Operational Characteristics Related to Memory in Operating Information Devices with Hierarchical Menu

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Abstract. In an aged society, easy-to-use information devices are necessary. In order to develop information devices which elderly adults can use easily, it is important to bring out characteristics of elderly adults in using information devices based on their cognitive functions. In this study, the authors focus on a relation between memory function and exploration behavior in a hierarchical menu while learning process. An experiment is conducted with eight elderly adults and eight young adults. In this experiment, a hierarchical menu composed based on the library classification, not actual hierarchical menus, is used in order to eliminate differences of knowledge about information devices between elderly and young adults. As a result, it seems that decrease of episodic memory increases a possibility of improper selections in the hierarchical menu when doing the same operations as previous operations.

Keywords: Elderly adults, Hierarchical menu, Memory function.

1 Introduction

Since growth of an information society force the elderly to use complicated information devices such as a mobile phone, it is necessary to develop information devices which elderly adults are able to use easily. Elderly adults feel difficulties in operating devices more than young adults due to decrease of physical and cognitive functions with aging. Therefore, there have been many studies dealing with the decrease and aiming at ease-to-use devices for elderly adults.

In recent years, many studies focus on decrease of cognitive function with aging. Satoru S. et al.[1] investigated the effects of age-related decrease of cognitive functions on use of a ticket vending machine for the Japanese bullet train and indicated that age-related decrease of cognitive functions is differentially related to problems with using information devices. Kartin A. et al.[2] indicated that spatial abilities are essential and an adequate mental model is decisive for PDA navigation performance as a result of examination with elderly and young users.

However, few previous researches, including above researches, focus on continual use of the same device, repeat of the same operation and decrease of memory function. Although taking advantage of experiences of the same operation performed previously is one of important things to use devices easily, elderly adults might be confused about how to reach an operational goal which they have experienced before due to decrease of memory function. Therefore, in order to develop an easy-to-use

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device, it is important to clarify operational characteristics related to memory function and to design devices based on its characteristics. In this paper as a first step, operational differences between elderly adults and young adults are compared from a perspective of memory function. In order to examine the differences, a hierarchical menu is used because it is a common component in many information devices.

2 Relation between Memory Function and Exploration Behavior

Considering use of common information devices, we repeat the same operation many times. Because users can operate information devices once they learn how to use them through experience of operations, it is important to learn for using information devices. However, during the process of learning how to use, it is required to recall the previous experience for smoother operation when repeating the same operation on the same device. Recalling the previous experience is related to memory function. The objective in this section is to consider effects which decrease of memory function has on repeated exploration behavior in the learning process.

2.1 Relation between Memory Function and Operation of Information Devices

Tulving [3] proposed episodic memory and semantic memory as categories of long term memory. He defined those memories as follows. Episodic memory is "information about temporally dated episodes or events, and temporal-spatial relations among these events". Semantic memory is "a mental thesaurus, organized knowledge a person possesses about words and other verbal symbols, their meaning and referents, about relations among them, and about rules, formulas, and algorithms for the manipulation of these symbols, concepts, and relations".

Linton [4] presented a conclusion that the number of trials or experiences has contrastive effects on episodic and semantic memories as a result of six-year study in which memory tests with her own diary was conducted. Although increased experience with any particular event class increases semantic or general knowledge about the event, episodic memory becomes confusable and can not be distinguished. That is, repeating similar experiences transforms episodic memory into semantic memory. Therefore, episodic memory seems to play an important roll in the learning process.

Considering use of information devices, whether users can recall previous operational information from episodic memory affects whether they can use information devices smoothly in the learning process. Recalling which item user selected or how a screen changed leads to smooth operation of information devices.

Fig. 1 shows a relation between memory function and operation which we consider based on the seven stages of user activities by D. A. Norman [5]. Operational process includes estimation, selection and evaluation. Users estimate which item more likely to lead to an objective function, select item based on the estimation and evaluate whether or not the selection is correct. In the evaluating process, users store a result of evaluation in episodic memory. In the estimating process, users estimate based on information in episodic memory if they performed the same operation previously or knowledge in semantic memory if they perform the operation for the first time.

