Consideration of short-term memory for explaining the general difficulty of tasks on a display

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Abstract

People tend to feel difficulty in working on displays rather than on paper. We suppose that rather long holding time, for our short-term memory, requested by working on a display is a dominant reason of difficulty with complicated tasks on a display. That's because working on a display, on which we often have to watch multi sheet of documents alternatively, generally force us longer memory holding time than when we are working on multi sheet of real papers. Subjects were requested to process tasks which need cross-reference between multi pages of documents with two viewing conditions of the pages; one was parallel showing of the multi pages and another was alternate showing of the multi pages. Measured results showed longer working time in the alternate showing condition. We regard the increase of the working time in the alternate showing condition as a result of shortage of short-term memory ability more eagerly requested by the alternate showing condition.

1. Introduction

We tend to feel difficultly in working on displays rather than on paper especially when the work requests cross references among documents. We should consider not only the impact of media style, reflective or emissive, but also the impact of reading style; paper documents are generally read page by page, while documents on displays demand the use of scrolling or switching show of multi pages. Switching or scrolling procedure of text screen required for referencing process between different pages must request longer period of memory holding time than when we were allowed to refer multi papers for each page on a desk.

Our supposition is that human ability of short-term memory is not sufficient for the rather longer holding time requested by the referencing tasks on a display[1]. We measured performances of tasks which request cross references between multi pages at two kinds of display conditions: parallel showing and alternate showing of multi pages[2) 3)]. We expected this measurement must clarify the reason why we tend to feel difficultly in working on displays, on which we are often forced to use alternate viewing of multi pages[4)].

2. Experiment 1: Performance measurements on tasks with cross-references between pages

2.1 Experimental Methods

Subjects were requested to answer the best solution of transfer of trains. Figure 1 shows an example of two pages with which a subject requested to find the best solution for 2 times transfers. The first page shows departure time and total required time for transferring two different trains including running time of a train.

The second page shows time tables at each station. Figure 2 and Table 1 shows displaying modes in two viewing conditions of the pages: (a) parallel showing of the multi pages and (b) alternate showing of the multi pages. Subjects (8 students of twenties) were requested to answer the departure time of their final train after the fastest transit. Any writing of notes was prohibited before writing down each final answer. We prepared 5 ranks of tasks with different difficulty; the number of transfer was (1, 2, 3, 4, 5) times for each rank of task respectively. All the timetables (2- 6 tables) necessary for each rank of tasks were laid out in one page. We prepared four digits of departure time and two digits of required time universally for all the tasks. Subjects were requested to memorize the departure time and required time in the first page and then go to the second page in order to choose appropriate trains by using each time tables. Subjects were allowed to return to the first page only when they were luck of memory of departure or required times for choosing their trains. Subjects were also requested to answer their frequency of reference of the first page as an index of memory decay.

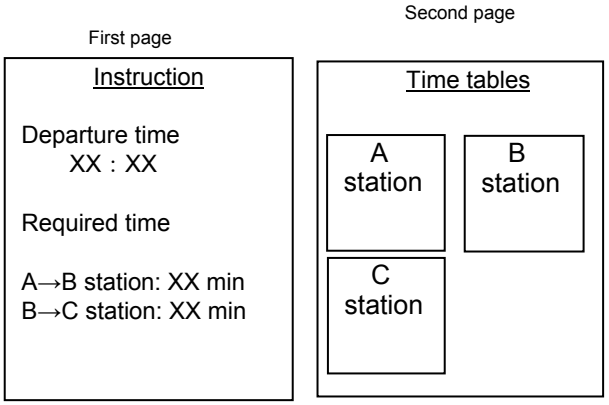
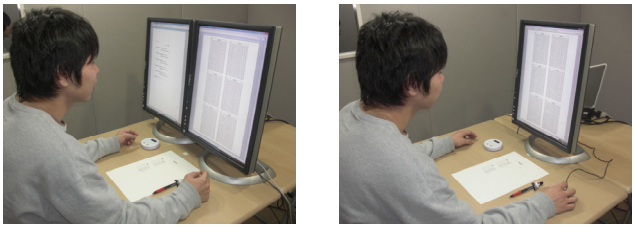


Figure 1. *Page layout of a typical task with 2 transfers.*



(a) Parallel showing (b) Alternate showing

Figure 2. *Typical scenes of experiment 1*

Table 1 Displaying modes used in the tasks in experiment 1

Showing condition	Display area	Number of screens	Paging method
a) Parallel	2 pages	2	Needless
b) Alternate	1 page	1	Click

2.2 Results: Experiment 1

2.2.1 Working time

Figure 3 shows working time at each task. Working time naturally increases as the number of transfer increase. The alternate showing indicates longer working time than the parallel showing when the transit was more than three times.

