DESIGNING FOR EMPATHY
RESEARCH EXPANDING AGING EXPERIENCE SUIT FOR EDUCATIONAL PURPOSES

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1. INTRODUCTION

With more and more aging issues under the contemporary circumstances, designers, researchers, and design educators need to pay attention to these issues in relation to the product design field. As an important aspect of developing design criteria, designing for empathy can be seen as a great approach to help designers and design student with the product, service, and system design. Developing empathy through experience provides opportunities for students to understand how the older adults feel, what they experience, and why they act in certain ways in their real life. Hence, kits or devices that can provide students with an aging experience can be important in the early stages of the product design process. In this paper, topics related to aging simulation, experience development, and a current lab aging kit will be explored.

1.1. PRODUCTS AND ENVIRONMENTS FOR THE AGED

According to the U.S Census, there were 40.3 million more people who were 65 years and over living in America in 2010 compared to 2000. The population over 65 is expected to increase more rapidly in the near future as the first Baby boomers (1946-1964) turned 65 in 2011 (Rahrer, 2013). As a result, the concept of 'ease of use of product' is becoming considered applicable to the general population including older adults (Vanderheiden et al., 2000). Representing a 286.7 billion dollar elder care market segment in 2012 and 319.8 billion dollars in 2013 (BCC research, 2014), the products and spaces designed to meet the needs of this growing demographic is increasing but still not meeting all their needs. There is a gap between designers' knowledge and the needs of the older user even though the changes associated with aging are well documented (Boot et al., 2012) and are known to impact the manner in which older adults interact with products and spaces (Boot et al., 2012). Design for aging is a supported by many fields of study including gerontology, ergonomics, human factors, occupational therapy and design (Gilbert, & Rogers,1999; Josh, 2013). Transgenerational design, design for aging, and human centered design educate designers and healthcare providers using a combination of readings, lectures, and training. One mode of education is focused on developing empathy for the individuals, in this case older adults.

1.2. AGING EXPERIENCE AND SIMULATION

Problems experienced by older adults can be categorized into four categories: cognition, motivation, physical, and perception (Holzinger et al., 2007). The physical effects of aging cannot be classified clearly; however studies show a number of common physical illnesses as well as capability declined that can be classified as age-related issues. Simulation of elderly physical capability declined is a recent practice within the field of empathy design. Simulation is a method that encourages designers to put themselves in 'someone else's shoes' (Cardoso, &

Clarkson, 2012). According to Gaba (2004), simulation is a technique to replace or amplify real experiences with 'guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner'. Simulation has been embraced by the healthcare community as an important method for improving clinical training and patient safety (Wang, 2011). Meanwhile, education about the aging process has been an important foundation for improving knowledge about caring for older adults. The study shows that if the aging process is being understood or informed correctly, the quality of caring for older adults can be improved (Yu, & Chen, 2012). Hence, it is beneficial for designers and the students who are planning to be in the design field in the future to have a simulated aging experience. By going through the aging simulation process, they can experience some of the frustrations or challenges an older adult might feel when they use a product or act under a certain environment. However, despite the advantages of using aging simulation techniques, research in this area still has a series of important limitations that need to be considered. First of all, realism ought to be under consideration when using the aging simulation technique. Realism in this context refers to the level of fidelity that the simulation devices or kits present and how accurate they are in simulating capability declined (Cardoso, & Clarkson, 2012; Hitchcock, 2001). Secondly, aging simulation techniques are typically constrained to external components that reduce the wearer's physical abilities, which is not an accurate replication of what the older adults may experience (Hitchcock, 2001; Hitchcock, 2003). In addition, it has been widely acknowledged that simulation does not enable the wearer to fully understand the consequences of being constantly suffered from capability declined (Cardoso, & Clarkson, 2012). In reality, it is important to consider that older adults may suffer from capability limitations for a long time. And older adults may have learned how to compensate for it by relying on products and surroundings. In this way, designers may not predict or experience even though wearing the aging simulation kit.

1.3. PROBLEMS WITH EXISTING AGING SUITS

There is several aging suits currently used or 'on the market'. In 1990, Ford Motor Company developed an aging suit called "Third Age Suit" for understanding the challenges faced by older adults when entering and exiting vehicles. Though developed for understanding experiences with cars, the 'Third Age Suit' has been used in multiple industries (Cardoso, & Clarkson, 2012). The newest version can be seen in the left side of Figure 1. In 2005, a Massachusetts Institute of Technology (MIT) team named their aging simulation suit AGNES ('Age Gain Now empathy System). The later version can be seen in the middle of Figure 1. The GERT (GERontologic test) suit can be seen in the right side of Figure 1 (Rahrer, 2013).

