Comparative Study between Old and Young People's Basic Characteristics for Control Device Design

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***Abstract*—User interface plays an important role in product safety and usability as an interactive part between user and product. In particular, in the case of the elderly, bad user interface design causes some problems in the aspects of usability and safety. Therefore, two topics on user interface were studied. In the first study, we identified some population stereotypes for the elderly in comparison with young people. Experimental models for controls of commercial products were made to effectively perform the experiment. One hundred aged and one hundred young people participated in this experiment. The results show the old people's population stereotype on control movement was not remarkably different in comparison with the young. However, the elderly's stereotypical relationships were dominantly weaker than those of the young in most cases. In the second study, we performed an experiment to identify the elderly's characteristics for controlling some button-type controls in comparison with young people. The experiment focused on the elderly's movement time for controlling push-buttons, which is one of the most popular controls in computerized products such as cellular phones, remote controllers, etc. In the case of old people, it is important to identify the effects of button size and moving distance for movement time to design some senior-friendly products. In this aspect, the effects of the index of difficulty (ID) that is calculated by moving distance and button size for movement time were identified for the elderly in comparison with young people. Ten old and ten young persons participated in this experiment. Some experimental devices were made for this experiment. In the result, the movement time that a subject takes to control the button was significantly influenced by the index of difficulty (ID) and showed a significant difference between the aged and the young. Also, a significant interaction effect between ID and age was identified for movement time.**

I. INTRODUCTION

The number of senior citizens is rapidly increasing according to the lengthening average life span. This induces many social issues such as the development of welfare policies and products for senior citizens.

Old people have decreased sensitivity, muscular strength, flexibility, mobility, memory, and learning in comparison with young people [1]. Therefore, it is difficult for old people to use products designed for young people and they can have some accidents. The American National Safety Council announced that 50.7% of household accidental deaths were old people. The elderly stay at home most of the day because they have declined in health, but there are many risk factors caused by unsuitable designs for facilities and products. Thus, old people are always exposed to danger from accidents.

Therefore, the universal design concept of products or environments that can be easily used by old people or the disabled is coming. Universal design is an approach to create environments and products that recognize the diversity of users, regardless of their ability or age. If persons with limited abilities can easily use a product, then normal persons will also be able to easily use the product, which is the basic concept of universal design. The focus of universal design for products is user interface. User interface is one of the most important parts of any product because it determines how easily a user can do what he or she wants. Bad UI design can bring about errors and take more time for the user to use a product, and sometimes serious accident can occur.

Controls are very important parts in using a product. In many cases, senior citizens have trouble controlling some control devices because of problems with control size, shape, direction of movement, etc. Therefore, it is necessary to study old people's characteristics for operating control devices and to consider those characteristics in design.

In this aspect, two topics, old people's characteristics for controlling push-type buttons and old people's control-movement relationship were studied.

II. CONTROL MOVEMENT RELATIONSHIP

We studied control-movement habit patterns that are consistent from person to person without special training or instructions for the elderly. These are sometimes referred to as population stereotypes and must be considered first in product design for old people.

When population stereotypes are designed into the product, (1) learning is faster, (2) reaction time is faster, (3) fewer errors are made, and (4) user satisfaction is higher. Two things should be kept in mind about the use of population stereotypes: (1) some are stronger than others; that is, some expectations are shared by greater proportion of a population than are others, (2) in some circumstances it may be necessary to violate one population stereotype to take advantage of another in the design of some products; and sometimes it is impossible to avoid this [2]. Recommended relationships between control movement and system or component response are shown in Table 1 [3].

There are two principles in stereotypical control-display relationships. The first is called the scale-side principle, that is, the expectation that the pointer will move in the same direction as the side of the control knob which is on the same side as the scale marking on the display. This principle operates when the control is at the top, bottom, or side of a vertical display. The second principle is called clockwise-for-increase principle which states that people will turn a rotary control clockwise to increase the value on

the display no matter where the control is located relative to the display [2].

