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The Effect of Content Familiarity on Memory-Based Attention Allocation

Hyunkyu Lee
Beckman Institute
University of Illinois at Urbana-Champaign

Min-Shik Kim
Department of Psychology
Yonsei University

Studies of attention and working memory address that working memory contents guide attention to the memory-matching object in the scene. The present study investigated whether familiarity of working memory contents modulates the memory-based attention allocation. We measured the attention allocation by comparing response times (RT) for memory-matching or non-matching probes while maintaining either novel or familiar object in working memory. When a novel object was maintained in working memory, probe RTs at the memory-match object were significantly faster than those on non-match object (Experiment 1). However, when participants maintained a familiar or highly learned object in working memory, there was no probe RT advantage for the memory-match object (Experiments 2, 3, and 4). These results demonstrate that working memory does not automatically bias attention towards the memory-matching item; instead, the bias was present only for novel working memory contents. Thus, the guidance of attention by working memory contents could be due to a top-down strategy where participants re-sample the memory item in the visual array in order to reduce the cognitive complexity of working memory maintenance.

Key words : visual working memory, spatial attention, familiarity

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† Corresponding Author : Min-Shik Kim, Department of Psychology, Yonsei University, Seoul, 120-749, Korea
E-mail : kimm@yonsei.ac.kr

A large body of studies indicates a close link between working memory and selective attention (for a review, see Awh, Vogel & Oh, 2006; Cowan, 2001). The classical view of the relation between attention and working memory addresses that attention acts as a gate, controlling what information is allowed into the working memory stores. Due to limited processing resources, the visual system cannot process every single object in the visual field in a given moment (Broadbent, 1958; Neisser, 1967; Schneider & Schiffrin, 1977). Selective attention improves the efficiency of the visual system by filtering irrelevant information from the stimulus stream, and the selected information is stored and manipulated in working memory (WM) (Baddeley & Hitch, 1974; Baddeley, 1996). However, recent studies have proposed an interactive relationship between selective attention and working memory by demonstrating that working memory representations bias the allocation of attention to objects matching to the working memory contents (Desimone & Duncan, 1995; Downing, 2000; Oh & Kim, 2004 Woodman & Luck, 2004).

The biased competition theory provides a framework for understating the top-down bias from working memory on the selection of attention (Bundesen, 1990; Desimone, 1998; Desimone & Duncan, 1995; Duncan, 1998; Harter & Aine, 1984). According to this theory, sensory inputs in the visual field compete for one another to become the focus of attention. In this competition, active maintenance of the target in working memory can bias attention in favor of the matching item in the visual field. The memory-matching item, therefore, becomes more likely to be the focus of attention and processed for perceptual awareness and motor behavior. Substantial single-cell and neuroimaging studies suggest the evidence for the working memory bias to attention selection (Chelazzi, Duncan, Miller, & Desimone, 1998; Chelazzi, Miller, Duncan, & Desimone, 1993 Pessoa, Gutierrez, Bandettini, & Ungeleider, 2002; Postle & D 'Esposito, 1999). For example, Chelazzi and his colleagues (1993) showed that in a delayed match to sample task, some macaque inferior temporal neurons continued to show sustained neural activation to the target during the delay period. According to the biased competition theory, the sustained neural activation biases the competition among items in visual field in favor of the memory-matching item. In this manner, the memory-matching item receives a competitive advantage and eventually becomes selected.

Direct behavioral evidence that attention is drawn to the objects matching to working memory content is addressed in Downing (2000). In this study, participants were instructed to remember a visual item such as human faces, common objects or meaningless objects in working memory. During a delay interval, two items were presented; one of these items matched the memory representation, and the other did not match. Participants performed a discrimination task on a small bracket (probe) appearing at the location of one of the two items. Downing measured the amount of attentional allocation by comparing response times for discriminating the probe appearing in one of the competing item locations (e.g., Kim & Cave, 1995, 1999, 2001). Results showed that response times to probes at the location of the matching item were faster than to probes at the location of the non-matching item, suggesting that active maintenance of an object in working memory biases selective attention toward the matching object in the visual field, even when there is no explicit search goal.

