A Study on the Mode of User Interface for the Elderly.

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Most people have one of the consumer electronic appliances such as a digital watch, a digital clock, a digital camera, a compact disk player, or a cell phone. When using the consumer electronic appliances, there are many interaction problems happened since the users cannot understand the relationships between buttons and their contents on the display. One of the reasons was the mapping problem between buttons and display contents for a digital product. The digital clock, with buttons and a small display, represents a typical consumer electronic product. Therefore, a digital clock was chosen to study the mapping problems, and five different interfaces, namely Type A, Type B, Type C, Type D and Type E, were designed. The interfaces had three same functions – date, time, and alarm functions. The modes of these user interfaces are described as follows:

1. Type A was a spatial correspondence by the top-bottom mapping
2. Type B was a spatial correspondence by a vertical order of contents and horizontal order of buttons
3. Type C was a horizontal mapping of spatial proximity
4. Type D was a hierarchical structure of the display contents
5. Type E was a dialogue mode of the display contents with a touch-screen

All the interfaces were simulated on a LCD notebook with a touch-screen.

Forty elderly subjects (above 65 yrs) and forty middle-elderly subjects (45-64 yrs) participated in this study. Every subject had to operate three tasks, i.e. to operate time setting, to set the alarm time, and to set date. For every interface, the three tasks should be conducted successively, and the total operation time was recorded. Furthermore, we investigated how problems occurred with the operation of these interfaces, and collected all data by questionnaires, interviews, and observations. After finishing all tasks, the subjects answered questionnaires and were interviewed how errors happened.

According to the results of this study, the interface of Type E was the best interface for the elderly since its interface design was a direct relationship between what eyes saw and what hands did. The interfaces of Type A and Type D were two poorer interfaces for the elderly. Since the interface of Type A was not good relationship between the buttons and display contents and the interface of Type D was the hierarchical structure of display contents, the elderly had difficulty in understanding the operation processes and button functions. On the whole, the natural mappings between buttons and display contents could be helpful for the elderly to operate. These results would be discussed in more detail.

A Study on the Mode of User Interface for the Elderly

Abstract

The purpose of this study was to investigate the mode of user interface of consumer electronic appliances for the elderly. For this purpose, a digital clock was chosen with five different interface modes in this experiment. Forty elderly subjects (above 65 yrs) and forty middle-elderly subjects (45-64 yrs) participated in this study. Each subject had to operate three different tasks such as time setting, alarm time setting, and date setting. We investigated how problems encountered when performing these tasks, and collected data such as operation time, total number of input, and subjective estimation. The findings of this study indicated that the interface modes had significant effects on operation time, number of total input, and subjective estimation. On the whole, the mode of the natural mapping between buttons and display contents could be helpful for the elderly to operate.

Keywords: the elderly, user interface, electronic appliance, digital clock

Introduction

Owing to the progress in the microprocessor control system, growing number of electronic appliances are used in our daily lives. The characteristics of electronic appliances are a digital display and some buttons. When using the digital product, the user inputs through the buttons and gets feedback from the digital display. The product and the user interact successively, until the operational goal is achieved. However, most digital products have many functions, and their structures are complex. Almost all users are not able to use a single function without trial and error, or referring to manuals. Furthermore, some users such as novices or elderly people give up using some functions after a few failed trials. Some interaction problems occur from the poor mapping between components of the solid user interface and the graphic user interface (Han et al., 2001, Lee and Liao, 2003). For example, using a digital watch or digital clock, there are many interaction

problems since the users cannot understand the mappings between buttons and display contents. Therefore, a good mapping between buttons and display contents of electronic appliances can be helpful for the user.

