Perceived Difficulties in Using Blenders by User Groups and Product Features

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Abstract

Background In an aging society, the issue of usability merits increasing attention when the design of home appliances is discussed. Although usability tests have been adopted for more usable products to various users, no consensus has been reached by experts on the value of the usability tests frequently based on opinions of healthy young men. It means this existing approach is possibly not sufficient to reflect varied user segments including the elderly. Thus, this study aims at finding evidence to show the necessity of user diversity in usability issues by comparing perceived difficulties (degrees and points of difficulty) of two different user groups in using blenders.

Methods To identify the perceived difficulties of two groups with four different types of blenders, a survey accompanying the experiment was executed. Data was gathered through convenience sampling, and 34 elderly users without UX specialty and 44 young users with UX expertise completed the survey with a use test according to their usage. Immediately after the tasks were performed, the participants were asked to answer questions according to their experience using a five-point Likert scale.

Results The results of the two-way analysis of variance showed a disparity of perceived difficulties between the user groups and indicated the inadequacy of the present usability test, which focus on healthy young men. The results also identified the preferred features of blenders. Despite the disparity of perceived difficulties between the user groups, in most tasks, the participants noted common preferred features such as the light weight of jars, the ease in opening/closing lids, and simplicity of the buttons used for operation. The features can be adopted for the redesigning of blenders and referred to for the designing other products.

Conclusions Between the two user groups, the elderly without UX expertise and the young UX experts, a disparity of perceived difficulties in using blenders was found. When this finding is interpreted as user effects and product feature effects, it can be considered as a signal that the present usability test can be improved by adopting user diversity to reflect various user segments in the real world. To make products beneficial for more people, supportive measures that offset the downsides of the present usability test should be explored and implemented.

Keywords Accessibility, Blender Design, Older Users, Perceived Difficulty, Usability

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1. Introduction

Countries across the globe are inevitably becoming aging societies. An aging society is one where a large percentage of the population is aged 60 years and older. Looking at the numbers and percentages of the over-60 population, the global number was 868 million in 2014, or 12% of the total world population, and the numbers are projected to rise: 1.2 billion (16%) by 2030 and 2.03 billion (21%) by 2050 (Bluestone, 2015). South Korea has shown a rapid pace toward an aging society. Its over-65 population, in 1970, accounted for only 3.1% of the domestic population; the percentage rose in 2000 to 7.2%, but by 2060, it will be 40.1% (Kim, Shin, Lim, & Son, 2013). As such, South Korea entered an aging society in 2000, and in 2018, it will become one of the aged societies whose over-65 population takes up more than 14% of the total domestic population.

This radical change in the demographic landscape urgently requires the design community to reconsider the design of everyday products. The current trend of products becoming more advanced, that is, requiring a relatively higher status of physical and mental functions, is at odds with the demographic trend of aging. In other words, current products seem mainly designed for and target users in their 20s to 50s or those without any functional impairments, whereas the dramatically increasing number of the elderly tells its possibilities as a lucrative segment which shouldn't be ignored. "Senior shift" initiatives of Aeon, the largest distribution company in Japan super aging society, can be taken as instance. "Shift to senior-oriented markets" is considered as the key driver of personal consumption with accomplishing significant growth (Aeon, 2012) and should be regarded as an opportunity factor to create economic momentum (Cho, 2014).

It is indicated that when the number of products requiring high capabilities increases, a similarly increasing number of people are being excluded from using such products. According to the World Health Organization (1980), impairment, a loss or deviation in body functions and structure of individual dimensions, leads to disabilities that hinder the use of products, and these individual disabilities finally result in a handicap that includes disadvantages from social dimensions. As an instrumental view relating to product use, a product that allows persons with impairment or disabilities to use it helps expand their abilities and ultimately promotes their social participation.

With an aging population, the increasing number of people who have mild impairments belonging to a gray area between no disability and with disability corroborates the necessity for a more accessible daily life environment. This context of our real world has compelled the design community seek ways to develop more accessible surroundings. As the population of those with physical impairment grows, so does the societal pressure to provide people with accessible products. Meanwhile, this changing population landscape shows an expanded market potentiality for products; that is, by meeting the needs of older users and people with impairments.

Designers' efforts to create an accessible environment have unfolded under different names depending on region, such as design for all in continental Europe, universal design in the US and Japan, and inclusive design mainly in the UK (Heylighen & Bianchin, 2013). Although all of them have a common ground, that is, design for the challenges due to impairment or degradation of physical and mental functions, each of the movements seems to have slightly different viewpoints. Universal design focuses on improved product supportiveness in terms of users' perspective, such as easy, equitable, and intuitive use, as shown in the seven principles of universal design; inclusive design considers a balanced perspective between inclusivity and economic benefits or burden on product developers as well (Kim, 2015; Keats & Clarkson, 2003), allowing developers to expect commercial benefits (Mace, Hardie, & Place, 1990). Despite the different views, their common goal, addressing users' needs beyond "average" or "typical" users, of universal design and inclusive design would be fulfilled through efforts to make products more usable.