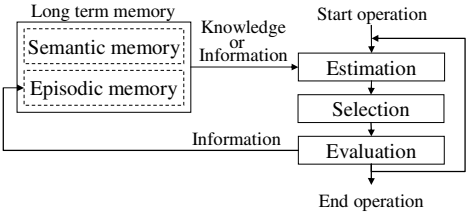

Fig. 1. A Relation between Memory Function and Operation of Information Devices

2.2 A Hypothesis about Effects of Decrease of Memory Function on Learning Process in Operating Information Devices

In the field of cognitive psychology, episodic memory decreases with aging [6]. On the other hand, semantic memory does not decrease with aging [7]. Therefore, we made a following hypothesis. Decrease of episodic memory increases a possibility of improper selections in the hierarchical menu when doing the same selections as previous selections because it makes storing information about operations difficult. Moreover, when selecting an improper item because of failing to recall information from episodic memory, a selected improper item is the same as previous selection because decision of an item to select is related with semantic memory.

3 Experimental Method

The objective of this experiment is to examine the hypothesis about effects of decrease of episodic memory on operating information devices in the learning process. Therefore elderly participants and young participants do exploration tasks in a hierarchical menu. In order to extract the difference in learning process between elderly adults and young adults, participants do the same task four times and tendencies of results are compared among participants.

3.1 Hierarchical Menu Used in This Experiment

In this research, we focus on effects of decrease of episodic memory on operating information devices in the learning process. There is a possibility that use of a hierarchical menu of a mobile phone for this experiment affects exploration behavior of elderly adults and young adults due to differences of knowledge about information devices which they have. Therefore we make a hierarchical menu for this experiment based on the library classification, Nippon Decimal Classification in order to eliminate differences of exploration behavior between elderly adults and young adults based on differences of their knowledge.

A task is to search the hierarchical menu for a designated book. Searching the hierarchical menu in this experiment for a book seems to simulate searching hierarchical menus of information devices for an objective function.

3.2 Participants

Eight elderly adults (four women and four men), ranging in age from 65 to 74 years (M = 69.0, SD = 3.0) and eight young adults (one woman and seven men), ranging in age from 20 to 23 years (M = 21.5, SD = 0.9) participate in the experiment. They use mobile phone usually. We got informed consent from all participants before the experiment.

3.3 Experimental Equipment

The hierarchical menu and the task were made up by Visual C++ 2008 and run on a Dell Latitude D520 notebook PC that was connected to a 22 inches display for PC with a display resolution of 1680 × 1050. Operations required to do the tasks was performed with a computer mouse. In order to measure eye movement of participants, a SMI contact-free eye tracker, iView X^{TM} RED, is set on the display and controlled with Lenovo T500 notebook PC. Fig. 2 shows the appearance of this experiment.

Fig. 2. Appearance of the experiment

3.4 Preliminary Confirmation

In this experiment, participants have to read letters on the display. If it is difficult for them to read letters, their exploration behavior is likely to be affected by the difficulties. Therefore, as a preliminary confirmation, participants read aloud some sentences composed of letters which are the same size as letters used for the hierarchical menu on the display and we confirmed that participants have no problem reading letters in this experimental condition.

Since operations in this experiment are performed with a computer mouse, participants practice to click buttons on the display in order to get used to perform with the computer mouse. Moreover, we confirmed that participants have no problem using the mouse computer.

3.5 Tasks

Participants search the hierarchical menu previously described for a designated book. One task is to search for one book. Books which participants search for in this experiment are decided under following four conditions: (1) the number of letters composing a book title ranges from seven to nine, (2) the number of letters composing

a book title which is converted into only hiragana characters ranges from 10 to 14, (3) book titles do not include words used in the highest layer or second layer of the hierarchical menu, (4) arrangement of books to search for is balanced in the hierarchical menu in order that participants encounter many items evenly.

Fig. 3 shows an explanation of order of tasks. Participants search for four books four times and 16 books once respectively in a total of 32 tasks. Participants search for four books which are searched for four times repeatedly and four books which are searched for once through the tasks by turns. Moreover order of tasks is randomized for each participant. In addition, since point of focus in this study is learning process, we analyze results of tasks related to books searched for repeatedly.

