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Selective Effects of Selective Attention

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By

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Dedication

To my amazing parents, Kent and Sandy Bowers
For always believing in me and supporting me through every step of my education

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Abstract

Selective Attention is the process by which an individual attends to one stimulus while ignoring other distracting stimuli. Selective attention at encoding has been found to consistently impair memory performance. However, little research has found conclusive evidence as to the impact of selective attention during initial retrieval, and how that impacts retrieval on later tests, or the influence of the types of stimuli that participants are ignoring. The following series of experiments outline how selective attention impairs memory immediately and after a delay, during encoding and retrieval. Experiments 1-3 manipulated attention during retrieval. Experiment 1 found that selective attention during retrieval impaired initial and subsequent testing. The status (Target or Lure) of the ignored stimulus also impacted participants' ability to correctly recognize stimuli during subsequent testing. Recognition memory was worse when the original stimulus consisted of one Target and one Lure, as opposed to two Targets or two Lures. Experiment 2 increased the difficulty of the subsequent memory test and found that this increase in difficulty only impacted the memory for ignored stimuli and the full attention advantage was eliminated. Experiment 3 was conducted to better understand to extent to which participants remember ignored stimuli by asking participants to endorse these items on a recognition memory test. These results also replicated Experiment 1 and 2, in that participants were worse at recognizing a stimulus if it was originally an ignored Lure during the initial test and was paired with a to-be-ignored Target. Experiment 4 manipulated attention during encoding. Participants were worse at recognizing a stimulus that was originally studied under selective attention, compared to stimulus originally studied under full attention. Overall, these results suggest that selective attention consistently impacts memory when presented during encoding, but the effect of selective attention during retrieval is less reliable. Additionally, participants do not truly ignore background stimuli and their ability to remember ignored stimuli depends on if a stimulus was paired with an object of the same or different status.

Keywords: selective attention, recognition memory, ignored stimuli, encoding, retrieval

Introduction

At any moment, individuals attend to several objects, people, and activities simultaneously, particularly with the increased prevalence of portable technology such as smartphones. For a student, pulls on attention may be personal, such as the blinking light on a cell phone during a lecture, or an email notification on a laptop or from neighboring students, such as the screens of those nearby who are off task. These types of distractions can disrupt learning and memory (Sana, Weston, & Cepeda, 2013). In this and other cases in which there are multiple options for the allocation of attentional resources, selective attention, the process by which an individual attends to one task or stimulus while simultaneously ignoring another task or stimulus, comes into play.

Rock and Gutman (1981) conducted an early study on the interplay between selective attention and memory. They had participants study single (full attention) or overlapped objects (selective attention). The results of the experiment demonstrated that individuals who studied the overlapped objects (e.g., a red house overlapped with a picture of a green table) had worse memory performance compared to individuals who studied single objects (e.g., a red house presented alone) suggesting that selective attention at encoding impairs later memory performance.

Since Rock and Gutman (1981), extensive research has explored how selective attention impacts memory and how to reduce that impact (for reviews see, Driver, 2001; Mulligan, 2008). In a review of selective attention research, Driver (2001) noted that selective attention during encoding increases reaction times and decreases accuracy during the retrieval phase for adults. This effect has also been found for children, suggesting that selective attention impacts memory across the lifespan (Ballesteros, Reales, & Garcia, 2007). One explanation for the reduction in performance after selective attention at encoding is the increase in information that is being processed, and thus being retrieved, in the selective attention condition as compared to the full attention condition. This finding of impaired memory for items selectively attended to at encoding has been replicated in several studies (for a review see, Mulligan, 2008).

A question of interest to some researchers investigating effects of selective attention on memory performance has been the fate of the items that are ignored (e.g., green objects in Rock & Gutman if participants are responding to the red object). In a true visual selective attention paradigm, the competing stimuli must occupy the same visual field (Chelazzi et al., 2010). Thus, participants must actively ignore the background stimulus and actively attended to the target stimulus. However, since both stimuli occupy the same visual field, it is technically impossible to completely ignore the background stimulus. If the participant is attempting to ignore the background item, they might only recognize perceptual features of the background stimulus and not encode the identity of the stimulus (Butler & Klein, 2009). This leads to increased recognition of ignored stimuli relative to novel stimuli during a later recognition memory test, and also explains why individuals remember attended stimuli better than ignored stimuli if tested using a recognition memory paradigm (which allows performance based on perceptual features) but not a recall test (Lachter et al., 2004). One important factor of how participants remember ignored stimuli, are the status of stimuli in a pair (Target/Target or Target/Lure). For example, a Same pairing (in which both the attended and ignored stimulus are both either Targets or Lures) the attended stimulus is paired with an ignored stimulus of the same status, thus the context of the pair is the same. In contrast, when a Target and Lure are paired together, the context of the pair is different.