With the emerging user-centered market, the term usability was coined in the late 1970s through the early 1980s (Jordan, 1998) to replace "user friendly," which was considered to have a vague and subjective connotation (Bevana, Kirakowskib, & Maissela, 1991). The common definition of usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, 1988). Nielsen (1993) specifies usability relates to the learnability, efficiency, memorability, errors, and satisfaction elicited by product use.

Although product usability generally includes both performance and satisfaction on grounds of the widely accepted definition, whenever usability criteria are addressed, user affect or experience (Desmet & Hekkert, 2007) has given priority to quantifiable performance criteria, such as time to learn, error rate, and time to complete a task (Tractinsky, Katz, & Ikar, 2000). However, the discourse on usability issues has seen a shift from a functional perspective emphasizing on practical aspects to an experimental perspective focusing on the entirety of user experience (Brave & Nass, 2008; Forlizzi & Battarbee, 2004; as cited in Sonderegger & Sauer, 2010). In the arguments over the practical and entire aspects of usability, it is worth considering a matter of objective and subjective usability. The objective usability relates to measures not dependent on perception of users while the subjective usability refers to users' perception of or attitudes towards the results, for instance, a case of objective time versus subjectively perceived duration (Hornbæk, 2006; Kim, Kim, & Han, 2012). Thus, though integrating the both helps researchers find whole picture of usability, considering that conflating them leads to different conclusion, it is still necessary to distinguish the subjective from objective measures (Hornbæk, 2006).

On the other hand, despite the concrete concept of usability, fresh perpectives to measure usability have been continuously proposed. These proposals likely need to revisit common conceptions of how to measure usability (Brkić-Spasojević, Putnik, Shah, Castro, & Veljković, 2013; Hornbæk, 2006). Taking this exploratory perspective, think the diversity of users in the real world where usability does not perfectly guarantee actual use (Reed & Monk, 2011). When considering usability tests, usability is evaluated under the potential use of targeted groups composed of specified individuals, so having similarity by the specifications, whereas actual use occurs with various individuals having different characteristics across age, social background, level of education, physical and mental functions and others.

In recognizing the disparity between usability in many present usability tests and actual use, it seems worthwhile to refer to a universal usability and accessibility test to supplement the usability test. Universal usability is defined as "more than 90% of all households being successful users of information and communication technologies at least once a week" that considers a broad audience of unskilled users (Shneiderman, 2003). Often considered interchangeable with usability, accessibility emphasizes usability based on user diversity. The definition for accessibility is being "...usable by people with the widest range of capabilities" (ISO, 2003). Meanwhile, the Web Accessibility Initiative (WAI), as defining Web accessibility as "people with disabilities can use the Web ...", focuses on usability for people with disability (Henry, 2006). Thatcher et al.,(2003) propose that accessibility is a subset of usability and accessibility problems are particular types of usability problems. However, though accessibility is possibly treated as a special part of the usability evaluation, some problems typically thought as accessibility problems affect non-disabled users as well, and are therefore not within the scope of usability problems (Petrie & Kheir, 2007). As shown Table 1, whereas usability analysis stresses the amount of time, similarity of users, and representation of the largest intended user segment as critical measures, accessibility analysis considers the independent completion of critical tasks rather than the time required, diversity of users, and representation of diverse user sements (Lemke & Winters, 2008). When thinking the different foci of the universal usability and accessibility tests(or accessibility) from usability tests(or usability), it can be noted that accessibility and usability problems can be seen as two partially overlapping sets. Then, working with diverse users in usability tests and taking their needs discovered seems to bridge the gap between usability of potential use and actual use in the real world, which would contribute to getting a whole picture of usability of the product tested.

Table 1 Comparison of accessibility and usability analyses (Lemke & Winters, 2008, with modifications)

Usability Analyses	Accessibility Analyses	Key Words
- Task analysis is commonly the focus of usability analysis.	– Barrier occurrences are the focus of accessibility analysis	– Task Completion vs. Barrier Occurrence
– Timing is often a critical measure.	– Timing is a less critical measure as long as critical tasks can be completed, whereas independent use is a critical measure. – Use with assistive technologies is also an important measure.	– Amount of Time to Complete Tasks vs. Independent Use Regardless of Time Amount
– Specific users are selected to represent the largest intended user group(s). – Users with similar characteristics are recruited to allow statistical comparison of data.	– Users with disabilities are selected to represent performance characteristics that may not be included in traditional usability analyses. – Users with diverse characteristics are recruited to detect new performance characteristics.	– Similarity of Users vs. Diversity of Users