Many advanced and advancing countries in the world have aged societies. Elderly people have become a substantial part of consumer groups in the market. But consumer products have seldom been designed to target elderly people (Czaja, 1997; Howell, 1997; Freudenthal, 1999). The elderly people have many user interface problems when they operate appliances such as digital watches or digital clocks with simple menus (Lee and Liao, 2003), since there is progressive decline in physiological and psychological ability for the elderly (Hawthorn, 2000). It is very important that the designers have to understand their unique physical characteristics before designing a product (Rogers and Mynatt, 2003). Using natural mapping, lower mental workload is required for the operations (Sanders and McCormick, 1993), and it will be suited for the elderly and other people alike. This concept is also called universal design (Mace, 1997) or inclusive design. As mentioned above, the user interface with natural mappings will benefit the user especially for the elderly, but it is a difficult task for designers. In order to render natural mappings applied effectively, the purpose of this study was to investigate the mode (natural mapping) of user interface of consumer electronic appliances for the elderly.

Methods

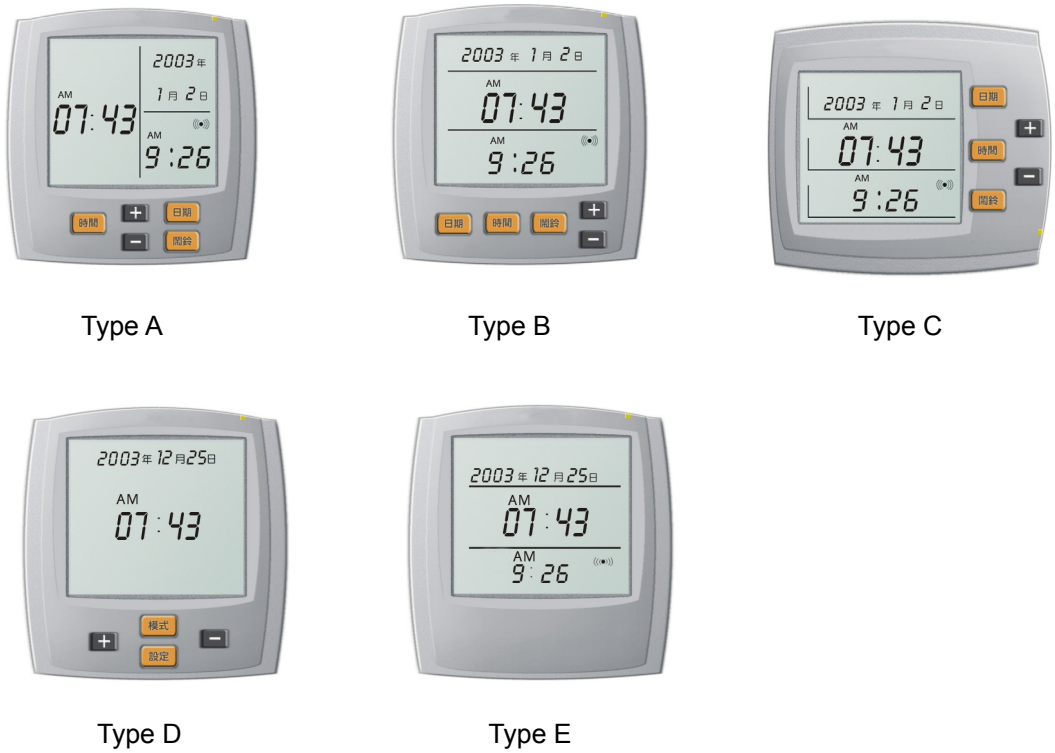
Because a digital clock, equipped with buttons and a small display, represents a typical electronic product, the digital clock was chosen to study mapping problems in the study. The digital clock was designed with five different interface modes, namely Type A, Type B, Type C, Type D, and Type E (Fig. 1). The five interface modes have three same functions – date, time, and alarm. The modes of these user interfaces are described as follows:

(1) Type A was a spatial correspondence by the top-bottom mapping;
(2) Type B was a spatial correspondence by a vertical order of contents and horizontal order of buttons;
(3) Type C was a horizontal mapping of spatial proximity;
(4) Type D was a hierarchical structure of the display contents;
(5) Type E was a dialogue mode of the display contents with a touch-screen.

