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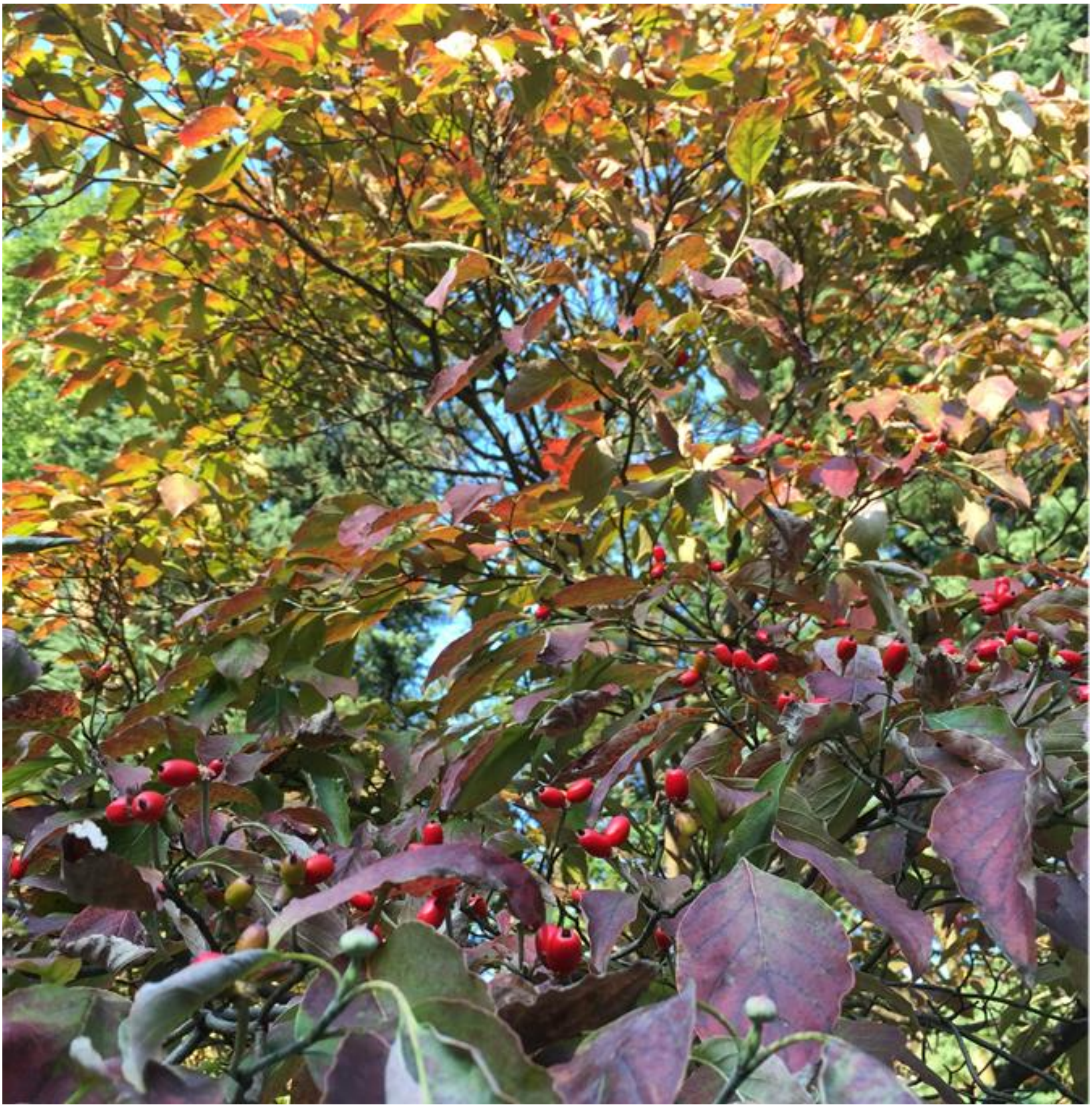