In usability issues, there are studies considering diversity in user characteristics. Thong, Hong, and Tam (2002) empirically identified that individual differences, computer selfefficacy, computer experience, and domain knowledge were important predictors of perceived usefulness and perceived ease of use of digital libraries. Lemke and Winters (2008) evaluated the accessibility of medical products used in hospitals with 12 users having different disabilities, and identified design features that could help mitigate their barriers. Story et al.(2010) identified access and safety barriers in the use of different types of medical equipment with patient participants with various physical and sensory disabilities. Kim and Christiaans (2012) surveyed influence of consumers' personal characteristics and product properties on soft usability problems and observed cognitive and personal characteristics were related with types of soft usability problems. Fung et al. (2015) explored the frustration of 19 users with physical and sensory impairments in using positive airway pressure ventilation, a home medical device, through in-depth interviews. Kim and Christiaans (2016) found that users' demographic characteristics such as age and educational level had significant influence on their behavior in complaining soft problems and reacting to them. However, despite such various efforts to work with diversity of users and implication of the study results, contributions to making a better test form still remain critical to accommodate actual use by various user.

Generally, hard data on products such as performance standards, guidelines, and usability outcomes have been based on studies with healthy young males. It is not appropriate for such data to be adopted in products designed for users with different characteristics from those of the healthy young men (Gardner-Bonneau, 2007). This situation indicates the necessity of efforts to reflect the real world where the aged or inexperienced users live as referencing perspectives of accessibility or universal usability; the wide gap in the mental and physical functions between healthy young users and impaired users need to be recognized and considered when designing products.

However, the present circumstances of preferring to the healthy young male centered usability test tell us that more contributions are required to make rich resources; it shows they are not enough to represent all user segments having different usability issues and then beased on the assertion what attributes of users are effective on usability issues and what features of products are influential on users. As a starting point of constructing the firm foundation to show insufficiency of the current approach to represent different user groups, this study aims at showing the necessity of diverse user groups in usability issues by comparing perceived difficulties of two different user groups from levels of UX expertise and physical and mental functions in using blenders used in most households. In addition, it tries to identify influence of product features of blenders on perceived difficulties as well.

2. Methods

With 78 participants in total, a survey with laboratory tests was conducted to determine perceived difficulties when using blenders as the apparatuses in this study. With growing interest in health and beauty, Philips electronics appointed a blender as one of the personal health care products for healthy living in terms of their "Health Continuum" strategy

(Han, 2017), and Electrolux electronics started to enrich their small kitchen appliance lines including blenders (Park, 2016). The blender penetration rate of 38% in 1979 increased to 64% in 1989 nationwide (Chae, 2005). Since the boom of 1980s (Ahn, 2015), the domestic blender market of Korea has expanded. Its market size was about $151 million in 2016 and is estimated as about $178 million respectively (Park, 2017). As regards perceived usability, the survey examined the extent to which individual participants felt the severity of difficulty in terms of physical and mental functions of users required to use each blender. In the survey, participants were asked to perform tasks and then answer the severity questions based on a given task scenario on four blenders.

2. 1. Recruitment of Participants

Of the 78 participants, 34 were categorized to the elderly group and 44 to the young professionals group. They were contacted through convenience sampling in the Daegu–Gyeongbuk region, South Korea. In terms of age range, the young professional group included those between 20 and 49 years old, whereas the elderly group comprised those aged 60 years and over. The young professional group consisted of UX designers who had knowledge and experience on researching and analyzing home appliances, automobile, and mobile phones from UX perspectives. The length of their career varied from 1 to 13 years. To reduce the cost of contacts, the young professionals group participants were initially gathered through the author's personal network, namely, the project collaborators who worked as UX design professionals and who helped formulate the perceived severities test of blenders in this study. The initial participants were then asked to spread the survey to other designers through their personal networks. Meanwhile, the elderly participants were gathered through either a manager of a senior club in the Daegu region or the author's personal network. This group consisted of people over 60 years old who lived independently and who could use or operate blenders without others' help.

The first contact to participants was followed by e-mails and meetings to explain the goal and process of the survey and perceived severities tests on some blenders. To comply with the ethics and safety requirements of the institutional review board, the study obtained the participants' informed decision and agreement on participating to the survey and test. Before the test, each of the participants was given face-to-face explanation for them to have a better understanding of the survey and test. Upon their agreement to participate in the survey and comply with the test, they were asked to submit a written agreement with their signature. They were informed about the test's purpose, data confidentiality, and incentive for participating in the study, in the form of a gift worth KRW 50,000. The recruitment methods in this study might have produced a biased sample relative to the entire elderly and young professional population in that it focused on residents in the Daegu–Gyeongbuk region.

2. 2. Development of the Questionnaire

The survey questionnaire consisted of perceived difficulties-related questions. To develop the questionnaire, this study adopted the following process. First, applicable questions were collected through literature review with respect to usability or accessibility related to physical and mental functions. Second, through interviews with four UX design professionals, the content validity of the preliminary questions was verified. Third, behavior sequense of the task scenario were reviewed, and potential problems during the test were discussed with the professionals. Based on the findings of the three steps, a draft of questionnaire was drawn and comprised of physical and mental function demand-related questions, prior experience-related questions, and demographic information questions. In this study, the prior experience questions simply asked whether each participant had an opportunity to use any types of blenders and the blenders given in the test. Lastly, the final version of the questionnaire was developed through iterative discussion with the professionals regarding the focus on wording and terminology, and conciseness of the questionnaire. It included a total of 24 questions such as prior experience of 2 items, demographic information of 3 items, handling jar of 12 items, handling lid of 3 items, and handling knob of 4 items (see Table 2). Except prior experience of the blender answering yes or no, each question was rated on a five-point Likert scale from 1 (strongly disagree) to a 5 (strongly agree).

