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Hold it! memory affects attentional dwell time

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Abstract

The allocation of attention, including the initial orienting and the subsequent dwell time, is affected by several bottom-up and top-down factors. How item memory affects these processes, however, remains unclear. Here, we investigated whether item memory affects attentional dwell time by using a modified version of the attentional blink (AB) paradigm. Across four experiments, our results revealed that the AB was significantly affected by memory status (novel vs. old), but critically, this effect depended on the ongoing memory context. Specifically, items that were unique in terms of memory status demanded more resources, as measured by a protracted AB. The present findings suggest that a more comprehensive understanding of memory's effects on attention can be obtained by accounting for an item's memorial context, as well as its individual item memory strength. Our results provide new evidence that item memory and memory context play a significant role in the temporal allocation of attention.

The allocation of attention is affected by several factors, including bottom-up, reflexive capture for stimuli that are highly salient in their physical features, and top-down, voluntary orienting toward task-relevant stimuli (Berger, Henik, & Rafal, 2005; Cheal & Lyon, 1991; Hopfinger & West, 2006; Jonides, 1981; Müller & Rabbitt, 1989; Posner & Cohen, 1984). The role of memory in attentional allocation, however, remains unclear. Previous studies have shown that item memory affects the initial capture of attention, although the results have been inconsistent. Some studies have found evidence for attentional capture for a novel word compared with previously studied words (Johnston, Hawley, Plewe, Elliott, & DeWitt, 1990; Wang, Cavanagh, & Green, 1994), whereas others found evidence that a familiar word captures attention more than a novel nonword does (Christie & Klein, 1995). Despite different experimental conditions and a different pattern of results, these studies have suggested that item memory does influence the initial attraction of attention. Recent studies have suggested that item memory also affects how long attention dwells on an item. Chanon and Hopfinger (2008) found that fixations during scene viewing were more frequent and for longer duration on old (previously studied) items than on new items, regardless of self-reported strategies, suggesting that item memory may have an involuntary effect on attentional dwell time.

In the previous eyetracking study (Chanon & Hopfinger, 2008), however, there was no immediate cost to dwelling longer on an item, and therefore, it is unclear how strong or automatic this effect may be. In the present study, we utilized a different method for quantifying the temporal allocation of attention—the attentional blink (AB) paradigm—in which there is a significant cost for increasing the dwell time on an initial target item. The AB refers to the finding that the correct identification of one target in a rapid serial visual presentation (RSVP) stream causes a marked impairment for detecting a second target presented shortly (~200–500 msec) after the first target (Broadbent & Broadbent, 1987; Raymond, Shapiro, & Arnell, 1992). Here, across four experiments, we varied the memory status of the targets and distractor

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items in order to test whether item memory and memory context significantly affect the temporal allocation of attention.

EXPERIMENT 1

Method

Participants—Eight healthy undergraduate students, ages 18–20 years (4 female), from the University of North Carolina participated. Each participant received course credit as compensation and had normal or corrected-to-normal vision.

Materials and Procedure—Participants first completed three blocks of encoding. Black-and-white pictures of individual items (on average 2.6° × 3.3°) were extracted from the line-drawing library of Van Diepen and De Graef (1994). Pictures were presented one at a time and in a random order, for 1,000 msec each, separated by a 2,000-msec interstimulus interval (ISI). For each encoding block, participants were required to make a different judgment about the pictures by answering the following questions: (1) Is the object heavy or light? (2) Does the object belong inside or outside? (3) Do you own the object? Thirty-six objects were studied in this way, 30 of which were used in the subsequent AB trials.

Each AB trial began with a fixation cross, presented for 500 msec, followed by an RSVP stream of 15 black line drawings. Each picture was presented for 120 msec, with no ISI. The nontarget stimuli consisted of randomly selected pictures from the previous encoding task. Therefore, the majority of the pictures in the AB trials had been previously encoded (i.e., they were old). Each trial included two targets, distinguished by color. The first target (T1) was drawn in red, the second (T2) in blue. Half of the T1 pictures had been encoded (i.e., old items); the other half had never been viewed by the participants (i.e., new items). T1 appeared randomly at Serial Position 4 or 6. T2 was always an old item and appeared equally often in random order two, three, or four serial positions after T1 (denoted as lag 2, 3, or 4). At the end of the stream, participants reported the identities of both targets. There were 40 trials of each combination of memory status and lag. The dependent variable was the mean accuracy (percent correct) for T2 identification.

Results

A two-way ANOVA was performed on T2 accuracy with the factors of T1 memory status (old T1 or new T1) and lag (2, 3, or 4). Only trials in which T1 was correctly identified were included. The ANOVA revealed a significant main effect of memory status, since T2 accuracy was significantly reduced when T1 was a new item compared with when it was an old item (new, M =.262; old, M =.450) [$F(1,7) = 74.770$, $p < .001$]. There was also a significant main effect of lag on T2 accuracy (lag 2, M =.160; lag 3, M =.377; lag 4, M =.554) [$F(2,14) = 47.647$, $p < .001$]. In addition, there was a significant interaction between memory status and lag [$F(2,14) = 8.832$, $p = .003$]. To further examine this interaction, paired t tests were conducted, using the Benjamini– Hochberg (B–H) procedure to correct the alpha level for multiple comparisons (Benjamini & Hochberg, 1995). Figure 1 depicts T2 accuracy at each lag. At lag 2, T2 accuracy on old-T1 trials (M =.163, SD =.095) was not significantly different from that on new-T1 trials (M =.103, SD =.054) [$t(7) = 1.176$, $p = .061$]. At lag 3, however, T2 accuracy was significantly worse for new-T1 trials (M =.183, SD =.151) than it was for old-T1 trials (M =.469, SD =.172) [$t(7) = 8.12$, $p = .008$]. This effect was also significant at lag 4 (new-T1 trials, M =.350, SD =.127; old-T1 trials, M =.556, SD =.161) [$t(7) = 4.660$, $p = .001$].