In spite of the massive evidence that working memory representations bias the deployment of attention, there is still debate on whether contents in working memory "automatically" lead to the selection of memory matching object. Woodman and Luck (2007) tested if working memory representation biased the deployment of attention when the remembered item appeared as a distractor in the search array. Woodman and Luck reasoned that if working memory representation guides attention automatically to the memory-matching item in the search display, then participants would be slower to detect a search target when the memory item is presented as a distractor compared when memory items is not presented in the search array. The results demonstrated no evidence that memory-matching distractor interferes with the selection of the search target, suggesting the contents of working memory can be used to either facilitate or inhibit the deployment of attention to the memory item based on task context.

If the attention bias from working memory is not automatic, then the next question is when and how working memory representation biases visual attention to the memory item? We propose that familiarity level of item in working memory is a natural process to affect allocation of attention. Compared to familiar object, holding unfamiliar object in working memory is a cognitively demanding process because of the lack of long-term, and episodic memory support. Mishkin and Delacour (1975) showed that maintaining a novel object in a delayed matching to sample task requires laborious retention of a novel and complex visual stimulus across a delay period. In contrast, maintaining familiar objects in a delayed matching to sample task can be accomplished by the aid of long-term memory knowledge (Eri csson & Kintsch, 1995; Fuster, 1995; Kimberg, D'Esposito, & Farah, 1997). Neuroimaging evidence suggests that novel objects and familiar objects are processed differently during encoding and maintenance in working memory. In many areas of medial temporal cortex, neuronal responses to encoding of novel object are stronger than those to familiar object (Gabrieli, Brewer, Desmond, & Glover, 1997; Kirchhoff, Wagner, Maril, Stern, 2000; Stern, Corkin, Conzalez Cuimaraes, Baker, Jennings, Carr, Sugiura, Vedantham, & Rosen, 1996).

In the following experiments, we developed a direct test of the role of contents familiarity of working memory on the deployment of attention. We propose that our cognitive system might adapt top-down strategy of re-sampling the memory item in the search array in order to reduce the complexity and to improve working memory performance. If this top-down re-sampling strategy is one mechanism governing the memory-based attention allocation, then memory-based attention bias should be stronger when participants remember a novel item in working memory compared to when they remember a familiar item.

We used a dual task procedure to examine the role of contents' familiarity on the memory-based attention bias. Participants were presented with one memory item, which was either novel (Experiment 1) or familiar (Experiment 2, 3 & 4), and were instructed to remember the memory item for a memory test at the end of trial. During the retention interval, participants performed probe discrimination task. Most importantly, two items - one matching to memory item and another non-matching to memory item - were flashed briefly before the probe presentation. On 50% of trials, the probe was presented on the memory-matching item. If working memory contents guide attention regardless the contents' familiarity, then the bias of attention to memory item, indexed by response time to the probe, should not be affected by working memory contents familiarity. In contrast, if working memory contents' familiarity influences the bias of attention to the memory-matching item, then there should be attention benefit for memory-matching item only when participants remember novel objects in working memory.

Experiment 1

In Experiment 1, we first replicated the bias of attention in favor of working memory contents while participants remembered a novel item in working memory. As the novel memory item, we used 2-dimensional meaningless line drawing objects (see Figure 1). The use of novel and meaningless objects as a memory item precludes the encoding of item with the aid of long-term, episodic memory or in verbal manner. The primary question was whether the novel, meaningless item in working memory would bias attention to the memory-matching item in the visual array.

Method

Participants. Thirteen Yonsei University undergraduates with normal or corrected-to-normal vision volunteered for course credit.

Stimuli. A set of 48 novel shapes (those used in Experiment 1 of Chun and Jiang, 1999) was used as memory items in the experiments. The stimuli measured approximately 4° by 4° of visual angle from a viewing distance of 57 cm. The current and all following experiments were conducted using a Pentium-III computer. Stimuli were presented on a 17-in. LG Flatron monitor with a refresh rate of 75Hz (13.3 ms/frame).

Procedure. Figure 1 illustrates the procedure and timing. The sequence and timing were identical to those used by Downing (2000). Each trial was initiated by pressing the space bar. A fixation point appeared for 1000 ms, followed by a single object (memory item) presented at the center of the screen for 1000 ms. No same memory item was repeated during an experiment. Observers were instructed to remember the item in working memory for memory test at the end of trial. A fixation point was then presented for 1,506 ms, followed by two objects presented simultaneously side by side for 187 ms. The short duration of the two objects' presentation (187 ms) precluded any eye movements towards a certain object. The objects were centered 4° from fixation, one to the right and one to the left. One of the two objects always matched to the memory item (memory-match object) and the other was a new randomly selected item (non-match object). The memory-match object appeared equally often on the right and on the left of a fixation. After a 40-ms fixation display, a bracket was presented for 106 ms at one location of the two objects (probe). Considered that at least 100 ms is required to shift attention between objects, the 40 ms delay between two items and probe assured to measure the attention allocation on the two items. The bracket was oriented either up or down, and was approximately 0.5° in visual angle. The up bracket appeared with the same probability as the down bracket. Observers pressed the 'j' key if the bracket was oriented up and the 'n' key if the bracket was oriented down. After a 1,506-ms delay, a single object (memory-test item) appeared at the center of the screen and remained until the participants responded (memory task). Half of the time this memory-test item was identical to the original

