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You must Remember the Whole for the Reappearance of A Part to Capture Your Attention

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When an external stimulus refreshes an internal representation maintained in a person’s working memory, it captures his or her attention. This working memory-based attentional capture has been demonstrated in various contexts using different stimuli. However, few studies have investigated this phenomenon using part of a visual display maintained in working memory to capture attention. In four experiments, I addressed this issue using a dual-task paradigm. The participants remembered the spatial locations of four colored disks for later recognition, judged the direction of a moving stimulus along with a static distractor, and recognized whether a probe display matched the memorized locations. Color was irrelevant to both the memory and attention tasks. In the valid condition, the color of the moving target was identical to the previously displayed color, and in the invalid condition, the color of the static distractor was the same as the previously displayed color. In Experiments 1 and 2, four white disks were used in a recognition task to probe the to-be-remembered locations. In Experiment 3, four white hexagon stars were used in a recognition task to probe the locations. In Experiment 4, a solid line showed the contour of the four locations for the recognition task. Colored disks were used as stimuli in the motion task for Experiments 1 and 4, whereas colored crosses were used in Experiment 2. Experiment 3 combined the design of Experiments 1 and 2 as a within-subject design. The results showed working memory-driven attentional capture only in Experiment 1 and an object-matched condition in Experiment 3, with two colored disks presented in the motion judgment task and four white disks probed for location memory. The contrast in the results across the three experiments suggests that the parts must be an important aspect of the memorized representation for its reappearance to capture a person’s attention. When the judgment required comparison with the memorized representation based on the four disks, the spatial locations of the four disks were crucial for accurate decision making. Thus, the reappearance of one colored disk could capture attention, whereas the appearance of a cross in the same color could not. When the spatial configuration of the four disks was emphasized in the memorized representation (Experiment 4), the reappearance of the same part did not capture attention.