All the interfaces were simulated on a LCD notebook (Clevo-3220) with a capacitive touch screen (Ingenious Technology Co., One Touch). In order to avoid the influences of visual

perception, a bigger font size (height > 7 mm) was used, and each subject could see the experimental contents (including characters and icons) clearly in this study.

Forty elderly subjects (age 62-77, M = 68.8, SD = 3.8) and forty middle-aged subjects (age 42-56, M = 51.2, SD = 4.1) participated in this study. The protocol was explained, and informed consent was obtained from each subject. In order to check the subjects' experience levels of using electrical and electronic appliances, sixteen pictures of electrical and electronic appliances (i.e. microwave oven, digital clock, washing machine, mobile phone, digital camera etc.) were shown to the subjects. The subjects selected them if they have operation experiences. The number of those appliances selected was from 4 to 14 in this study, and the average value was 9.2 (SD = 2.6). The average value plus/minus fifty percentage of standard deviation was used as the divided point of experience level (Wu, 2003); the low, medium, and high experience level were established as 4-7, 8-10, and 11-14, respectively, from the number of those appliances selected.



Type A　　Type B　　Type C

Type D　　Type E

Fig. 1　The interface modes of the digital clock used in this study.

Eighty subjects were divided at random into three groups – G1, G2, and G3 in this study. All subjects had to operate the interfaces of Type D and Type E. The interfaces of Type A, Type B, and Type C are quite similar. In order to avoid the accumulation of the operational experience, the subjects of group G1, G2, and G3 operated the interface of Type A, Type B, and Type C, respectively. As a result, each subject operated only three

interface modes in this study. Table 1 shows the arrangements – subject groups, operational order of interface modes, and the number of the subjects. Each subject had to operate three tasks, such as time setting, alarm time setting, and date setting, for the chosen interface mode. For each task, the number (time setting = 14 times, alarm time setting = 14 times, date setting = 16 times) of the exact operation was the same for the five interface modes. For each mode of operation interface, the three tasks should be conducted successively, and the total operation time and the number of total input (including mistake input) were recorded. Furthermore, we investigated how problems

Table 1 Arrangements: subject groups, operational order of interface modes, and the number of the subjects

Subject groups	Operational order of interface modes	Elderly subjects (persons)	Middle-aged subjects (persons)
G1	Type A、Type D、Type E	6	6
	Type D、Type A、Type E	6	6
G2	Type B、Type D、Type E	7	7
	Type D、Type B、Type E	7	6
G3	Type C、Type D、Type E	7	8
	Type D、Type C、Type E	7	7

Table 2 The results of subjective estimation on interface modes

Items of the questionnaires \ Interface modes	Type A	Type B	Type C	Type D	Type E	p value	Post hoc tests
Q1: Is it easy to operate time setting?	2.9 / 3.0	3.7 / 4.2	3.6 / 3.9	2.2 / 3.0	4.3 / 4.1	p<0.001	[A, D] < [B, C, E]
Q2: Is it easy to set the alarm time?	2.8 / 3.1	3.9 / 3.9	3.7 / 3.9	2.1 / 2.4	4.2 / 3.9	p<0.001	[A, D] < [B, C, E]
Q3: Is it easy to set date?	2.9 / 3.2	4.0 / 4.2	3.6 / 3.8	3.1 / 3.1	4.4 / 4.1	p<0.001	[A, D] < [B, C, E]
Q4: Is it clear to see the characters of the display?	4.1 / 4.2	4.3 / 4.3	4.0 / 4.2	4.0 / 4.0	4.3 / 4.3	p<0.05	-
Q5: Is it easy to understand the contents of the display?	2.8 / 3.0	4.0 / 4.1	3.7 / 3.9	2.4 / 2.7	4.2 / 3.9	p<0.001	[A, D] < [B, C, E]
Q6: Is it satisfied with the design of the digital clock?	2.9 / 3.0	4.0 / 4.1	3.9 / 3.9	2.3 / 2.7	4.2 / 3.9	p<0.001	[A, D] < [B, C, E]

Data shown are the average values of the elderly / those of the middle-aged.

