlooked and required attention. Both were prone to stumbling in the slides and base; Tripp Trapp® was considered with less comfortable and slippery seat; and Nomi's seat and supports are made with synthetic polymer. Nevertheless and

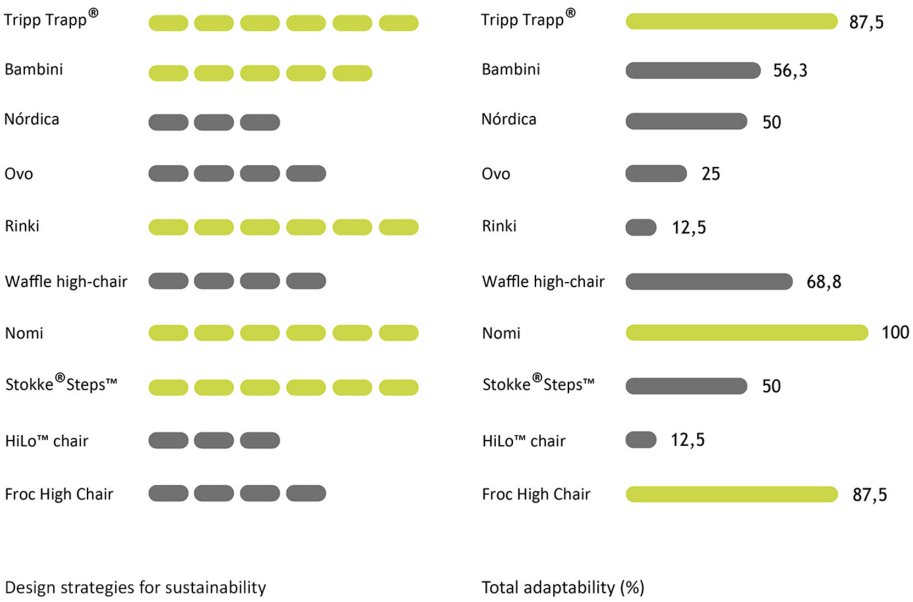

Fig. 2. Design strategies for sustainability results + physical adaptability study results, digital illustration: Cristina Salvador.

bearing in mind those issues, the overall examples of these two models provided directions for the development of the design strategies for sustainability proposal, in the high chair design project, which is the main objective of this research.

3 Conclusions

In the development of the evolutive high chair models in the case study, specific design strategies have been applied, reaching positive results towards sustainability, namely in Tripp Trapp®, Rinki, Nomi, Stokke®Steps™ and Bambini models. But by crossing the results from the sustainability study with the results from the physical adaptability study, Tripp Trapp® and Nomi chairs stand out, with consistant high scores. Although in previous studies other issues surfaced and required attention, these two approaches, not only applied more design strategies for sustainability, but also seemed to better fulfill the need for more physical adaptability, which means are more suitable to the child's dimensions, while growing and that, consequently, may extend the product's lifespan. Therefore, these models may represent good examples of design thinking and practice towards a more sustainable development, in the overall scenario of children's furniture.

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Study on Backpack Carrying Health of Children

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Abstract. In order to study the influence of backpack on children's health under different load conditions four groups of children in kindergarten, junior primary school age, senior middle school age and junior high school students were selected for the experiment. Children carry different weight percentage of backpack movement according to the group, using vicon infrared high-speed motion capture system to collect spatial coordinate. The results of data analysis showed that the mean value and variance of shoulder balance, hip balance and cervical spine forward Angle were all higher than that of no-load state, there are significant differences between different backpacks ($p < 0.03$). Therefore, the primary goal of children's backpack carrying health is to protect cervical vertebra by changing the design of children's backpack.

Keywords: Children's backpack · Motion capture system · Carry health · Balance ability

1 Introduction

For children, backpack is an essential tool in learning and life. With the development of the times and technology, more and more backpacks with various shapes and functions are available for students to choose. It is a common phenomenon in today's society that children carry too much weight in their backpacks, which will affect their bodies. When people are backpacking, the body is loaded from the outside, and the position of the center of gravity is changed. In order to maintain the stability of the body and resist the external pressure, the gait and body posture will be changed. Carrying too much weight or carrying too much time will do harm to the spine, back and balance of the body.

Menz et al. [1] believed that the overall position and mass of the human body mass center have changed due to the load on the back, so the human body must change the walking gait to maintain balance, so as to adapt to the load application. Ramprasad et al. [5] investigated 200 healthy male students aged 12 to 13, and studied the influence of backpacking on their body posture when they were loaded with 5% body weight, 10% BW, 15% BW, 20% BW and 25% BW. The results showed that when the backpack was loaded with more than 15% BW, the angle of atlantooccipital joint changed significantly; when the backpack was loaded with more than 10% BW, the angle of cervical vertebra and spine changed significantly.

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Brueggemann [6], Cheung [7] and Singh [8] have studied the influence of different backpack weights on body posture in the state of motion. They all come to the conclusion that the heavier the backpack weight is, the more obvious the change of body posture is. Chansirinukor et al. [9] believed that a schoolbag with more than 15% BW on its back would make children unable to maintain normal standing posture.

In this paper, children of different ages are selected for testing, so that they carry different weight percentage loads of backpack movement according to their groups, using vicon infrared high-speed motion capture system to capture and collect the space coordinate data of left and right shoulder peak points, the first cervical point, the seventh cervical point, and the left and right hip bone points. Then calculate the balance of left and right shoulder, left and right hip bones and the angle of cervical vertebra forward when children are empty or carrying backpack through software, and compare and analyze the data of each angle horizontally and longitudinally.

2 Experimental Design

2.1 Subjects

A total of 12 school-age children with different age groups in Beijing were randomly selected as the experimental subjects, which were divided into kindergarten group, lower grade group of primary school, primary school higher grade group and junior high school group, each group had 3 people. 4–6-year-old subjects were classified into kindergarten group, 7–9-year-old subjects into primary school lower grade (1–3 grade) group, 10–12-year-old subjects into primary school higher grade (4–6 Grade) group and 13–15-year-old subjects into junior high school group. Screening principles: 1) at least one boy and one girl in each group; 2) each group includes one overweight or skinny child. The lower grade of primary school is Grade 1–3, and the higher grade is grade 4–6.

2.2 Experimental Equipment

The weights of the subjects and the backpack were measured by the electronic scale, with the measurement range of 0–100 kg and the accuracy of 0.1 kg. The trunk posture was measured by the Vicon motion capture system.

2.3 Experimental Backpack

The backpack used in this experiment is a common backpack for students on the market. The external dimension of the backpack was 240 mm–350 mm, the height was 320 mm–420 mm, and the thickness was 100 mm–210 mm. There are significant differences in the influencing factors of comfort in each age group. In order to compare the influence of posture in each age group, a backpack was selected for each age group. The external dimensions of backpack should be classified according to different school ages. Table 1 shows the size of backpack used in different school age groups.

