Display Locations of Information on Wide Screen Display Devices

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In this study, a calculation task was given as a main task. The task was shown in the center area of a wide screen display. As a sub task, a random quadrilateral shape was shown at the left and right edges of the display device. This was a reaction-based asking the subject to press the space key whenever the quadrilateral shape was displayed. I analyzed the correlation between display location and reaction time when these two tasks were conducted simultaneously. Results demonstrated the following: (1) Regardless of the difficulty of the task, “upper-right corner” and “center of the right edge” of the screen are display locations that make it difficult to see the displayed information. (2) It was clear that for the four display locations “upper-left corner”, “lower-left corner”, “center of the right edge”, and “just below the center of the right edge”, the discovery of information took longer as the difficulty of the task shown in the center of the display increased.

Keywords: display location, wide screen, useful field of view, reaction time, task

1. Introduction

Market research conducted in 2013 on information terminal equipment indicated that screen sizes above 20 inches accounted for approximately 60% of display devices in the global market, while wide types with screen aspect ratios of 16:9 and 16:10 accounted for 94% (Information Terminals and Technologies Committee, 2014). This trend toward larger and wider devices is particularly evident with personal computers (PCs), where the screen aspect ratio was previously 5:4 for conventional devices and is currently 16:9 for recent devices. Consequently, the computer working environment has greatly changed.

The desirable working distance between the PC screen and a user is typically small—about 0.6 ± 0.15 m (ISO 9241-5, 1998). The visual information processing ability (visual field) of humans, however, is such that an object at the center of the visual field can be clearly seen, but an object becomes more difficult to see as the distance between the object and the center of the visual field increases (Alpern, 1962; Miura, 2012). The human effective field of view lies in a range that can be used or that functions when a certain visual task is performed (Mackworth, 1976; Hatada, 1986). Therefore, information at the periphery of a wide screen display device could be overlooked or processed more slowly when the viewer focuses attention at the center of the screen. Some types of information-processing activities can be triggered solely by an input of information. Others require an additional input of attention or effort. Because the total quantity of effort which can be exerted at any one time is limited, concurrent activities which require attention tend to interfere with one another (Kahneman, 1973).

The present study investigated the effects of use of a wide screen display device on performance of a calculation task displayed at the center of the screen as a main task. A secondary reaction task (sub task) consisted of a random display of a quadrilateral at the right or left edge of the screen, and the subjects were asked to press a space key when the quadrilateral was displayed. The subjects performed these two tasks simultaneously, and the relationship between the display location of information and the reaction time was analyzed.

2. Experiment

2.1 Subjects

The subjects were seven male university students aged 19–24 years. The computation career is more than five years in all subjects. Before the experiment, each subject’s eyesight and visual field were confirmed to
be normal. The subjects were asked to get a full night’s sleep by going to bed by 11:00 pm before the experiment to avoid sleepiness during the tasks.

Figure 1. The scenery of the experiment.

Figure 2. An example of the experiment screen. (Display location No.)

2.2 Environment
The height of the display device was adjusted so that the center of the screen was at the eye position of each subject (Figure 1). The screen was perpendicular (90 degrees) to the desk, and the distance between the screen and the subject’s eyes was 0.6 m. The room temperature was 23°C, the humidity was 55 ± 7%, and the illumination at each subject’s hands was 580 ± 8 lx. The subjects were asked “not to move your face closer to the display device and not to lean on the desk” and “not to disengage your first finger from the space key; always keep it resting lightly on the space key.”