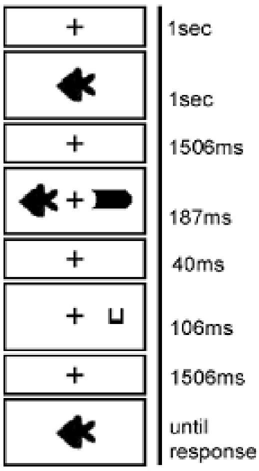

Figure 1. Procedure to investigate the attention allocation on the memory-match and non-match object location using a probe discrimination task. One memory item appeared, followed by two objects. One of them matched to the memory item and the other object did not match. A probe appeared either on the memory-match object location (memory-match) or the non-match object location (non-match)

memory item; the other half of the time the memory-test item was replaced with a new randomly selected item. Observers made an unspeeded change/no change response.

There were two probe conditions (memory-match and non-match). On half of the trials, the bracket appeared at the location of the memory-match object, and on the other half of the trials, the bracket appeared at the location of the non-match object. There were 48 trials total, 24 trials for each condition. Each observer received 16 un-analyzed practice trials at the beginning of experiment.

Results and Discussion

RTs were analyzed for trials in which responses to both the probe task and the memory task were correct. The general accuracy for the probe task was 94.7%. The general accuracy for the memory task was 98%. RTs greater than 1000 ms were excluded from the analyses; this trimming eliminated less than 1% of the data. The mean RTs for probe task were analyzed with a within-subject analysis of variance with probe condition (memory-match, non-match) as a factor. The mean RTs from the probe task appear in Figure 2A. Response times were reliably faster to the probes at the location of the memory-match object (424.8 ms) than to probes at the location of the non-match object (443 ms), $F(1, 12) = 7.9$, $p < .05$. The mean accuracy of probe task and memory task did not show significant effect between two probe conditions.

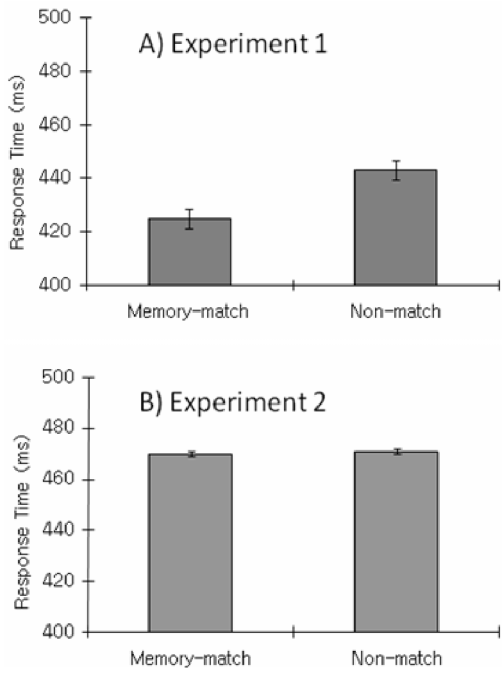

Figure 2. (A) Results of Experiment 1. (B) Results of Experiment 2. Participants exhibited a memory-based attentional benefit when they maintained a novel item in working memory, but this effect was absent with familiar item in working memory. Error bars are within-subject 95% confidence intervals on the memory-match versus non-match comparisons.

These results demonstrate that novel object in working memory can bias attention to the memory-matching object in visual field, replicating Downing (2000) founding. The effect size found in the current experiment (~20 ms) was equivalent to that found in Downing study (~16 ms).