Table 1. Recommended external dimensions of backpack (unit: mm)

Backpack size	Width	Thickness	Height
Kindergarten group	240–270	100–120	320–350
Primary school junior group	280–310	170–190	360–390
Senior group of primary school	310–340	170–190	390–420
Junior middle school group	320–350	190–210	390–420

2.4 Pasting Mark Point

The children in the test wore dark self-fitting clothes and black elastic socks on their feet. According to the Vicon human body model built in advance during the experimental design, a total of 6 reflective mark points are pasted, and the specific pasting position is shown in Table 2.

Table 2. Vicon Mark point paste position

Mark point no	Mark point code	Position	Explain
Mark01	1st jingzhui	First cervical vertebra	
Mark02	7th jingzhui	Seventh cervical vertebra	
Mark03	L jianfeng	Left shoulder acromion	Highest point of left shoulder
Mark04	R jianfeng	Right shoulder acromion	Highest point of right shoulder
Mark05	L kuan	Left hip	The most prominent part on the left and right sides of buttocks
Mark06	R kuan	Right hip joint	

2.5 Vicon Action Capture Recording

Different groups have different test weights. The children in the kindergarten group were loaded with 0.5 kg, 1 kg and 2 kg backpacks. The children in the lower grade group and the higher grade group were loaded with 1 kg, 2 kg and 4 kg backpacks. The children in the middle school group were loaded with 2 kg, 4 kg and 6 kg backpacks. In front of the eye in the motion capture area, walk for 10 s (1000) at your normal walking speed and attitude, and collect the most stable 6S (600 frames) data in the middle of the travel from different load-bearing backpacks.

The printing area is 122 mm × 193 mm (4.8 in. × 7.6 in.). The text should be justified to occupy the full line width, so that the right margin is not ragged, with words hyphenated as appropriate. Please fill pages so that the length of the text is no less than 180 mm, if possible. Use paper size A4 210 mm × 297 mm (8.27 in. × 11.69 in.),

Top and Bottom margins: 52.1 mm, Left and Right margins: 43.9 mm (Top and Bottom margins: 2.05 in., Left and Right margins: 1.73 in.).

3 Analysis of Experimental Data

3.1 Selection of Experimental Data

In order to calculate the shoulder balance and hip balance of human body in motion, the angle between the left and right shoulder peak points, the left and right hip joint points and the XY plane (horizontal plane) were compared under the condition of load and no load, so as to reflect the influence of backpack on the balance ability of human body. Through the change of the angle between the line of the first cervical vertebra and the seventh cervical vertebra and the XY plane, we can get the degree of the backpack leading to the forward tilt of the cervical vertebra.

3.2 Calculation of Experimental Data

Firstly, the test data were standardized, and then the statistical analysis software (SPSS) was used for t-test analysis. There were significant differences in shoulder balance, hip joint balance, cervical curvature and upper body forward leaning between walking with no load and back load.

4 Experimental Results

4.1 Influence of Backpack Load on Shoulder Balance Ability During Walking

Analyze the shoulder balance through the coordinate change of left and right shoulders in z-axis. After standardizing the test data, use the data statistical analysis software (spss21.0) to conduct paired-t test analysis on the balance of left and right shoulders of each school-age group, as shown in Table 3.

Table 3 shows the changes of shoulder balance angle of subjects in different age groups when they are carrying different backpacks with no load or with different loads respectively. In addition, there was significant difference in shoulder balance between different age groups ($P < 0.01$). With the increase of age, the influence of backpack on shoulder balance of children will be smaller and the shoulder balance ability of junior middle school group was almost not affected.

4.2 Effect of Backpack Load on Hip Joint Balance During Walking

By analyzing the coordinate changes of left and right hip joints in Z axis, the hip joint balance was analyzed. After the standardized processing of test data, the balance of backpack hip joint in each school-age group was analyzed by paired-t test using spss21.0, as shown in Table 4.

Table 3. Analysis of the balance difference between left and right shoulders

School age group	Different load backpack	$\bar{x} \pm s$	P	Test result	$\bar{x} \pm s$	P
Kindergarten group	No load	0.037 ± 0.012	<0.01	Significant difference	0.151 ± 0.350	<0.01
	0.5 kg	0.239 ± 0.048				
	1 kg	0.236 ± 0.045				
	2 kg	0.077 ± 0.018				
Primary school junior group	No load	0.040 ± 0.015	<0.01	Significant difference	0.070 ± 0.008	
	1 kg	0.136 ± 0.328				
	2 kg	0.129 ± 0.170				
	4 kg	0.800 ± 0.389				
Senior group of primary school	No load	0.030 ± 0.004	<0.01	Significant difference	0.030 ± 0.002	
	1 kg	0.052 ± 0.009				
	2 kg	0.042 ± 0.008				
	4 kg	0.048 ± 0.012				
Junior middle school group	No load	0.024 ± 0.015	<0.03	Significant difference	0.008 ± 0.002	
	2 kg	0.028 ± 0.015				
	4 kg	0.027 ± 0.023				
	6 kg	0.037 ± 0.043				

Table 4. Analysis of balance difference of hip joint

School age group	Different load backpack	$\bar{x} \pm s$	P	Test result	$\bar{x} \pm s$	P
Kindergarten group	No load	0.062 ± 0.100	<0.01	Significant difference	0.104 ± 0.005	<0.99
	0.5 kg	0.183 ± 0.266				
	1 kg	0.137 ± 0.006				
	2 kg	0.162 ± 0.022				
Primary school junior group	No load	0.054 ± 0.010	<0.01	Significant difference	0.102 ± 0.056	
	1 kg	0.089 ± 0.014				
	2 kg	0.133 ± 0.019				
	4 kg	0.158 ± 0.107				
Senior group of primary school	No load	0.024 ± 0.015	<0.01	Significant difference	0.100 ± 0.003	
	1 kg	0.028 ± 0.015				
	2 kg	0.027 ± 0.023				
	4 kg	0.037 ± 0.043				
Junior middle school group	No load	0.034 ± 0.002	<0.01	Significant difference	0.101 ± 0.107	
	2 kg	0.063 ± 0.008				
	4 kg	0.138 ± 0.007				
	6 kg	0.155 ± 0.010				

Table 4 shows the changes of hip joint balance angle of subjects in different age groups when they are loaded with different backpacks and no load respectively. In addition, there was no significant difference in the influence of different load backpacks on the hip balance of children of different ages ($P > 0.05$). With the increase of age, there was no significant difference in the influence of backpacks on the hip balance of children from kindergarten to junior high school.

4.3 The Influence of Backpack Load on the Cervical Vertebra Anteversion Angle

The plane perpendicular to the XY plane of the two acromion points of the subjects was taken as the coronal plane. On this basis, the sagittal plane was obtained by rotating the plane 90°. The anteversion angle of the cervical vertebra was analyzed by calculating the angle change of the cervical vertebra (the line between the first cervical vertebra and the seventh cervical vertebra) in the sagittal plane. After the standardized processing of the test data, the data statistical analysis software (spss21.0) was used to analyze the forward tilt angle of the backpack cervical spine in each school-age group, as shown in Table 5.