Hoffman and Tzelgov (2012) conducted a study regarding the importance of the context of the paired stimulus. Participants studied pairs of overlapped words and then took a test over overlapped pairs. Hoffman and Tzelgov found that participants were better able to recognize a background stimulus when it was paired with the same stimulus with which it was studied. Hoffman and Tzelgov attributed their results to a shift in context. In a less direct sense, the current experiments are testing the same concept, but with a more general definition of context. I am defining context as the status of a stimulus (Target or Lure) not the specific stimulus. This is done because I am assuming that participants are only processing the perceptual details of the stimuli and not the entire stimulus (Lin et al., 2010). Previous research supports the concept that perceptual details of a background are sufficient to elicit a context effect (Zhaoping & Jingling, 2008).

The aforementioned studies have focused on the role of selective attention during the Study Phase (e.g., encoding phase). However, selective attention also plays a role at memory retrieval (e.g., multiple choice tests in which one chooses the correct answer among distracters or in attempting to pick out a friend in a crowd). To date, little research exists of selective attention influence at retrieval. However, a challenge to studying selective attention during retrieval is that it removes the ability to test the memory of "ignored" items because participants would not be responding to ignored stimuli during retrieval, whereas when selective attention is manipulated during encoding, participants can later be tested over the ignored stimuli.

The present experiments were aimed at testing both the impact of selective attention during retrieval and the memory for ignored items presented during these trials. This was accomplished by modifying a study regarding effects of divided attention (completing two tasks simultaneously) at retrieval during initial and repeated testing (Dudukovic, DuBrow, and Wagner, 2009). Previous research suggests that selective attention and divided attention both impair memory performance (for review see Driver, 2001; Mulligan, 2008), however, they are still considered two separate processes and might not influence memory in the same way. Both selective and divided attention consistently impair memory when presented during encoding, but there are less consistent results (for both attentional tasks) when attention is manipulated at retrieval.

Dudukovic and colleagues conducted a recognition memory study that manipulated both divided attention and repeated testing. In the first experiment, participants studied a list of pictures and completed both divided and full attention recognition memory tests. For the divided attention test, participants responded to images from the Study Phase while simultaneously completing an auditory task. The full attention test was similar, but without the auditory secondary task. After two days, the participants completed a second recognition test, under full attention. The results of the study showed a detriment of memory performance during the initial memory test for divided attention trials in Experiment 1 but not Experiment 2. Both experiments demonstrated that items responded to under a divided attention memory test had reduced recognition during the second test relative to items responded to under full attention.

The results of Dudukovic et al. (2009), as well as previous research on selective attention, suggest that there are three unanswered questions about the role of selective attention at retrieval. First, will selective attention have an effect at retrieval? Because most selective attention research has focused on encoding manipulations and results regarding divided attention are mixed, I did not have a specific prediction for this question. Second, will effects of selective attention at retrieval show up in later memory tests? I predicted there would be an effect if selective attention performs like divided attention (Dudukovic et al., 2009). Finally, when viewing selective attention items, how much of the non-responded item (the background/ignored stimulus) is processed? Again, the literature here is mixed. There have been reports of failure to see priming effects on implicit tests of the ignored items (Butler & Klein, 2009; Ballesteros et al., 2007) but other work has shown some explicit memory for ignored items when tested using a selective attention paradigm (Martiny-Huenger, Gollsitzer, & Oettingen, 2013).

Overview of Experiments

Three experiments were conducted to test the effect of selective attention at retrieval on initial and subsequent tests. Experiment 1 used the basic design of Dudukovic et al. (2009) but with a selective attention test as opposed to a divided attention test. Experiment 2 sought to test the robustness of the effects of selective attention by increasing task difficulty for the second test. Experiment 3 tested memory for ignored items by changing the final recognition memory test to encourage endorsement of all previously presented items. Because the designs of Experiment 1-3 were similar, they are reported together to facilitate comparison. Finally, a fourth experiment was conducted to replicate previous research on the detrimental effect of selective attention at encoding. To preview, the results collectively suggest that selective attention consistently impairs retrieval on a later test and that participants do have some memory for to-be-ignored background items. The effect of selective attention at retrieval remains uncertain.