The semantic differential method, 5-points scale, was used for the subjective estimation of this study.

Scale: 1 = very disagree; 2 = disagree; 3 = no comment; 4 = agree; 5 = very agree.

encountered when operating those interfaces, and collected other data by questionnaires and interviews. The questionnaire has six questions (Table 2) regarding the subjects' responses. After finishing the three tasks for an interface mode, the subjects answered questionnaires and were interviewed how errors happened.

Results and Discussion

According to the results, the changes of operation time were significant between the two subject groups ($p<0.05$, Fig. 2); the subjects had more difficulties in operating the Type A and Type D interface modes than those of the other three modes ($p<0.001$, Table 2). It is suggested that the higher level of difficulties of an interface (such as Type A or Type D), the greater the age differences will be. This result was consistent with Vercruyssen's report (1997). Especially, for the middle/high experience subjects, the operation time was longer for elderly subjects than that for the middle-aged subjects in Type A mode（$p<0.05$）; for the middle experience subjects, the operation time was longer for middle-aged subjects than that for the elderly subjects under Type D（$p<0.05$）. It is clear that the elderly subjects took longer time than the middle-aged subjects for the interface mode of Type A, since the elderly subjects began to decline in the capabilities of motion, perception, and cognition (Rogers and Mynatt, 2003). However, contrary results for the interface mode of Type D were obtained. The middle-aged subjects took longer time than the elderly subjects because the former had higher number of total input (M = 155 times, Fig. 3) than the latter (M = 129 times, Fig. 3) for Type D. It was also found that the middle-aged subjects made several mistakes during the operation processes for Type D; consequently, more inputs and longer operation time (M = 769 seconds, Fig. 2) was needed in this study.

For both age groups, the number of total input was 1.3 to 3.5 times of the total exact operation (44 times). It seems that most subjects could not operate the tasks correctly; they made mistakes during the operation processes. According to the results, the experience level affected the operation time ($p<0.001$, Fig. 4) and the number of total input ($p<0.001$, Fig. 5). There was a significant negative linear relationship between the experience level and the operation time ($F(1, 229) = 15.0$, $p<0.001$, $r = -0.25$), and the number of total input ($F(1, 229) = 11.3$, $p<0.01$, $r = -0.22$). On the whole, if the subjects had high experience in using electrical and electronic appliances, they would operate the task quickly (less operation time and less number of total input).