Table 2 Attributes of question items to assess physical and mental functions required in using blenders

Category	Attribute of statement	
Prior experience	– Of any types of blenders (whether having a chance to be exposed to them)	
	– Of the blenders given in this test (whether having a chance to be exposed to them)	
Demographic information	– Gender	
	– Age	
	– Education level	
Handling jar.	– Feeling of hand strength required	– to lift the jar up / down
		– to attach the jar
		– to lean the jar
	– Feeling of hand coordination required *	– to attach the jar
	– Feeling of arm strength required	– to attach the jar
		– to lift the jar up / down
		– to lean the jar
	– Feeling of range of arm required	– to lean the jar
	– Feeling of cognitive ability required *	– to detach the jar
		– to attach the jar
Handling lid	– Feeling of hand strength required	– to open the lid
		– to close the lid
	– Feeling of cognitive ability required *	– to close the lid
Handling knob	– Feeling of hand strength required	– to control the switch selector / the buttons
	– Feeling of hand dexterity required	– to control the switch selector / the buttons
	– Feeling of visual acuity required	– to control the switch selector / the buttons
	– Feeling of cognitive ability required	– to control the switch selector / the buttons

* eliminated at confirmatory factor analysis

2. 3. Survey and Test Administration

This study conducted a survey and tests on four blenders being sold in the Korean blender market. The selection standards of blenders, types of brands and product attributes, were drawn to represent product features of blenders in the domestic market of the day. In terms of the brand types, this market consisted of two groups, domestic and foreign. Regarding the attributes, there were three groups of glass, plastic and composite of plastic and aluminium by jar material when having a similar jar capacity around two liters, two groups of a selector switch and buttons by control types, and four groups of either requiring adjustment of direction or not and either requiring some physical force to open/close or not by lid types. Hence, keeping mutually exclusive and collectively exhaustive as much as possible, four blenders were chosen as research apparatus. More specifically, each blender represented a certain type of the attributes. Blender A represented a foreign brand product having a heavy glass jar, a selector switch and a lid with requiring light physical force to open/close and a little adjustment. Blender B showed a domestic brand having a heavy glass jar, button type controls, and a lid with much physical force. Blender C stood for a domestic brand with a light plastic jar, a selector switch, and a lid of requiring light force to open/close and careful adjustment. Blender D typified a foreign brand with a light but invisible jar, both a selector switch and button type controls, and a lid of requiring much force to open/close (see Table 3). The survey and tests were carried out at the participants' work places or a community house with which participants were familiar, to ensure they were in a comfortable state of mind during the test. To assist participants or manage unexpected problems during the tests, the author and test helpers stood in observance. The participants were asked to use four different blenders whose brand names were covered. Before using the blenders, the scenario of the intended use and outline of the tasks were described to the participants. Then, as the test proceeded, according to the six behavior steps (opening the lid, controlling the knobs/wheel, detaching the jar, lifting the jar, pouring blended juice into a cup, and fitting the jar into the body), tasks to be performed were read aloud by the test helpers. Immediately after the tasks were performed, the participants were asked to answer questions according to their experience using a five-point Likert scale from 1, indicating "strongly disagree," to 5, indicating "strongly agree." Participants were instructed to use the blenders as independently as their sense of safety and comfort allowed.

Table 3 Product features of blenders tested in this study

	Blender A	Blender B	Blender C	Blender D
Image				
Jar	–Made of glass –Heavy weight –High visibility –Way of detachment: lift jar, no twist	–Made of glass heavy weight –High visibility –Way of detachment: lift jar, no twist	–Made of plastic –Light weight –High visibility –Way of detachment: twist and lift jar, per the icons	–Made of aluminum and plastic –Light weight –Limited visibility –Way of detachment: twist then lift jar
Control panel	–Six–position selector –switch with numbers –Five speeds –Turn knob	–Buttons with text labels –Two speeds –Press buttons	–Three–position selector switch with numbers –Two speeds –Turn knobs	–Rotary selector switch and buttons with guide text and visual icons –Variable speeds –Turn knob
Lid	–To close, place the lid on top of jar –Made of rigid plastic –Rounded triangular shape having height	–To close, place and press the lid with relatively much force –Made of rigid plastic –Circular shape having height	–To close, place, turn and carefully adjust the lid –Made of rigid plastic –Circular shape having height	–To close, place and press the lid with relatively much force –Made of soft plastic –Circular shape with flat

3. Results

3. 1. Characteristics of Participants

Table 4 summarizes the characteristics of the participants.