2.3 Methods
The experiment used a 24-inch wide display device, with a screen size of 0.531 × 0.299 m (aspect ratio 16:9). As shown in Figure 2, the calculation task—addition of 2 two-digit numbers—was automatically generated and displayed at the center of the screen. The subjects were asked to solve each calculation problem mentally and their oral answers were recorded. The difficulty of the calculation task was controlled by setting the display intervals between calculation problems at 2 and 4 seconds. The size of each number on the screen was 0.015 m in length and 0.020 m in width. The reaction task consisted of a quadrilateral
randomly displayed at one of 14 locations at the right or left edge of the screen (seven locations at the right edge and seven locations at the left edge) at intervals of $5 \pm 1$ seconds. The subjects were asked to press the space key on the keyboard immediately after a quadrilateral was displayed. The duration between the time when the quadrilateral was displayed and the time when the space key was pressed was recorded as the reaction time. When the space key was not pressed, the quadrilateral disappeared 4 seconds after it was displayed and the reaction time was recorded as 4 seconds. The screen had a white background; the numbers in the calculation task and the quadrilateral in the reaction task were black.

The experiment was explained to each subject, who then performed a preliminary training task for 2 minutes. The subjects then took a 5-minute break and the experiment was launched. During the experiment, the subjects were asked to perform the calculation and the reaction tasks simultaneously for 5 minutes. The subjects could select the order of the tasks. After completing each task, the subjects were asked to fill in a subjective evaluation paper, where they were asked to answer question items that included “the display interval between calculation problems” and “the time sufficient for solving a problem,” using a seven-point evaluation scale.

3. Results

3.1 Correct answer rate for the calculation task

Figure 3 shows each subject’s correct answer rate for the calculation task. The correct answer rate was the ratio of the number of correct answers to the number of calculation problems displayed in 5 minutes. A calculation problem that could not be answered due to insufficient time was counted as a wrong answer. As shown in Figure 3, the correct answer rate was lower for all subjects for a display interval of 2 seconds between calculation problems compared to 4 seconds. A two-way analysis of variance (ANOVA) using “the display intervals between calculation problems” and “the subjects” as factors revealed that the differences between the display intervals were statistically significant ($F(1,6) = 22.53, P < 0.01$).

Figure 4 shows the results of the subjective evaluation. The score of each question item (seven grades from +3 to -3 scores) represented the average of the subjects. The score for “the display interval between calculation problems” was 2.43 for the display interval of 2 seconds and -0.29 for the display interval of 4 seconds. The subjects therefore evaluated the display interval of 2 seconds as “too short.” The score for “the time sufficient for solving a problem” was -2.71 for the display interval of 2 seconds and 0.57 for the display interval of 4 seconds. Therefore, the display interval of 2 seconds was evaluated as “insufficient.”

![Figure 3. A correct answer rate of each subject.](image-url)
3.2 Reaction time of the reaction task

Figure 5 and Table 1 shows the reaction time at each of the 14 display locations. The average for the subjects is shown in order to depict the overall tendency. When the display interval between calculation problems was 2 seconds, the display location with the longest reaction time was No. 11, followed by No. 8, in that order. When the display interval between calculation problems was 4 seconds, the display location with the longest reaction time was No. 8, followed by No. 11. The reaction time was longer (i.e., the reaction was slower) at the display locations of No. 8 (the upper-right corner) and No. 11 (the center of the right edge) for the display intervals of 2 and 4 seconds. A two-way analysis of variance (ANOVA, N=7) using “the display intervals between calculation problems” and “the display locations” as factors revealed that the differences between the display intervals were statistically significant (F(1,168) = 10.87, P < 0.01).

The differences in the reaction times were then examined at each display location for display intervals of 2 and 4 seconds. Figure 6 shows that the display locations where the difference in the reaction time exceeded 190 milliseconds were No. 1 (the upper-left corner), No. 7 (the lower-left corner), No. 11 (the center of the right edge), and No. 12 (just below the center of the right edge).
Table 1. The average and standard deviation of the reaction time. (msec.)