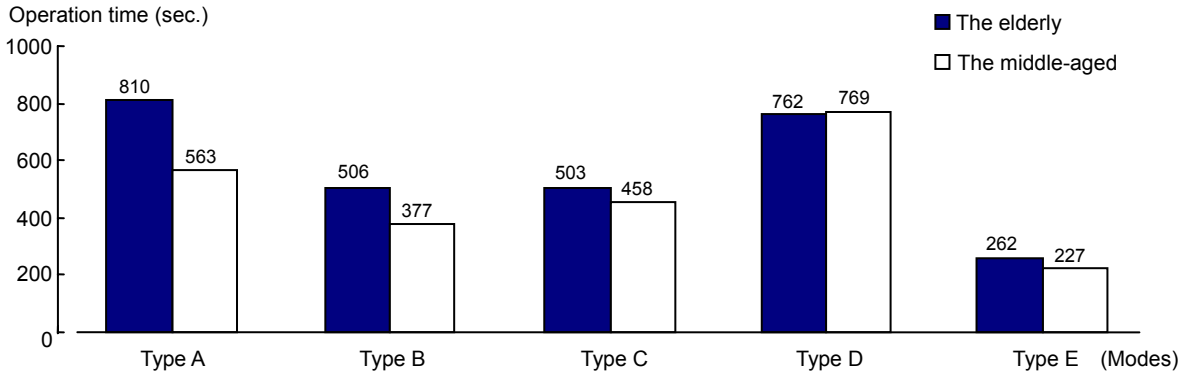


Fig. 2 The results of operation time on interface modes

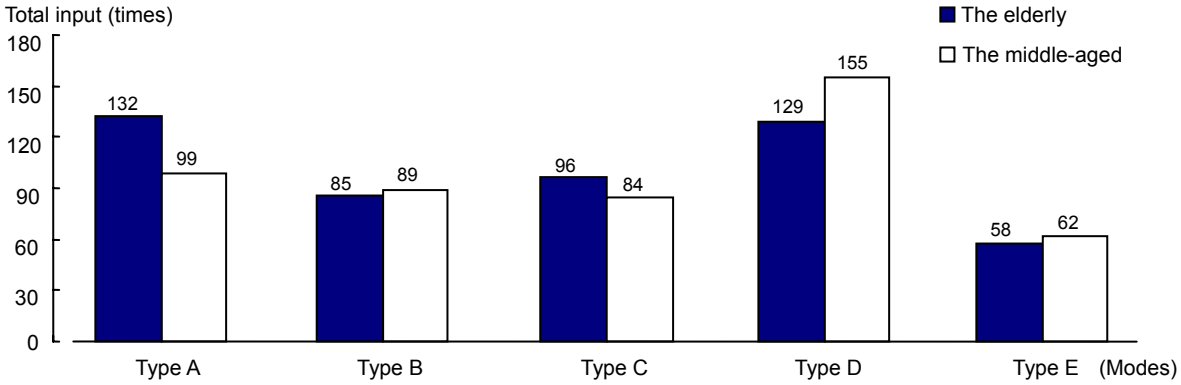


Fig. 3 The results of total input on interface modes

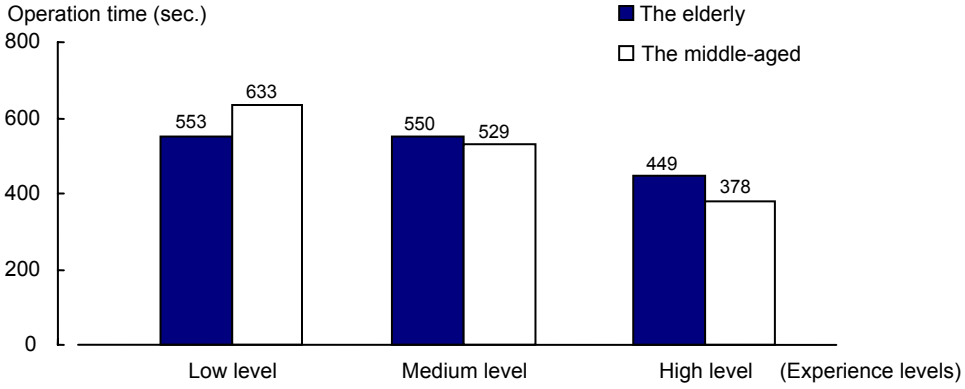


Fig. 4 The results of operation time on experience level

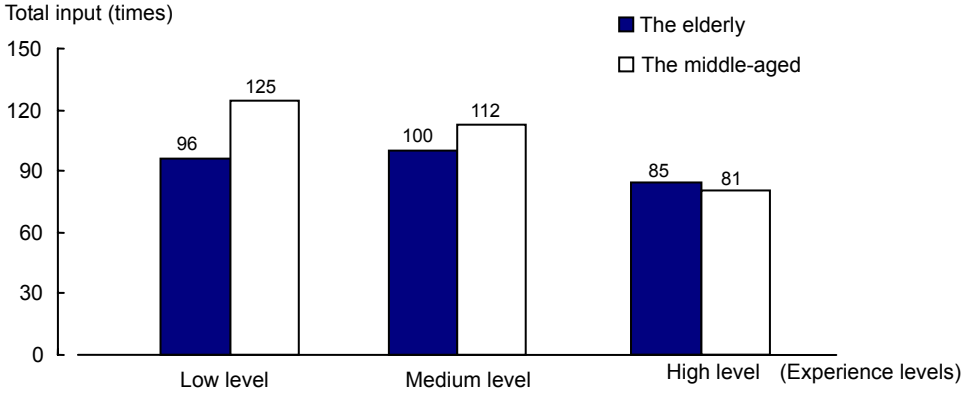


Fig. 5 The results of total input on experience level

Considering the results of operation time (Fig. 2), number of total input (Fig. 3), and subjective estimation (Table 2), the subject preferred the Type E interface mode, and did not like to operate the interface modes of Type A and Type D. The interface mode of type E was designed as a dialogue mode with the display contents in a touch-screen, so the subject operated it efficiently (less operation time, less number of total input, and high user satisfaction). It is suggested that the dialogue mode with the display contents in a touch-screen was a preferred interface mode for both age groups in this study. The Type D interface mode was designed as the display contents in a hierarchical structure. From the results of interviews, the subjects commented that they did not like to operate the interface mode of Type D because its operation was too complex to use. Consequently, more operation time, more input, and low subjective estimation were taken for Type D. The interface modes of Type A, Type B, and Type C were designed by means of different mapping between buttons and display contents. Compared with Type B/Type C, Type A was not easy to operate (Table 2). It seems that the mapping between buttons and display contents was better for Type B/Type C than Type A, and there were less operation time for Type B/Type C (Fig. 2).

This paper is aimed to investigate the user interface design of typical electronic products such as digital clocks. In particular, elderly people and middle-aged people took part in this study. According to the results of the present study, the subjects operated tasks by trial and error until tasks were achieved, and many user interface problems were encountered. It is considered that the user interface problems encountered here will also occur in other electronic appliances; nevertheless, it is concerned about which interface mode used in this study is easier for users. On the whole, the best interface was Type E, followed by Type B/Type C, Type A, and the worst one was Type D in this study. Type E was