Although T2 accuracy was our main interest, we also examined T1 accuracy (see the Appendix). Mean T1 accuracy was 81.6% with no significant effect of lag [$F(2,14) = 1.298$, $p = .304$]. A main effect of memory status showed that overall T1 accuracy was reduced when it was a new item (new, M =.754; old, M =.921) [$F(1,7) = 14.458$, p =.007], but there was no interaction between memory status and lag [$F(2,14) = 1.244$, p =.318].

Discussion

The results of this experiment provide new evidence that the memory status of an item significantly affects the temporal allocation of attention. The AB remained robust for a longer time when T1 was a new item than when it was an old item. Both types of T1 produced a large AB at lag 2, but accuracy was largely recovered by lag 3 on old-T1 trials, whereas accuracy remained low until lag 4 on new-T1 trials. This delay in the recovery of the AB demonstrates that the attentional dwell time on T1 was significantly lengthened when T1 was a new item as compared with when it was an old item.

These results suggest that new items may hold attention longer because they have never been viewed before. However, the new item also had a unique memory status relative to the ongoing context, because all the distractors were old. To test whether it was the newness of the item or the memorial uniqueness that caused the protracted AB, we conducted a second experiment in which the memory context was reversed. In Experiment 2, we used abstract line drawings that minimize verbal processing in order to reduce any possible effects resulting from differences between the times to generate names for old and new items.

EXPERIMENT 2

The memorial context of Experiment 1 was reversed by using new rather than old items as distractors. Thus, old T1s were now unique relative to ongoing context, contrary to Experiment 1, in which new items were unique. If the attentional effects observed in Experiment 1 were solely due to the newness of T1, then the memorial context should not matter, and new items should again produce a protracted AB. However, if these effects are dependent on the memorial context, Experiment 2 should display opposite results from those of Experiment 1; specifically, old T1s should cause a longer AB than new T1s would.

Method

Participants—Sixteen undergraduate students, ages 18–20 years (10 female), from the University of North Carolina participated. Each participant had normal or corrected-to-normal vision and received course credit as compensation.

Materials and Procedure—Participants first completed three blocks of encoding. The abstract shapes were extracted from the set of line drawings designed by Slotnick and Schacter (2004) to limit verbal processing (www2.bc.edu/~slotnics). Each line drawing was distinguished by its unique (nonnameable) shape. In addition, each shape was one of 36 colors, and no two encoded items possessed the same color, in order to increase the likelihood of deep encoding. Participants were instructed to study each line drawing (average size 7.9° × 7.9°) in preparation for a later memory test. The stimuli were presented one at a time, and each block was self-paced. Sixteen objects were studied, 10 of which were used in the subsequent AB trials.

The AB trials were similar to those in Experiment 1, but with a few differences. The nontarget (distractor) stimuli were all new pictures, with a black background; T1 and T2 had gray backgrounds. T1 was equally likely to be an old or a new item, and it appeared randomly at Serial Position 4 or 5. T2 consisted of only new items, and it appeared in random order one, two, or three positions after T1 (i.e., lag 1, 2, or 3). There were 10 items per stream, and each picture was displayed for 176 msec with an ISI of 52 msec. Because of the increased duration and the inclusion of an ISI, the lags here are not temporally equivalent to those in Experiment

1. At the end of each trial, participants made an *old*/*new* response to T1 and matched the color of T2 to a color on a 3 × 3 grid of color patches. There were 24 trials of each combination of memory status and lag. Following the AB task, participants completed a recognition memory test.

Results

A two-way ANOVA and paired *t* tests were conducted on T2 accuracy, as was done in Experiment 1. Only trials on which the T1 task was correctly completed were included. The ANOVA revealed significant main effects of both memory status and lag. T2 accuracy was significantly reduced when T1 was an old item, as compared with when it was a new item (old, M =.493; new, M =.578) [$F(1,15) = 12.516$, p =.003], and T2 accuracy was different between lags (lag 1, M =.464; lag 2, M =.501; lag 3, M =.626) [$F(2,30) = 7.331$, p =.003]. Finally, there was a significant interaction between memory status and lag [$F(2,30) = 3.658$, p =.038]. Paired *t* tests were again corrected for multiple comparisons using the B–H correction procedure. At lag 1, T2 accuracy was significantly worse for old-T1 trials (M =.399, SD =.176) than it was for new-T1 trials (M =.514, SD =.154) [t (15) = −3.46, p =.002]. This difference was also significant, and even larger, at lag 2 (old-T1 trials, M =.473, SD =.267; new-T1 trials, M =.627, SD =.150) [$t(15) = −3.62$, p =.001]. At lag 3, T2 accuracy was no longer different [$t(15) = −0.162$, p =.437] between old-T1 trials (M =.589, SD =.240) and new-T1 trials (M =.597, SD =.237). (See Figure 2.)

Mean T1 accuracy (see the Appendix) was 83.2%, with a significant effect of memory status (new, M =.872; old, M =.798) [$F(1,15) = 21.152$, p <.001]. No significant main effect of lag was found (lag 1, M =.790; lag 2, M =.799; lag 3, M =.808) [$F(2,30) = 0.370$, p =.694], and no interaction between memory status and lag was found [$F(2,30) = 0.596$, p =.558].

