The Effect of Presentation on Visual Working Memory

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Abstract. This paper reports experiments investigating the effect of presentation on visual working memory (VWM) when set-size increases. The capacity of VWM is limited to approximately four items (Luck & Vogel, 1997) and increasing set-size impairs the performance in visual tasks. Also, the performance in visuospatial tasks was better in the simultaneous presentation than in the sequential presentation. However, it is possible that large set-size in the simultaneous presentation caused overload in visual processing, and also, there is a possibility to increase interference among stimuli.Therefore, we speculated that performance in a simultaneous presentation would show a sharper decrease than in a partitioned presentation, which divides stimuli into two halves in order to reduce visual processing load and interference among stimuli when number of stimuli increases. Thus, the experiments with two types of set-size and two types of presentations (simultaneous and partitioned) were performed.The experiment examined whether a probe item was old or novel after seeing 4 or 8 items that appeared at random locations. These items were displayed either in simultaneous or in a partitioned manner. The results revealed a significant interaction between set-size and presentation. In a small set-size condition, performance was better in the simultaneous presentation than in the partitioned presentation. However, no difference was found between performances for both presentations in the large set-size condition, as it was influenced by the partitioned presentation. The results proposed that the partitioned presentation was more stable method to show items than the simultaneous presentation when set-size is large.

1 Introduction

Vision is one of the most important sensation of humans, and that many related researches have been performed over time. Through these researches, it became known that visual information is processed utilizing a variety of factors, including color and shape (Egeth, Virzi, & Garbart,1984; Friedman-Hill & Wolfe, 1995), spatial positioning (Posner, 1980; McCormick & Klein, 1990), brightness differences (Donk & Theeuwes, 2001; Belopolsky, Theeuwes, & Kramer, 2005) and object motions (Saenz, Buracas, & Boynton, 2003). Vision performs visual processing by utilizing these factors, and such processing is influenced by total number of stimuli. This being that human's capacity of Visual Working Memory (VWM) is limited to approximately 4 items. (Luck & Vogel, 1997). Thus, increase in set-size would impair the

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performance in visual tasks (Duncan & Humphreys, 1989; Trick & Pylyshyn, 1993), and such a VWM with limited storage capacity does not store the exact information of each individual item. Instead, the relational information of an individual item on the basis of global spatial configuration is used for storage (Jiang, Olson & Chun, 2000).

This strategy of VWM supplements its limitation in storage capacity that visual processing possesses. Therefore, the method of presenting the relational information of stimuli has advantages for the visuospatial tasks. This means that accuracy in simultaneous presentation is higher than sequential presentation when same numbers of stimuli are presented (Lecerf & Ribaupierre, 2005).

However, simultaneous presentation is not always the best method. Rather, when the number of stimuli increases, simultaneous presentation needs to process all of the visual information at once and due to limitation in processing loads, the performance diminishes. On the contrary, it may be considered that the method of presenting the information in parts could reduce the load in visual processing which needs to be done at once. Hence, in this study, we would like to verify the hypothesis which the simultaneous presentation is effective in smaller number of stimuli, and partitioned presentation is more effective for the large number of stimuli.

2 Experiment

Experiment was designed to investigate whether a simultaneous presentation was always better than a partitioned presentation. Experiment had 4 conditions of which 2 set-size (small and large), and 2 presentation conditions (simultaneous and partitioned) for experiment participants to perform visual tasks.

If the overload is occurred for simultaneous presentation with large set-size, the performance result in a simultaneous presentation would be better with partitioned presentation with small set-size, however the performance result in a simultaneous presentation will not be better with partitioned presentation with large set-size.

To investigate this assumption, accuracy rates, hit rate, correct reject rate and Pr score were analyzed as a primary dependent variable.

Pr score was the discrimination measure for Accuracy of confident and non-confident recognition. [probability of a hit minus probability of a false alarm] (Lecerf & Ribaupierre, 2005).

Participants performed all conditions with 2 set-size conditions in 2 presentation conditions.

Participants. Seven undergraduate students participated in exchange for course credit. All subjects had normal or corrected-to-normal vision.

Stimuli. Twenty alphabetical characters (excluding A,E,I,O,U,Y) was used. The size of stimulus on the screen was 1.6°x1.6° and was presented as white character in black background of 15°x15° size.