Table 5 shows the changes of neck forward angle of subjects in each school-age group when they are carrying different backpacks with no load or with different loads. The results showed that there was a significant difference in the change of cervical

Table 5. An analysis of the difference of cervical vertebra anteversion angle

School age group	Different load backpack	$\bar{x} \pm s$	P	Test result	$\bar{x} \pm s$	P
Kindergarten group	No load	0.258 ± 0.018	<0.01	Significant difference	0.321 ± 0.255	<0.06
	0.5 kg	0.268 ± 0.227				
	1 kg	0.579 ± 0.054				
	2 kg	0.639 ± 0.058				
Primary school junior group	No load	0.257 ± 0.016	<0.01	Significant difference	0.357 ± 0.047	
	1 kg	0.310 ± 0.043				
	2 kg	0.455 ± 0.147				
	4 kg	0.623 ± 0.065				
Senior group of primary school	No load	0.234 ± 0.042	<0.01	Significant difference	0.196 ± 0.016	
	1 kg	0.270 ± 0.043				
	2 kg	0.352 ± 0.027				
	4 kg	0.563 ± 0.084				
Junior middle school group	No load	0.237 ± 0.017	<0.01	Significant difference	0.241 ± 0.120	
	2 kg	0.299 ± 0.058				
	4 kg	0.377 ± 0.080				
	6 kg	0.607 ± 0.162				

vertebra anteversion angle between no-load and different load backpacks ($P < 0.01$). The cervical vertebra anteversion angle in no-load state was smaller than that in load backpack state, and the influence of different load backpacks on the cervical vertebra of the children was significant. In addition, there was no significant difference ($P > 0.05$) in the influence of different load knapsack on children's neck posture in different age groups. It can be seen that the influence of knapsack on children's neck posture was divided into two grades according to the boundary of primary school's low age and primary school's old age. The influence degree of primary school's low age group and kindergarten group was very high, while that of primary school's old age group and junior high school group was reduced.

5 Conclusion

Through the horizontal comparison between no-load state and different backpacks, we get that the average value and variance (dispersion) of shoulder balance, hip balance, cervical vertebra forward tilt angle of children in the backpack state are greater than that in the no-load state. In addition, there are also differences between different load backpacks, among which the load backpack with the least influence has little influence on shoulder balance ability and cervical vertebra forward tilt angle.

By comparing the influence of backpack on children's body posture in different age groups, we conclude that with the increase of age, the influence of backpack on children's walking shoulder balance will be smaller and smaller. The shoulder balance ability of the junior middle school group has hardly changed. The influence of backpack on hip balance and neck posture did not decrease with age. The hip balance ability of all ages is almost the same, which shows that the influence of backpack load on children's hip will not decrease with the development of their body. The influence degree of cervical anteversion was gradually reduced, which was divided by the age of primary school and the age of primary school. However, the degree of influence on the posture of the neck (that is, the change of the angle of cervical vertebra forward tilt between the backpack and the empty state) is much higher than the degree of influence on the balance ability of the shoulder and hip. From this point of view, the protection of children's backpack to cervical spine should be an important goal of current research on children's backpack health.

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Research on Information Architecture and Design Strategy of AR-HUD in Urban Rail Information Displayed System

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Abstract. From the perspective of human factors, the significance of information system design and research is not to make the system intelligent, but to adapt to the user's use and purpose. Task analysis is an effective way to improve the usability and learnability of the system within the scope of user capabilities. In this paper, the task analysis method is used to analyze the task field of urban rail drivers. Combined with the "task-information" theory, summarize the driver's demand for the function of information display system. Task is the task in the situation. Using the theory of situational awareness, analyze the cognitive characteristics of drivers and finds the key points of design. The design strategy of ar-hud in urban rail information display system is summarized. On this basis, the preliminary design practice is carried out and verified.

Keywords: Urban rail information display system · Ar-hud · Task analysis · Situational awareness

1 The Current Situation of Urban Rail Information Display System and the Introduction of AR HUD

With the development of transportation, urban rail has become another major means of transportation for people to travel. In China, for example, by 2018, more than 30 cities are building urban rail projects, with the mileage under construction exceeding 1833 km. However, the tasks of urban rail drivers are various, and the amount of information to be observed is huge. At present, most urban rail adopts automatic train control system (ATC) based on Communication technology. Urban rail drivers need to observe ground signal control system, such as annunciator, signal indicator and road information, such as road maintenance personnel, etc., and also need to observe the information of driving display unit (TOD). The existing TOD is generally located in the upper space of the DMI console of urban rail, not driving. In the best field of vision of the operator, the driver should often deviate his line of sight. When the driver observes the distant target and the near instrument panel, there will be a process of "line of sight focusing". Frequent line of sight focusing will cause slow visual response speed and visual fatigue, which will bring potential safety hazards and increase the task load of the driver.

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According to the design guidelines for in car information display issued by TPL, the UK Transport Research Institute, the in car visual display should reduce the user's recognition time, ensure that the driving vision does not shift for a long time, and the information should be accurately understood in a short browsing process. Visual observation of navigation or other non driving tasks forms the visual deviation of driving tasks. The longer the deviation time, the lower the safety. Ar-hud is to use AR imaging technology to cover digital images in the real world we see, so that the information projected by HUD is integrated with the real driving environment. Ar-hud projects information on the windshield in front of the vehicle to ensure that the driver's vision does not deviate for a long time, which can reduce the risk of the driver's head down leading to the realization of deviation [1]; adding positioning virtual objects in the three-dimensional scale space to reduce the user's recognition time, improve the driver's driving efficiency, reduce the task load, and improve the driving safety and experience.

2 Task Information Architecture of Urban Rail Transit

In this paper, the task analysis method is used to analyze the domain task of urban rail drivers. Rasmussen proposed in his theory of ecological interface design (EID) that human behavior can be divided into three levels [2] (Fig. 1 shows). The first layer of behavior is skill based behavior, which is a kind of skillful reflexive action without thinking. The second layer is rule-based behavior, which is a behavior sequence constructed by using existing rules to achieve specific goals. The third layer is strategy based behavior, which is cognitive reconciliation based on external conditions. The decision-making behavior of Shi, and the behavior combination is formed through the rule layer and skill layer. According to Rasmussen's theory of ecological interface design (EID), this paper puts forward three levels of human operating interaction system. According to the characteristics of this behavior level, Michon divides driving tasks into three categories: one is to maintain the normal operation of the vehicle, the so-called control task; the other is to maintain the safe and effective driving of the vehicle, according to the traffic rules and driving environment, the task of safety interaction with other vehicles and the surrounding environment, the so-called Manoeuvring task; the third is route planning, etc. Strategic task that needs driver's reasoning and conception [3]. Three levels divide the task level and structure of urban rail drivers.