After the AB task, participants completed a recognition memory test for single objects (one fourth new, one fourth encountered in only the encoding phase, one fourth encountered in the encoding and AB phases, one fourth encountered only during the AB phase). Participants were asked whether they had studied the item during the encoding phase. They correctly judged 94.8% of the studied items as studied, and the additional exposure during the AB phase made no difference (studied only, M =.927, SD =.149; studied and used in AB phase, M =.969, SD =.067) [$t(15) = −1.000$, p =.333]. In addition, participants correctly judged 93.8% of items that were new or seen only during the AB phase as not studied, with no differences between new items (M =.906, SD =.211) and those seen only during the AB phase (M =.969, SD =.067) [$t(15) = 1.103$, p =.287]. Thus, the initial encoding, not the subsequent exposure during the AB task, was the critical factor in establishing these memories.

Discussion

In direct contrast to the results of Experiment 1, the present experiment showed that the AB was extended when T1 was an old item as compared with when it was a new item. Together, these data provide strong evidence that the effects of memory on attention are not critically dependent on the particular memory status of an item (old or new) but, rather, on the memorial uniqueness of an item relative to ongoing context. However, in Experiment 2, we used quite different stimuli from those in Experiment 1. Therefore, before further interpreting the results of these experiments, we conducted an additional experiment to replicate the findings of Experiment 1 (longer AB following new items, when context is old) using the stimuli and timing of Experiment 2.

EXPERIMENT 3

Method

Participants—Seventeen undergraduates, ages 18–20 years (13 female) and with normal or corrected-to-normal vision, from the University of North Carolina participated for course credit.

Materials and Procedure—Stimuli and procedures were the same as those in Experiment 2, except that the memory status of the nontarget distractors and T2 was old instead of new.

Results and Discussion

For T2, the ANOVA revealed a significant main effect of memory status (new, M =.585; old, M =.542) [$F(1,16) = 11.907$, p =.003] and a significant effect of lag (lag 1, M =.424; lag 2, M =.593; lag 3, M =.664) [$F(2,32) = 17.176$, p <.001]. The interaction between memory status and lag approached significance [$F(2,32) = 2.632$, p =.087]. At lag 1, T2 accuracy was significantly worse for new-T1 trials (M =.358, SD =.238) than for old-T1 trials (M =.433, SD =.206) [t (16) = 2.140, p =.024]. This same significant effect was present, and was even larger, at lag 2 (new-T1 trials, M =.482, SD =.257; old-T1 trials, M =.616, SD =.194) [t (16) = 3.520, p =.001]. At lag 3, there were no longer any significant differences [$t(16) = 1.026$, p =. 160] in T2 accuracy between old-T1 trials (M =.668, SD =.226) and new-T1 trials (M =.636, SD =.247). (See Figure 3.) Despite the change in the stimuli and tasks, the findings of Experiment 3 replicated the key finding of Experiment 1: The AB was extended when T1 was a new item, as compared with when it was an old item, when the memory context was old items.[1]

Mean T1 accuracy (see the Appendix) was 77.9%, with no significant effect of memory status [$F(1,16) = 1.692$, p =.212]. A significant main effect of lag was found [$F(2,32) = 7.770$, p =. 002], as was a significant interaction between memory status and lag [$F(2,32) = 7.439$, p =. 002]. However, paired t tests revealed no significant differences in T1 accuracy between old and new T1s at any lag [lag 1, $t(16) = -1.89$, p =.039, not significant when corrected for multiple comparisons; lag 2, $t(16) = -0.410$, p =.344; lag 3, $t(16) = -1.301$, p =.106].

In the item-recognition test, participants correctly judged 90.2% of the studied items as studied, with no differences between items seen or not seen in the AB phase (studied only, M =.902, SD =.196; studied and used in AB phase, M =.902, SD =.167) [$t(16) = 0$, $p = 1$]. In addition, participants were highly accurate at judging items that were new as not studied (M =.902, SD =.166). (Note that there were no “seen once” items in this experiment, in contrast to Experiment 2, because the distractors here were composed of old items.)

The findings of Experiment 3 provide additional evidence that memory significantly affects the temporal allocation of attention, as is demonstrated by an extended AB when T1 was memorially unique. However, our Experiments 1–3 leave open the possibility that the effect could have been driven by the relation between T1 and T2, as opposed to the relation between T1 and the distractors (i.e., memory context).[2] Indeed, recent work (Juola, Botella, & Palacios, 2004) has demonstrated that T2 performance is worse when T1 and T2 come from different categories (e.g., letter vs. digit) rather than from the same category (collapsed across type of distractor category). We conducted Experiment 4 in order to test whether our effects are driven by the ongoing memorial context set up by the distractors or by a mismatch between T1 and T2.

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[1]Across our experiments, the effect of memory status on the AB did not depend on whether or not the memory status of the item was task relevant. Memory status was irrelevant to the task in Experiment 1 and relevant in Experiments 2 and 3.

[2]We thank Mark Nieuwenstein for pointing this out.

EXPERIMENT 4

This experiment was similar to Experiment 2 (wherein distractors and T2 were always new), except that, here, T2 was always old and, thus, never matched the distractors. This manipulation allowed us to test whether the effects found previously were due to a mismatch between T1 and T2 or between T1 and the context (as set by the distractor stream). Since the results of both Experiments 2 and 3 converged on the finding that memory context was critical, both designs would be equally useful for investigating the present issue; however, the present experiment used the basic design of Experiment 2 for practical reasons.[3] If the attentional effects observed in our Experiments 1–3 were due to the memory context of the distractor stream, in the present experiment, old T1s (being memorially unique relative to the distractors) should produce a protracted AB even though they match the memory status of T2 (old T1, old T2). However, if our previous effects are dependent on the memorial similarity between T1 and T2, a longer blink should be produced here when T1 and T2 do not match (new T1, old T2).

