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Optimal Slope of Touch Panel －Comparison between Young and Older Adults－

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Abstract － **Touch panels are becoming increasingly common alternatives to traditional indirect devices such as mouse. However, older adults are not willing to utilize touch-panel based ATM or ticket machines, because they feel that using ATM properly is too difficult and annoying for them. The aim of this study was to identify an optimal slope of touch panel interface. Whether using a direct input device by older adults would lead to smaller difference of performance between preferred and non-preferred hands was also examined. For both young and older adults, the slope conditions of 30, 45, and 60 degrees, and the target size of 60 x 60 pixels were found to lead to higher performance. With the increase of movement distance d, the movement velocity tended to increase for both age groups. The difference of movement velocity between young and older adults tended to increase with the increase of movement distance d. The difference of performance between non-preferred and preferred hands was smaller relative to their young counterparts. Moreover, the difference of performance between young and older adults was smaller when using a touch panel than when using a mouse.**

1. INTRODUCTION

There are many touch panel interfaces such as ticket machines at stations, or ATM (automatic teller machine) in banks, post offices, or convenience stores. Older adults, however, are not willing to utilize these equipments. The utilization of ATM by older adults is low as compared with younger generations. Almost all of older adults who are not willing to utilize ATM is feeling that using ATM properly is too difficult and annoying for them. Touch panels are becoming increasingly common alternatives to traditional indirect devices such as mouse.

There are many reports suggesting that older adults exhibit deficits in various cognitive motor tasks (Goggin et al. 1989, Goggin and Stelmach 1990). It is expected that such degradation of cognitive-motor functions of older adults would lead to inconveniences when using input devices.

Walker, Philbin, and Fisk (1997) showed that novice older adults were less accurate in using a mouse in a target acquisition task that their young counterparts. Walker, Millians, and Worden (1996) and Smith, Sharit, and Czaja (1999) showed that older experienced mouse user have similar problems. Touch panel offers a “where you point is where you go” (WYPIWYG) operation. As age differenced in mouse use accounted for by age differences in mapping operation when using a mouse, it is expected that touch panel compensate for the age related difference when using a mouse, and that touch panel leads to faster and more accurate pointing (Murata, 2005; Iwase and Murata, 2004).

It was verified that user performance and preferences favor touch panels over mouse and keyboard (Karat, 1984). Martin (1988) discussed configuration of a numerical keypad for touch panel, and found that keypads with square keys resulted in improved speed and a higher degree of accuracy than keypads with either a longer horizontal dimension or a longer vertical dimension. Rogers, Fisk, McLaughlin, and Pak (2005) assessed whether and how task demands and user age influenced task performance for a direct input device (touch panel) and an indirect input device (rotary encoder). They showed that performance was moderated by both age and task demands.

Although touch panels are ubiquitous in many interfaces, its installation slope is not fixed in many instances. Touch panels at ATM and at ticket machines are installed horizontally and vertically, respectively. However, there seem to be few studies that clarified the optimal slope of touch panel interfaces. As mentioned above, touch panel compensate for the age related difference when using a mouse, and that touch panel leads to faster and more accurate pointing.

Charness, Holley, Feddon, and Jastrezembski (2004) showed that the light pen minimized age differences in performance relative to the mouse. Moreover, older adults were found to be less efficient using their non-preferred hand than young. It is expected that the difference of performance between preferred and non-preferred hands when using a direct input device becomes smaller than that when using a direct device such as a mouse. However, such a tendency was not verified in Charness et al. (2004). If such differences of performance between preferred and non-preferred hands is small when older adults are using a direct input device, this can be regarded as an advantage of using direct input devices.

The aim of this study was to identify an optimal slope of touch panel interface. Whether using a direct input device by older adults would lead to smaller difference of performance between preferred and non-preferred hands was also examined.