(1) Control task: the control task is a skill operation driving task. The object of the task is the vehicle, and the main purpose is to maintain the normal driving of the vehicle. The transformation and execution of control tasks mainly come from the control instructions of strategy tasks and skill tasks [4]. Task time is often measured in milliseconds. The behaviors of control tasks include: control braking and braking control, traction, interior lights, warning lights, sirens, wipers, doors, etc. The interactive components of the control task include: traction pull rod, brake pull rod, emergency brake button, as well as control components such as warning light or wiper door

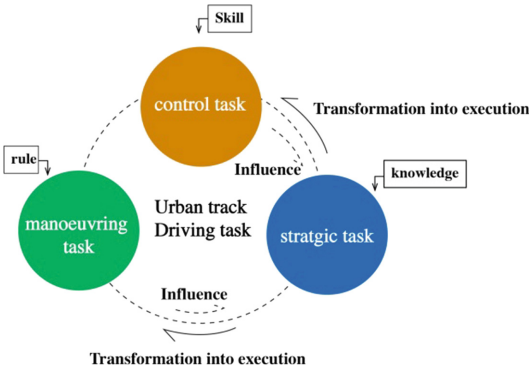


Fig. 1. Driving task model

button. The control task is to realize the basic form function of the vehicle by the user's interactive control.

(2) Manoeuvring task: Manoeuvring task is a rule-based driving task. The task object is the whole driving environment, including driving environment and traffic lights. In essence, the Manoeuvring task is to monitor the driving related information in the environment, with vision as the main sensing channel, and the task time is in seconds, including turnout moving, entering and leaving the tunnel, meeting the train, observing the signals, flags or signboards and other behaviors. The main purpose of technical tasks is to ensure the safety of driving, driving according to the planned path, maintaining a balance between speed and comfort, and maintaining an acceptable driving state.

(3) Strategic task: strategic task is a kind of knowledge-based driving task. The task object integrates human, vehicle and environment, requires complex information processing and decision-making, [5] and controls technical and control tasks in general. The task time is calculated in minutes or hours. Strategy task is a high-level task in driving, which needs more cognitive resources. Strategic tasks can occur before or during driving. Its contents include: train mode selection, departure, arrival and parking, how to reach the destination, etc. When necessary, ATC will also assist the driver to make strategic task decision and execution, such as speed monitoring and overspeed protection, and even start emergency braking automatically.

Norman proposed that Tasks determine the types and levels of information, and information is Task Centered. According to the theory of "task-information" system, [6] the display information of urban rail ar-hud can be screened and classified (Fig. 2 shows).

Task name is the name of the task to be executed, behavior is the main behavior in the task process, and info name represents the visual information of the interface associated with a task [7]. In order to ensure the smooth implementation of urban rail tasks, the display interface needs to present six types of display information. They are the vehicle status information corresponding to the control task, including speed

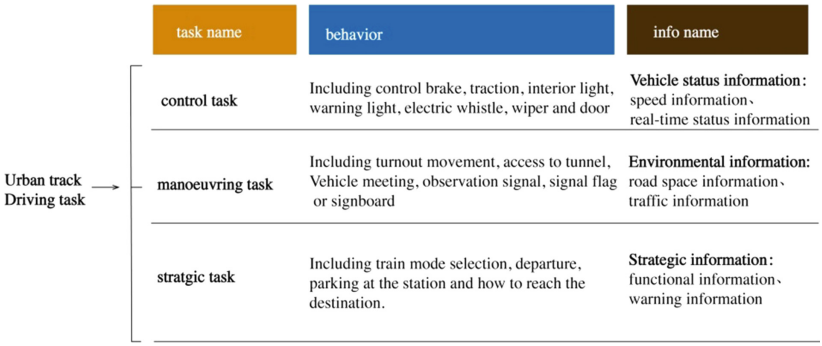


Fig. 2. Display information of urban rail ar-hud

information and real-time status information. The control task mainly requires the driver to control the traction rod, brake rod and emergency brake button. Therefore, the information system needs to have timely feedback on these behaviors. The traction rod, brake rod and emergency brake together constitute the speed information and information system. It is necessary to display the train speed in real time. The grades of traction rod, brake rod and emergency braking constitute the real-time status information. For the completion of warning lights or wiper cars, the driver needs to control knobs, buttons and other control components, and can make hardware feedback through knobs, buttons and so on. The environmental information of corresponding Manoeuvring tasks: including road space information, traffic Communicating information. Turnout moving, entering and leaving tunnels, meeting cars and so on are behaviors in the field of road space. Ar-hud can enhance the space information in front through real scene superposition, such as strengthening the display of the road in front under poor visual conditions. Observation signals, flags or signboards are behaviors in the field of traffic. Traffic information can be identified and enhanced visually through ar-hud; strategic information corresponding to strategic tasks, including functional information and warning information. Departure, arrival and how to stop at the destination are the main behaviors of drivers. Ar-hud can realize the functions of imaging the best stop point, stopping distance and recommended speed. If the driving speed of the driver does not match the speed recommended by the automatic train operation control system, the information system needs to remind the driver of overspeed through the warning information. By combing the theory of "task information" system, six kinds of interface visual information are needed: speed information, real-time state information, road space information, traffic information, function information, state information and warning information.

3 Driving Situation Awareness Design Strategy and Design Practice

Driving tasks exist in situations. Situational awareness is a psychological representation of users' external environmental information, which mainly refers to their awareness of what is happening around you and their understanding of what these information means to you now and in the future. The center of situational awareness is task goal, and the information in the environment is only related to task goal intentionally, which is the key to assist users in task decision-making. Situational awareness plays a key role in the design of information display when users realize the decision-making. Endsley's three-tier model theory is a classical situational awareness theory [8] (Fig. 3 shows).

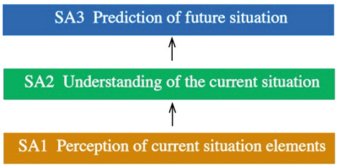


Fig. 3. Three level model of situational awareness

Endsley divides situational awareness into three levels: perception, understanding and prediction. Information is processed from the perspective of information chain. Driving scenario tasks mainly include: first, the control of the train needs to rely on short-term memory and perception; second, the user's perception of the vehicle and environmental status; third, through complex decision-making process planning, driving route execution needs to be decomposed into several sub driving tasks. Gugerty and Tirre puts forward the definition of driving situational awareness. Driving situational elements include: route knowledge, scene understanding (environment and interaction knowledge), spatial positioning knowledge, vehicle knowledge. Situational awareness interacts with information storage in memory to help users form decision-making and action execution in the driving process, and the performance of action execution will be fed back to perception to enter a new circulate In the situational awareness of the wheel [9] (Fig. 4 shows). Based on Endsley's three-tier model theory, this paper analyzes the design strategy of ar-hud in urban rail information display system, including information perception design strategy, information understanding design strategy, information prediction design strategy.