Method

Participants—Twenty-four undergraduate students, ages 18–20 years (17 female), from the University of North Carolina were recruited. One participant was excluded because of an apparent lack of encoding of the studied items (performance was at chance for identifying studied items as old and near chance for identifying unstudied items as new). Each participant had normal or corrected-to-normal vision and received course credit as compensation.

Materials and Procedure—Stimuli and procedures were the same as those in Experiment 2 (e.g., new distractors), except that the memory status of T2 was now always old.

Results and Discussion

A two-way ANOVA and paired *t* tests were conducted on T2 accuracy (for trials wherein T1 was correctly identified). No main effect of memory status was found (new, $M = .579$; old, $M = .550$) [$F(1,22) = 1.870$, $p = .185$], but there was a significant main effect of lag (lag 1, $M = .510$; lag 2, $M = .571$; lag 3, $M = .613$) [$F(2,44) = 6.412$, $p = .004$], and the interaction between memory status and lag approached significance [$F(2,44) = 2.503$, $p = .093$]. Paired *t* tests were again corrected for multiple comparisons using the B–H correction procedure. At lag 1, there was no difference between T2 accuracy for old-T1 trials ($M = .517$, $SD = .156$) and that for new-T1 trials ($M = .504$, $SD = .194$) [$t(22) = 0.415$, $p = .341$]. However, there was a significant difference between old- and new-T1 trials at lag 2 (old-T1 trials, $M = .527$, $SD = .173$; new-T1 trials, $M = .615$, $SD = .149$) [$t(22) = -2.23$, $p = .018$]. At lag 3, T2 accuracy was no longer different [$t(22) = -0.397$, $p = .348$] between old-T1 ($M = .607$, $SD = .144$) and new-T1 trials ($M = .620$, $SD = .127$). (See Figure 4.) Overall, an extended blink was found when T1 was old among new distractors, despite the fact that old T1 stimuli matched the memory status of the T2 stimuli (i.e., old). If the observed effects had been due to the relationship between T1 and T2, new T1s (being memorially different from old T2s) should have produced a longer blink. However, memorially unique targets (old T1s) led to a protracted blink here, providing further evidence that the effects observed in the present set of experiments are driven by memory context (the relationship between T1 and the distractors) and not by category switch costs or by memory priming between T1 and T2.

Mean T1 accuracy (see the Appendix) was 78.8% with a significant effect of memory status (new, $M = .837$; old, $M = .738$) [$F(1,22) = 12.847$, $p = .002$]. No significant main effect of lag

[3]Specifically, the recoding and reprogramming of the correct T2 response (the color on a color grid) was more easily achieved for a few old items (as required for a manipulation of Experiment 2) than it would have been for the many new items that would have been required for a manipulation of Experiment 3.

was found (lag 1, *M* =.796; lag 2, *M* =.770; lag 3, *M* =.798) [$F(2,44) = 1.747$, $p = .186$]. A significant interaction between memory status and lag was found [$F(2,44) = 14.664$, $p < .001$]; however, this interaction on T1 responses does not seem related to the T2 effect, since paired *t* tests revealed that this interaction on T1 responses was driven by the lack of an effect at lag 1 trials (old T1, *M* =.798, *SD* =.116; new T1, *M* =.794, *SD* =.154) [$t(22) = 0.149$, $p = .441$], whereas the memory context effect on T2 responses occurred at a different lag (i.e., on lag 2 trials).

For the recognition memory test, participants correctly judged 95.3% of the studied items as studied, and the additional exposure during the AB phase made no difference (studied only, *M* =.927, *SD* =.131; studied and used in AB phase, *M* =.978, *SD* =.057) [$t(22) = -2.07$, $p = .024$, n.s., with B–H correction]. In addition, participants correctly judged 91.3% of items that were new or seen only during the AB phase as not studied, with no differences between new items (*M* =.913, *SD* =.132) and those seen only during the AB phase (*M* =.902, *SD* =.206) [$t(22) = 0.157$, $p = .438$].

General Discussion

Whereas much research on involuntary attention has focused on the initial attraction of attention, recent studies have investigated factors that influence attentional dwell time as well (e.g., Most & Jungé, 2008). Exploring both of these mechanisms is imperative in order to fully understand how memory affects attention. Indeed, the holding of attention may be even more important than the initial orienting in affecting cognition and subsequent actions. Here, we provided new evidence that item memory plays a significant role in this aspect of attentional allocation. Using the AB paradigm, we found that a T1 unique in memory status (an old item among new distractors or a new item among old distractors) increased the duration of the AB. This effect was not dependent on the memory status of T1 alone or on the relationship between T1 and T2 but was dependent on the context (i.e., the memory status of surrounding distractors).