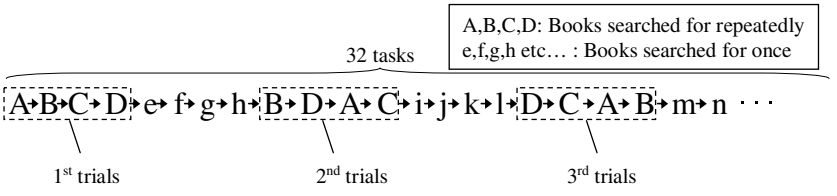

Fig. 3. Explanation of Order of Tasks

Fig. 4 shows screenshots which are used in this experiment. After the confirmation of the book title, participants click on a button placed in the center of a screen and start a task. Following the click on the button, the screen changes into a screen of the highest layer in the hierarchical menu whose screenshot is provided on the left side of Fig. 4. Since the title of the book is displayed at the top of the screen consistently, participants can confirm the title anytime. In layers other than the highest layer, a button, "Return to next superior layer", is displayed at the bottom of the screen. Participants can return to next superior layer by clicking on this button. Forth layer includes various titles of books which are put in double parentheses. When participants select the designated book in the forth layer, the task ends. Before starting exploration tasks, participants search the same hierarchical menu for four books in order to confirm that participants understand the task.

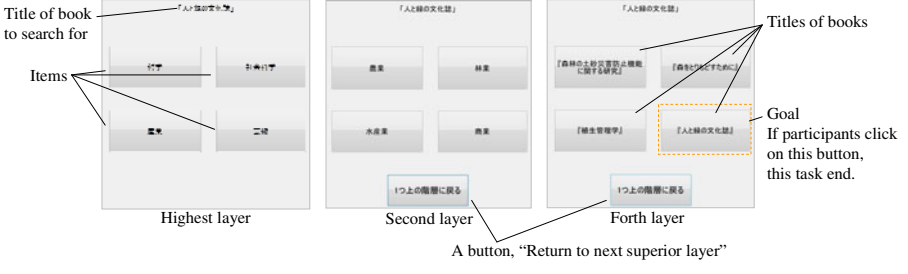

Fig. 4. Screenshots of the Hierarchical Menu in the Experiment

If participants are not in a proper node in second layer to achieve the task within 90 seconds from the start of the task, an experimenter tells participants about the item to select in the highest layer as a first clue. In addition, if participants are not in a proper node in third layer to achieve the task within 150 seconds form the start of the task, an experimenter tells participants about the item to select in second layer as a second clue. These clues are given so that participants reach to the goal after exploring the menu and use the experience of the previous exploration because the point of this experiment is recalling previous selection in the menu.

3.6 Measurement of Episodic Memory

We conduct the fill-in-the-blank question concerning the hierarchical menu in order to measure episodic memory of participants. Fig. 5 shows an appearance of a form used for fill-in-the-blank question. Since measurement of episodic memory is conducted by recalling words showed by experimenter orally or descriptively, in this experiment, measurement of episodic memory is conducted by filling blanks in a form with names of items in the hierarchical menu as shown in Fig. 5. Episodic memories of participants are compared based on the number of filled blanks. Participants do the fill-in-the-blank question five minutes after finishing the exploration tasks in order to prevent recency effect. That is, if the question is conducted immediately after the exploration task, the number of filled blanks increases because of using information existing in short term memory.

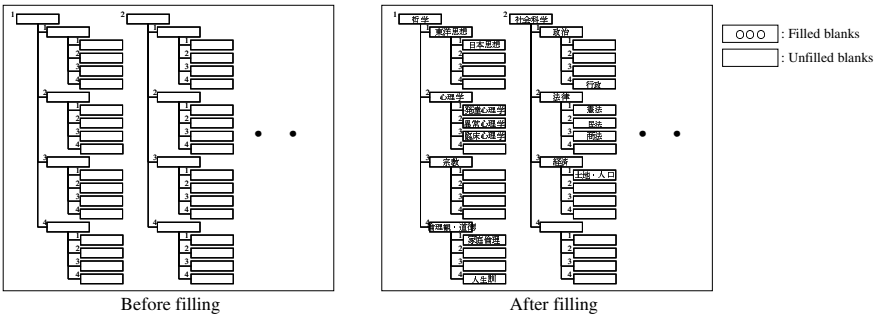

Fig. 5. Fill-in-the-blank Question concerning the Hierarchical Menu

4 Results and Discussion

4.1 Difference of Episodic Memory between Elderly and Young Participants

Fig. 6 shows a result of fill-in-the-blank question concerning the hierarchical menu in terms of the number of blanks filled correctly. Mann-Whitney U test result showed that there is a significant difference between result of the elderly group and the young group ($p<.01$). Therefore, episodic memory of the elderly group is lower than that of the young group.