Information Perception Design: The design of information perception is aimed at the user's situational awareness. The perception layer is the foundation of the formation of situational awareness, and situational information perception is the information collection of the original information in the environment. [10] in order to make the vehicle run normally, the control task takes up a lot of cognitive resources, such as control brake lever, traction lever (Fig. 5 shows); it also includes the cognition of train information, such as traction level and braking level. Limited by their own cognitive limitations, the user's cognition of the vehicle is often not fully intuitive. It is necessary

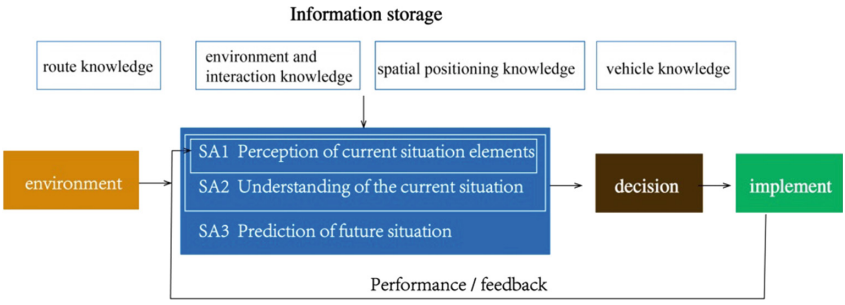
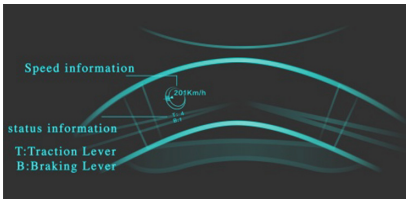


Fig. 4. Situational awareness in driving

to recognize the feedback of various controls in the vehicle and the information of various middleware, such as the accurate value of train speed, which needs to be displayed through the central control. Speed is an extremely important condition in the process of train operation, so the information design of ar-hud should have a high degree of perception (Fig. 6 shows), the speed information needs to be displayed permanently and located in the important display area. For the urgent task with high time urgency, the user needs to respond quickly to the decision-making task with strong warning information, which belongs to the trigger display layer.



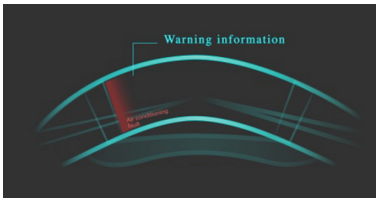


Fig. 5. Information perception design practice-1 **Fig. 6.** Information perception design practice-2

Information Understanding Design: The design of information understanding is aimed at the design of situational awareness understanding layer. Situational awareness understanding is the process of users' internal processing of perceived information. Its main purpose is to understand the meaning of information, including the understanding and evaluation of current situational state. For the overall operation route or remote route, use numerical understanding or graphic understanding to assist the driver to form a good overall route knowledge (Fig. 7 shows). For the near-end route or the need for subtle operations, (Fig. 8 shows) such as stop at the station, the driver needs to stop at the station on time, use both numerical understanding and spatial understanding. Ar-hud needs to strengthen the display of spatial information while displaying the remaining distance to the station, and AR displays the best stop area. At the same time, it is also necessary to follow the metaphor of the ATC system, for example, red is forbidden or strong reminder.

Fig. 7. Information understanding design practice-3

Fig. 8. Information understanding design practice-4

Information Prediction Design: The prediction of future situation is the highest level of situation awareness. Scenario prediction helps users to make decisions by predicting the changes of environmental information and future state. Including the prediction of operation plan, as well as the prediction of driving environment and driving status. Ar-hud can display the overall operation line through the abbreviated circuit diagram before departure. In order to complete the train departure and stop on time, the automatic train operation control system can display the recommended speed information through real-time speed measurement and distance measurement. In addition, (Fig. 9 shows) ar-hud can monitor the forward route and provide display support. For example, it can capture the road information and traffic signal information for the driver in the dark and rough weather (Fig. 10 shows). It can also capture the vehicle information in front according to the vehicle scheduling information of the control center in advance to remind the driver that he is about to meet the vehicle (Fig. 11 shows).

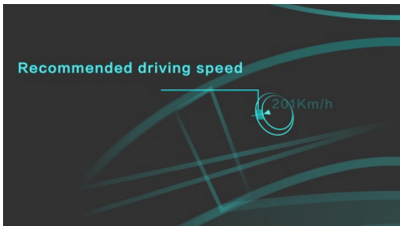


Fig. 9. Information prediction design practice-5

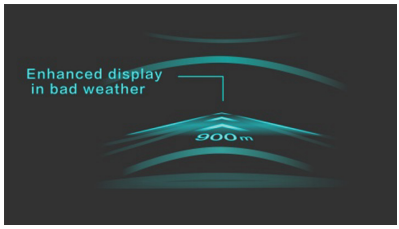


Fig. 10. Information prediction design practice-6

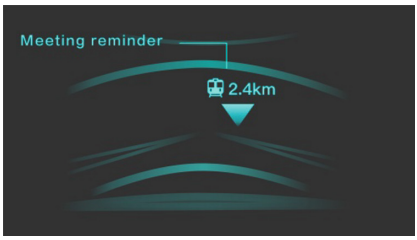


Fig. 11. Information prediction design practice-7

4 Summary

This paper combines the theory of task analysis and situational awareness with the theory of design, computer science and geography to explore the application of the theory in the information display system, which has certain reference value and guiding significance for the design of human factors and information display system, and also has certain exploration discovery and reference significance for the re positioning of ar-hud in the urban rail information display system and its future development direction.

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The Accessibility Design and Evaluation of Civil Aircraft Cockpit

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Abstract. Controls in aircraft cockpit shall be accessible and usable for pilots in different body sizes. The appropriate representative of pilot population that should be taken into account in accessibility design is identified in this paper. General requirements for accessibility design are proposed. According to different operation frequencies, urgencies, and duration of the controls, a principle of arranging cockpit controls in different accessible areas is proposed. Finally, the cockpit accessibility test evaluation procedures and attentions are introduced.

Keywords: Accessibility · Civil aircraft · Cockpit design

1 Introduction

AMC 25.1302 [1] requires that controls shall be accessible and usable by the flight crew. Therefore, it is necessary to follow specific design principles and consider the accessibility of the controls in the cockpit during designing a civil aircraft cockpit. Besides, effectively evaluation of cockpit accessibility should be carried out to ensure that the cockpit is accessible for pilots in different body sizes in a manner consistent with the urgency, frequency, and duration of their tasks. In this paper, a method for designing and evaluating the accessibility of civil aircraft cockpit is proposed from the perspective of engineering designers.

2 Appropriate Representation of Pilot Population

The goal of cockpit accessibility design is to provide acceptable performance for a broad range of pilot physical attributes. Therefore, the appropriate pilot population representation is the key of the cockpit design. Based on regulations, industry standards, and engineering experience, the pilot population representation that should be considered when designing the accessibility of cockpit are as follows:

According to 14 CFR, CS, or CCAR 25.777(c), the controls must be located and arranged, with respect to the pilot's seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flight crew when any member of this flight crew, from 5′2″ to 6′3″ in height, is seated with the seat belt and shoulder harness fastened.