Other recent studies have supported the hypothesis that it is not necessarily the item memory strength per se but, rather, its memorial uniqueness (relative to the current context) that affects attentional allocation. Diliberto, Altarriba, and Neill (2000) investigated the initial orienting of attention and found that attention was involuntarily captured by the one word out of four simultaneously presented words that was unique in its memory (novel vs. familiar). Although that study showed the importance of uniqueness in the initial capture of attention, attentional dwell time and the temporal memorial context were not investigated. Evidence that memorial uniqueness affects attention has also come from eyetracking studies. For example, Ryan, Althoff, Whitlow, and Cohen (2000) investigated the influence of relational memory (memory between items) on attention. Participants viewed familiar scenes in which one region of the scene was manipulated (e.g., insertion of an item). These manipulations within old scenes increased attentional allocation to the one location that was new (i.e., modified), demonstrating the impact of relational memory on attention. In addition to relational memory, a recent eyetracking study has shown the impact of item memory on attention. Chanon and Hopfinger (2008) demonstrated that when viewing new scenes (in which almost all items were new), participants looked more often and for longer durations at old items than at new items. In agreement with our present findings, these previous studies support the idea that the effects of memory on attention are influenced by the interaction of item memory and memory context. Whereas the eyetracking studies examined memory context in terms of relation to other items presented in the same static scene, the present study addressed how attention is affected by memory context across time. Furthermore, our present results provide even stronger evidence that the effect of memory context is not voluntary or easily overcome, because the effect is robust even when there is an almost immediate cost (i.e., the inability to identify the second target in the AB trial).

The primary goal of the present experiments was to investigate how item memory and memory context affect the temporal allocation of attention. Since these experiments are the first evidence that memory context is a significant factor in determining attentional dwell time, previous models of the AB have not directly accounted for this pattern of results. Although our experiments were not intended to test theories of the AB, it may be useful to consider our results in terms of these accounts. Our data are not easily explained by models of the AB that emphasize the limited capacity of short-term memory (STM) itself (Raymond, Shapiro, & Arnell, 1995), because it is unclear why memory status would change the capacity of STM. Our finding that memory affects the duration of the AB also does not fit well with suppression/inhibition models (e.g., Raymond et al., 1992), which assume a fixed time course for inhibition or a set refractory period initiated by T1 processing. However, recent models that add a variable-length consolidation process as part of the refractory period (e.g., Bowman & Wyble, 2007) provide a better account of the present effects. This consolidation process, or tokenization, reflects the binding of an item's representation to its episodic context (Chun, 1997). Tokenization may include the processing of critical features and the binding of these with an object file (Kahneman, Treisman, & Gibbs, 1992). Accordingly, in our experiments, context may prime a tokenization process that includes a particular memory status as a standard feature, making processing more efficient when the target matches the memory context. When the memory feature of an item varies from the ongoing context, the tokenization process may be slowed, producing a larger and protracted AB.

Another recent model of the AB, the temporary loss of control (TLC) model, suggests that category discrepancies can affect the blink (Di Lollo, Kawahara, Ghorashi, & Enns, 2005). However, this model was founded on studies using overlearned material (such as numbers and letters) and does not consider the use of memory as a category distinction. Although it is possible that differences between memorially unique T1s and nonunique distractors may be processed as are any other general category difference, our present results (in conjunction with another recent study) suggest that memory status is not simply another category distinction. Specifically, a study by Juola et al. (2004) provides an excellent parallel to our present Experiment 4. Their study used stimuli differing in overlearned general categories (i.e., numbers and letters), instead of stimuli differing in memory status. As in our Experiment 4, the category of T1 was manipulated to be similar or different from the distractors, and the T2 category was always different from the distractors. Critically, Juola et al.'s results indicate that it was the *nonunique* T1 that resulted in a robust AB, whereas a unique T1 produced no AB (i.e., flat function across lags). In contrast, our study found a reversed pattern: The *unique* T1 item produced a longer AB than did a nonunique item. Although differences exist between the timing and original purpose of their study and ours, a comparison of these results suggests that the effects of memory (as shown in our experiments) seem to be distinct from those of general categories (as shown by Juola et al., 2004). Although memory may be acting as a type of category distinction and may, therefore, be related to the TLC account of the AB, memory itself seems to be special, producing a unique effect on attention. In addition, recent research has suggested that this effect may also extend to working memory (Akyürek & Hommel, 2005; Nieuwenstein, Johnson, Kanai, & Martens, 2007). For example, a recent study using an AB paradigm found that accuracy on T2 is significantly reduced when the target exactly matches an item being held in working memory (Nieuwenstein et al., 2007). Our data suggest that this effect may not be due simply to the item being held in working memory but, rather, that the target being held in working memory had a different memory status than the surrounding distractor items did. Although further studies are needed to more directly compare the effects of working memory and item memory on attention, the present results provide new evidence for a critical interaction between memory and attention.

In conclusion, the present study provides new evidence for an aspect of attention that has not been well understood: the influence of item memory on attentional allocation. Whereas previous work has emphasized the role of item memory strength alone, the findings here suggest that a broader view that also accounts for an item's memorial context is necessary. These results provide a first step in establishing that item memory uniqueness, determined through the interaction of item memory strength and temporal memory context, plays a significant role in the temporal allocation of attention.