the best interface for both age groups since all functions were listed in the original display with a touch-screen. Users could choose any available function without thinking its relationships between buttons and display contents, i.e. a direct relationship between what eyes saw and what hands did (Dul and Weerdmeester, 1993). It is also suggested that the subjects carried out the task of Type E with less thinking about how to use, and accomplished it efficiently. Therefore, the interface mode of Type E with a dialogue mode in a touch-screen is good for the elderly. The interface mode of Type D has a hierarchical structure, making the subjects unable to understand the operation processes and button functions; therefore the subjects performed tasks with more thinking about how to use, and made more effort to finish tasks. So the interface mode of Type D is not good for elderly people. From the view of mapping, the Type B/Type C interface modes were designed as a

spatial mapping between the buttons and display contents (Type B has a spatial correspondence by a vertical order of contents and horizontal order of buttons and Type C has a horizontal mapping of spatial proximity). And, their relationships could be understood easily (Table 2), consequently facilitating the task performance for the subjects. The interface mode of Type A was designed as a spatial correspondence by a top-bottom mapping; the subjects were not satisfied with Type A and the results were poor (Table 2). Compared with Type B/Type C, the interface mode of Type A is not good for the elderly.

Conclusions

Based on the findings of this study, the interface modes had significant effects on operation time, number of total input, and subjective estimation. On the whole, the interface of Type E was the best interface for the elderly since its interface design was a direct relationship between what eyes saw and what hands did. The interfaces of Type A and Type D were two poorer interfaces for the elderly. Since the interface of Type A was not good relationship between the buttons and display contents and the interface of Type D was the hierarchical structure of display contents, the elderly had difficulty in understanding the operation processes and button functions. On the whole, the mode of the natural mapping between buttons and display contents could be helpful for the elderly to operate.

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