Experiments 1-3

The primary goals of Experiment 1 were to test if selective attention during initial testing impairs retrieval, and if that manipulation impairs memory for the stimuli during a subsequent test. To do so, participants studied a list of pictures and then took two recognition memory tests. The first contained both full and selective attention trials. The second was a full attention test that instructed participants to endorse items from the Study Phase. Additionally, during subsequent testing, I examined accuracy for untested stimuli compared to stimuli that were selectively ignored during initial testing. Finally, I tested if effects of selective attention depend on the nature of the selective attention trials. For example, if a participant is making a response to a Target stimulus, which is paired with a Lure, this could result in different memory performance compared to being tested on a Target paired with a to-be-ignored Target as the background stimulus. I was most interested in how participants responded to these different types of stimuli within the same test, thus, all data was collected via a within subjects design.

Experiment 2 further examined the influence of selective attention on immediate and delayed memory by increasing the difficulty of the second test phase. In order to increase task difficulty, the stimuli during Test Phase 2 were changed to words that corresponded to the earlier presented pictures. For example, if a participant viewed a picture of a basket on the study list, they should respond, “Yes” if the word “Basket” appeared during the second test phase. Research with divided attention suggests that increases in difficulty enhance effects of divided attention on memory (Anderson et al., 1998; Hicks & Marsh, 2000; Mulligan, 2008; Troyer et al., 1999). To my knowledge, this study is the first of its kind to change the type of stimuli for both the attended and ignored stimuli. Experiment 3 examined memory for ignored information by having participants respond endorse any stimuli presented at any point during the study so far, as opposed to discriminating between items seen during Test Phase 1 and those seen during the Study Phase. This manipulation is essential to test for memory differences between background/distracting stimuli and completely novel stimuli.

Methods

Overview of terminology. For all experiments, "Target" refers to any object that appeared on the study list, and "Lure" refers to any object that did not appear on the study list. "Full attention (FA)" stimuli were objects that were tested individually during Test Phase 1, no background or ignored stimulus was present. "Selectively attended (SA)" stimuli were objects to which the participant made a response (e.g., the black object in the overlapped pair) that were tested during Test Phase 1 under selective attention. "Selectively ignored (SI)" stimuli were objects that were ignored during Test Phase 1 (e.g., the blue, background object in the overlapped pair). For the selectively attended and selectively ignored stimuli, a label of "Same" or "Different" was also associated with the stimuli. "Selectively Attended Same (SAS)" stimuli were objects tested during Test Phase 1, under selective attention, which were paired with another object of the same status. "Selectively Ignored Same (SIS)" stimuli were stimuli that were ignored during Test Phase 1, which were paired with another object of the same status. For example, if both objects in an overlapped pair were Targets, that was considered a Same pairing. Additionally, if both objects in an overlapped pair were Lures, that was also considered a Same pairing. "Selectively Attended Different (SAD)" stimuli were objects tested during Test Phase 1, under selective attention, which were paired with another object of a different status. "Selectively Ignored Different (SID)" stimuli were stimuli that were ignored during Test Phase 1, which were paired with another object of a different status. For example, if one of the objects in an overlapped pair was a Target and the other was a Lure, it was considered a Different pairing. "Untested (UT)" stimuli did not appear during Test Phase 1, but were presented during Test Phase 2, which may have been studied (Untested Targets) or presented for the first time during Test Phase 2 (Untested Lures). Table 1 summarizes the stimuli types.

Table 1. *Stimuli Status During Test Phase 2*

Label for Test Phase 2	Appeared During Test Phase 1	Required Response During Test Phase 1	Stimulus Pairing
Full Attention (FA)	Yes	Yes	Individual – No Pairing
Selectively Attended Different (SAD)	Yes	Yes	Black Overlapped (Target/Lure)
Selectively Attended Same (SAS)	Yes	Yes	Black Overlapped (Target/Target or Lure/Lure)
Selectively Ignored Different (SID)	Yes	No	Blue Overlapped (Target/Lure)
Selectively Ignored Same (SIS)	Yes	No	Blue Overlapped (Target/Target or Lure/Lure)
Untested (UT)	No	No	Individual – No Pairing

Participants

A different sample of 120 participants completed each experiment. Participants were enrolled in Seton Hall University and participated for course credit. Recruitment took place via Seton Hall University's participant recruitment website. Before the start of testing, all participants were given a consent form explaining the procedure and information about the study. The sample size was determined using G*Power and effect sizes from pilot data to achieve a power of .8 for the effect of a difference in memory performance between full and selectively attended stimuli during Test Phase 2.