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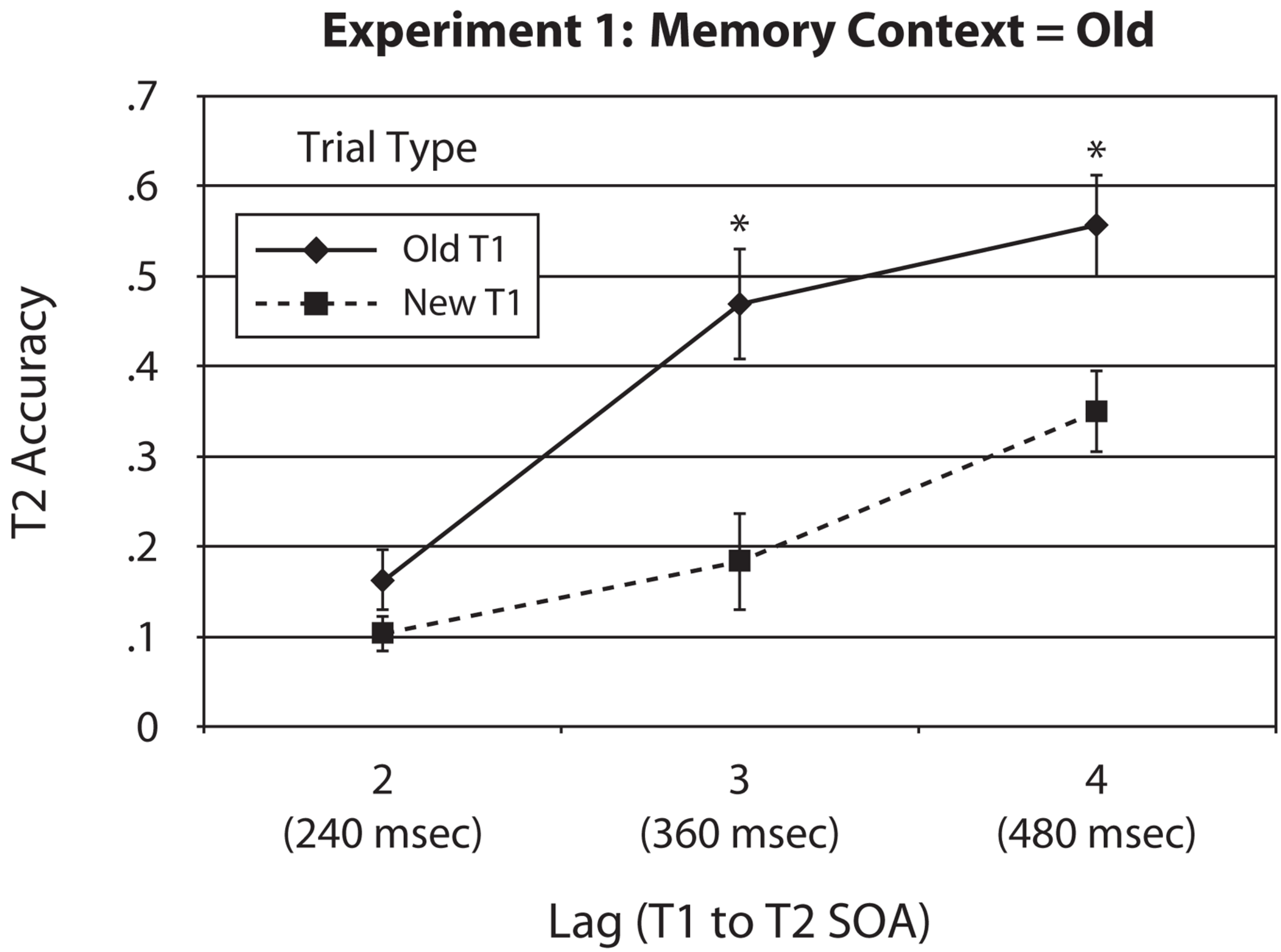

Figure 1.
T2 accuracy (Experiment 1). SOA, stimulus onset asynchrony between T1 and T2. *Significant after B–H correction for multiple comparisons (Benjamini & Hochberg, 1995).