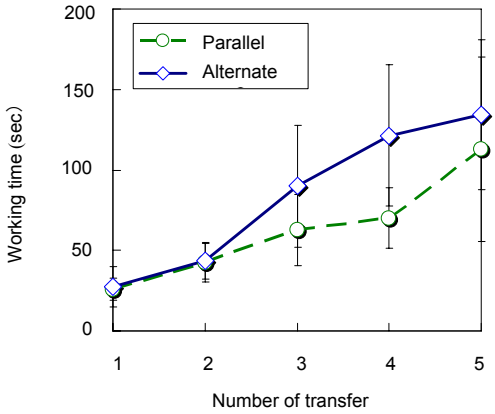


Figure 3. *Working time of each task*

2.2.2 References during working

Figure 4 shows rate of subjects who went back, for reference, to the first page during their task. We can find that re-reference clearly increased when the transfer timing was more than three times at both conditions: parallel showing / alternate showing.

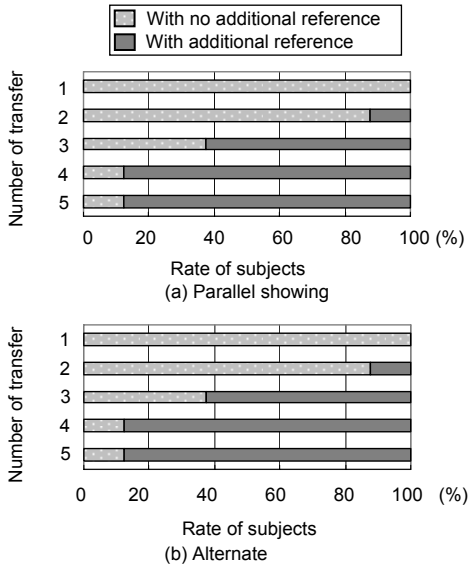


Figure 4. *Referring frequency of subjects*

3. Experiment 2: Measurement of forgetting curve

3.1 Experimental Methods

Figure 5 is a supposed memory decay curves when a subject once seen 7 or 10 digits of numerical characters and then remembered at certain timing. The inferior performance shown by the alternate display conditions should be explained with Figure 5. The alternate showing condition must request longer period of memory holding, at referencing situation using switching of displayed pages, than that requested by the parallel showing condition. This means that the alternate showing condition must use lower part of memory curve, where memory holding is further decreased, than that for the parallel showing condition. Consequently, the difference of the required memory holding time must lead the big difference of task performance between the parallel and the alternate display condition.

Our next focus was then set to get actual memory decay curve: forgetting curve. Experimental conditions are listed in table 2. Arabic figures of n digits (n= 3, 5, 7, 10, 13) were shown on a display to subjects for n seconds. The subjects were then requested to write down the Arabic figures, which had been shown on a display, certain seconds (3, 5, 10, 20 seconds) after the end of displaying time. Figure 6 shows a typical scene of experiment 2. Figure 7 shows the sequence flow of the experiments 2. A blank screen was shown during memory holding time for the subjects.

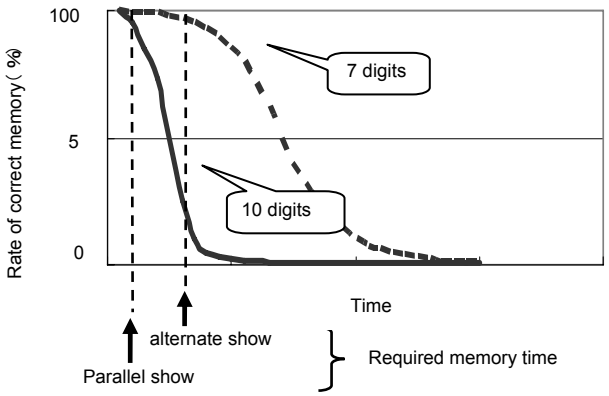


Figure 5. *Supposed decay model of short-term memory decay*

Figure 6. *Typical scene of experiment 2*

Table2 Conditions of experiment 2

Items	Conditions				
Figure length requested for memorizing (digits)	3	5	7	10	13
Showing time for memorization (sec.)	3	5	7	10	13
Memory holding time requested	3, 5, 10, 20 sec.				
Conditions during memory holding time	Watching a blank screen				
Displaying conditions	LCD with back light (20.1 inch., UXGA) Font: MS Ming style, 44 point				
Subjects	6 students (twenties)				
Location	Noise attenuating room				
Illuminance	600 lx (on the desktop)				