Materials

All stimuli were inanimate (non-living) objects due to the results of Van Arsdall et al. (2012), which suggests that participants' memory for animate stimuli was superior to memory for inanimate stimuli. A total of 130 objects were presented during the experiment. All stimuli were from Snodgrass and Vanderwart (1980) and were re-colored, re-sized and overlapped by the experimenter. During the study and test phases described below, the objects were presented singularly in black outline. During the first test, some objects were presented overlapped. Overlapped stimuli consisted of black objects on top of blue objects. Participants always responded to the black object to ensure no perceptual differences between the studied objects and the tested objects. The words corresponding to the pictures that were included in Experiment 2 were typed in black font. The experiments were programmed using E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA).

Procedure

The timeline of the study is presented in Figures 1. Briefly, the experiment had 3 phases. There was a Study Phase followed by two test phases that were separated by a 10-minute distracter. The Study Phase and Test Phase 1 were identical for Experiments 1-3. Each study was conducted within participants.

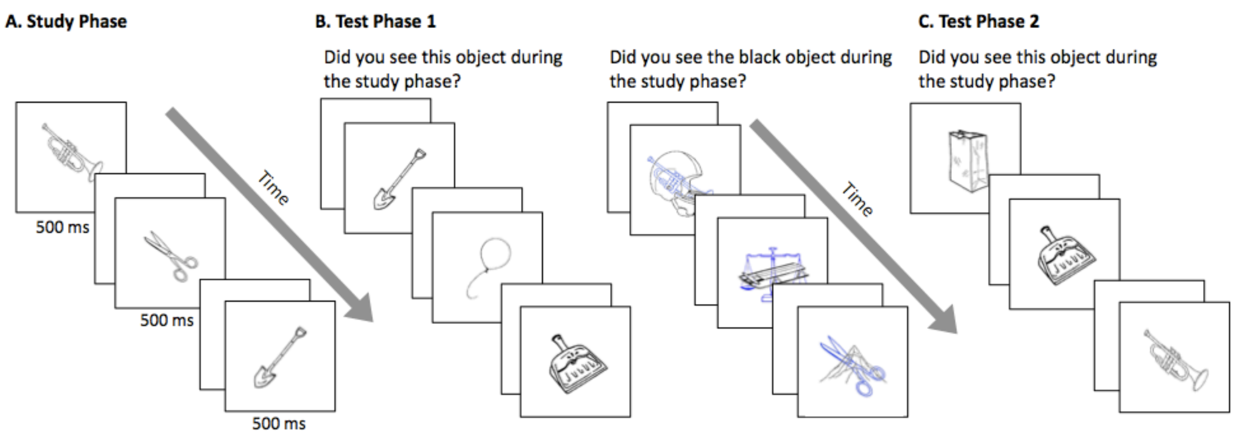

Figure 1. This illustrates the Study Phase and Test Phase 1 used for Experiments 1-3, and Test Phase 2 used for Experiment 1.

Study Phase. Participants viewed 60 stimuli and 10 buffer stimuli, all stimuli were presented individually for 500ms with a 250ms ISI in a freshly randomized order for each participant (Figure 1A).

Test Phase 1. Immediately after the Study Phase, the participants completed a full attention and a selective attention memory test, both of which were self-paced. During the full attention test, participant responded to 20 individual objects (half Targets and half Lures). Participants were asked to press the “yes” key if they saw that object during the Study Phase, or “no” if they did not see that object during the Study Phase. The selective attention test contained 40 overlapping, different colored objects (one black object overlapped with one blue object). Participants were asked to respond to only the black object and press the “yes” key if they saw the black object during the Study Phase, or “no” if they did not see the black object during the Study Phase (Figure 1B). Half of the black objects were Targets and half were Lures. In addition, half of the blue objects were of the same status as the black object (e.g., Target/Target or Lure/Lure pairing) and half were of a different status (Target/Lure or Lure/Target pairing). All participants were tested on both individual and overlapping objects. The order of the tests was randomly determined, as were the order of the items in each test phase.