2. METHOD

2.1 Participants

Twenty participants took part in the experiment. Ten were male adults aged from 65 to 81 years. In this study, the older adults had an average of 8.53 hours on Web navigation. Ten were male undergraduate students aged from 21 to 24 years. The young adults had an average of 13.4 hours spending on Web navigation. The visual acuity of the participants in both young and older groups was matched and more than 10/20. They had no orthopaedic or neurological diseases.

The handedness of all participants was checked using a test battery developed by Oldfield (1971) and Chpman (1987). The handedness of all participants was right.

2.2 Apparatus

A 10.4-inch touch panel (Digital, FP2500-T11) was used. The resolution was 640 x 480 pixels, and dot pitch of the touch panel display was 0.033 cm. The distance between the center of touch panel and the participant was set to the 50% value of the participant's arm length. The bottom of touch panel was set to the position that corresponded to 50% of the participant's height.

2.3 Task

The temperature inside the laboratory was 20℃. The illumination and the brightness on the touch panel surface were 175lx and 240cd/m^2, respectively. The participants were required to carry out a task with standing position. After touching the center of touch panel, a target to be pointed appeared at one of eight directions (right, upper right, upper, upper left, left, lower left, lower, lower right). The participant was required to press the target using an index finger of either preferred or non-preferred hand. If the coordination of touch (press) was within the target square, this was regarded as a successful trial. Other cases were regarded as error trials. An example of the experimental display is shown in Figure 1. A side view of touch panel is shown in Figure 2.

2.4 Design and Procedure

The between-subjects experimental factor was participant age (young and older adults). The within-subjects experimental factor was the slope of touch panel and the handedness (preferred and non-preferred hands). The direction of target (eight conditions as mentioned above), the movement distance (four levels: 50, 100, 150, and 200 pixels), and the target size (four levels: 20 x 20pixels, 40 x 40pixels, 60 x 60 pixels, and 78 x 78 pixels) were also within-subject factors. Due to the limitation of touch panel display, the target size of 80 x 80 pixels could not be realized. For each combination of slope and handedness, a total of 128 pointing trials were carried out. The order of performance of direction, target size, and movement distance was randomized across the participants. The order of performance of 10 combinations of handedness and slope was also randomized across the participants.

Prior to their involvement in the experiment, participants signed an informed consent document. Before the experiment began, participants were given instructions for the pointing task and allowed a few practice trials.

Participants were required to respond as quickly as possible while keeping their accuracy as high as possible, and they were allowed to rest between sessions composed of combinations of handedness and slope. After each slope condition was completed, the psychological rating on visibility and ease of press was carried out using a five-point scale (1=very poor, 5=very good).

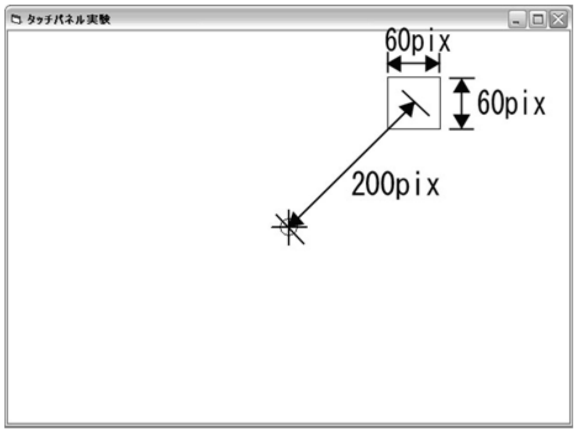


Figure 1 Experiments display (target size: 60 x 60pix, distance from center: 200pix).

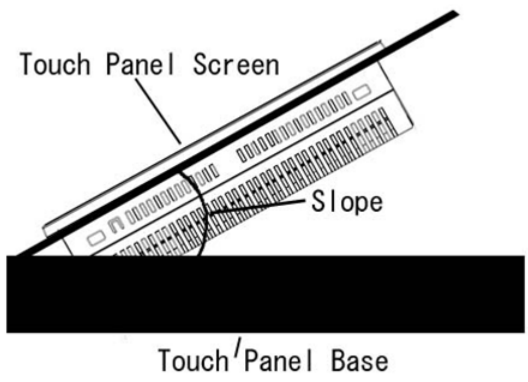


Figure 2 Side view of touch-panel.

