Investigation into Designing of Elderly Products Intending for the User's Behavior Experiencing

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Abstract. Body gestures are the key point affect the elderly daily life (ADL). Seidel, D., et al. [1] An innovative designing method based on user's behavior experience is proposed in order to improve the experiencing and to mine innovative points of elderly product design. Complete interactive processes between users and products are captured through penetrating into users living scenes. A Laundry Behavior Coding (LBC) system is proposed special for the elderly in China. Ethnography methods, behavior observation, oral presentation and in-depth interviews are also deployed. 20 participants (10 young and 10 elderly) participated the study focused on drum washing machine. A special Behavior Interaction Model (BIM) is established by extracting the behavior coding gap, which is obtained by comparing the coded sets of both the old and the young. Implicit demands are discovered in order to realize innovative designing of laundry machine for the old and to enhance users' experiences.

Keywords: Elderly products · Behavior experience · Data encoding · Implicit demand · Design innovation

With 200 million people that are over 60-year-old, China has entered the acceleration period of aging in 2014. User experience is the key to verify the market and the product. However, user's sensory experience and emotional experience are always concerned while behavior analysis is ignored. Body gestures involved in ADL (a.k.a. activities of daily life) including cooking, laundering, house working and shopping, etc. are the key restrictions to the independency of elderly people's daily life [1]. However, most of the products design is aiming at young group. The significant differences of physiology including bones and muscles between the old and the young are ignored, which leads to a conditionality in using gestures of the old. The International Organization for Standardization (ISO) [2] suggests a trunk inclination of >60° and maintained for 4 + s as 'Critical' gestures. Currently 3 % of cooking and 10 % of laundry gestures accounted for critical gestures for the old [3]. Gestures including bad bending and torsion, unbalanced stretching, squatting knees and neck inclining will increase the risk of getting ill, increase the difficulty of usage while reduce the efficiency.

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Understanding users' demands and abilities is a key factor in users' experiences designing [4]. The purpose of this paper is to investigate the elderly people's implicit demands from their daily life behavior data to avoid risky gestures. Meanwhile, capturing their implicit demands will become a new breakthrough in innovative designing for elderly products. Bad experiencing as well as unreasonable usages of elderly products can be resolved. In this manner, the independency of the elderly people will be advanced.

1 Introduction

The user experience concept proposed by marketing expert Betnd.H.Schmitt [5] contains five parts, the sensory, emotional, thinking, behavior and associate experience. The user experience is the key issue to validate the success of the market, and the 'behavior experience'is the most direct experience between the users and the products. All the interact information is passed from the sensory system to the behavior system. The useful product information can be obtained by the users through direct interaction with the products. Jelle Stienstra [6] described a design method based on the experience of the behavior. This method emphasizes a close loop of 'behavior – perception' which turns virtual behavior into 'tangible materiality'. In this manner, behavior activities can be used directly or indirectly into the design knowledge.

There are many research methods about working gestures in Ergonomic. Karhu decomposed the working gestures into codes of the back, arms and legs respectively through an observation method which is based on the behavior coding of OWAS (Ovako Working Posture Analysis System) [7]. Gestures can be indicated sequentially in this way. At the same time, OWAS method can be used to evaluate the coding risk level and high level risk must be improved immediately. In a similar method, REBA (Rapid - Body Assessment) [8], body postures can be divided into the trunk, neck, legs, upper arm, forearm and wrist 6 parts. The risk level of work posture can be concluded by the means of the posture angle measure .RULA (Rapid Upper Limb Assessment [9]) method is used to evaluate the work of the Upper Limb active task. It can collect and analyze the data of the wrist, arm and body gestures. The research proves the reliability of the behavior data acquisition through observation methods. However, focus of these researches lies in evaluating working gestures of adults. Gestures of the elderly people still lack of investigation.