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Original Article

Effects of pointing movements on visuospatial working memory

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ABSTRACT

Results of several studies indicate that pointing movements can interfere with visuospatial working memory (VSWM). The interference effect of movements of pointing to target locations is explained as attributable to failure of the appropriate use of retrieval strategies. This study further investigated the effects of pointing movements on VSWM performance, particularly addressing retrieval strategies. 28 participants (17 women, 11 men; *M* age = 23.0 yr, range = 21–29) were administered a VSWM task based on the Corsi blocks task, but modified to make it difficult for participants to use efficient retrieval strategies such as chunking or forming global visual images. Participants were required to recall the locations of targets in forward and backward order. Three conditions with respect to encoding were tested: (a) In the target-pointing condition, participants were required to point to the target locations. (b) In the no-pointing condition, participants were required only to view the presentation of targets. (c) In the irrelevant condition, participants were required to point to irrelevant locations. Significant differences were observed among the conditions and between the recall directions. However, performance when pointing to the target locations was not reduced compared to that achieved when viewing the presentation of targets. Results of this study support the view that the interference effect of pointing movements to the target locations derives from failure of the appropriate use of efficient retrieval strategies. Results also suggest that the effects of pointing movements on VSWM performance are task-dependent.

<Key-words>

Spatial memory, action, memory strategies, encoding, retrieval

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Ⅰ. Introduction

Working memory is related to the capacity of maintaining and processing goal-related information simultaneously [1]. Working memory has been implicated as playing a crucially important role in everyday cognition tasks [2]. Although several working memory models have been proposed, the most influential model is Baddeley's multi-component model [3,4]. In that model, working memory is assumed to be divided into four subsystems. The visuospatial sketchpad, a subsystem responsible for temporarily maintaining and manipulating visuospatial information (visuospatial working memory, VSWM), is assumed to operate at the interface between vision, attention, and action [5].

Within the scope of VSWM and action, many studies have examined the impact of action on VSWM. Some of the studies, although they are few, have indicated that action can facilitate VSWM performance. For example, Chum et al. [6] showed that pointing movements to target locations facilitated recognition performance in a VSWM task. That facilitatory effect was interpreted as attributable to increased spatial-based perceptual selection by action or increased egocentric coding, or both.

Results of several studies have shown that action can interfere with VSWM. Some of the studies demonstrated that performance in a VSWM task is reduced by concurrent tapping or pointing to irrelevant locations [7–9]. These interference effects are explainable as attributable to shifts of spatial attention by tapping or pointing movements during encoding. Furthermore, even movements of pointing to relevant locations can interfere with VSWM. Rossi-Arnaud et al. [10] investigated the effects of movements of pointing to the target locations on VSWM performance in a free recall task. In their study, participants were required to remember the target locations while pointing to them or viewing them. Results show an interference effect of pointing movements: The recall accuracy was significantly better when passively viewing presentations of the targets than pointing to them under certain conditions. The finding was explained as follows: pointing movements to the target locations prevented the development and the use of efficient retrieval strategies such as parsing the configurations into chunks [11], and forming global visual images [12]. However, given that both facilitatory and interference effects of pointing movements were observed by Dodd & Shumborski [13], the impact of action, particularly that of pointing movements on VSWM, remains controversial.

According to an explanation by Rossi-Arnaud et al. [10], when considering the effects of pointing movements, whether a person can use efficient retrieval strategies such as chunking and forming global visual images is extremely important. Therefore, under such circumstances that the use of efficient retrieval strategies is always restricted, no interference effects are expected to be observed for pointing movements to the target locations on VSWM performance. Pointing movements might increase VSWM under such circumstances. This study was undertaken to investigate the effects of pointing movements on VSWM performance under different circumstances.