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In addition to height, other body dimensions, such as sitting height, sitting shoulder height, arm length, hand size, etc., can have significant effects on the geometric acceptability of the cockpit for pilots within the specified height range. So these body dimensions should also be reasonably considered during accessibility design.

Some acceptable means of accounting for human size variations include:

(a) Cockpit accessibility test evaluation: Selecting individuals for testing based on reference to an anthropometric database or industry standards which contain information collected from comparative studies of human body measurements and properties, such as GJB 4856;
(b) Cockpit accessibility simulation: Supplementing physical mock-ups with computer anthropometrically-based models; or
(c) Comparing physical measurements of control position to physical measurements in anthropometric databases or industry standards.

3 Cockpit Accessibility Design

3.1 General Accessibility Design Requirement

Well-designed and well-placed controls are essential to safe operations. However, limited space on the cockpit may force compromises when locating controls, so not all controls can be placed in an optimum location. The design of cockpit controls should meet the following general requirements to ensure the overall accessibility of the cockpit:

(a) Controls used most frequently by flight crew should be the most accessible;
(b) Ensure the controls can be operated with a single hand, so that, the remaining hand is free to operate the primary flight controls;
(c) Controls should be useable by both left-handed and right-handed pilots. Especially for controls that require speed or precision in force or motion (e.g., cursor control devices), and controls that are designed to be operated by one specific hand (e.g., sidestick that can only be reached with the left hand for left seat pilot);
(d) Controls that are normally used in flight shall be accessible without interfering with the visibility of critical displays;
(e) For maintenance functions or other functions not intended for pilot use, the related controls should not readily accessible by pilots during normal flight operations;
(f) Dedicated controls should be provided for frequently used functions;
(g) For aircraft that are designed for multi-crew operation, the incapacitation of one pilot must be considered in the determination of minimum flight crew. In the event of incapacitation of flight crew member(s), any control required for flight crew member operation must be viewable, reachable, and operable by other flight crew members, from the seated position.
(h) Accessibility should be shown in conditions of system failures, flight crew incapacitation, and minimum equipment list (MEL) dispatch

(i) If resetting a circuit breaker or replacing a fuse is important for flight safety, that circuit breaker or fuse must be so located and identified that it can be readily reset or replaced in flight.
(j) Use of controls should not affect other pilot operate the necessary controls;
(k) Use of controls should not require the pilot to hold a position for extensive amounts of time without adequate support;

3.2 Classification of Accessible Areas

The space in the aircraft cockpit can be divided into four areas according to different accessibility: type I accessible zone, type II accessible zone, type III accessible zone, and inaccessible zone [2].

(a) Type I accessible zone: The minimum functional accessible zone with the shoulder harness fastened. This area is a functional area where the pilot can reach and operate with the arms and shoulder muscles naturally stretched when pilot is seated in the designed eye position with the seat belt and shoulder harness fastened.
(b) Type II accessible zone: The maximum functional accessible zone with the shoulder harness fastened. This area is a functional area where the pilot can reach and operate with the arms and shoulder muscles maximum stretched when pilot is seated in the designed eye position with the seat belt and shoulder harness fastened;
(c) Type III accessible zone: The maximum functional accessible zone with the shoulder harness unfastened. This area is a functional area where the pilot can reach and operate with the arms and shoulder muscles maximum stretched when pilot is seated in the designed eye position with the shoulder harness unfastened;
(d) Inaccessible zone: This area is a functional area where the pilot cannot reach and operate even the arms and shoulder muscles maximum stretched when pilot is seated in the designed eye position with the shoulder harness unfastened;

3.3 Controls Arrangement Principle

In addition to meeting the general requirements for accessibility, when arranging cockpit controls, they should also be arranged in different accessible areas according to their frequency of use and importance.

Controls can be arranged according to the following principles:

(a) Controls usually located in type I accessible zone:

- Controls used frequently in normal flight operations, or for primary flight control. Generally, they include sidesticks, controls on the glareshield, and most of the controls on the central pedestal, e.g. display control panel, flight mode control panel, thrust levers, flaps levers, etc.;
- Controls that require high accuracy of speed, force, or movement, such as cursor control devices, sidesticks, nose wheel steering handwheels, etc.;
- Major alarm switches, such as the master warning/caution switch;
- Important emergency equipment and critical emergency controls required to operate within a short time, such as oxygen masks.

(b) Controls usually located in type II accessible zone:

- Controls used less frequently in normal flight operations, e.g. landing gear control panel, lighting control panel, anti-ice control panel, electrical control panel and other system control panels;
- Controls or equipment operated in case of emergency or abnormal conditions. Such as: fire control panel, emergency evacuation switch, etc.;
- Controls that need to be operated by the pilot should be located in type I or II accessible zone as much as possible.

(c) Controls usually located in type II accessible zone: Controls not usually operated by the pilot during flight, such as maintenance panels;

(d) Inaccessible zone: Controls that may be operated by the pilot under normal/abnormal conditions should not be located in this area.

4 Cockpit Accessibility Test Evaluation

Cockpit accessibility evaluation mainly adopts two methods: cockpit simulation evaluation and test evaluation. The simulation evaluation is developing a virtual prototype and a 3D human body model during the design to conduct a preliminary accessibility evaluation of the cockpit [3]. The widely used software is CATIA. The accessibility test evaluation is part of the cockpit static evaluation. The cockpit layout and controls layout will be evaluated, through the simulation of actual flight maneuvers on the engineering prototype, to prove that the cockpit accessibility is acceptable. The combination of the two evaluation methods can shorten the cockpit design cycle and ensure the reliability of the evaluation results. This paper focuses on the accessibility test evaluation.

The cockpit accessibility test procedures and attentions are as follows:

(a) Select the test subjects: In order to ensure the confidence of test results, the number of test subjects should be no less than 40. It is necessary to choose test subjects of different flight experience according to the content of evaluation questionnaire. The test subjects with body size at the 5th, 50th, and 95th percentiles of the pilot anthropometric database should be selected, and the number of subjects at the 95th and 5th percentiles should be no less than 5. In addition, the test subjects should include lean body, medium body and hypertrophy, and the number of subjects in each body shape should be no less than 5;

(b) Design a test evaluation questionnaire: The cockpit accessibility test mainly uses questionnaires to evaluate. The questionnaire can be a combination of subjective and objective sections [4]. The objective section records that the control is located in which accessible area for the subject, and if the control's layout meets the accessibility requirements. The subjective section records subjective feelings about comfort, operability or any other aspects in use of the controls. Table 1 is an example of evaluation questionnaire;

(c) Test evaluation: Before the test, the subjects should read the test instructions and attentions carefully, and be familiar with the various evaluation index. Then register the subject's name, age, height, weight, and measure the anthropometric data

Table 1. Example of evaluation questionnaire

Controls		Tuning control panel	Flaps lever	……
Accessibility area	Type I	√	√	
	Type II			
	Type III			
	Inaccessible			
Can it be operated with a single hand?		Yes	Yes	
If it interferes with the visibility of critical displays when use?		No	No	
……		……		
Any suggestion for it (about comfort, operability or any other)				

such as shoulder width, hip width, chest thickness, and waist thickness. During the test, subjects enter the engineering prototype cockpit in groups of two and sit in the left and right flight crew seats. Then the subjects should adjust their posture to a comfortable sitting position and adjust the seats position to ensure that they are at the design eye positions. After completing the above preparations, the subjects should evaluate the accessibility of the cockpit controls according to the test evaluation questionnaire;

(d) Process test data: After the test, the test data should be processed to obtain the cockpit accessibility evaluation results.