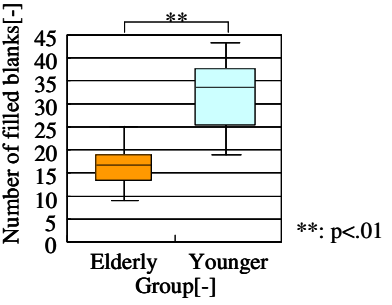

Fig. 6. A Result of the Fill-in-the-blank Question concerning the Hierarchical Menu

4.2 Comparison of the Number of Futile Selections

We compared the elderly group with the young group by the number of futile selections. A futile selection is an unnecessary selection to achieve a task.

Fig. 7 shows results of the number of futile selections with respect to the trial number. Since the number of participants is not large, these results show not average value but median value. Mann-Whitney U test results showed that there is a significant difference between results of the elderly group and the young group in third trials ($p<.05$).

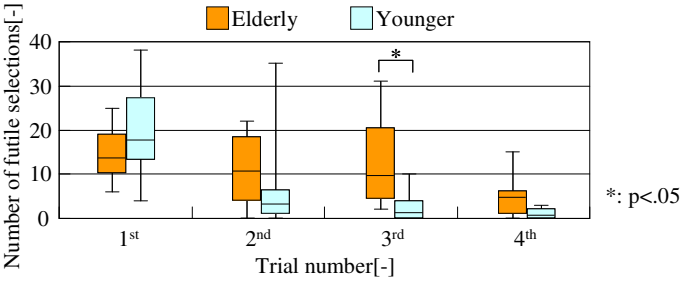

Fig. 7. Results of the Number of Futile Selections

In this experiment, participants search the hierarchical menu composed based on the library classification for books. In first trials, because participants depend on not knowledge about information devices such as mobile phones but knowledge about words, the number of futile selections reflects the difference of knowledge about words among participants. Moreover, because knowledge about words is stored in semantic memory, in first trials, semantic memory, not episodic memory, seems to be related to exploration behavior in the hierarchical menu. In contrast, in second, third and forth trials, it is important to recall what they did in previous trials. That is, it is important to retrieve information from episodic memory. If they can recall which item led to the goal or which item did not lead to the goal, the number of futile selections decreases in second, third or forth trials.

In first trials, there is not much difference between results of elderly and young group. However, after first trials, there are different tendencies between results of the elderly and the young group.

A result of first trial implies that there is not much difference between knowledge of words of the elderly group and the young group. On the other hand, different tendencies of results in trials after second trials, which seems to be attributed to the difference of episodic memory, implies that decrease of episodic memory increases the possibility of improper selections in the hierarchical menu when doing the same task repeatedly.

4.3 Consideration in Elderly Participants

Fig. 8 and fig. 9 show transitions of the number of futile selections in elderly participants and young participants. Participants are put in descending order of results of fill-in-the-blank question concerning the hierarchical menu from left to right. The result of Ss8 is better than that of YSs5 and the results of Ss2 and Ss5 are as good as that of YSs2.

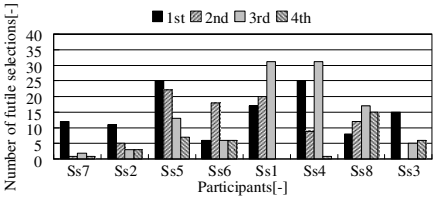

Fig. 8. Results of the Number of Futile Selects among Elderly Participants

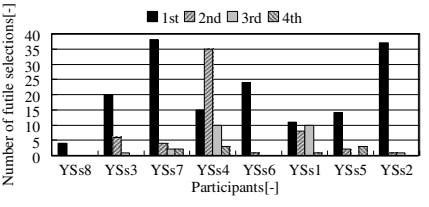

Fig. 9. Results of the Number of Futile Selections among Young Participants

If participants store information about the hierarchical menu gained by performing tasks in episodic memory and use its information, the number of futile selections should decrease with increase in the number of trials. In young participants whose results of fill-in-the-blank question are not lower than those of elderly participants, the number of futile selections tend to decrease from first trials to forth trials except of YSs4. On the other hand, in Ss7, Ss2 and Ss5 whose results of fill-in-the-blank question are as good as those of young participants whose results are relatively low, the number of futile selections tend to decrease from first trials to forth trials. However, in other elderly participants, the number of futile selections does not decrease or decreases once and then increases again even with increase in the number of trials.