Test Phase 2

Experiment 1. Following a 10-minute delay after Test Phase 1, participants were presented with 120 objects individually and instructed to press the “yes” key if they saw the object during the initial Study Phase, or “no” if they did not see the object during the initial Study Phase. This test was also self-paced, with randomized object order presentation (Figure 1C). Objects were categorized by their status regarding the Study Phase (Target or Lure), by how the object was paired at Test Phase 1 (None [Full Attention Trials], Same [Target/Target or Lure/Lure], or Different [Target/Lure]), and whether or not the item was subject made a recognition memory response to the stimulus during Test Phase 1 (Attended or Ignored). Thus, there were 6 different types of stimuli for both Targets and Lures. Each category contained 10 stimuli for a total of 60 Targets and 60 Lures. The 60 Targets were those presented in the Study Phase. Table 1 describes these various conditions and Figure 1C shows the timeline from the participant’s perspective.

Experiment 2. Participants responded to words instead of objects. The objects corresponded to objects seen during the Study Phase and Test Phase 1. Participants were instructed to press the “yes” key if the word corresponded to an object seen on the initial Study Phase, or “no” if it did not. In all other respects, the design was identical to Experiment 1. This test was also self-paced, with freshly randomized word presentation for each participant.

Experiment 3. Experiment 3 was identical to Experiment 1 with one exception. Participants were asked to press the “yes” key if the object appeared at any point in the experiment so far, and only press the "no" key if they had never seen the object before. To facilitate comparisons with Experiments 1 and 2, the labels of Target/Lure were maintained from Test Phase 1, despite the majority of stimuli technically being Targets for Test Phase 2. The only true Lures in Experiment 2 were the 10 novel (untested) Lure items that appeared for the first time during Test Phase 2. Although this is a small number of Lures, other studies have shown that participants respond similarly to distracter-free and distracter-containing recognition tests (Wallace, 1982). This was also done to maintain identical recognition memory tests across Experiments 1 and 3 to facilitate comparisons.

Analysis

Test Phase 1. For each experiment a 2(Status: Target or Lure) x 3(Stimulus Pairing: None, Same Different) x 2(Test Order: FA First, SA First) mixed design ANOVA were conducted for Test Phase 1, with Test Order being the only between subjects variable. While test order was not originally anticipated to influence results, descriptive statistics suggested that Test Order was an important variable, and thus, was included in the analysis. Depending on significant interactions and main effects, follow up ANOVAS were conducted for Stimulus Pairing for Targets and Lures separately, as well as follow-up paired-samples *t*-tests to test for differences between individual stimuli types.

Test Phase 2. For each experiment a preliminary 2(Status: Target or Lure) x 2(Recognition Memory Response Made at Test 1: Yes, No) x 3(Stimulus Pairing: None, Same, Different) x 2(Test Order: FA First, SA First) mixed design ANOVA were conducted for Test Phase 2, with Test Order being the only between subjects variable. This ANOVA was conducted to test for overall effects of Test Order. If Test Order was found to be a significant variable, a 2(Status: Target or Lure) x 3(Stimulus Pairing: None, Same Different) x 2(Test Order: FA First, SA First) mixed design ANOVA was conducted for stimuli that participants made a recognition memory response to during Test Phase 1, and for stimuli that participants did not make a recognition memory response to during Test Phase 1, with Test Order being the only between subjects variable. Depending on significant effects, further tests were conducted to compare differences among stimuli that participants responded to during Test Phase 1 (FA, SAD, SAS) as well as for stimuli that participants did not responded to during Test Phase 1 (SID, SIS, UT). Thus, four repeated measures ANOVAs were conducted to test for differences in the four groups previously described (Targets: FA, SAD, SAS; Lures: FA, SAD, SAS; Targets: SID, SIS, UT; Lures: SID, SIS, UT). This was done for both Test Order conditions, when the four-way interaction was significant, for a possible total of up to eight repeated measures ANOVAs. Follow-up paired-samples *t*-tests were conducted to test for differences between individual stimuli types.

Results and Discussion

The proportion of "yes" responses is reported as the dependent variable for all experiments. For all tests, the significance level was set to .05 for ANOVAs. A Bonferroni correction was used for follow up contrasts, which set the significance level to .017 (2-tailed).