Table 4 Demographic characteristics of the sample

Items		Elderly group	Young professionals group	Total
Age	25–34	–	19	19 (24.4%)
	36–45	–	21	21 (26.9%)
	46–55	–	4	4 (5.1%)
	61–70	12	–	13 (16.7%)
	71–80	21	–	21 (26.9%)
	81 and older	1	–	1 (1.28%)
	Total	34	44	78 (100%)
Gender	Male	9	20	29 (37.2%)
	Female	25	24	49 (62.8%)
	Total	34	44	78 (100%)
Education level	Lower than high school	18	–	18 (23.1%)
	High School	6	2	8 (10.3%)
	College degree	3	40	43 (55.1%)
	Higher than college degree	7	2	9 (11.5%)
	Total	34	44	78 (100%)

3. 2. Reliability and Validity

To evaluate the reliability and validity of the survey questionnaire used in this study, the reliability coefficient was estimated for the internal consistency of items, and confirmatory factor analysis was performed to investigate construct validity (convergent and discriminant validity) using SPSS 18 and AMOS 18. The reliability coefficient values (Cronbach's alpha) of three factors, namely, handling jars, handling lids, and handling controls, ranged from 0.960 to 0.721, exceeding the threshold of 0.7 (Nunnally, 1967). To reach the conditions, some variables with low loading were elimitated, variables related to cognitive and hand coordination abilities in handling jars, cutaneous sensory and arm strength abilities in handling lids. Convergent validity, a subtype of construct validity (see Table 5), was assessed with average variance (AVE), composite reliability (CR), and standardized factor loading. All of the convergent traits were clearly greater than the threshold cited in relevant literature; standardized factor loadings of all measurement items greater than 0.5, AVE greater than 0.5, and CR greater than 0.7 at $p < 0.001$ (Fornell & Larcker, 1981). The reliability and convergent validity requirements were thus met. Discriminant validity was assessed through comparing all of the squared values of each correlation coefficient to the AVEs of constructs and then identifying the results of multiplication by correlation coefficient±2 and standard error. All requirements of the discriminant traits were clearly met; the squared correlation coefficients were greater than the AVEs (Fornell & Larcker, 1981). Further, between each correlation coefficient±2 multiplied by its standard error, there was not a 1.0 outcome (Anderson & Gerbing, 1988). These results indicated that discriminant validity was acceptable as well.

Table 5 Convergent validity of confirmatory factor analysis

Factor	Variable	λ	AVE	CR
Handling jars	JV1	.841	.755	.955
	JV2	.856		
	JV3	.923		
	JV4	.942		
	JV5	.702		
	JV6	.721		
	JV7	.894		
	JV8	.897		
	JV9	.791		
Handling lids	LV1	.932	.864	.927
	LV2	.983		
Handling knobs	KV1	.650	.565	.838
	KV2	.637		
	KV3	.613		
	KV4	.632		

Table 6 Discriminant validity of confirmatory factor analysis

Factor	Handling jars	Handling lids	Handling knobs	AVE	CR
Handling jars	1			0.755	0.955
Handlign lids	.407	1		0.864	0.927
Handlig knobs	.567	.441	1	0.565	0.838

3. 3. Perceived difficulties in using blenders

The four blenders were tested to compare the degree of physical and mental functions required to operate them, considering the motor (the hands and upper extremities), cognitive, and sensory functions of the proprioceptive and visual senses. The majority of participants (73.1%) had use experience of blenders and most participants of 97.4% except two participants (a participant per group) were not exposed to the four blenders tested in this study. The participants were asked to use each blender and answer the survey questions according to the given task scenario. Although a number of participants had hesitated to remove the jars from the body part in the how-to-open task, all of the participants completed the tasks successfully. Two-way analysis of variance (ANOVA) tests with Scheffé post hoc comparisons at .05 were performed to confirm the effects of user groups and blender types (by product attributes) on demand extent with respect to physical and mental functions required for using blenders. More specifically, the tests focused on three factors, namely, handling jars, handling lids, and handling controls. In addition, the test aimed to determine which blender type required the least body function capabilities.

3. 3. 1. Handling Jars

The task of handling jars included sub-tasks of moving, tilting, lifting up/down, and attaching/detaching jars in position. Completing these sub-tasks required motor functions (muscle strength and range of motion, ROM) of the upper extremities and hands, and proprioceptive functions belonging to a sensory function. When asked about the perceived difficulty in dealing with the jars, focusing on the upper extremity and hand functions, and proprioceptive functions, the responses of both participant groups were as follows. Models A (elderly group, M=1.897 vs. young professionals group, M=3.042) and B (elderly group, M=2.051 vs. young professionals group, M=3.113) were perceived more demanding than model C (elderly group, M=1.337 vs. young professionals group, M=1.802). Model D (elderly group, M=1.362 vs. young professionals group, M=2.628) was the least demanding. Participant ($F(1, 295)=219.184$, $P=.000$) and blender type ($F(1, 295)=28.693$, $P=.000$), except for their interaction ($F(1,295)=1.493$, $P=.217$), had statistically significant effects on handling jars.