5 Conclusion

Good accessibility of the controls is very important for civil aircraft cockpit. In the design process of the cockpit, an integrated design method should be adopted to fully consider the body size differences of the users (i.e., the pilots). The cockpit should meet the general accessibility requirements, and the controls should be arranged in different areas according to their importance. At the same time, the accessibility evaluation should be carried out as early as possible to prevent inappropriate design and make the aircraft cockpit friendly.

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Analysis and Design of High-Heel Shoes' Side Curve Based on Kansei Engineering

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Abstract. The shape of high-heeled shoes can be fully reflected in the side curve, which is the key to the design of high-heeled shoes. What this paper focuses on is how the change of curves reflects different emotional characteristics and satisfies different psychological demands. Methods: In view of the increasing aesthetic and personalized needs of high-heeled shoes, a parameter identification of product form-design method through the SDM is built in the paper, to obtain the perceptual image value of high-heeled shoes design elements, and then by grey correlation calculation, the key factors of product image model can be identified. Results: The importance rank of the factors which reflect the common emotional intention of high-heeled shoes can be acquired. Conclusion: According to the method constructed in this paper, the improved design result meets the expected design input. The method has guiding significance for the emotional intention design of high-heeled shoes.

Keywords: Kansei engineering · SDM · Grey correlation analysis · High-heeled shoe · Form design

1 Introduction

High-heeled shoes worn by modern women have played a pivotal role in footwear and even all apparel products since the end of the 15th century and the beginning of the 16th century, conveying the message of beauty and fashion to people, highlighting women's tall and graceful figure, and eventually becoming women Identity and important self-dressing dress [1]. Different colors, materials, decoration and modeling curves can give shoes different emotional intentions [2]. The research of this paper aims at the overall shape design of high-heeled shoes, and the characteristics of the shape of high-heeled shoes can be fully reflected in its side curve [3], which is the key to the design of high-heeled shoes [4]. In order to identify how to reflect the different Kansei characteristics through the shape change of lines and meet the different style demands of shoe wearers, we want to explore the relationship between them quantitatively through the method of Kansei Engineering.

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2 Characteristics Induction of High-Heeled Shoes

This paper first divided high-heeled shoes into 18 basic models from a styling perspective through extensive market research [5], such as pumps, cones, peep toe, open toe, stiletto, sling back, low-heeled shoes (kitten), chunky heels (chunky), horseshoe heel (spool), platform shoes (platform), lace shoes (mary jane), t-strap, hollow shoes (d'orsay), wedge heel (wedge), scarpins, ankle straps, ruby slippers and lobster claws.

3 Materials and Methods

3.1 Semantic Difference Scale Development

SDM (semantic difference method) was used to study the Kansei engineering of high-heeled shoes [6]. Through further analysis, the most representative Kansei words were selected, and their antonyms were found for matching. The Kansei words were as follows: "living" corresponds to "professional", "implicit" to "unrestrained", "lovely" to "lofty", etc. After extensive collection and selection, factor analysis and cluster analysis, 20 pairs of 40 Kansei words were finally selected. Then the questionnaire survey was carried out, and 10 pairs of 20 Kansei words were finally determined, and the recognition degree was from high to low in order: "fashionable-classical", "elegant-wild", "luxurious-rustic", "casual-formal", "streamlined-geometric", "implicit-unrestrained", "stable-lightweight", "popular-personalized", "traditional-avant-garde", "simple-complicated". Using SDM and Likert scale, the number axis was established, as shown in Table 1.

Table 1. The SD scale for Kansei words

Fashionable	1	2	3	4	5	Classical
Elegant	1	2	3	4	5	Wild
…	1	2	3	4	5	…
Simple	1	2	3	4	5	Complicated

3.2 Sample Images Collection

According to the research on high-heeled shoes in the previous chapter, except for some extremely special types of shape and structure, most of the common high-heeled shoes in the current market belonged to the combination of other basic type features, so this large type of high-heeled shoes was selected as the research target. The Chinese and English names of these dozens of shoes were searched in search engines with the words of "side" and "side view". Attention was paid to avoid the complicated high-heeled sandals and high-heeled boots (with large structural differences and irregular patterns). More than 70 high-heeled shoes side photos were traced, about 50 plane images were obtained, and then 20 with obvious difference characteristics were selected as samples according to similarity, as shown in Fig. 1.

Fig. 1. The 20 sample images for test

3.3 Determination of the Kansei Elements

After the first two steps, the product semantics revealed by each sample of high-heeled shoes could be described in a Kansei word. According to the turning trend of the side curve and the basic components of each part of shoes in the manufacturing process, 10 Kansei element indexes are preliminarily formulated by sketch description. After comparative study sample analysis, the specific Kansei elements finally combined and refined were shown in the sketch of Fig. 2, which are divided into: A. front, B. sole, C. heel, D. back, E top line and F. decoration.

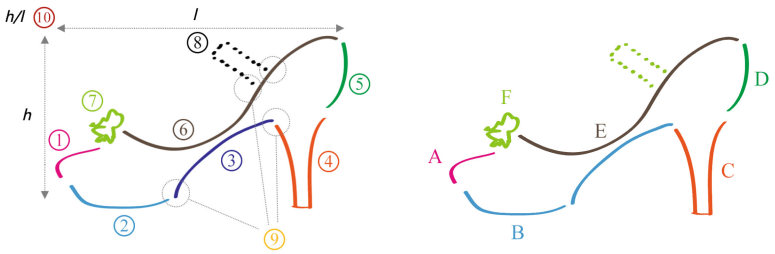

Fig. 2. The Kansei elements preliminarily formulated and finally selected

4 Grey Correlation Analysis

In this study, the grey correlation model was used to calculate the grey correlation degree of each Kansei element index A–F and image sample. According to 10 pairs of 20 words in the SD scale, 10 representative image words on the right side were

selected, which were classical, wild, rustic, formal, geometric, unrestrained, lightweight, personalized, avant-garde and complicated. Taking the Kansei element "classical" as an example, the steps to calculate the correlation degree of each index are as follows.