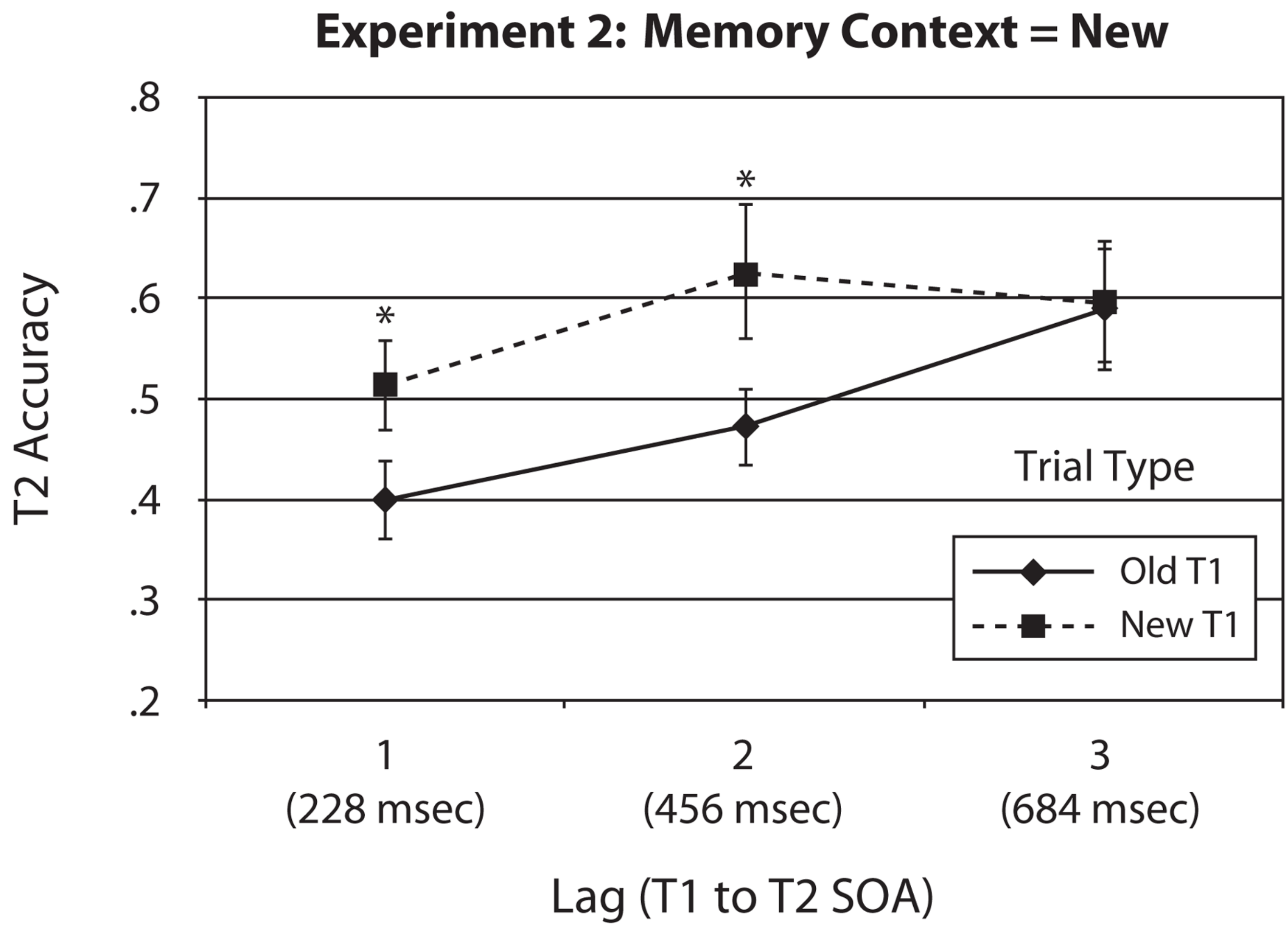

Figure 2.
T2 accuracy (Experiment 2). SOA, stimulus onset asynchrony between T1 and T2. *Significant after B–H correction for multiple comparisons (Benjamini & Hochberg, 1995).

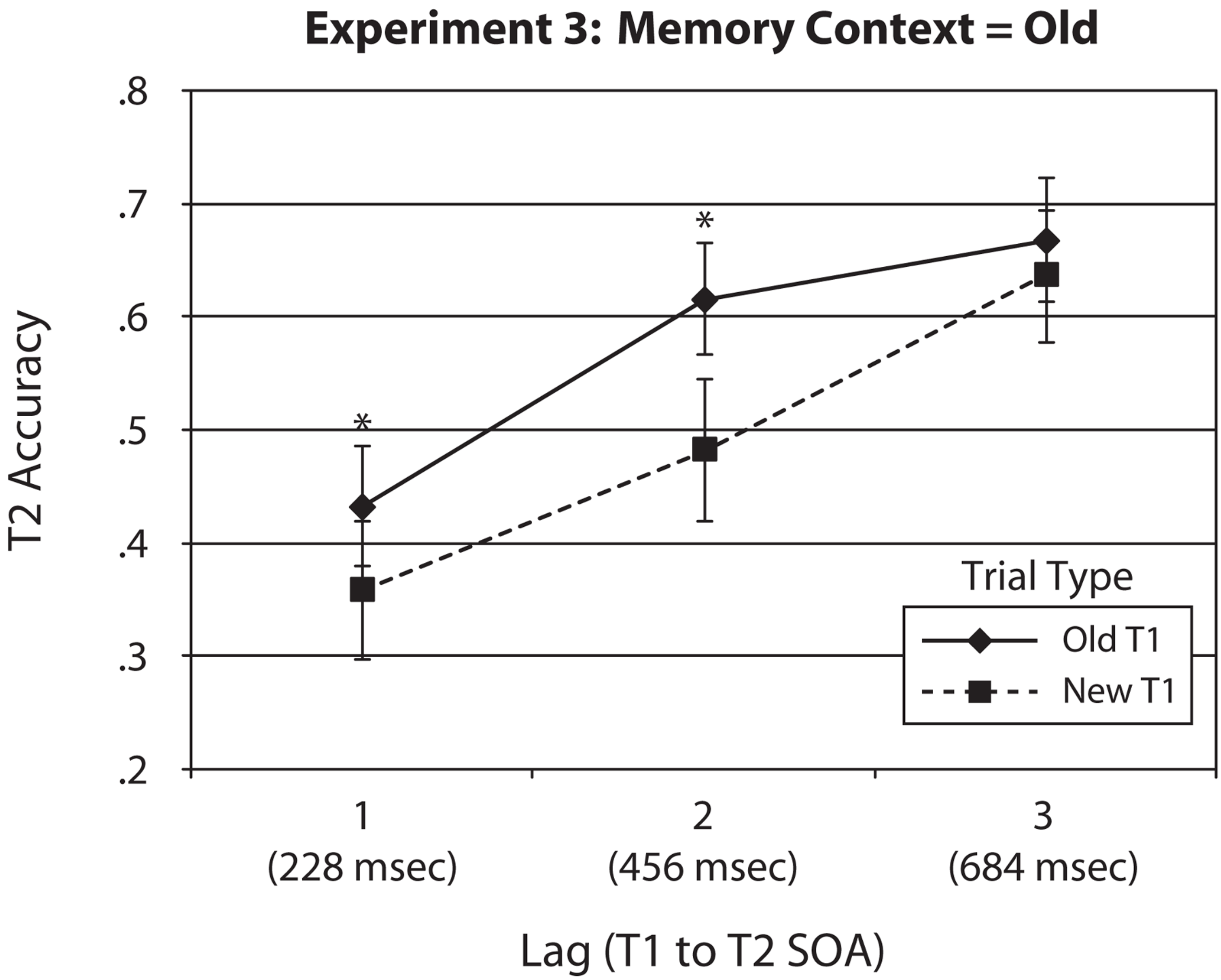

Figure 3.
T2 accuracy (Experiment 3). SOA, stimulus onset asynchrony between T1 and T2. *Significant after B–H correction for multiple comparisons (Benjamini & Hochberg, 1995).