3. RESULTS
3.1 Error rate

In Figure 3, the error rates are plotted as a function of slope and target size ((a)young, (b)older adults). The error rate in Figure 3 corresponds to the mean value of preferred and non-preferred hands. The error rate for the target size conditions of 60 x 60 pixels and 78 x 78 pixels was less than 20%.

A three-way (age by handedness by slope) ANOVA was carried out on the error rate. A significant main effect of age ($F(1,18)=5.0$, $p<0.05$) and a significant slope by age interaction ($F(4,72)=2.6$, $p<0.05$) were detected. Fisher's PLSD revealed significant differences between 0 and 30 degrees, between 0 and 45 degrees, between 0 and 60 degrees, between 0 and 75 degrees, between 45 and 75 degrees, and between 60 and 75 degrees.

For each age group, a two-way (handedness by slope) ANOVA was conducted on the error rate. As for the young adults, only significant main effects of handedness ($F(1,9)=17.4$, $p<0.01$) and slope ($F(4,36)=5.2$, $p<0.01$) were detected. No significant interaction was revealed. Concerning the older adults, only a main effect of slope ($F(4,36)=5.5$, $p<0.01$) was detected. The error rates operated with a preferred hand for young and older adults were 25.7% and 19.7%, respectively. The error rates operated with a non-preferred hand for young and older adults were 29.7% and 21.9%, respectively.

3.2 Operation time

It is evident from Fitts' law that the pointing time increases with the increase of movement distance and with the decrease of target size. Fitts' model can be described using movement distance d and target size s as follows.

$$pt=a+b\log_2(d/s+0.5) \qquad (1)$$

where pt is pointing time, and parameters a and b are empirically determined by model fitting to Eq.(1). Using target size conditions where error rate were less than 20% (60 x 60 pixels and 78 x 78 pixels), a three-way (age by handedness by slope) ANOVA was carried out on the pointing time. Only a significant main effect of age ($F(1,18)=10.2$, $p<0.01$) was detected.

3.3 Movement velocity

Movement velocity was defined by dividing movement distance d by pointing time pt. In Figure 4, movement velocity is plotted as a function of slope and distance for young and older adults. With the increase of movement distance, the movement velocity tended to increase, and the difference of movement velocity between young and older adults tended to enlarge.

Using target size conditions where error rate were less than 20% (60 x 60 pixels and 78 x 78 pixels), a three-way (age by handedness by slope) ANOVA was carried out on the movement velocity. Significant main effects of age ($F(1,18)=14.1$, $p<0.01$), slope ($F(4,72)=5.5$, $p<0.01$), and handedness ($F(1,18)=5.5$, $p<0.05$) were detected. No significant interactions were detected. Fisher's PLSD revealed significant differences between 0 and 30 degrees, between 0 and 45 degrees, between 30 and 75 degrees, between 45 and 75 degrees, and between 60 and 75 degrees.