Procedure. 2 different set-size conditions were used. Set with 4 items designate d as small, and set with 8 items designated as large. For the small set-size condit ion, 4 alphabetical characters were selected randomly from 20 characters pool, an d did the same for large set-size by randomly picking 8 characters.

2 different methods of presentation was used, as one being presenting all stimuli at once (simultaneous presentation), and the other being partitioned presentation by sequentially showing presentation which is divided into 2 sets. Each stimulus was displayed for 50msec (ex. For the partitioned presentation, 8 stimuli was divided into 2 sets, and that 4 stimuli were displayed in sequential manner for 200msec, and rest 4 stimuli were displayed after that in 200msec)

When participants pressed "Space" key, fixation is displayed for 2000msec and stimuli were displayed in random locations according to conditions. After that blank screen was displayed for 1000msec, display of Probe was followed. (Figure 1.)

All participants were instructed to press 'z' if the Probe is "Old" and '/' if the Probe is "Novel". There were no limitation in the response time, however we have excluded result exceeding 5000msec.

Participants have performed practice trials between 15 to 20 times, and executed 160 trials (40 trials per each condition). Set-size conditions were displayed randomly, and presentation conditions were presented randomly with counterbalanced sequences.

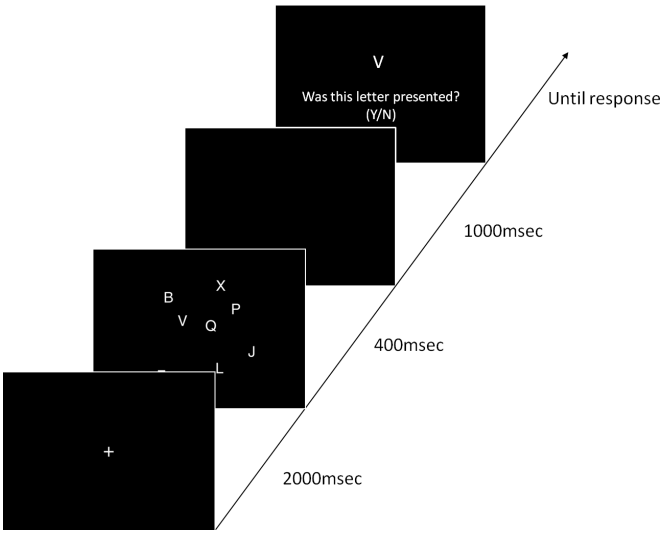

Fig. 1. An example of large set-size and simultaneous condition

3 Result

The experiment data was analyzed in a repeated measure ANOVA.

The accuracy rate was significantly higher in small set-size condition than in large set-size condition. $F(1,6) = 49.743$, $p < .01$. The main effect of set-size conditions in all dependent variables was significant. The main effect of presentation conditions was not significant. $F(1,6) = .763$, $p > .05$. The interaction between set-size and presentation was significant. $F(1,6) = 6.873$, $p < .05$. (Figure 2.)

There was no difference between presentation conditions in hit rate and correct reject rate. $F(1,6) = 1.229$, $p>.05$, $F(1,6) = .795$, $p>.05$, respectively.

The interaction of set-size conditions and presentation conditions in hit rate and correct reject rate was not significant. $F(1,6) = 5.757$, $p>.05$, $F(1,6) = 1.087$, $p>.05$, respectively.

In Pr score, the main effect of presentation conditions was not significant. $F(1,6) = .617$, $p > .05$. However, the interaction of set-size conditions and presentation conditions was significant. $F(1,6) = 9.136$, $p < .05$.

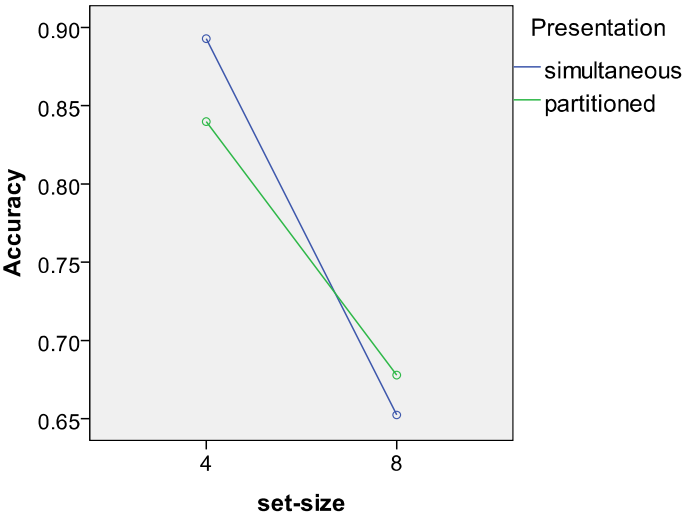

Fig. 2. Result from Experiment. Total accuracy rate.