2 Methods

2.1 Sampling

Laundry is a typical task in elderly people's daily life. The whole procedure of the laundry consists of some common gestures including neck rotation stretching, arm outstretching, trunk bending twisting and bent leg supporting, etc. Analyzing those common gestures such as bowing, kneeling and hand picking during laundry gives a guiding significance in investigating other tasks as taking a vehicle, shopping and using bathroom. Thus, the laundry task is chosen as a typical case in this study.

2.2 Data Collection Methods

Compared to the young, the elderly takes special behavioral strategies. With the purpose of investigating the implicit demands of the elderly people, a sample of 10 elderly people and 10 young people is chosen to provide the useful data. A laboratory environment rather than home environment is deployed in order to prevent experimental errors including different types of laundry machines and different factors of familiarities. Those subjects are requested to finish a preset task using the same laundry machine.

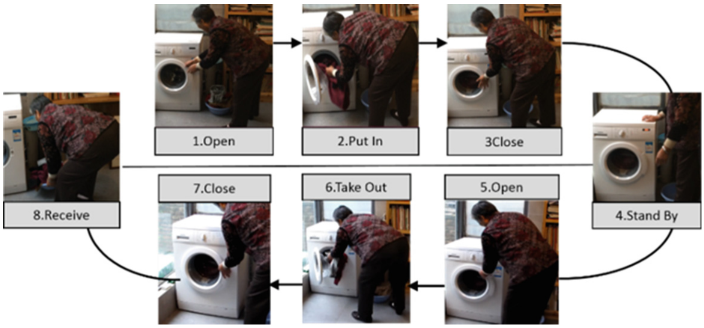

Fig. 1. Laundry procedure

(a) Preparation.

- Pretest. A video of using a laundry machine is made by the researchers in elderly people's home before the experiment, which aims at summarizing the procedures during laundry as illustrated in Fig. 1. Suggestions for environment arrangement are also shown in this video.
- Subjects choosing. The subjects in this research are classed as the young and the elderly. 10 subjects including 3 male and 7 female with the age over 70 are recruited randomly at the retired community of Nanjing University of Science and Technology. 10 subjects including 4 male and 6 female with the age between 20 and 30 are also recruited in Nanjing University of Science and Technology. All of the 20 subjects have the experience of using laundry machines.
- Testing device. A tumbling-box laundry machine for home use, a video camera and special testing caps with red marks are provided. Subjects are asked to wear the testing caps before the experiment. Red marks are also located on their shoulders, hips and knees.
- Testing missions. By reference to Fig. 1 during the pretest, the whole testing consists of opening, putting in clothes, closing, standing by, opening, taking out clothes, closing and clothes storage.
- Notes. Test can be shut down at any time if the subject feels uncomfortable or unavailable.

(b) Testing.

1. Adapting the experiment environment and learning the instruction.
2. 20 subjects with red marks performing the 8 test missions. Each one performs independently in order to prevent the behavioral learning effect.
3. Video recording is performed from the side view in order to capture the behaviors.
4. Short interviews are made after the test.

2.3 Behavior Coding Set

The position of neck, waist and knees are commonly the pain points of the elderly in China. The Laundry Behavior Coding (LBC) system is established according to the actual situation of the elderly in China and the position coding system provided by D. E. Gyi et al. [10]. Moving angles of neck, shoulder, waist and knees of the subjects are fully recorded by the camera, which leads to a whole video. The LBC System is shown in Fig. 2. Seven variables including angles of neck, trunk and knees, torsion of trunk, hand picking, leg supporting and additional aids are observed. The angle threshold values are set as 30, 60 and 90 degrees. Numbers of 1, 2, 3, and 4 are selected for coding. It should be noted that the angle of neck, which is chosen to distinguish the differences between the young and the elderly, is not a real angle as indicated in Fig. 2.