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Ⅱ.　Method

Participants

A total of 28 adults (17 women, 11 men; *M* age = 23.0 yr, range = 21–29) volunteered to participate in the experiment. All participants were recruited from a university in Japan. All had normal or corrected-to-normal vision. Ethical approval for the study was obtained from the institutional review board. Informed consent was obtained from all participants before the experiment started. No participant showed any hesitancy during the experiment.

Materials

All participants were administered a VSWM task based on the Corsi blocks task [14), but it was modified particularly with respect to the stimulus array and presentation of a target stimulus to prevent participants from using efficient retrieval strategies. A stimulus array included black dots arranged in a five-column matrix (the number of rows varied across trials), which were concentrated only within one-third of the screen width. Subsequent to the presentation of the stimulus array, target dots appeared in red, one per row, by 1000 ms. Target dots were presented consistently from the bottom row to the top row. Consequently, using compact stimulus arrays and upward presentation of target stimulus, it was presumed to be difficult for participants to use efficient retrieval strategies such as chunking or forming global visual images.

Procedure

All participants were tested individually in a private room. Each participant was seated in front of a 15-inch monitor when performing the VSWM task. In the task, participants were asked to recall the locations of target dots in both forward and backward order.

Figure 1 presents an example of trial sequences. At the start of each trial, black dots were presented on the screen in a five-column matrix. Subsequently, target dots appeared in red, one per row, from the bottom row to the top row by 1000 ms. After a blank screen for 2000 ms, the original dot array was presented. Participants were required to indicate the locations of the target dots in forward or backward order by pointing to the screen.

The three conditions were tested in a within-subject design. The conditions were the following.

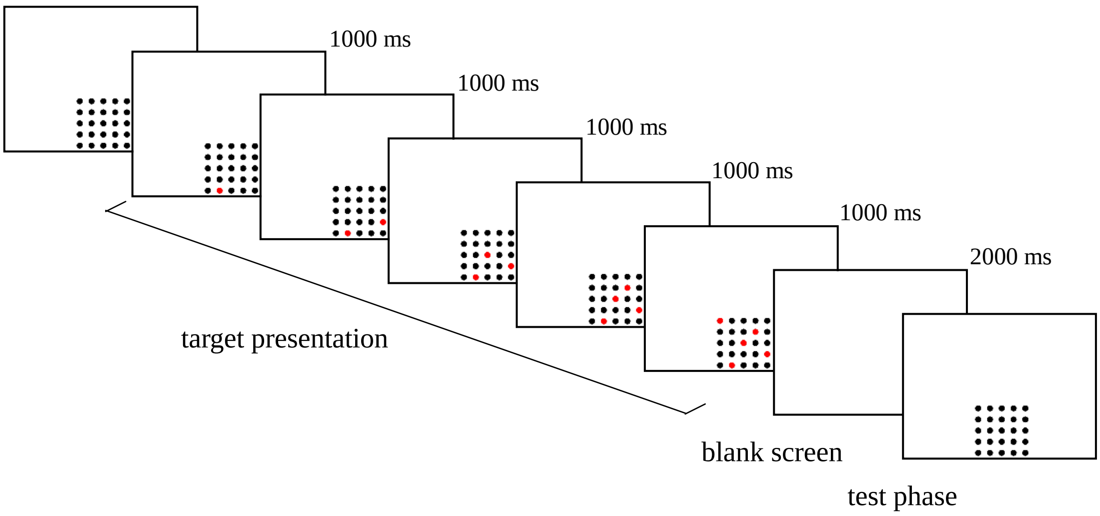
1. In the target-pointing condition (TP), participants were asked to remember the locations of target dots while pointing to them consecutively along with their appearance.
2. In the no-pointing condition (NP), participants were asked to remember the locations of target dots while viewing them.
3. In the irrelevant-pointing condition (IP), participants were asked to remember the

locations of target dots while pointing to the external sides of the rows from the bottom to the top consecutively along with their appearance of target dots.

In addition, articulatory suppression was induced in all conditions by asking participants to count aloud from 1 in ascending order along with their appearance of target dots. This procedure was intended to prevent phonological encoding.