Experiment 2

Experiment 2 examined whether familiar object in working memory would lead to attention benefit for the memory-match object as shown in novel object. We increased the memory item's familiarity by repeatedly presenting four objects as memory items throughout the experiment. Four items from 48 memory items in Experiment 1 were randomly selected for each participant, and used as memory items. If the attention benefit found in Experiment 1 was specific to maintaining a novel object, we should find less or no advantage for memory-matching objects in Experiment 2 where participants remember the same four items as a memory item repeatedly. If, however, working memory representations bias attention regardless of working memory content's familiarity, then we would find faster probe RTs on the memory-match condition over non-match condition.

Method

Participants. Fourteen Yonsei University undergraduates with normal or corrected-to-normal vision volunteered for course credit.

Stimuli. Stimuli were identical to those in Experiment 1 with one exception. Four memory items were selected randomly for each participant from the pool of 48 memory items in Experiment 1. The four memory items were presented in random order, and the four trials were considered one set of trials. The set was presented 12 times throughout the experiment, generating 48 total trials.

Procedure. The procedure was identical to that in Experiment 1. As in Experiment 1, there were two probe conditions (memory-match and non-match).

Results and Discussion

Data from one participant was dropped because of low performance, which was below 80% on the probe discrimination task. The general accuracy for the probe task was 98.5%. The general accuracy for the memory task was 97.4%. Trimming long (> 1000 ms) RTs eliminated less than 1% of the data. The mean probe RTs appear in Figure 2B. Observers' mean probe RTs were analyzed with a within-subject analysis of variance with probe location (memory-match, non-match) as a factor. Interestingly, in Experiment 2 there was no significant difference between memory-match (470 ms) and non-match (471 ms) conditions, $F(1, 12) = .006$, $p > .05$. The mean accuracy of probe task and memory task did not show significant effect between two probe conditions.

These results suggest that attention is not automatically captured by item matching to working memory contents. Most importantly, the results demonstrate that the content familiarity could be one factor determining the bias of attention to the memory-matching item. There appears to be a top-down strategy involved in the memory-based attention selection. Novel memory items used in Experiment 1 create higher level of encoding and maintaining complexity than the repeated memory items used in Experiment 2. Our visual system might use the strategy that re-samples the memory-matching item in the visual array in order to attenuate the cognitive complexity caused by remembering a novel item. The familiar objects, in contrast, can be encoded and maintained relatively easily by the aid from long-term, or episodic memory trace. In consequence, it becomes less optimal to attend to the memory-matching item in the visual array.

However, there is one concern that the small number of possible memory items in Experiment 2 manipulated not only the memory familiarity but also the task difficulty. Although we used meaningless objects in order to preclude verbal encoding, it is possible that the participants used verbal or semantic encoding strategy for the small set of memory items. To address this, Experiment 3 was conducted.

Experiment 3

Experiment 3 was identical with Experiment 2 with one exception; 24 instead of 4 items were used as memory items. The 24 memory items were presented as a memory item in random order and the 24 trials was considered as one set of trials. The set was repeated 8 times throughout the experiment. Experiment 3 has two advantages over Experiment 2. First, because a memory item repeated after every 24 trials, participants are less encouraged to use verbal or semantic encoding strategy. Second, because the 24 memory items repeated 8 times, we could see how the attentional benefit on the memory-match object changes as the memory item familiarity increases. Specifically, if the memory-based attention bias is due to the re-sampling strategy to overcome encoding and maintaining stress of novel item, we should see the less attention benefit on the memory-matching probe as repetition of memory item increases.

Method

Participants. Twenty-six Yonsei University undergraduates with normal or corrected-to-normal vision volunteered for course credit.

Stimuli. Displays were identical to those in Experiment 2 with two exceptions. First, 24 from 48 memory items in Experiment 1 were selected for memory items in Experiment 3. 24 memory items were presented in random order and the 24 trials were considered as a set. The set was repeated 8 times, generating 192 total trials.

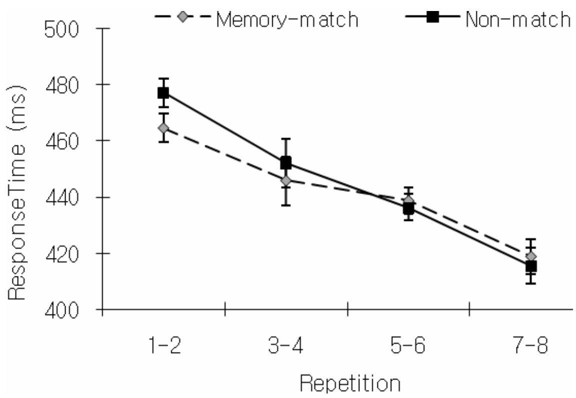

Figure 3. Results of Experiment 3. As memory item familiarity increased, the memory-based attentional benefit decreased. Error bars are within-subject 95% confidence intervals on the memory-match versus non-match comparisons.