3.4 Psychological rating on visibility and ease of press

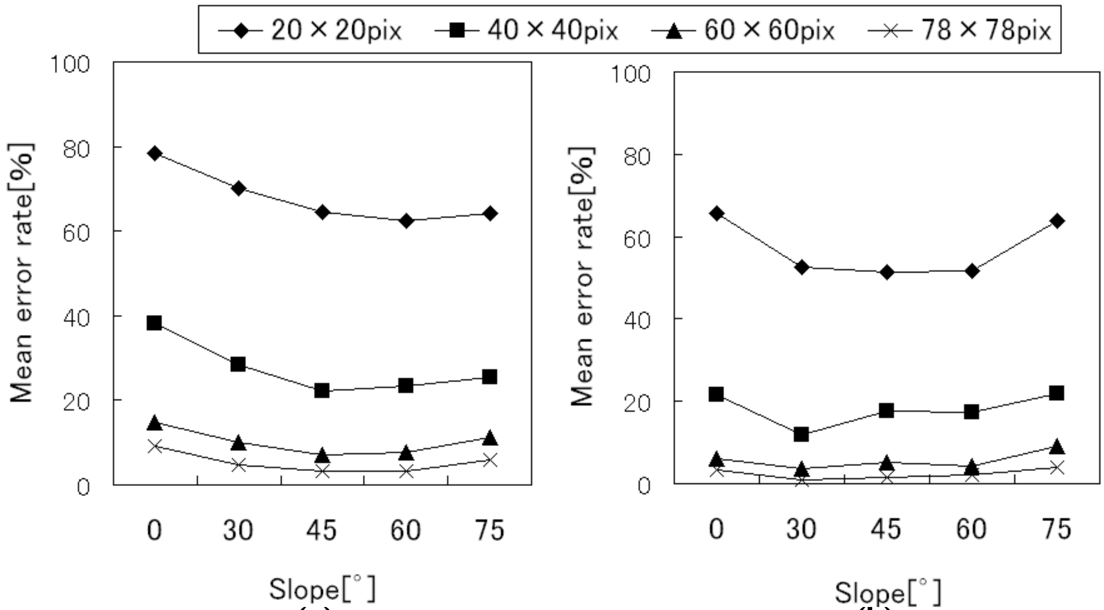
The mean rating scores on visibility and ease of press compared among slope conditions and between age groups are shown in Figures 5 and 6, respectively.

As a result of Friedman test carried out on both scores of visibility and ease of press, both scores of young adults were found to be significant among slope conditions ($p<0.01$). Multiple comparisons revealed the following significant differences: visibility(between 30 and 75 degrees ($p<0.05$), and between 45 and 75 degrees ($p<0.05$)) and ease of press (between 0 and 75 degrees ($p<0.05$), between 30 and 75 degrees ($p<0.01$), and between 45 and 75 degrees ($p<0.01$)).

A similar analysis was carried out for older adults. As a result of Friedman test carried out on both scores of visibility and ease of press, both scores of young adults were found to be significant among slope conditions ($p<0.01$). Multiple comparisons revealed the following significant differences: visibility(between 30 and 75 degrees ($p<0.01$), and between 45 and 75 degrees ($p<0.01$)) and ease of press (between 30 and 75 degrees ($p<0.01$), and between 45 and 75 degrees ($p<0.01$)).

4. DISCUSSION
4.1 Effects of slope on performance

In the range of this experiment, the slope conditions from 30 to 60 degrees were found to lead to lower error rate. As shown in Figure 4(b), when the target size is small (20 x 20 pixels), the error rates from 30 to 60 degrees were smaller than those under other slope conditions. The slope conditions from 30 to 60 degrees also led to faster movement velocity. The psychological rating on visibility and ease of press also supported the effectiveness of slope conditions from 30 to 60 degrees. Future research should identify in more detail the optimal slope between 30 and 60 degrees.



(a) (b)

Figure 3 Mean error rate as a function of slope and target size. (a) young, (b) older adults.