Table 1. Recommended Control Movements

Function	Control Action
On	Up, right, forward, pull
Off	Down, left, push
Right	Clockwise, right
Left	Counterclockwise, left
Up	Up, rearward
Down	Down, forward
Retract	Rearward, pull, counterclockwise, up
Extend	Forward, push, clockwise, down
Increase	Right, up, forward
Decrease	Left, down, rearward

Although fairly clear-cut population stereotypes do exist for certain control-display relationships, these are by no means universal. These may be different according to country, age, culture, nation, etc. In particular, old people can differently respond on control movement from the young because of the inclination of physical, perceptual, and sensory functions. Thus, it is necessary to first study their basic characteristics to design products for the aged.

A. *Experiment*

Experimental models for controls such as in Fig. 1 were made to effectively perform the experiment. One hundred old and one hundred young people participated in this experiment. In order to make a comparative study of control-movement relationships between the old and the young, the experiment was also performed for the young.

Fig. 1. Two examples of experimental models

B. *Results*

- Toggle switches

The toggle switch control for 'switch on' was dominantly 'up' for vertical direction and 'right' for horizontal direction. The percentages were 69% for the old and 96% for the young for vertical switches and 66.7% and 82.7%, respectively, for horizontal switches. From these results, we can conclude that the control movement of old people for the on/off toggle switch was not different with the existing natural relationships. However, old people's stereotypical relationships were weaker than those of the young.

- Knobs

For knobs, stereotypical relationships between control movement and response were 'clockwise' for 'power on' and 'turn up volume', with 81% and 87.5% for old people, and 96% and 98% for young. From these results, we can conclude that old people's actions for knob-type controls were not different with the existing natural relationships. However, the elderly's stereotypical relationships were weaker than those of the young.

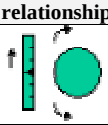
- Rocker switches

For up/down operating rocker switches, 62% of old people and 79% of young pushed the upper part of switch. For left/right operating rocker switches, 54.2% of senior citizens and 81.2% of young people pushed the right side of the switch, so a stereotypical relationship for left/right operating switches was not identified in old people.

- Display-control relationships

For rotary controls and linear displays where the control is placed below or to the right of the display in the same plane, the clockwise-for-increase principle was identified for both old and young. For rotary controls and linear displays where the control is placed above or to the left of the display in the same plane, the counterclockwise-for-increase principle was identified for both the old and the young. However, the stereotypical relationships were weaker for the elderly.

Table 2. Display-control relationships

Display/control relationship	young	old
	100%	93.8%
	84%	66.7%
	98%	91.5%
	88%	56.2%

III. Old people's Characteristics for Controlling Push Type Buttons

A. *Experiment*

In this experiment, we performed an experiment to identify old people's performance variations for button control tasks in comparison with young people. We made some experimental models to effectively perform this experiment.

Movement time is the time required to physically make the response called for by the stimulus. It begins when the movement is initiated and ends when the movement is terminated. The time required to complete a movement depends on the nature of the movement and the degree of accuracy required [2].

In general, movement time would be affected by the moving distance and the precision demanded by the size of the target to which one is moving. The longer the distance and/or the smaller the target, the longer the movement will take. In this experiment, effects of moving distance and

target size on movement time were studied for old people in comparison with the young.

The experiment task was to press a button that was at a distance of some centimeters (20, 30cm). The moving distance from subject's hand to the button was as seen in Fig. 2. Button size was varied in four levels; 6mm, 10mm, 14mm, and 18mm in radius. Ten elderly (average=69.5; maximum=75, minimum=65) and ten young people (average=24.3; maximum=28, minimum=20) participated in this experiment. All experimental conditions were randomly selected to obtain unbiased data. Experimental models were made to effectively carry out this experiment. Fig. 2 shows a scene from this experiment.