Capturing the angle of neck is realized by finding the angle between the line from the red mark to the sagittal cervical root node and the vertical line. According to the method of TO de Souza [11], the trunk angle is captured through the line from femoral greater trochanter node to shoulder center node of sagittal plane and the vertical line. The angle of knee is the angle between legs. The objects of LBC System are images. Therefore, an image of putting into/taking out clothes is captured as a combination of typical gestures including waist bending, kneeling and grabbing. The videos of 20 subjects are collected. Images are captured and processed into codes in the manner of LBC System, which is shown in Fig. 3. Coding set of the differences between the young and the elderly are obtained, which makes a preparation for further investigation.

Laundry Behavior	Action Coding			
Neck Angle (NA)	1. 0-30°	2. 31° -60°	3. 61° -90°	4. >90°
Trunk Angle (TA)	1. 0-30°	2. 31° -60°	3. 61° -90°	4. >90°
Trunk Twist (TT)	1.None	2.Left	3.Right	•
Knee Angle (KA)	1.0-30°	2.31° -60°	3.61° -90°	4. >90°
Hand Pick (HP)	1.Both	2.Left	3.Right	•
Leg Support (LS)	1.Both	2.Left	3.Right	•
Additional Aids (AA)	1. None	2.Left hands	3. Right hands	4.Other

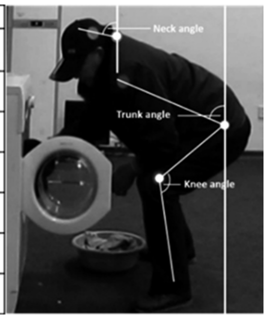

Fig. 2. Laundry behavior coding (LBC) system

Gender / Age	Female 22	Male 23	Female 21	Male 21	Female 20	Female 21	Female 22	Male 24	Male 21	Female 22
NA	1	2	1	4	1	4	2	2	3	2
TA	1	1	1	2	1	4	2	1	2	2
TT	1	1	1	3	1	3	1	1	1	1
KA	3	3	3	4	2	4	2	2	1	2
HP	1	2	1	1	1	3	1	3	1	1
LS	2	2	3	1	1	1	1	3	3	1
AA	1	1	1	1	1	1	1	2	1	1

Gender / Age	Male 72	Female 74	Female 70	Female 76	Female 80	Female 80	Female 80	Male 72	Male 78	Female 72
NA	4	3	3	4	4	3	3	4	3	3
TA	3	3	3	3	3	3	3	3	3	3
TT	1	1	1	2	2	1	1	1	1	1
KA	4	4	4	4	4	4	4	4	4	4
HP	1	3	1	3	3	2	1	3	3	2
LS	1	1	1	1	1	1	1	1	1	1
AA	1	2	1	2	2	3	1	2	2	3

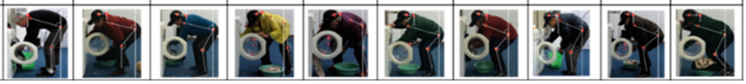

Fig. 3. A list of the difference codes

3 Results

3.1 Significance Level of Typical Behaviors

First of all, observation of the marked lines on subjects' bodies indicate a striking difference between the young (n = 10, mean age = 21.7 and SD = 1.1) and the elderly (n = 10, mean age = 75.4 and SD = 3.9). What's more, statistics and analysis of the codes show that obvious differences are obtained between the angles of necks (NA), the angles of trunks (TA), the angles of knees (KA), leg supporting (LS) and additional aids (AA). However, the differences between the torsion of trunks (TT) and hand picking (HP) are relatively small. With the aids of SPSS, a box plot of the codes from the young and the elderly are obtained, which is shown in Fig. 4.