Test Phase 1. Descriptive statistics are presented in Figure 2.

Experiment 1. A 2(Status: Target or Lure) x 3(Stimulus Pairing: None, Same, Different) x 2(Test Order: FA First, SA First) mixed design ANOVA was conducted for Test Phase 1, with Test Order being the only between subjects variable. There was a main effect of Status in that participants responded "yes" more for Targets than for Lures [$F(1,120)= 1157.741$, $p<.001$, $\eta_p^2=.906$]. There was no main effect of Stimulus Pairing ($p=.328$) or Test Order ($p=.821$). Importantly, there was a three way interaction between Status, Stimulus Pairing, and Test Order [$F(2,240)= 14.214$, $p<.001$, $\eta_p^2=.106$]. Overall, it appeared that when participants completed the FA test first, selective attention stimuli impaired memory performance relative to full attention stimuli. However, when participants completed the SA test first, performance on selective attention stimuli actually improved relative to full attention stimuli. That is, participants were more successful on whatever recognition memory test was completed first.

Since previous research suggests that selective attention tasks should impair memory, relative to full attention tasks, a difference score was calculated to test for the difference in performance for FA stimuli compared to SAS stimuli, and FA stimuli compared to SAD stimuli. This resulted in two different scores, 1) the difference in hit rates between FA stimuli and SAS stimuli, 2) the difference in hit rates between FA stimuli and SAD stimuli. From these scores it was then possible to compare these differences for participants who completed the FA test first, compared to those who completed the SA test first with independent samples *t*-tests. The importance of these comparisons was to see if the effect of selective attention was greater for those who completed the FA test first, compared to those who completed the SA test first. Results suggested that when participants completed the FA test first, there was a greater decrease in memory for SAD stimuli (*M*=.17, *SD*=.19), compared to the increase in memory for SAD stimuli (*M*=.04, *SD*=.24) when participants completed the SA test first [$t(120)= 3.222$, $p=.002$, $d=.60$]. There were no differences for SAS stimuli ($p=.04$).

Overall, this suggests that selective attention at initial retrieval did impair memory, compared to full attention. However, this was only true if participants completed the full attention test first. While this effect was not seen when participants completed the SA test first, the overall differences in hit rates for full and selective attention stimuli was greater when participants completed the full attention test first.