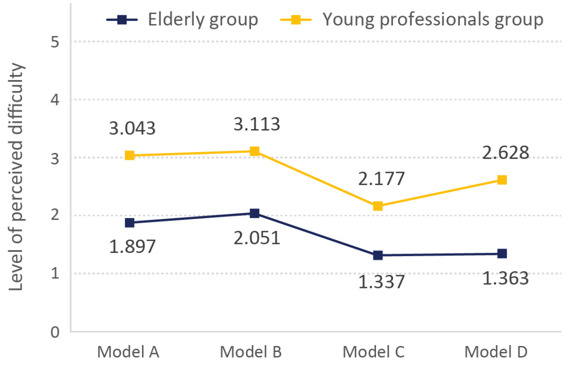

Figure 1 Comparison of the perceived difficulty in handling jars

Table 7 Two-way ANOVA on the perceived difficulty in handling jars

Items	SS	df	MS	F	Sig.
Participant type	86.458	1	86.458	219.184	.000
Blender type	33.954	3	11.318	28.693	.000 A, B〉C〉D
Participant * blender type	1.766	3	.589	1.493	.217
Error	116.364	295	.394		
Corrected total	239.034	302			

3. 3. 2. Handling Lids

Handling lids had sub-tasks of holding, covering, and opening. These tasks were mainly related with motor functions (coordination, muscle strength, and ROM) of the hands. On the difficulty of the hand functions necessary to deal with the lids, the analysis results of the responses of both participant groups are as follows. Models B (elderly group, M=2.912 vs. young professionals group, M=3.966) and D (elderly group, M=3.088 vs. young professionals group, M=3.954) were regarded more demanding than models A (elderly group, M=1.397 vs. young professionals group, M=1.909) and C (elderly group, M=2.147 vs. young professionals group, M=3.272). User group ($F(1, 304)=67.206$, $P=.000$) and blender type ($F(1, 304)=63.651$, $P=.000$), except for their interaction ($F(1,304)=1.599$, $P=.190$), had statistically significant effects on handling lids.

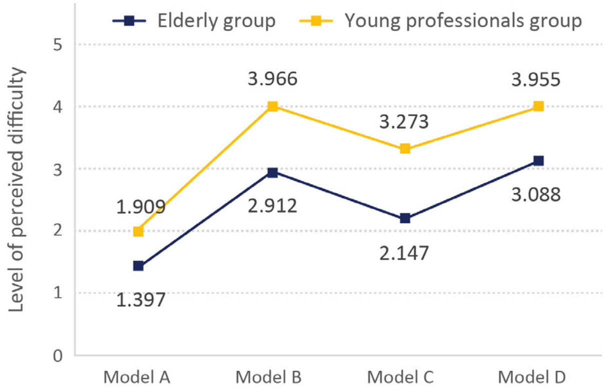

Figure 2 Comparison of the perceived difficulty in handling lids

Table 8 Two-way ANOVA on capability demands for handling lids

Items	SS	df	MS	F	Sig.
Participant type	60.705	1	60.705	67.206	.000
Blender type	172.483	3	57.494	63.651	.000 A<C<B, D
Participant * blender type	4.333	3	10444	1.599	.190
Error	274.597	304	.903		
Corrected total	520.074	311			

3. 3. 3. Handling Controls

Handling controls consisted of sub-tasks of holding and twisting jog wheels (or pressing buttons), understanding how-to-operate instructions, and interpreting graphical symbols. These tasks were mainly related with motor functions (muscle strength and ROM) of the hands and cognitive functions. On the difficulty in dealing with the controls, in both user groups, model D (elderly group, M=1.625 vs. young professionals group, M=2.199) was deemed more demanding than models B (elderly group, M=1.44 vs. young professionals group, M=1.837) and C (elderly group, M=1.401 vs. young professionals group, M=1.858). User group ($F(1, 302)=65.457$, $P=.000$) and blender type ($F(1, 302)=4.062$, $P=.007$), except their interaction ($F(1,302)=1.193$, $P=.313$), had statistically significant effects on handling controls.

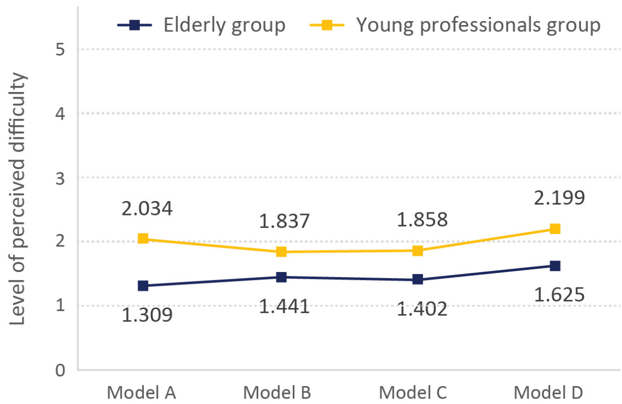

Figure 3 Comparison of the perceived difficulty in handling controls

Table 9 Two-way ANOVA on the perceived difficulty in handling controls

Items	SS	df	MS	F	Sig.
Participant type	22.047	1	22.047	65.457	.000.
Blender type	4.105	3	1.368	4.062	.007 B,C<D
Participant * blender type	1.205	3	.402	1.193	.313
Error	101.720	302	.337		
Corrected total	129.374	309			

4. Discussion

Differences in perceived difficulties were observed by the characteristics of participants like levels of physical and mental functions and usability expertise, and by product features of blenders (focusing on jars, lids, and controls of blenders).