Fig. 2. Scene from the experiment

B. *Results*

Firstly, the index of difficulty (ID) was calculated from moving distance and button size, and then the effect of the ID was validated for movement time. Table 3 shows the results. In these results, the movement time that a subject took to control a button was significantly influenced by the ID and showed a significant difference between old people and young. Also, the interaction effect between the ID and age was significant for the movement time.

Average movement times according to each experimental condition are represented in Fig. 3. As can be seen in the graph, the higher the ID, the longer the movement time took. In particular, movement time increased steeply and incrementally with the ID for the elderly, and the variation of movement time was higher in the aged than the young.

Table 3. ANOVA on movement time

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ID	2.039	7	.291	4.227	.000**
AGE	4.115	1	4.115	59.708	.000**
ID * AGE	1.412	7	.202	2.926	.007**
Error	9.925	144	6.892E-02		
Total	159.884	160			
Corrected Total	17.491	159			

* sig. at level 0.05

Fig. 4 shows graphs plotting movement time with ID in both old and young people and Fitt's equations. As can be seen in the graph, movement times effectively fit with Fitt's equation, so it was validated that movement time can be estimated by Fitt's equation in both old and young.

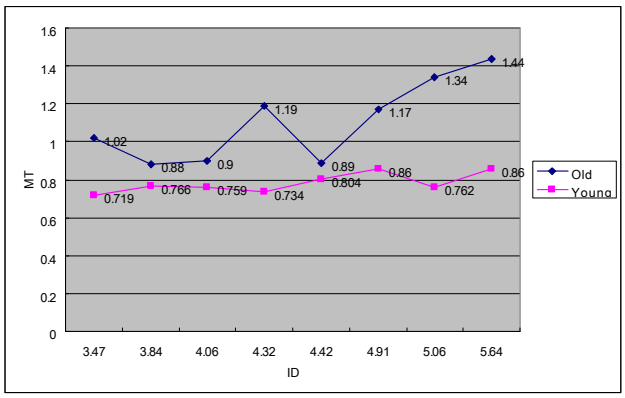
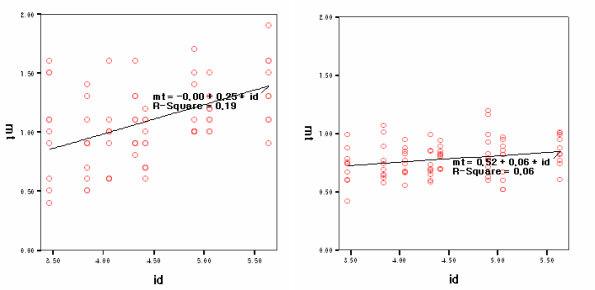


Fig. 3. Average movement time with ID



a. Old people b. Young people

Fig. 4: Control performance

IV. Conclusion

It is rare to consider old people's characteristics in product design, even though the number of senior citizens is increasing fast. In this aspect, old people's characteristics for controlling control devices were studied in comparison with young people.

Firstly, we studied senior citizen's control-movement characteristics. The results show that the relationships on control movement were not remarkably different in comparison with the existing principles. However, the stereotypical relationships were dominantly weaker than in the young in most cases.

Secondly, old people's movement time for controlling push buttons with button size and moving distance was studied. As the result, the elderly's performance for controlling button was not remarkably different in comparison with the existing principles. Movement time was affected by the ID that was calculated by moving distance and button size. In particular, movement time increased more steeply in increments of ID for older people than young. This means that the index of difficulty in the case of user interface design for old people has to be lower than with the young. Also, Fitts' Law, which has successfully described the one- or two-dimensional control task, was validated for the task of controlling buttons and well described old people's performance.

In order to design a product for the aged, product designers have to know and understand their characteristics for controlling the product. If not, they won't be able to design a product for senior citizens. In this aspect, this study can offer important, valuable and useful results.

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