4.1 Determination of Reference Sequence and Comparison Sequence

In this paper, the Kansei elements was set as a parameter sequence, which was composed of A. front, B. sole, C. heel, D. back, E. top line and F. decoration. Through sorting out the results of the questionnaire, the original data were obtained.

4.2 Normalization of Indicators

The average method is used to normalize the original data.

$$x'_{ij} = \frac{x_{ij}}{\frac{1}{n}\sum_{i=1}^{n} x_{ij}}. \tag{1}$$

Where, x_{ij} represents the value of sample i of the *j-th* indicator and x'_{ij} represents the standard value of indicator j.

Thus, the normalized data results were obtained.

4.3 Calculation of Grey Correlation Coefficient

In this paper, the reference sequence is: $\{s^*\} = \{s_{o1}, s_{o2}, \ldots, s_{on}\}$, and the comparison sequence is: $\{s\} = \{s_{i1}, s_{i2}, \ldots, s_{in}\}$, the correlation coefficient ξ_{ik} of the *k-th* index of the *i-th* sample and the *k-th* optimal index value in the reference sequence are calculated by the correlation analysis method.

$$\xi_{ik} = \frac{\min\limits_{i}\min\limits_{k}|s_{ok} - s_{ik}| + \rho \max\limits_{i}\max\limits_{k}|s_{ok} - s_{ik}|}{|s_{ok} - s_{ik}| + \rho \max\limits_{i}\max\limits_{k}|s_{ok} - s_{ik}|}. \tag{2}$$

Where, ρ is the resolution coefficient, $\rho \in [0, 1]$, generally 0.5, which is introduced to reduce the influence of extreme value on calculation.

Table 2. Grey correlation coefficient of the Kansei element "classical"

Kansei elements	A. front	B. sole	C. heel	D. back	E. top line	F. decoration
Sample	Average value	Average value	Average value	Average value	Average value	Average value
1	0.7058	0.7112	0.7926	0.7790	0.7692	–
2	0.9316	0.9735	0.8912	0.8697	0.9664	–

(*continued*)

Table 2. (*continued*)

Kansei elements	A. front	B. sole	C. heel	D. back	E. top line	F. decoration
Sample	Average value	Average value	Average value	Average value	Average value	Average value
3	0.8562	0.5892	0.6553	0.6410	0.5959	–
4	0.8135	0.9896	0.7826	0.6865	0.6941	–
5	0.8848	0.9190	0.8457	0.9572	1.0000	–
6	0.8361	0.7268	0.9991	0.7284	0.7279	–
7	0.7925	0.7150	0.6376	0.7193	0.8100	–
8	0.7377	0.6133	0.6623	0.7687	0.6504	–
9	0.7357	0.7012	0.9443	0.7545	0.6455	–
10	0.7554	0.5688	0.7829	0.6311	0.5200	–
11	0.8110	0.7369	0.8470	0.6941	0.5932	–
12	0.7515	0.5903	0.6757	0.7268	0.6145	–
13	0.9924	0.9655	0.9589	0.9885	0.8183	0.3982
14	0.8135	0.6999	0.7528	0.6865	0.6724	0.4428
15	0.7537	0.8396	0.9282	0.9013	0.9910	0.6729
16	0.9348	0.7167	0.7574	0.9956	0.7830	0.4631
17	0.8468	0.9600	0.6794	0.7536	0.7297	0.4199
18	0.9777	0.6867	0.9282	0.9353	0.8703	0.4209
19	0.7558	0.6947	0.7876	0.7314	0.7057	0.4404
20	0.7753	0.9679	0.7180	0.9986	0.8263	0.6648

Table 3. The sorted table of the Kansei element "classical"

Kansei elements	A. front	B. sole	C. heel	D. back	E. top line	F. decoration
Average value	0.6934	0.6319	0.6683	0.6667	0.6028	0.6392
Priority	1	5	2	3	6	4

Thus, the results are shown in Table 2.

According to Formula 3, the average value of grey correlation coefficient can be calculated to get the grey correlation degree of each index, as shown in Table 3:

$$\xi_k = \frac{1}{n}\sum_{i=1}^{n} \xi_{ik}. \tag{3}$$

The results are as follows:

It can be seen that the influence of element A. front and C. heel is greater; the influence of D. back and F. decoration is in the middle; the influence of B. sole and E.

Table 4. The sorted table of all Kansei elements' grey correlation coefficient

Kansei elements		A. front	B. sole	C. heel	D. back	E. top line	F. decoration
Classical	Average value	0.6934	0.6319	0.6683	0.6667	0.6028	0.6392
	Priority	1	5	2	3	6	4
Wild	Average value	0.6799	0.7048	0.6971	0.6781	0.7129	0.7180
	Priority	5	3	4	6	2	1
Rustic	Average value	0.7557	0.6477	0.7128	0.7094	0.7800	0.6884
	Priority	2	6	3	4	1	5
Formal	Average value	0.7054	0.6651	0.6678	0.6876	0.6774	0.6906
	Priority	1	6	5	3	4	2
Geometric	Average value	0.6570	0.6353	0.6333	0.5924	0.6226	0.7185
	Priority	2	3	4	6	5	1
Unrestrained	Average value	0.6444	0.6038	0.6448	0.6688	0.6384	0.6267
	Priority	3	6	2	1	4	5
Lightweight	Average value	0.6106	0.6517	0.6061	0.6002	0.6330	0.7269
	Priority	4	2	5	6	3	1
Personalized	Average value	0.6385	0.6233	0.6562	0.7307	0.6679	0.6404
	Priority	5	6	3	1	2	4
Avant-garde	Average value	0.6515	0.5920	0.6308	0.5686	0.6535	0.7131
	Priority	3	5	4	6	2	1
Complicated	Average value	0.6626	0.6154	0.6357	0.6891	0.6519	0.6071
	Priority	2	5	4	1	3	6

top line is less. In the same way, we can calculate the rest of the Kansei elements' grey correlation coefficient, and sort out all the results to get the following table (Table 4).

5 Design Result

According to the analysis results in the previous chapter, it was assumed that a design improvement proposition is to design a high-heeled shoe that emphasizes "classical" but has a little "unrestrained". "Classical" score highest sample 10 was selected as the basic version, and "unrestrained" score highest samples 18 and 20 were taken as the improvement direction. D. back, C. heel and A. front were chosen to modify mainly. In addition, the sample 16 with the highest "unrestrained" back was used as reference for improvement. Furthermore, the design sketch was drawn and rendered in PS to make the visual effect more realistic and full to improve the accuracy of evaluation, as shown

Fig. 3. The rendering design result

in Fig. 3. After another round of questionnaire evaluation, the revised design met the design input and expectation.

6 Conclusion

Taking Kansei engineering concept as an important design criterion not only identifies the most important or influential design elements, but also reasonably allocates design resources for new high heeled shoes, which is very beneficial to the development of the industry.

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