These results seem to strengthen the opinion that decrease of episodic memory increases the possibility of improper selections in the hierarchical menu when doing the same task repeatedly.

4.4 Comparison of the Number of Gazed Items

Fig. 10 shows results of the number of items gazed in the highest layer. Because the number of items in the highest layer is four, a maximal value of this index is four. In

addition, because the measurement of eye movement of two young participants failed, the results of the young group include results of six young participants. Mann-Whitney U test results showed that there is a significant difference between results of the elderly group and the young group in all trials ($p<.05$).

If participants know the item to select or arrangement of items, the number of gazed items decreases. Although results of the elderly group and the young group are both decreasing with an increase in trial number, the decreasing trend of the young group is more sharply. This result implies that decrease of episodic memory has an effect on remembering the item to select or arrangement of items and makes exploration in the hierarchical menu difficult.

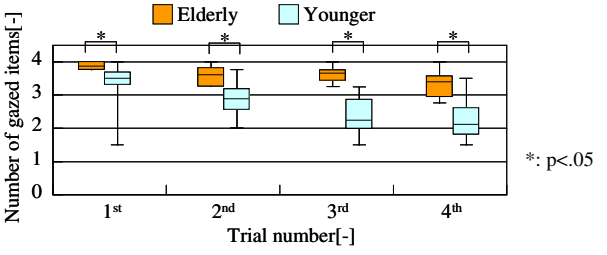

Fig. 10. Results of the number of items gazed in the highest layer

4.5 Analysis of Improper Selections

In order to consider the effect of decrease of episodic memory, repetitional mistakes are analyzed. A repetitional mistake means to select an improper item which participants selected in previous tasks at the node leading to the goal. For example, when a participant selects an improper item, "item X", in first trials, if he/she selects "item X" in second and third trials, the number of repetitional mistakes counts as two. But even if he or she selects "item X" many times in the same trials, the number of repetitional mistakes counts as one.

If the hypothesis that people decide based on information in semantic memory when failing to recall information from episodic memory is valid, people make similar mistakes. Therefore, repetitional mistakes were analyzed. In the elderly group, 53 of total 79 improper selections made by all elderly participants were repetitional mistakes. The proportion of repetitional mistakes to improper selections is high. This result implies that participants decided an item to select based on knowledge stored in semantic memory because he/she could not recall information from episodic memory.

5 Conclusion

This paper analyzed relation between episodic memory and learning process with the hierarchical menu composed based on the library classification. The major conclusions to be drawn from results are as follows.

- Decrease of episodic memory increases the possibility of improper selections in the hierarchical menu when doing the same selections as previous selections.
- The same improper selections as previous improper selections account for the large portion of improper selections.

In the future work, we are going to examine easy-to-recall factors of information devices, cognitive functions which affect learning, and propose information devices based on gained results. For example, storing information and presenting information about mistakes when users are confused is one of conceivable assistance for users with decreased episodic memory. Because they are more likely to make similar mistakes, it is helpful for them to present information related to previous mistakes.

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References

1. Satoru, S., Takatsune, K.: Effects of age-related decline of visual attention, working memory and planning functions on use of IT-equipment. Japanese Psychological Research 52, 201–215 (2010)
2. Kartin, A., Martina, Z.: Effects of age, cognitive, and personal factors on PDA menu navigation performance. Behavior and Information Technology 28, 251–268 (2009)
3. Endel, T.: Episodic and Semantic Memory. In: Endel, T., Wayne, D. (eds.) Organization of Memory, pp. 381–403. Academic Press, New York and London (1972)
4. Marigold, L.: Transformation of Memory in Everyday Life. In: Ulric, N. (ed.) Memory observed: Remembering in natural contexts, pp. 77–91. W.H.Freeman, San Francisco (1982)
5. Donald, A.N.: Cognitive Engineering. In: Donald, A.N., Stephen, W.D. (eds.) User Centered Systems Design: New Perspectives in Human-Computer Interaction, pp. 31–61. Lawrence Erlbaum Associates, Hillsdale (1986)
6. Lars, G.N., Lars, B., Karin, E., Lars, N., Rolf, A., Gösta, B., Stig, K., Maud, W., Bengt, W.: The Betula Prospective Cohort Study: Memory, Health and Aging. Aging, Neuropsychology and Cognition 4, 1–32 (1997)
7. Marilyn, S.A., Hope, S.H., William, M.: Changes in Naming Ability With Age. Psychology and Aging 3, 173–178 (1988)