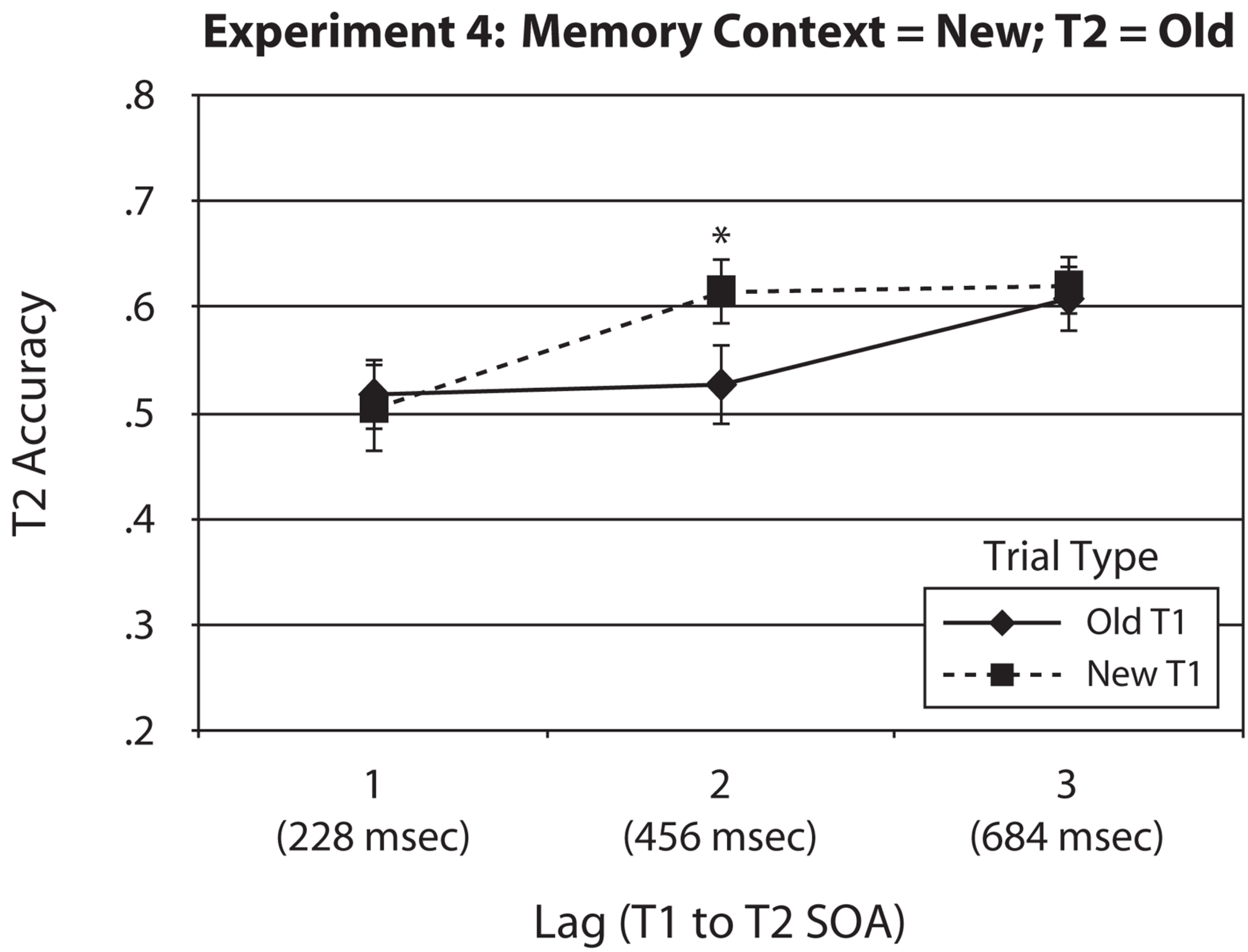

Figure 4.
T2 accuracy (Experiment 4). SOA, stimulus onset asynchrony between T1 and T2. *Significant after B–H correction for multiple comparisons (Benjamini & Hochberg, 1995).

Appendix

T1 Accuracy for All Experiments

Lag and T1–T2 SOA	Old T1		New T1		Mean Difference	
	M	*SE*	*M*	*SE*	*M*	*SE*
Experiment 1						
Lag 2 (240 msec)	.883	.067	.779	.126	.059	.100
Lag 3 (360 msec)	.890	.076	.719	.214	.285	.163
Lag 4 (480 msec)	.883	.083	.763	.116	.206	.090
Experiment 2						
Lag 1 (228 msec)	.726	.144	.846	.115	−.120	.167
Lag 2 (456 msec)	.715	.100	.877	.122	−.161	.110
Lag 3 (684 msec)	.727	.141	.881	.113	−.154	.182
Experiment 3						
Lag 1 (228 msec)	.687	.178	.810	.210	−.124	.270
Lag 2 (456 msec)	.793	.130	.813	.177	−.021	.207
Lag 3 (684 msec)	.754	.136	.815	.175	−.060	.191
Experiment 4						
Lag 1 (228 msec)	.798	.116	.793	.154	.004	.140
Lag 2 (456 msec)	.692	.153	.849	.131	−.157	.193
Lag 3 (684 msec)	.725	.112	.871	.101	−.145	.146

Note—T1–T2 SOA, stimulus onset asynchrony between T1 and T2.