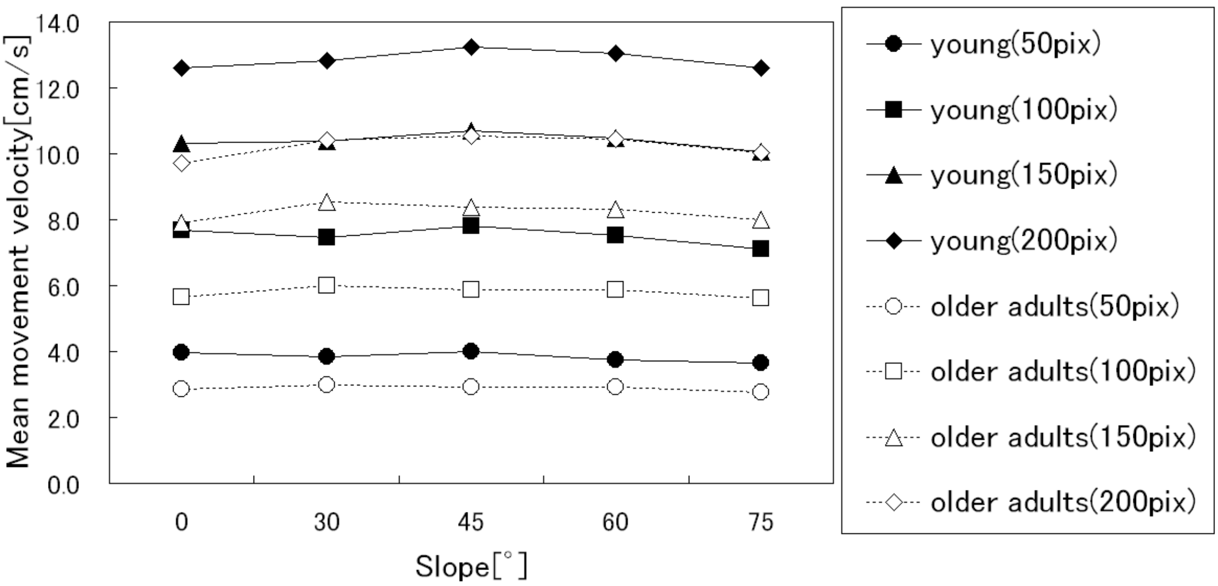


Figure 4 Mean movement velocity as a function of slope and distance for young and older adults.

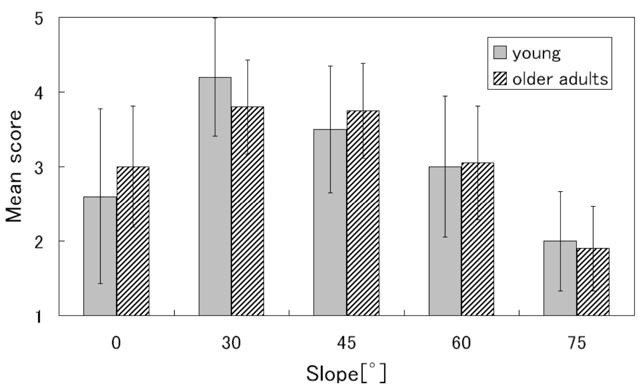


Figure 5 Mean score of visibility as a function of slope and age.

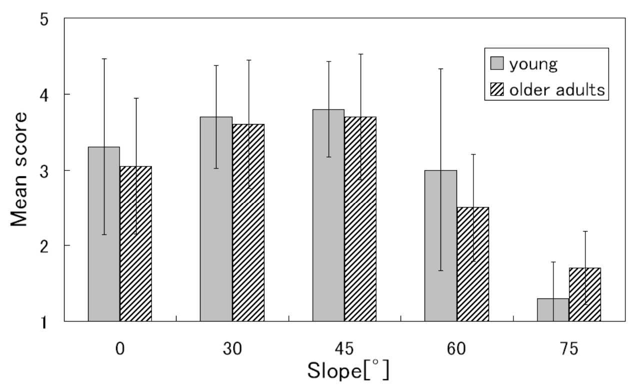


Figure 6 Mean score on ease of press as a function of slope and age.