Procedure. The procedure used in Experiment 3 was identical to that used in Experiment 1. There were two probe conditions (memory-match and non-match) and 4 repetition conditions (repeat 1-2, 3-4, 5-6, and 7-8 times).

Results and Discussion

Data from four participants were dropped because their single cell performance on either the memory task or probe task fell below 80% correct. The general accuracy for the probe task was 98.2%. The general accuracy for memory task was 96.6%. Trimming long (> 1000 ms) RTs eliminated less than 1% of the data. Participants' mean RTs were analyzed with a within-subject analysis of variance with probe condition (memory-match, non-match) and repetition (1-2, 3-4, 5-6 and 7-8 times) as factors. The mean probe RTs appear in Figure 3. There was no significant main effect of probe condition, $F(1, 21) = 2.2$, $p > .05$. The main effect of repetition was significant $F(3, 63) = 10.1$, $p < .001$. As the repetition increased, the probe RTs decreased. We assume that the effect is mainly due to facilitated response by training. The interaction between probe condition and repetition was not significant, $F(3, 63) = 1.3$, $p > .05$.

A planned comparison revealed that response times were reliably faster to probes at the memory-match object (465 ms) than to probes at the non-match object (476.5 ms) only at 1-2 repetition trials, $t(21) = -2.7$, $p < .05$. There was no significant difference in RTs between probe conditions when memory items were repeated more than 3-4 times.

We conducted a within-subject analysis of variance with only 2 repetition conditions (1-2, most novel memory item trials and 7-8, most familiar memory item trials) and probe conditions as factors. The main effect of probe location was not significant $F(1, 21) = 2.1$, $p > .05$. The main effect of repetition was significant $F(1,21) = 16.5$, $p < .001$. Most important, the interaction between probe location and repetition was marginally significant $F(1,21) = 4.2$, $p = .054$.

Participants' mean accuracies on probe task and memory task were analyzed with a within-subject analysis of variance with probe condition (memory-match, non-match) and repetition (1-2, 3-4, 5-6 and 7-8 times) as factors, and revealed no significant main effect or interaction.

One thing we note from the results of Experiment 3 is that there is a main effect of repetition, such that as the memory items' familiarly increased, the response time for the probe decreased. One might argue that the facilitated process speed by familiar memory item hides the attentional benefit for memory-matching object. In other words, the high familiar memory item might still bias attention to the memory-matching object, but the highly facilitated probe process cancels out the effect. Although the current study cannot rule out the possibility, this explanation is very unlikely. In the current experiment, the delay between two items and probe presentations was only 40 ms. Considered that the attentional shifts between objects requires at least 100 ms, the null effect between two probe conditions suggests no attention capture to the memory-matching object in the highly familiar target condition.

The results of Experiment 3 provide further evidence that memory-matching item attracts attention only when participants remember novel item in working memory. Moreover, current study replicates the results of Experiment 1 and 2 using within subject design. In the 1-2 repetition condition, attention was biased to the memory-matching item as in Experiment 1. However, as the familiarity of memory items increased, the attention benefit for the memory-matching item disappeared, as we have seen in Experiment 2.

Experiment 4

Experiments 2 and 3 demonstrated that only a novel object in working memory biases attention to the memory-matching object in visual field. We reasoned that the attentional benefit for the memory-matching object is due to top-down strategy of re-sampling memory item in the visual array to attenuate the cognitive load for maintaining a novel item in working memory. The familiar item in working memory, in contrast, is supported through the aid from long-term and episodic memory trace on its encoding and maintaining processes.

In Experiment 4, we directly compared the memory-based attention bias between long-term memory representation and novel working memory. It is expected that there would be no attention benefit for memory-matching item when remembering item having long-term memory representation.

Method

Participants. Twenty-one Yonsei University undergraduates with normal or corrected-to-normal vision volunteered for course credit.