Keywords: *attentional capture, memory strategy, working memory*

The relationship between working memory and selective attention has been demonstrated by numerous studies. These studies have shown that the content of working memory biases attention. This effect of working memory-driven attentional capture has been clearly demonstrated in various contexts and using different stimuli. In most studies, a dual-task paradigm that combines a recognition task and an attentional task is used. At the beginning of a trial, a to-be-remembered item is presented and participants are instructed to remember it for the recognition task at the end of a trial. In the interval between the removal of the to-be-remembered item and presentation of the recognition task, participants perform an irrelevant attentional task. The critical finding from such studies is that although the to-be-remembered item is unrelated to the attentional task, it still captures the attention of the participants. However, few studies have investigated a context in which part of a visual display is maintained in working memory to capture attention. I address this issue using four sets of experiments and a dual-task paradigm. Eighty-seven undergraduate students (19, 19, 30, 19 participants in Experiments 1–4, respectively) participated in these experiments for either course credit or NT$130. The participants remembered the spatial locations of four colored disks for later recognition and judged the direction of a moving stimulus (up or down) along with a static distractor. After recording the responses of the participants, four location probes were presented and the participants were asked to judge whether the location probes matched or did not match the remembered locations. In all four experiments, color was irrelevant to both the recognition and attentional tasks. In the valid condition, the color of the moving target was identical to the previously displayed color. In the invalid condition, the color of the static distractor was the same as the previously displayed color. In Experiments 1 and 2, four white disks were used in a recognition task to probe the to-be-remembered locations. In Experiment 3, four white hexagonal stars were used in a recognition task to probe the locations. In Experiment 4, a solid line showed the contour of the four locations for the recognition task. Colored disks were used as stimuli in the motion tasks for Experiments 1 and 4, whereas colored crosses were used in Experiment 2. Experiment 3 combined the designs of Experiments 1 and 2 to obtain a within-subject design. After providing informed consent, the participants performed 16 practice trials and 64 experimental trials for each experiment. The procedure used in the present study was similar to that used in the second experiment described in Downing (2000). Each trial began with the presentation of a fixation point for 700 ms. Four locations were probed and presented for 1,500 ms, after which the participants were instructed to memorize the locations. A fixation point was then presented for 1,500 ms as the maintenance interval. Subsequently, two objects located at 10º of visual angle from the center were presented on either side of the fixation point for 187 ms. One of the objects was then moved by approximately 0.5º of visual angle, either upward or downward, for 53 ms. Following this, the objects were replaced by a question mark. The participants were asked to judge the direction of movement by pressing either the ‘‘k’’ key for upward motion or the ‘‘m’’ key for downward motion. After recording the responses of the participants, the memory probe was presented and the participants were asked to decide whether the locations were identical to the memorized ones by pressing either the ‘‘z’’ key for same or the ‘‘x’’ key for different. The reaction time (RT) data from the motion discrimination task for trials in which both motion discrimination and memory recognition were correct were analyzed. Additionally, RTs that deviated more than ± three standard deviations from a participant's mean were removed from subsequent analyses . As a result, 2.05%, 1.53%, 1.46%, and 1.97% of the trials were excluded from Experiments 1–4. The results of Experiment 1 showed that the accuracy was at ceiling for both the motion discrimination task (99%) and the recognition task (97%). A two-tailed t-test showed that the RTs were slower for the invalid (413 ms) than for the valid (396 ms) condition, $t(18) = 2.73$, $p = .007$, $d = .63$. There was no significant difference in accuracy ($p > .15$), which was quite high in both conditions. The results of Experiment 2 also showed that the accuracy hit the ceiling values for both the motion discrimination task (99%) and the recognition task (98%). A two-tailed t-test showed no differences in the RTs of the invalid (383 ms) and valid (380 ms) conditions, $t\ (18) = 0.81$, $p = .21$, $d = .19$. There was no significant difference in accuracy ($p > .08$) between the two conditions. The results of Experiment 3 showed that the accuracy was at ceiling in both the motion discrimination task (98%) and the recognition task (93%). A 2 (match condition: object-matched or feature-matched) × 2 (trial type: invalid or valid) repeated measures analysis of variance (ANOVA) of the motion discrimination RTs showed that neither of the main effects (match condition and trial type) reached the significant level (match condition: $F(1, 29) = 0.17$, $p = .68$, $\eta_p^2 = .006$; trial type: $F(1, 29) = 3.16$, $p = .09$, $\eta_p^2 = .098$). In addition, there was a significant interaction between match condition and trial type with respect to RT, $F(1, 29) = 6.40$, $p = .017$, $\eta_p^2 = .18$. Further analysis showed that performance was faster in the valid (405 ms) than in the invalid (418 ms) condition in the object-matched scenario, $F(1, 58) = 9.51$, $p = .003$, $\eta_p^2 = .14$. However, there was no difference between the valid (414 ms) and invalid conditions (410 ms) in the feature-matched scenario, $F(1, 58) = 0.66$, $p = .42$, $\eta_p^2 = .01$. There was no significant difference in accuracy between the two conditions. The results of Experiment 4 showed that the accuracy was at ceiling in both the motion discrimination task (98%) and the recognition task (94%). A two-tailed t-test showed no differences in the RTs of the invalid (455 ms) and valid conditions (449 ms), $t(18) = 1.27$, $p = .11$, $d = .29$. There were no significant differences in accuracy ($p > .15$) between the two conditions. These results showed working memory-driven attentional capture only in Experiment 1 and in the object-matched scenario in Experiment 3, in which two colored disks were presented for the motion judgment task and four white disks were probed for location memory. The contrast in the results across the three experiments suggests that objects might be an important aspect of the memorized representation, given that their reappearance could capture attention. When the participants were required to make comparisons with the memorized representations of the four disks, the spatial locations of the disks were crucial for accurate decision-making. Thus, the reappearance of a colored disk could capture attention whereas the appearance of a cross in the same color could not. When the spatial configuration of the four disks was emphasized in the memorized representation (Experiment 4), the reappearance of the same object did not capture attention.