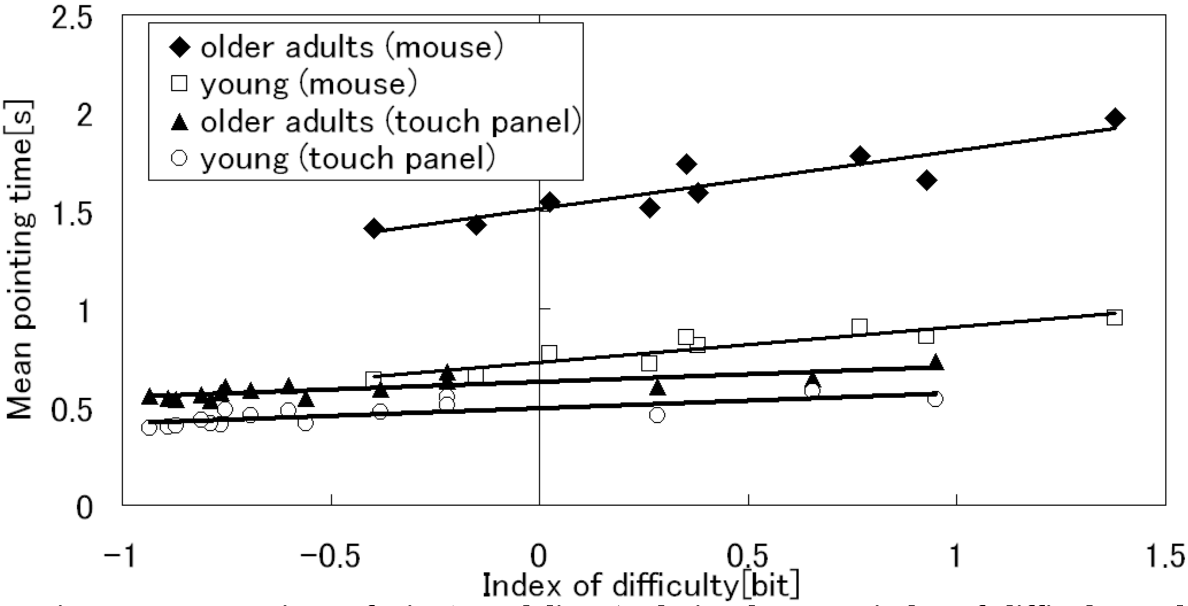


Figure 7 Comparison of Fitts' modeling (Relation between index of difficulty and pointing time) between mouse and touch-panel between young and older adults.

4.2 Effects of movement distance *d* on performance

As mentioned above, for both age groups, it tended that the movement velocity increased with the increase of movement distance. Participants tried to shorten the movement time by increasing the movement velocity when the movement distance was long. It must be noted that the difference of movement velocity between young and older adults was enlarged with the increase of movement distance. Therefore, touch panel interfaces for older adults should be designed so that the movement distance is as short as possible.

4.3 Effects of target size *s* on performance

Under the condition of target size of more than 60 x 60 pixels, the error rate was less than 20%. The target size of 60 x 60 pixels corresponds to about 2.0 x 2.0 cm. This is larger than the finger tip. The target size with more than the finger width should be recommended.

4.4 Effects of handedness on performance

As mentioned in the Results section, only older adults showed a tendency that the handedness did not affect the error rate. This indicates that older adults can perform properly either preferred or non-preferred hand. Charness et al. (2004) showed that the light pen minimized age differences in performance relative to the mouse. Moreover, older adults were found to be less efficient using their non-preferred hand than young. Therefore, it is expected that the difference of performance between preferred and non-preferred hands when using a direct input device becomes smaller than that when using a direct device such as a mouse. The results in this study verified the hypothesis that the difference of performance between preferred and non-preferred hands when using a direct input device becomes smaller.

4.5 Comparison of performance between mouse and touch panel

In Figure 7, Fitts' modeling is compared between mouse and touch panel, and between young and older adults. Here, the data of slope of 45 degrees and preferred hand were used to model the pointing time of touch panel. The data on mouse pointing were referenced from Takahashi and Murata (2008). The slope *b* of touch panel was smaller than that of mouse, which indicates that touch panels are less affected by movement distance and target size than mice. The touch panels are friendly interfaces especially for older adults, if the pointing conditions such as target size of more than 60 x 60 pixels are properly selected.

Future research should explore the possibility of touch panel in activities other than pointing such as menu selections or scrolling.

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