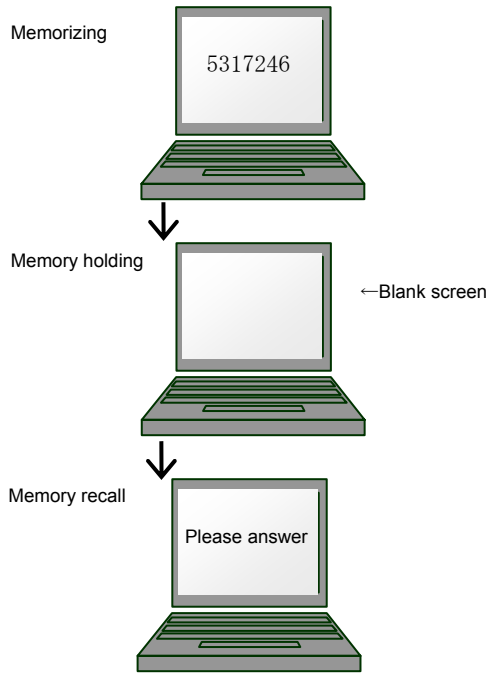


Figure 7. *Test sequence of experiment 2*

3.2 Results: Experiment 2

Memory retention rate was calculated for each condition by using the following formula:

Memory retention rate =
(Number of the subjects who could remember the full digits) / (Total number of the subjects) ⋯(1)

Figure 8 shows measured results of memory retention rate. Measured curves indicate earlier decay for longer figure length. Rapid decay to less than 50 % was shown in 3 seconds by the curves for 10 – 13 digits. Length of requested holding time must be critical for memory retention of larger digits.

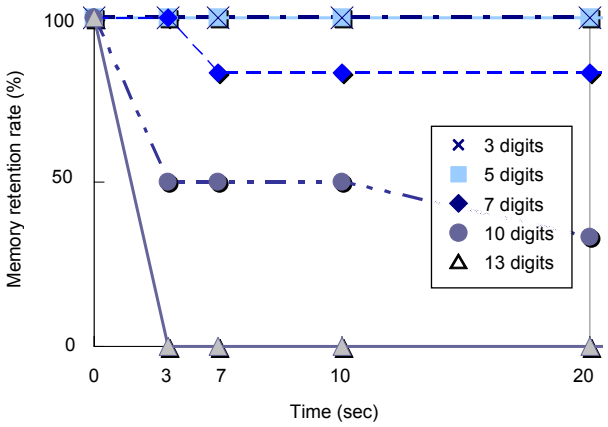


Figure 8. *Measured forgetting curves*

4. Discussion: reason why working time extended in alternate showing

Now, we can explain the longer working time in the alternate showing than the parallel showing indicated in Figure 3; results shown in Figure 4 and Figure 8 has brought us the basis for our explanation. A clear increase of the re-reference was shown, in Figure 4, for the tasks with more than three times of transit. The required memory holding time, during the referencing procedure, must be longer at alternate showing than at parallel showing. The memory decay is rather rapid when memory for critically larger number of digits, for human brain, is required as supposed in Figure 5 and proved by the measured results in Figure 8. Thus, the frequency of re-reference must be remarkably increased in the alternate showing condition, where required longer memory holding time must cause more frequent lost of memory. The increase in the frequency of re-reference, at the alternate showing condition, must increase its working time indicated in Figure 3.

5. Summary

1) The alternate showing condition showed longer working time than parallel showing condition when tasks were rather difficult.

2) The increase of the working time in the alternate showing condition should be considered as a result of increase of reference caused by the overflow of short-term memory because of longer memory holding time required.

References

1) Y. Koibuchi, M. Omodani, "A Reason Why Tasks on Displays Tend to be Preferred than Those on Displays– Focusing on short term memory –", Proc. Imaging Conference JAPAN 2008, pp. 628-632 (2008) [in Japanese].
2) S. Inoue, M. Omodani, "An evaluation and analysis of the difference of working performance between on a display and on papers- Focusing on the short-term memory", Proceedings of the 57th spring meeting, 2010; The Japan Society of Applied Physics. P.18-27(2010) [in Japanese].
3) S. Inoue, Y. Koibuchi, M. Omodani, "Measurement of short-term memory of human for studying the common difficulty of working on a display", Proceedings of IDW '09, p1415-1417(2009).
4) S. Inoue, M. Omodani, "An explanation of the relative difficulty of tasks on a display from a viewpoint of short-term memory", Proc. Imaging Conference JAPAN 2010, pp. 187-190 (2010) [in Japanese].

Author Biography

Sonomi Inoue was born in 1987. She received her B.E. degree in 2009 from Tokai University. She is expected to receive her M.E. degree from the graduate school of Tokai University in 2011. She is now engaged in a study of readability as a target of Electronic Paper.