- NA. ①80 % of the young subjects are classified in Code 1 and 2 with NAs less than 60°. ②All of the elderly subjects are classified in Code 3 and 4 with NAs greater than 60°.
- TA. ①50 % of the young subjects are classified in Code 1 with TAs less than 30°. 40 % of the young subjects are classified in Code 2 with TAs vary from 30° to 60°. ②All of the elderly subjects are classified in Code 3 with TAs vary from 60° to 90°.
- KA. ①All of the elderly subjects are classified in Code 4 with KAs greater than 90°. It should be noted that all of their KAs are equal or greater than 120° in actual measurements. ②50 % of the young subjects are classified in Code 1 and 2 with KAs less than 60°. 30 % of the young subjects are classified in Code 3 with KAs from 60° to 90°. 20 % of the young subjects are with KAs greater than 90°.

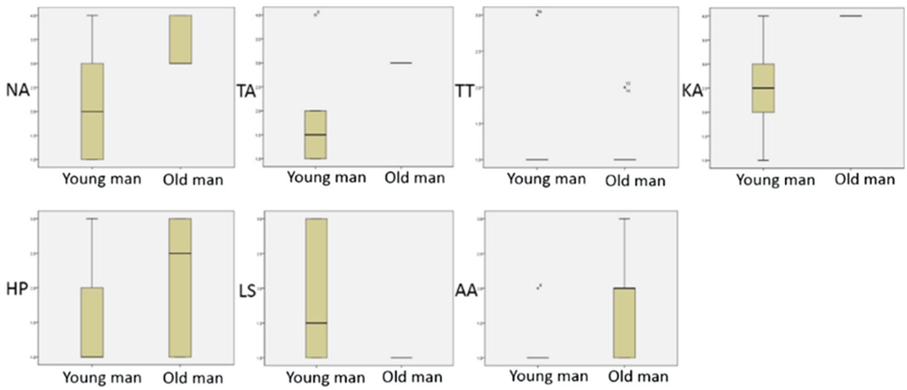

Fig. 4. Significance differences between the young and the elderly: NA: $p < 0.01$;TA:$p < 0.01$; KA:$p < 0.01$;LA:$p < 0.05$;AA:$p < 0.01$;

- LS. ①All of the elderly subjects are classified in Code 1, which means their bodies are balanced with both legs for supporting. ②50 % of the young subjects are classified in Code 2 and 3. Only left or right legs are used for supporting.
- AA. ①70 % of the elderly subjects are classified in Code 2 and 3. Additional assistances are applied using their left or right arms. ②90 % of the young subjects are classified in Code 1 with no additional assistances. Only 1 young subject are classified in Code 2 because the left arm is used for additional assistances.

3.2 Special Behavior Interactive Modeling

The testing results, which are illustrated in Fig. 5, show an obvious difference between the gestures of the young and the elderly during the laundry procedures. The main difference lies in NA, TA, KA, LS and AA. KA of elderly (≥120°, n = 10) is the key factor of the difference. In order to reach the bending scale, the elderly people have to bend much harder both in their necks and trunks, which leads to a result of unbalanced bodies. At this point, additional assistances of hands must be applied to come over the imbalance. According to the reports and interviews, KAs of the elderly are the results

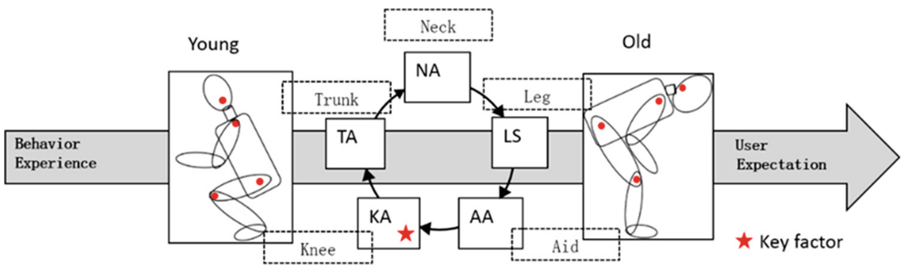

Fig. 5. BIM (behavior interactive modeling)

of three factors. The first factor is the pain in the knees during bending. The second factor is dizziness during unbending. The last factor is the additional assistance with hands to keep their bodies balanced. Analysis indicates that with a huge TA (60° to 90°, n = 10), lumber sprain could take place due to an overwhelming load for the sacral spine muscles. What's more, as all of their NAs are over 60°, muscles and bones at necks and shoulders are also under loads. On the other hand, with healthy knees, the young prefer a gesture of bending one knee during the laundry procedures. In this manner, their bodies and necks are relatively straighter than those of the elderly, which leads to a smaller load on waists, necks and shoulders.