Figure 1. Existing aging suits

These aging suits have a number of benefits for providing experiences similar to those of older adults, but they also have some limitations. First of all, these suits are complicated to put on and take off making the simulation a bit of a challenge when working with a group of designers. For example, only limited number of students or participants can try on these aging suits during a limited time such as during a class or design workshop. Also, students or participants need to wear the full suit to have a walking or mobility experience. This makes them less likely to wear the aging suit outside in a real environment. Additionally, these suits are quite noticeable owing to the many pieces that must be worn. Finally, the prices of these aging suits are quite expensive. For instance, the price of gerontologic test suit GERT is € 1,240(~$1,367). For many organizations, these prices are cost prohibitive thus limiting the number of individuals able experiences the simulations.

1.4. CURRENT LAB AGING KIT

The aging kit developed by our lab was designed with several priories: the materials or pieces could be easily obtained or ordered, the kit was to be inexpensive and the simulation could be used incrementally (to build an aging experience over time or so that certain elements of aging could be highlighted). The aging experience kit includes components to address age related changes in five areas:

Areas	Aging Kit
Vision	yellow safety glasses, visual simulators (light house international)
Hearing	in ear, over ear hearing protectors
Range of motion	Neck- soft foam cervical collar ($8~) Back- mid and lower: heavy-duty back support belt (~$10) elbow: flexible elbow brace ($9) Shoulder and upper back: 26" bicycle tire inner tubes (~$8), 13 grommets (~$28), and 4 Velcro straps (VELCRO ONE-WARP Straps, used for cord control ~$6), wrist- wrist guards (~$11) fingers: Velcro straps
Strength	Upper extremity- bicycle tire inner tubes fingers: Velcro straps, hand- Velcro straps
Tactic sensitivity	baby powder corn starch (~$4)

Table 1. Current aging kit in the lab

These kits are comprised of cost-effective, easily purchased components and have received positive feedback from students, design professionals and engineers who have used these aging kits in order to empathize with the older adult experience. The focus of this paper is the augmentation of the aging kit as an empathy tool by simulating changes of an older adult in their posture and gate by wearing a simple lower extremities component under the shoe.

1.5. PURPOSE OF THIS STUDY

The purpose of this study is to design a lower extremity component for our simple aging kit which is easy to wear, is compact in size and inexpensive, so that many individuals (including students, participants in design and conference workshops, and clients in product specific training sessions) can have a simple, whole body aging experience supporting empathetic design.

2. METHODS

While several attempts at generating a lower extremity component for the aging kit have been attempted for the aging kit (and not succeeded), this study will focus on our latest, successful design investigation. The assumption in this study was that changing the angle of the foot bed (the angle between ground and plane under the sole of the foot — from toe to the heal) could effect an individual's posture producing a stance and gate similar to the older adult such as bending their knees, hunching their back and shoulders forward, and decreasing their stride length owing to a shuffling gate. The prototypes of angled foot beds for aging kit were made; pilot research was conducted with 5 younger adults in a lab setting to assess the effects on postural and gate changes. Future work will be to compare the effects of the prototyped angled foot beds worn by young adults to those the postures and gates of older adults.

2.1. PROTOTYPING

Prototype shoes were made to test the assumption in a pilot investigation. Sandals were chosen for modification in order to making the prototype shoes because they can be adjusted not only on the upper part of the foot but also around the ankle for a secure fit. For the bottom part of the prototype shoes, three angles of inclination (0°, 12°, and 24°) were evaluated using lightweight plastic foam cut in wedge shapes. The foam wedges, for both the left and right feet, were attachable to the bottom of the sandals. Velcro was used to secure the top of the wedge to the bottom of the sandals.

Figure 2. Prototype

2.2. PILOT TESTING

The performances of the prototype shoes were pilot tested in a research lab. Five participants (2 males, 3 females, age range from 24 to 44 years with good physical health conditions) participated in the pilot test. Before the test, seven reflective markers were attached to the body for posture tracking purposes. The seven markers were placed on the right side of the participant's body: over the center of the temple, at the corner of eye (canthus), on the middle of the ear (tragus), over the 7th cervical (C7) vertebra, and the center of rotation (COR) of the shoulder, hip, and knee. The task performed was walking the length (walking distance = 189"~16') of the lab (which is a flat surface). Participants were asked to perform the walking task twice in each condition. The order of presentation of the shoe angle (0°, 12°, and 24°) was randomized. In the 0° condition, participants walked the length of the lab wearing the flat sandals provided to them. In the 12° and 24° conditions, participants wore the sandals with foam wedges affixed to the bottom of the sandals. Participants were asked to walk 'naturally' and were allowed to look where they felt comfortable (some looked at the ground, some at the wall). Participants' pace, stride length and posture were not controlled in an effort to observe the effect of the sandals and changes in foot angle on their natural gate and posture while walking. The pilot test for each participant, for each condition was video (GoPro camera) recorded from the right side of the participant. The camera was placed in the middle of the lab, parallel to the direction of participants' walking.