Participants were tested in 6 blocks (3 conditions × 2 recall directions). The order of the recall directions was counterbalanced. The order of the conditions was randomized among participants.

In all blocks, a self-terminating span procedure was used. Each block started with the five-row dot matrix, i.e., with a five-span trial. The rows were increased by one until the initial two trials of the same span length were consecutively failed. The rows were decreased by one if two trials failed consecutively. When a total of all trials at the same span length were recalled correctly, the block ended and the span length was scored.



<Figure1> Example of Trial Sequence: a Five-Span Trial.

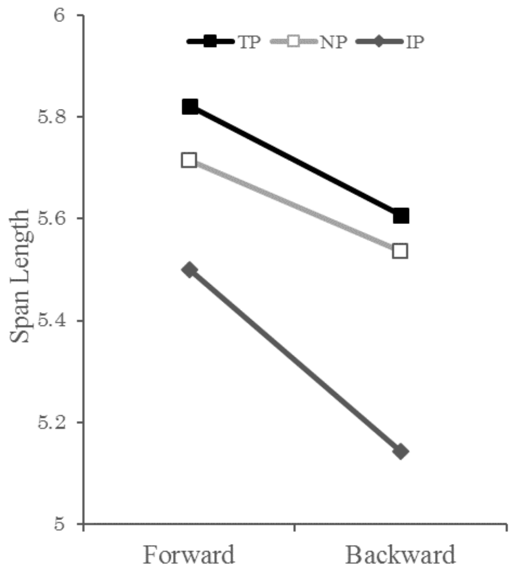
Ⅲ. Results

Table 1 presents means and standard deviations for span lengths in each condition. Figure 2 portrays mean span lengths in respective conditions. In all conditions, performance was better for forward recall than backward recall. In comparison between conditions, performance was slightly better in the target-pointing condition than in the no-pointing condition. Performance in the irrelevant-pointing condition became worse than in the other conditions for both forward and backward recall.

A 3 (condition) × 2 (recall direction) repeated measures ANOVA showed a significant main effect of condition ($F_{2, 54} = 3.38$, $p < .05$; $\eta^2_p = .11$) and recall direction ($F_{1, 27} = 4.66$, $p < .05$; $\eta^2_p = .15$), but the interaction was not significant ($F_{2, 54} = 0.37$, *ns*; $\eta^2_p = .01$). Post hoc Bonferroni tests revealed differences between the target-pointing condition and the irrelevant-pointing condition. Differences between the no-pointing condition and the irrelevant-pointing condition approached significance ($p = .06$; $p = .12$, respectively). No significant difference was found between the target-pointing condition and the no-pointing condition.

<Table 1>Means and Standard Deviations for Span Lengths in Respective Conditions

	TP		NP		IP	
	M	SD	M	SD	M	SD
Forward Recall	5.82	1.09	5.71	1.21	5.50	1.04
Backward Recall	5.61	1.10	5.54	1.10	5.14	0.89



<Figure 2> Mean Span Lengths in Respective Conditions.

Ⅳ. Discussion

This study was undertaken to investigate the effects of pointing movements on VSWM performance using a task in which the use of efficient retrieval strategies was always restricted. This study demonstrated that VSWM performance was reduced by concurrent pointing to the irrelevant locations (although the effect only approached significance), but was not by concurrent pointing to the target locations. The former result is consistent with reported findings from earlier studies [7–9].

The latter is the main result of this study. As expected, pointing movements to the target locations did not have interference effects in a task where the use of efficient retrieval strategies such as chunking or formation of global visual images was always restricted. Therefore, the result appears to support the view that the interference effect of pointing movements to the target locations results from failure of the appropriate use of efficient retrieval strategies [10]. Furthermore, VSWM performance was slightly better when pointing to the target locations than when viewing them for both forward and backward recall, although the difference was not statistically significant.