<table>
<thead>
<tr>
<th>Display location No.</th>
<th>2sec.</th>
<th>4sec.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ave.</td>
<td>SD</td>
</tr>
<tr>
<td>1</td>
<td>726.3</td>
<td>323.7</td>
</tr>
<tr>
<td>2</td>
<td>567.7</td>
<td>155.4</td>
</tr>
<tr>
<td>3</td>
<td>618.2</td>
<td>370.0</td>
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<tr>
<td>4</td>
<td>666.3</td>
<td>359.2</td>
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<tr>
<td>5</td>
<td>633.3</td>
<td>290.7</td>
</tr>
<tr>
<td>6</td>
<td>689.3</td>
<td>328.8</td>
</tr>
<tr>
<td>7</td>
<td>739.4</td>
<td>358.1</td>
</tr>
<tr>
<td>8</td>
<td>815.3</td>
<td>387.1</td>
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<td>512.0</td>
</tr>
<tr>
<td>12</td>
<td>750.7</td>
<td>286.0</td>
</tr>
<tr>
<td>13</td>
<td>665.3</td>
<td>178.8</td>
</tr>
<tr>
<td>14</td>
<td>707.0</td>
<td>318.0</td>
</tr>
</tbody>
</table>

Note: These data are the average and standard deviation of the discrimination time of the subject. (N=7)

Figure 6. A difference of the reaction time of each display location.

4. Discussion

This experiment used a distance of 0.6 m between the display device and the subject, and the subjects were asked to perform calculation and reaction tasks. The difficulty of the tasks was controlled by setting the intervals between calculation problems at 2 versus 4 seconds. The correct answer rate was lower for a 2 second display interval than for a 4 second interval; i.e., the reaction time was longer (the reaction was slower) when the display interval was 2 seconds. The subjective evaluation confirmed that the subjects found the display interval of 2 seconds too short and the time allowed to solve the calculation problems was insufficient. These results verified that changing the display interval between calculation problems controlled the difficulty of the calculation task.

The useful field of view is defined as the area around the fixation point from which information is being processed, in the sense of being stored or acted upon during a given visual task (Mackworth, 1976), usually 30 degrees in the horizontal direction (15 degrees to the right and left of center) (Hatada, 1986). Using this assumption of 30 degrees, the 0.6 m distance between the subject and the screen gave an effective field of
view of approximately 0.322 m in the horizontal direction in the present study. However, the width of the display device was 0.531 m, which was considerably wider than that effective field of view. The human effective field of view is reduced when the difficulty of a task or the number of requirements increases (Miura, 2012). Different mental activities impose different demands on the limited capacity. An easy task demands little effort, and a difficult task demands much. When the supply of attention does not meet the demands, performance falters, or fails entirely (Kahneman, 1973). In a divided attention situation where two sets of tasks and operations are performed, it is crucial how the capacity is distributed to each of them. If the primary task is difficult, the capacity distributed to the secondary task will not be sufficient, making the implementation of the secondary task tough (Miura, 2012). In the present experiment, the reaction time was longer (the reaction was slower) at the display locations of No. 8 (the upper-right corner) and No. 11 (the center of the right edge) when the display intervals for the calculation problems were either 2 or 4 seconds. This result indicated that information displayed at the upper-right corner and the center of the right edge of the screen was difficult to find, regardless of the task difficulty. The display locations that showed large differences in the reaction time between 2 and 4 seconds of the display intervals were No. 1 (the upper-left corner), No. 7 (the lower-left corner), and No. 12 (just below the center of the right edge). Therefore, discovery of information displayed at these three locations was further delayed with increases in the difficulty of the main task displayed at the center of the screen.

5. Conclusion

The human effective field of view, a visual characteristic, is limited, and the operation of a PC is characterized by a small distance between the user and screen. The use of a wide screen display device is expected to result in increasing delays in the discovery of information displayed at the right or left edge of the screen as the difficulty of a task displayed at the center of the screen increases. Focused attention at the center of a screen can delay or even prevent the user's awareness of information displayed at the upper-left corner, the lower-left corner, the upper-right corner, just below the center of the right edge, and the lower-right corner of the screen. Information should be displayed on wide screens while taking into account these unique human visual characteristics. For example, information displayed at the edge of a screen should perhaps include measures to alert the user to that area of the screen when the information is important.

References