4. 1. User Effects in Perceived Usability

Before discussing differences of perceived difficulties between the two groups, the elderly and the young UX experts, it needs to think participants' past experience interacting with blenders. The experience as prior knowledge of a domain equating "familiarity" (Bewley, Roberts, Schroit, & Verplank, 1987; Johnson & Russo1984) can lead to positive effect on interaction like faster time on task due to deeper understanding (Johnson & Russo1984), improved performance from automaticity (Lim, Benbasat, & Todd, 1996), or intuitive use and less susceptible error (Mieczakowski, Langdon, & Clarkson, 2009). However, in the test, only a participant per group in total two participants had use experience on a certain blender given in the test. Though their previous experience on the blender may help them use it more comfortably, if thinking other participants of 97.4% without exposure to any blenders tested in the study, familiarity effect on all participants seems to be said not considerable. Hence, this study more focuses on discussing other user effects such as users' UX expertise and physical and mental capacities.

Between the user groups, disparity of perceived difficulties was found regarding degrees and points of difficulties in all tasks. This disparity can be originated from weak similarity among older people and strong similarity among the young professional in terms of educational background and physical and mental function capabilities. Even though it is easily assumed that older people are quite similar each other because they experience aging which accompanies unavoidable health worsening, each of them is different. Most variations of their diversity, greater than the younger people, seem to result from personal factors such as sex, ethnicity, and occupation, as well as the physical and social environments (Beard, Officer, & Cassels, 2016). These influence health behavior from childhood and the impact is stored across lifetime as widening gap over others (WHO, 2008; Dannefer, 2003). This finding can be interpreted as user effects ; users' physical and mental capacities and their expertise related to product use influence perceived usability. Also, it probably links to needs to revisit how to measure usability (Brkić-Spasojević et al., 2013; Hornbæk, 2006) as valuing diverse paricipants in usability tests. This outcome is possibly in line with a controversial finding on the effectiveness of usability tests. Studies on usability tests have shown notable inconsistencies. While it is generally agreed that usability tests improve product usability (Säde, Nieminen, & Riihiaho, 1998; Sefelin, Tscheligi, & Giller, 2003; Walker, Takaya, & Landay, 2002), the effectiveness of usability tests on a small number of professionals has been questioned (Kessner, Wood, Dillon, & West, 2001; Molich, Ede, Kaasgaard, & Karyukin, 2004).

Meanwhile, contrary to the general prediction, in this study young professionals without any impairments consistently showed greater perceived difficulties in using the blenders than the elderly. This result can be associated with disadvantages of usability tests by expert evaluation; paying no attention to identify minor problems (Jeffries & Desurvure, 1992) which are possibly critical to non-mainstream users, insufficient to get information to accurately predict the eventual user behavior (Petrie & Beven, 2009), tending to focus on certain sections and ignore others (Slavkovic & Cross, 1999). It is supported by outcomes in other works. Cho and Lee (2009) reported that people in their 50s evaluated Korea's governmental portal sites as easier to use compared with people in their 20s, in terms of subjective perceived usability, contrary to the objective usability test results. Broberg and Willstrand (2014) compared experts' assessment and the self-assessment of elderly drivers on safe mobility, and the experts evaluated it as having poor performance compared with the self-assessment results of the elderly. These results appear to be associated with the strict standards inculcated by professional expertise and false self-assessment of the elderly who do not want to be seen as unable or too old. Based on these previous results, differences in users' age, body function capabilities, and UX expertise may affect perceived usability. Specifically, users' assessment of their expertise on usability tends to lead to harsh appraisal, whereas users' assessment of their weakness tends to result in generous ratings. At this point, matter for thought is participants' education level. Only 29.4% of participants of the elderly group have a formal education of college or higher but in the young professionals group the portion reaches up to 99.5%. Considering this difference in education level by groups, the assumption of the relation of professionality and perceived difficulty on product is interesting to note because expertise requires knowledge through education and training through real field experience. However, to see pure effects of the education level, it is needed to have a study with participants having different education levels but not having differences of professionality. Thus, current usability tests based on healthy young respondents are possibly too biased to reflect the diversity of home appliances users. A usability test on diverse users, including the elderly with a range of body function impairments, should be formulated to reflect the heterogeneity of actual users.