Stimuli and Procedure. The stimuli and procedure were identical to those in Experiment 1 with following exceptions. First, participants finished long-term memory training before they performed memory and probe tasks. The long-term memory training consisted of two sessions (learning session and test session). In the learning session, participants were presented with 24 novel objects and instructed to memorize them. The learning was self-paced. One object was presented at the center of the screen until participants reported that they fully memorized the object. After studying one object, the next object was presented. The memory acquisition was tested after participants reported that they finished learning all 24 objects. In the test session, one object was presented on the center of screen. Participants were asked to discriminate whether the object was one of the objects that they learned or not. In half trials, the test object was one of the studied objects, and in the other half trials, the object was new one.

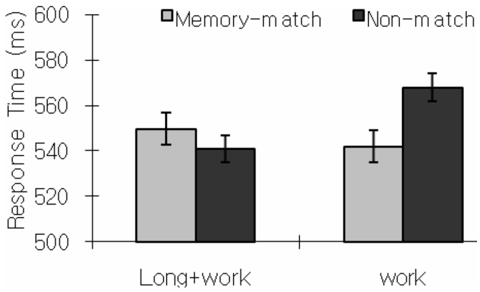

Figure 4. Results of Experiment 4. As in Experiment 1, participants exhibited a memory-based attentional benefit in the novel working memory condition, but this effect was absent in the long-term memory condition. Error bars are within-subject 95% confidence intervals on the memory-match versus non-match comparisons.

Participants repeated learning and test sessions until they reached 90% accuracy on the test session. After participants finished the test session they were given 10 arithmetic problems as an intermediate session. The purpose of the intermediate session was to insure that participants did not keep the learned objects in working memory. After the intermediate session, participants performed memory and probe task as in Experiment 1-3. There were two memory conditions (long-term and novel). On 50% of trials, previously learned object was presented as a memory item (long-term condition). On another 50% of trials, novel item was presented as a memory item (novel condition). There were also two probe conditions (memory-match and non-match).

Results and Discussion

Data from three participants were dropped because their single cell performance on either the memory task or probe task fell below 80% correct. The general accuracy for the probe task was 97.2%. The general accuracy for memory task was 96.7%. Trimming long (> 1000 ms) RTs eliminated less than 1% of the data. The mean probe RTs are shown in Figure 4. Observers' mean RTs were analyzed with a within-subject analysis of variance with probe condition (memory-match, non-match) and memory condition (long-term and novel) as factors. The main effect of probe condition was not significant $F(1,17) = 1.3$, $p > .05$. The main effect of memory condition was not significant $F(1,17) = .7$, $p > .05$. Most important, the interaction between probe location and representation storage was marginally significant $F(1,17) = 3.9$, $p = .064$.

A planned comparison showed that there was a significant RT difference between memory-match (541.8 ms) and non-match (567.9 ms) conditions when participants maintained novel object, $t(17) = 2.1$, $p < .05$. However, when participants hold the learned object as a memory item, there was no significant RT difference between memory-match (549.8 ms) and non-match (544.4 ms) conditions, $t(17) = .54$, $p > .05$.

Participants' mean accuracies on probe task and memory task were analyzed with a within-subject analysis of variance with probe condition (memory-match, non-match) and memory condition (long-term, novel) as factors, and revealed no significant main effect or interaction.

The results of Experiment 4 demonstrate direct comparison of memory effect on attention allocation between novel items and items with long-term representation. Replicating the results of Experiments 2 and 3, memory-matching items attracted attention only with novel memory item. The previously learned item, on the other hands, did not influence the attention bias to the memory-matching object in visual array.

One interesting finding is that the attention benefit in working memory condition was mainly due to the cost on the non-matching condition. Contrary to the matching condition showing no RT difference between memory conditions (long-term and working memory), the non-matching condition in working memory condition showed slowed RTs than those in long-term memory condition. These results suggest that the memory-bias from the contents in working memory might be due to the attention disengagement cost from the memory-matching item.

General Discussion

Based on the biased competition framework (Desimone & Duncan, 1995), several researchers suggested that active maintenance of an object in working memory shifts selective attention toward the matching object (Downing 2000; Pashler & Shiu, 1999; Soto, Heinke, Humphreys & Blanco, 2005). The present experiments investigated the mechanism of attentional bias to the memory-matching object. When participants remember a novel object in working memory (Experiment 1), the memory-match object showed an attentional benefitfrom working memory content, replicating that working memory contents bias attention in favor of the memory-matching object in visual array. However, when participants remember a familiar object in working memory, there was no attentional benefit for the memory-matching object as compared to the non-matching object (Experiment 2). Experiment 3 demonstrated as the familiarity of memory items increased, the attentional benefit to memory-matching object decreased. Direct comparison of a novel and long-term memory representation indicates that the memory-based attentional benefit only occurred for novel working memory contents (Experiment 4).