Special behavior interactive modeling (BIM) is realized by capturing the differences between the behaviors of the young and the elderly. The BIM, as shown in Fig. 5, is divided into two stages. The first stage is materialization of difference behavior experience. In this stage, the differences are scaled into quantitative descriptions. Among the specific numbers with visualized descriptions, the key codes can be obtained. In this study, the young subjects and the elderly subjects show obvious differences in variables of NA, TA, KA,LS and AA, especially in KA, LS and AA. The second stage is the transformation from the quantified differences into special behavior demands. This paper indicates that laundry procedures for the elderly should meet the demands that KA should be equal to or greater than 120°, TA should be smaller than 60° [2], two legs for supporting and additional assistance of hands to prevent imbalance.

4 Discussion

Because of musculoskeletal degeneration and weak balance, the elderly who operating laundry machines using waist bending/kneeling postures for a long time does not conform to ergonomics. In this paper, a new design has been obtained by transforming the elderly implicit demands into visual designing knowledge using special behavior interactive modeling (BIM) system. Comparing with the young, the elderly need to interact with products more smoothly for their specific needs. An improvement for the tumbling-box laundry machine has been proposed according to LBS system and BIM mapping method.

A diagram of critical state of bending is shown in Fig. 6 (left). The green area in TA is the suggested activity range for trunk with a maximum value of 60°. The elderly must maintain their TA less than 60°in the laundry process. [2] (TA3 and TA4 are dangerous codes). The red area in KA is the inhibited activity range for the knees with a minimum value of 120°. The elderly must maintain their KA over 120° in the laundry process. (KA1, KA2 and KA3 are dangerous codes). A one-hand operating laundry machine needs to be designed because of the variable of AA. It indicates that most elderly people require additional assist, because they fetched clothes with one hand frequently. The right diagram of Fig. 6 shows the bad gesture codes at neck, trunk and knees of the user, which suggests a multi-variable designing to improve NA, TA, KA and AA.

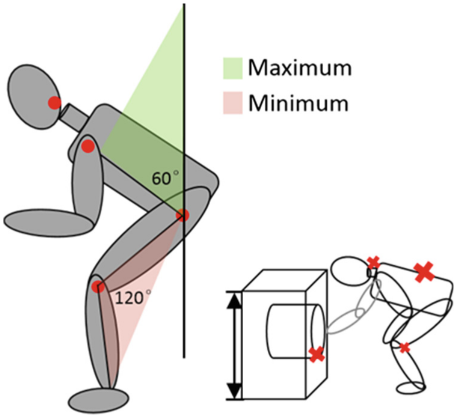

Fig. 6. Critical state of bending for elderly

5 Conclusion

Gestures including bad bending and torsion, unbalanced stretching, squatting knees and neck inclining will increase the risk of getting ill, increase the difficulty of usage while reduce the efficiency. Capturing the real implicit demands is the first step in understanding the elderly as their implicit demands are difficult to describe by their own. In this paper, ethnography methods, behavior observation, oral presentation and in-depth interviews have been deployed. A Laundry Behavior Coding (LBC) system have been proposed to visualize the implicit demands. This study shows a great significance in avoiding risky gestures as well as improving the independency of the elderly people. The implicit demands have been transformed into design knowledge to solve the mismatching problems occurred between elderly users' behavior experiences and product designing. Behavior cognitions and user's experiences have been advanced. Assistances have been provided for the innovative designing of the elderly products.

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