Figure 3. Pilot testing

2.3. DATA ANALYSIS

Tracker (a video analysis and modeling tool built on the Open Source Physics (OSP) Java framework [Tracker software, 2015]) was used to analyze the videos recorded during the pilot test. Tracker can be used manually or in an automated tracking mode to collect marker position data. Based on the positions of tracking markers, four angles in the walking position were tracked and calculated: head tilt (angle between the temple, the center of the ear (tragus) and the horizon or horizontal axis), neck tilt (angle between corner ear, COR shoulder and the COR hip), back angle (angle between the COR shoulder, COR hip and COR knee) and knee angle (angle between the COR hip, COR knee, and ankle). The stride length and number of steps taken across the walking distance were also measured in the Tracker program (Figure 4).

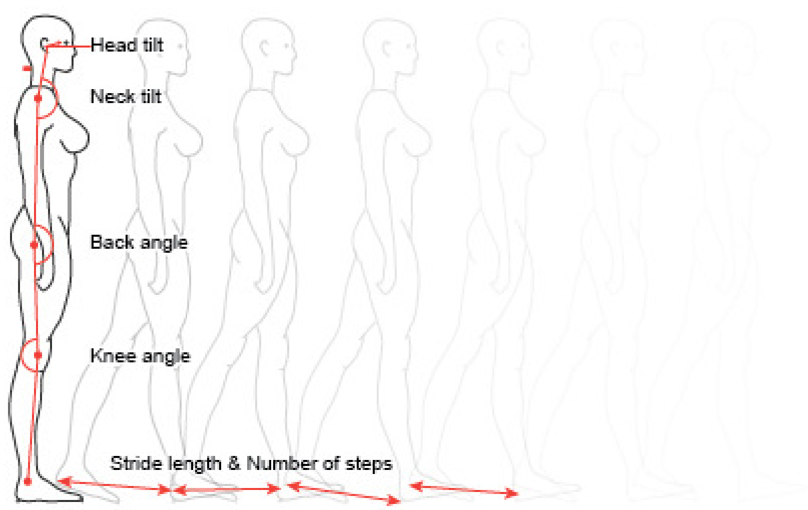


Figure 4. Measurements position

3. RESULTS

The following comparison depicts the differences between data sets with the aging simulation kit prototype shoes.

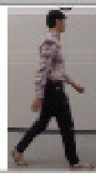
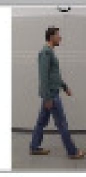
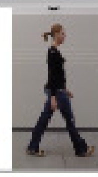
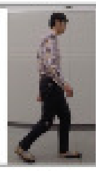
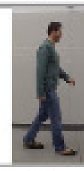
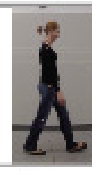
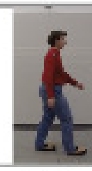
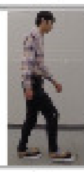
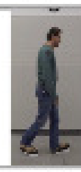
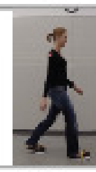
	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
 0 degree					
Average head tilt	15	26.8	19.9	30.2	28.0
Average neck tilt	155.5	160.7	174.5	156.7	183.8
Average back angle	170.5	187.2	198.0	222.2	165.0
Average knee angle	141.9	167.6	168.6	160.1	149.2
Average stride length	37.5	25.4	27.7	28.9	28.1
Number of steps	5	8	6	5	6
 12 degree					
Average head tilt	-3	23.3	-3.3	8.7	21.4
Average neck tilt	163.5	158.8	167.7	151.6	182.4
Average back angle	167.8	189.7	168.1	179.4	157.3
Average knee angle	149.6	166.3	158.3	160.5	142.4
Average stride length	31	23.9	22.7	26.7	20.5
Number of steps	6	7	8	6	9
 24 degree					
Average head tilt	-1.1	19.9	-12.0	6.3	9.3
Average neck tilt	157.9	165.7	164.9	160.9	187.5
Average back angle	163.7	188.6	166.9	179.9	148.5
Average knee angle	145.4	127.4	156.3	155.8	144.8
Average stride length	26.2	19.3	20.7	28.6	18.1
Number of steps	6	7	9	6	11