The results from Experiments 1 through 4 clearly demonstrate that the guidance of attention to the memory-matching item is not automatic. Instead, the results suggest that the guidance of attention by working memory contents is closely related to the familiarity of the working memory contents. Here, we are suggesting that the attention bias for novel memory item might be due to top-down strategy of re-sampling information in the visual field to attenuate the cognitive load requiring for maintenance of novel object in working memory. In order to increase the efficiency and decrease the cognitive complexity, the visual system might strategically attend to the bottom-up matching stimulus to support the active maintenance of a novel object. In contrast, when participants encounter a familiar object, they might rely on the long-term memory or episodic trace containing information about the relationship between object features (Kahneman, Treisman, & Gibbs 1992).

We should note that even the present study demonstrates that memory contents do not guide attention in automatic fashion, there are studies supporting the automatic guidance of attention by working memory contents. For example, Soto, Heinke, Humphreys and Blanco (2005) found that search was more efficient for the target appearing at a previously presented memory item, which is color or simple shape. Because colors and shapes are highly familiar features, the finding of search benefit from those simple memory items might seem incongruent to the current results. However there are few procedural differences between Soto et al's study and current study. In Soto et al, the memory cue briefly flashed several times and the time delay between memory cue and search display was short (188 ms). This procedure might perceptually activate the representation of colors and shapes in working memory. Most important, because the search display were presented until responses in Soto et al (2005), it is unclear whether the search benefit was due to memory-based automatic attentional benefit for the memory-match object or due to intentional strategy to attend at the memory-matching object.

Our results are important because they extend our understanding on the memory-based attention selection. One mechanism of memory-driven attention benefit is top-down re-sampling of the matching item in visual field as an endeavor to optimize the working memory performance. Our visual system draws attention to the memory-matching object in the environment in order to attenuate the cognitive load accompanied by novel working memory contents. This "cognition economy" is apparent in our experiments: Novel memory item guided attention to the memory-matching object in visual array, but familiar object did not. The biased-competition account, which is the main account for memory-based attention selection, could be extended along the lines of the cognition economy. The working memory contents do not automatically bias attention to the memory-matching item. The memory-based attention allocation might be based on the top-down mechanism of optimizing the cognitive load required for current task.

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자극 친숙성이 작업기억에 의한 주의 유도에 미치는 영향

이 현 규
University of Illinois at Urbana-Champaign
Beckman Institute

김 민 식
연세대학교 심리학과

최근 주의와 작업기억간의 관계에 대한 연구 중에는, 시각 장면에 제시된 대상이 작업기억 내용과 일치하는 경우 그 대상으로 시각적 주의가 유도되는 지를 알아보려는 시도들이 다수 포함되어 있다. 본 연구는 기억에 근거한 주의 할당 기제를 이해하기 위하여 작업기억 내용의 친숙성이 시각적 주의 유도에 영향을 주는지를 알아보았다. 시각 작업기억에 유지하고 있는 자극의 친숙성 정도를 조작하면서, 이들 자극과 일치하거나 혹은 일치하지 않는 자극의 위치에 탐사자극을 제시하여 탐사자극에 대한 반응시간을 측정함으로 주의 할당 정도를 측정하였다. 친숙하지 않은 자극이 작업기억에 유지되는 경우에는, 기억과 일치하지 않는 조건보다 일치하는 조건에서 탐사 자극에 대한 반응시간이 유의미하게 빠른 것으로 나타났다(실험 1). 그러나 작업기억에 유지되는 시각 자극이 친숙하거나 잘 학습되어 있는 경우에는 기억과 일치하는 지 여부가 주의 할당에 영향을 주지 않는 것으로 나타났다(실험 2, 3, 4). 이러한 결과는 작업기억이 기억과 일치하는 자극의 위치로 주의를 자동적으로 유도하는 것은 아니며, 작업기억에 유지되는 자극의 친숙성 정도가 주의 유도에 중요한 변인임을 보여준다. 따라서 작업기억 내용에 의한 주의 유도는 참가자들이 작업기억을 유지하는 인지적 어려움을 감소시키기 위하여 시각적으로 제시된 자극을 재표집(re-sample)하는 하향적 기제에 의한 것으로 해석될 수 있다.

주제어 : 시각적 작업 기억, 공간적 주의, 친숙성