4 Discussion

This study confirmed that there is difference in performance per number of stimuli and presentation condition. When the set-size increased, the accuracy decreased, however for partitioned presentation, the decrease in accuracy was smaller than simultaneous presentation. This can be interpreted that simultaneous presentation is better for smaller set-size, but as the set-size gets large, simultaneous presentation is not as good as partitioned presentation, and can be implied that simultaneous presentation is not the best method in all situation.

It can be suggested that there is limitation of how much the information can be processed simultaneously, that presenting large amount of information at once would decrement ability to process, whereas partitioned presentation would reduce amount of information which needs to be processed simultaneously by delaying the process time, in return would increase the overall efficiency of the process.

However, in this study, Hit Rate and Correct reject rate did not showed the meaningful result. This is may be, that the stimuli was displayed at random location,

where for partitioned presentation, identification to verify the location information had occurred 2 times which needs of big effort, and may ended up getting penalty.

If the further study fixes the location of stimuli display to reduce such a penalty, partitioned presentation would show more effective results. Despite such penalties, partitioned presentation in large set-size was shown to be effective, meaning that simultaneous presentation is not the best method for all events.

Through further experiments, the effect of partitioned presentation will be investigated through diverse conditions in set-size.

References

1. Belopolsky, A.V., Kramer, A.F., Theeuwes, J.: Prioritization by transients in visual search. Psychonomic Bulletin & Review 12(1), 93–99 (2005)
2. Donk, M., Theeuwes, J.: Visual marking beside the mark: Prioritizing selection by abrupt onsets. . Perception & Psychophysics 63(5), 891–900 (2001)
3. Duncan, J., Humphreys, G.W.: Visual search and stimulus similarity. Psychological Review 96(3), 433–458 (1989)
4. Egeth, H.E., Virzi, R.A., Garbart, H.: Searching for conjunctively defined targets. . Journal of Experimental Psychology: Human Perception and Performance 10(1), 32 (1984)
5. Eriksen, C.W., Yeh, Y.Y.: Allocation of attention in the visual field. Journal of Experimental Psychology: Human Perception and Performance 11(5), 583 (1985)
6. Friedman-Hill, S., Wolfe, J.M.: Second-order parallel processing: Visual search for the odd item in a subset. Journal of Experimental Psychology-Human Perception and Performance 21(3), 531–550 (1995)
7. Jiang, Y., Olson, I.R., Chun, M.M.: Organization of visual short-term memory. Journal of Experimental Psychology: Learning, Memory, and Cognition 26(3), 683 (2000)
8. Lecerf, T., De Ribaupierre, A.: Recognition in a visuospatial memory task: The effect of presentation. . European Journal of Cognitive Psychology 17(1), 47–75 (2005)
9. Luck, S.J., Vogel, E.K.: The capacity of visual working memory for features and conjunctions. Nature 390(6657), 279–281 (1997)
10. McCormick, P.A., Klein, R.: The spatial distribution of attention during covert visual orienting. Acta Psychologica 75(3), 225–242 (1990)
11. Palmer, J.: Attention in visual search: Distinguishing four causes of a set-size effect. . Current Directions in Psychological Science 4(4), 118–123 (1995)
12. Posner, M.I.: Orienting of attention. Quarterly Journal of Experimental Psychology 32(1), 3–25 (1980)
13. Sàenz, M., Buraĉas, G.T., Boynton, G.M.: Global feature-based attention for motion and color. Vision Research 43(6), 629-637 (2003)
14. Trick, L.M., Pylyshyn, Z.W.: What enumeration studies can show us about spatial attention: evidence for limited capacity preattentive processing. Journal of Experimental Psychology: Human Perception and Performance 19(2), 331 (1993)