Table 2. Comparisons between conditions of prototype shoes

Based on the data listed above, the results from the pilot test indicated that:

- All of the participants showed a decreasing degree of head tilt with increased prototype shoe angle;
- 3 participants showed dramatical changes in head tilt degree comparing shoes with 0° and 12°;
- 1 participant showed decreasing degree of neck tilt with increased prototype shoes angle;
- 3 participants' back angle decreased with increased degree of prototype shoes angle;
- 2 participants' knee angle decreased with increased degree of shoes angle;

- 4 participants' stride length decreased with increased shoes angle;
- 3 participants' stride length decreased dramatically comparing shoes with 0° and 12°;
- 4 participants increased the number of steps comparing shoes with 0° and 12°.

Following table summarizes the mean value of six measurements for the five participants. All irrelevant frames of video (where reflective marker on the pelvis was blocked by hand) were eliminated during the tracking process.

All Participants	0°	12°	24°	Change from 0 to 12°	Change from 0 to 24°
Average head tilt	23.0	6.4	3.3	16.6	19.7
Average neck tilt	161.9	160.4	162.4	1.5	-0.5
Average back angle	194.5	176.3	174.8	18.2	19.7
Average knee angle	159.6	158.7	146.2	0.9	13.3
Average stride length	29.9	26.1	23.7	3.8	6.2
Number of steps	6.0	6.8	7.0	-0.8	-1.0

Table 3. Mean value of six measurements for five participants

Based on the data listed above, the results from performance test indicated that:

- The participants' mean value of head tilt, back angle, and knee angle resulted in decreased angles with increased prototype shoes angle;
- The mean value of neck tilt did not result in a meaningful difference in the angle;
- The mean value of stride length and the number of steps decreased with increased prototype shoes angle.

4. CONCLUSION

The prototype shoes used were simple and made of inexpensive materials while achieving the goal of simulating the walking process of older adults. The expense of prototyping and time consumption for wearing and changing the layer on the shoes were recorded. The pilot experiment suggests an impact from the prototype shoes. First of all, by wearing this prototype shoes, the walking posture changed similar to the walking posture of the older adults such as bending their knees and tilting heads down. Also, participants showed different postures by changing the degree of the foot bed. Thus simulating the walking posture of the older adults in different ages by changing the degree of the foot bed may be possible. Also, the total cost to make this prototype was approximately $30, which is much less expensive than current aging suits. Note these shoes could be worn in conjunction with our aging kit (to provide a whole body aging experience) which is also very inexpensive. Based on the results from data analysis, the increased number of steps showed that participants tended to walk more cautiously while wearing the prototype shoes. The decreases in head tilt, knee angle, and back angle with the increased shoe angle suggests that participants experienced variable exposures to the characteristics of the older adults.

However, there are also a few aspects of the simulation that need to be improved. For the materials, Velcro was attached to the surfaces between each layer for changing the degree on the sole of the prototype shoes, and the strength of the Velcro decreased as the numbers of changes increased (perhaps due to the dust on the floor). To have a walking aging experience in a real environment such as on the street, the simulation kit needs to have a different method to attach / detach to the soles of the prototype shoes in order to change the degree. Even though the sandal can be tighten at the ankle, sometimes the prototype shoes fell off the foot of a participants while they were walking. This indicates that the prototype shoes need additional structures to be tightened not only on the upper part of the foot but also at the ankle for better fit and safety. During the pilot test session, the fish eye effect from GoPro camera had negative effects on the data analysis process. Some portions of the video could not be analyzed since fish eye effect distorts the images especially for the neck tilt. There is another issue for concern about the use of the prototype shoes. Each time participants (in the lab environment) or students (during the class) wear the prototype shoes with 12 degree and 24 degree, their muscles and soft tissues in the leg will be stretched. So during the first time experience they may feel uncomfortable this acting and walking similar to older adults. But once their body get used to the experience, they may adjust and no longer exhibit changes in their posture and gate. Hence, the prototype shoes have a limitation on the wearing time or number of experiences for one individual. Also, while using Tracker program to analysis the data, approximately 16 frames per 1 second were extracted. The data would have been more accurate with 64 frames per 1 second especially for knee angle since knee angle showed dynamic changes on a short time.

5. DISCUSSION

For the further research, the layers on the prototype shoes can address explore material stiffness in order to mimic participants' in different age ranges (60's, 70's, or 80's). Future investigations might also compare objective measures of postures and subjective measures of experience – ultimately benchmarking the performance of the simulation suit against older adults' experience.

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