To summarize, the disparity in the severity scores between the user groups indicates the merit of adopting opinions of diverse users in usability tests to avoid biased opinions by mainstream users who cannot represent all segments of users in the real world. Hence, in most cases, professional usability tests are effective but cannot fully explain real uses, indicating the necessity of some changes to the usability testing that include diverse users. However, the real situations of the business world seems not to allow chances enough to reflect all segments of users because more consideration of user diversity means more investment. Thus, in finding an equilibrium point where each of the players, manufacturers and diverse users including the impaired, is within their optimal payoff, inclusive design perspective can be referred to as a strategic approach. Keats and Clarkson (2003) suggests a flexible approach by taking the perspective of "Negotiable Maximum Population". "Negotiable" reflects the fact that at the prototype stage of design process, inclusiveness of products is changeable to achieve balance between a level of product requirements to support various users and size of target user population meaning market size to guarantee economic benefits of manufacturers within benefits of the both.

4. 2. Blender Features in Perceived Usability

Despite the different severity scores between the participant groups, similar patterns were found across the groups in each task. In the task of handling jars, blenders with glass jars were given higher severity scores compared to other with the plastic jar or aluminum jar with low visibility. Thus, this result may be interpreted into importance of jar weight as a compelling factor, rather than jar visibility, in handling a jar but it can be a outcome influenced by environmental conditions. If the task emphasized on getting a specific state of blending materials for food preparation, visibility would like to get higher priority. Thus, in handling a blender jar, possibilities of change of priority from weight to visibility should not be neglected but the current trend of using blenders to mix drinks, not to cook, (Oppenheimer & Reavey, 2003) may add weight to jar weight.

Although one of the blenders, model D, seemed to have a quite unfamiliar way to separate its jar, different blenders with a familiar way-to-separate glass jar had greater severity scores. Though it is also possibly explained as priority of jar weight to ease of detachment/attachment in that people may think a new way to separate jars as a matter of being accustomed, not as ease of use, social desirability bias (Nederhof, 1985) would like to drive some participants to deny an undesirable trait of being unable to separate the jar in order to make them look more favorable to experimenters. Though the participants were informed about the fact that this experiment was intended to determine usability of blenders not their intellectual abilities, they likely want to hide their suffering because they may fear their failure is thought as their inability. In handling lids, blenders requiring a substantial amount of muscle strength to open/cover lids regardless of ease in grip (proper shape and space of a lid to grasp) were given higher severity scores compared with those needing mere placement of lids on top of jars without pulling or pressing. Thus in handling lids it may be worthy of identifying priority of ease of opening/closing over secureness of lid seal in a follow-up study. In handling controls for operating the blenders, the blender with rotary selector switch and buttons with guide text and visual icons was determined as more difficult one than others regardless of whether they have a selector switch or buttons. Interestingly, however, only a blender had two different types of operation components. Its' feature probably made participants feel more psychological or cognitive burden in completing the given tasks, handling controls, under lack of information and time. It can be related to maximizers' way of thought which Simon(1956) termed as, considering all alternatives they can imagine to know for a certain.

5. Conclusion

With the emergence of aging societies across the globe, the increasing number of aging users requires designers to consider diverse users with various types and levels of impairments and pay more attention to usability in designing everyday products. Amid these concerns are doubts on the appropriateness of standard usability testing that rely on a handful of healthy young professionals. To make products better and beneficial, supportive measures that offset the downsides of the present usability test need to be explored and implemented.

The central concern of this study is the comparison of perceived difficulties between user groups and between blender types as a means to corroborate the findings of inadequacy of the usability tests often conducted on healthy professionals. In the survey with tests on four blenders, the two different user groups reported a disparity of perceived difficulties. The survey with tests also gathered helpful comments for designing blenders. First, the age and profession-related characteristics of participants have effects on perceived difficulties, which are related to perceived usability. Given the growing population of the elderly, this finding can be interpreted as signal of the need for participant diversity in usability tests and a negotiable approach of inclusiveness may be referred to as a starting point to discuss.

Though this study also contributes clues for a design guideline for blenders, this study has a number of limitations related to the nature of the sample including unbalanced gender ratio and the evaluation context such as a level of influence of prior experience. Although this study reveals important findings supported by a large sample of participants, more efforts are needed to shed light on the most appropriate methodology for assessing usability and interpreting the findings in real-life contexts. Hence, there would be the next steps. One would be to discern the effects of user diversity on usability test issues by recruiting a more comprehensive sample and expanding the scope to other categories of home appliance products. Even though this study found gross effects of user expertise possibly associated with education level and physical and mental health on perceived usability, it could not identify how and how much influence education put on expertise in usability issues. Thus the next study would be to discover amount of influence of each characteristic like education, level of expertise on each element of perceived usability from each of the physical and mental functions in using products. Additionally, it is also worthy to discover the priority between ease of opening/closing and secureness of lid seal in a follow-up study. Furthermore, with firmer ground, a follow-up study will be able to conduct a research with diverse user groups of a product in our real world.

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