However, the present study has several methodological limitations. First, this study did not take account of other variables that might influence whether interference effects of pointing movements were observed. Although Rossi-Arnaud et al. [10] showed that pointing movements reduced VSWM performance when participants pointed to the target locations in the first block and when the shorter sequences were presented, the present study did not consider those variables. Second, the results demonstrated that the differences among the conditions were significant, but the differences in span length were small. Particularly, the interference effect of movements of pointing to irrelevant locations was found to be much smaller than effects reported in earlier studies [7–9]. This might indicate that the task used for this study was less sensitive to concurrent pointing movements. Furthermore, in association with the task used, whether the task made the use of efficient retrieval strategies difficult was not well established. Therefore, caution should be exercised in interpreting the results. Finally, the results might be explained by the principle of transfer-appropriate processing [16]. In the present study, participants indicated the target locations by pointing. Therefore, the mode of encoding and the mode of retrieval were the same in the target-pointing condition. Possible interference effects of pointing movements to the target locations might be countered by the benefit.

Despite these limitations, the results, together with earlier findings that showed facilitatory or interference effects of pointing movements, suggest that the effects of pointing movements on VSWM performance are task-dependent. In fact, how pointing movements function differently depends on the paradigm used, as stated in the Introduction. However, results indicate the possibility that pointing movements can facilitate VSWM performance when several variables are controlled appropriately. Further study will be necessary with consideration of diverse variables including, for example, individual differences.

Ⅴ. Acknowledgments

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References

1) Conway ARA, Jarrold C, Kane MJ, Miyake A & Towse JN, editor(2007) *Variation in working memory*. New York: Oxford University Press.
2) Miyake A & Shah P, editor(1999) *Models of working memory: Mechanisms of active maintenance and executive control*. New York: Cambridge University Press.
3) Baddeley AD & Hitch GJ(1974) Working memory. In: Bower GH(Ed.). *The Psychology of Learning and Motivation*, New York: Academic Press, 8, 47-89.
4) Baddeley AD(2012) Working memory: theories, models, and controversies. *Annual Review of Psychology*, 63, 1-29.
5) Baddeley AD(2007) *Working memory, thought, and action.* New York: Oxford University Press.
6) Chum M, Bekkering H, Dodd MD & Pratt J(2007) Motor and visual codes interact to facilitate visuospatial memory performance. *Psychonomic Bulletin & Review*, 14, 1189-1193.
7) Vandierendonck A, Kemps E, Fastame MC & Szmalec A(2004) Working memory components of the Corsi blocks task. *British Journal of Psychology*, 95, 57-79.
8) Smyth MM, Pearson NA, Pendleton LR(1988) Movement and working memory: Patterns and positions in space. *Quarterly Journal of Experimental Psychology*, 40, 497-514.
9) Hale S, Myerson J, Rhee SH, Weiss CS & Abrams RA(1996) Selective interference with the maintenance of location information in working memory, *Neuropsychology*, 10, 228-240.
10) Rossi-Arnaud C, Spataro P & Longobardi E(2012) Effects of pointing on the recall of simultaneous and sequential visuospatial arrays: a role for retrieval strategies? *Psychological Research*, 76, 699-712.
11) Ridgeway D(2006) Strategic grouping in the spatial span memory task. *Memory*, 14, 990-1000.
12) Lecerf T & de Ribaupierre A(2005) Recognition in a visuospatial memory task: The effect of presentation. *European Journal of Cognitive Psychology*, 17, 47-75.
13) Dodd MD & Shumborski S(2009) Examining the influence of action on spatial working memory: The importance of selection. *Quarterly Journal of Experimental Psychology*, 62, 1236-1247.
14) Milner B(1971) Interhemispheric differences in the localization of psychological processes in man. *British Medical Bulletin*, 27, 272-77.
15) Morris CD, Bransford JD & Franks JJ(1977) Levels of processing versus transfer appropriate processing. Journal of Verbal Learning and Verbal Behavior, 16, 519-533.

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