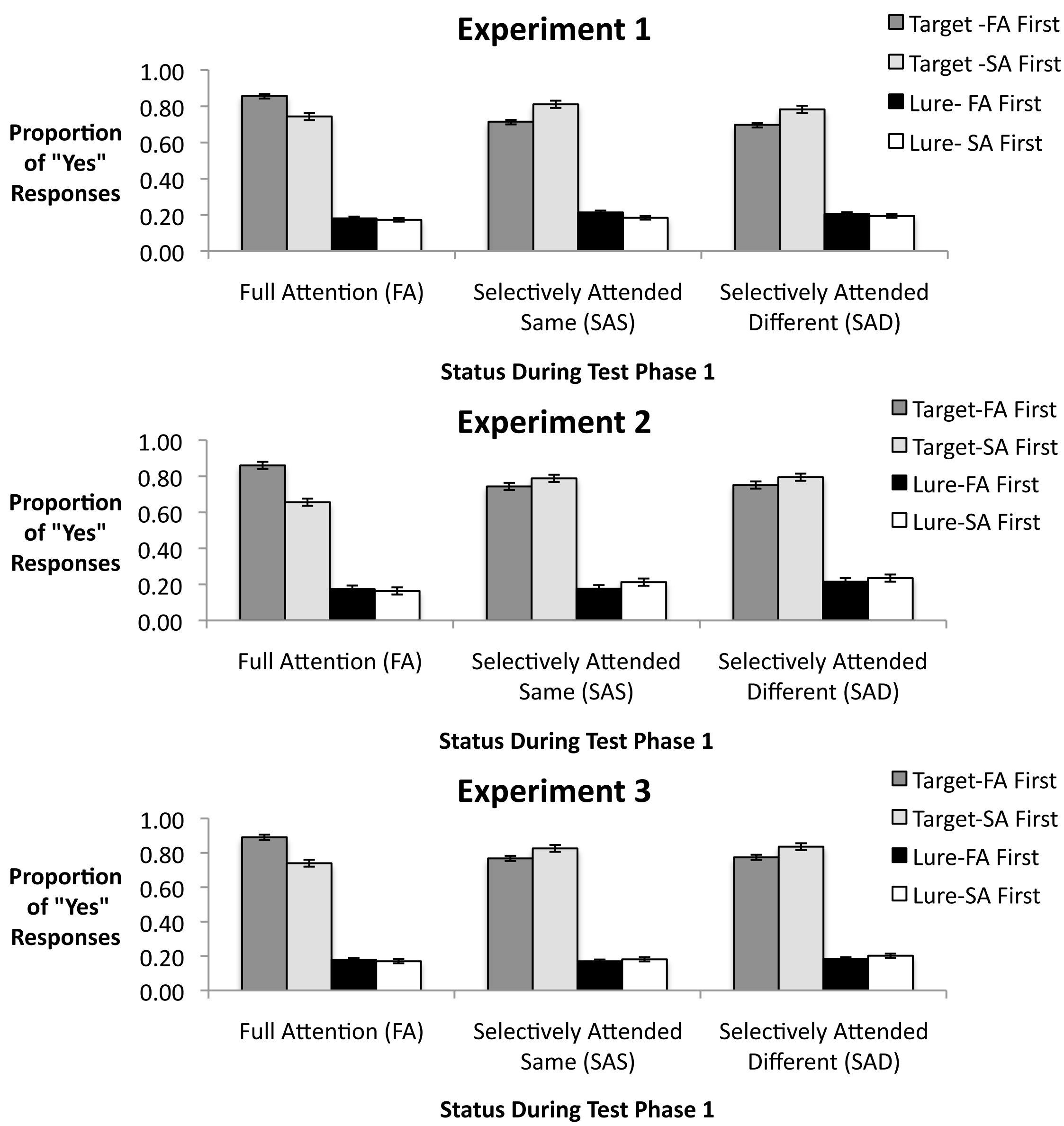

Figure 2. Means and standard errors for Test Phase 1 are displayed as a function of test order, response type, status and pairing.

Experiments 2 and 3. Identical to Experiment 1, overall ANOVAs revealed main effects of status for Experiment 2 [$F(1,120)= 930.230$, $p<.001$, $\eta_p^2=.887$] and Experiment 3 [$F(1,120)= 1722.977$, $p<.001$, $\eta_p^2=.936$]. There was no main effect of Stimulus Pairing (*p*s>.066) or Test Order (*p*s>.500). Again, there was a three way interaction between Status, Stimulus Pairing, and Test Order for Experiments 2 [$F(2,240)= 11.557$, $p<.001$, $\eta_p^2=.089$] and 3 [$F(2,240)= 14.120$, $p<.001$, $\eta_p^2=.107$]. The same analysis described above was conducted for Experiments 2 and 3. However, differences in hit rates for participants who took the FA test first, compared to participants who took the SA test first, did not differ for FA-SAS (*p*s>.208) or FA-SAD (*p*s>.378). Overall, this suggests that when participants completed the FA test first, selective attention at initial retrieval did impair memory, compared to full attention. However, when participants completed the SA test first, participants showed better memory for SA stimuli compared to FA stimuli. Overall, Test Order was the most important factor in determining how participants remembered different stimuli, not the actual differences in stimuli.

Collectively, these results are mixed. The results from Experiment 1 indicate that selective attention during retrieval does impair memory. However, only participants' memory for Targets was impaired by selective attention. Different effects were seen for Experiments 2 and 3. It is important to note that the procedure of all 3 experiments were identical at this point. Despite the similarities, Experiment 1 showed that participants were more likely to remember full attention stimuli than selective attention stimuli. However, due to the different pattern of results, depending on what order participants completed the tests, these same conclusions cannot be made for Experiments 2 or 3. These results are identical to those found by Dudukovic and colleagues (2009) in that there was an effect of attention during retrieval in an initial experiment, but that finding was not replicated on a subsequent experiment. This might be evidence that the effect of selective attention during retrieval is a weak effect that is difficult to detect. The small effect sizes for the Status, Stimulus Pairing, Test Order interaction (η_p^2=.106) seen in Experiment 1 supports this idea. I will return to the implication of these variable findings in the general discussion.

Test Phase 2. Descriptive statistics are presented in Table 2 and Figure 3.

Experiment 1. A 2(Status: Target or Lure) x 2(Recognition Memory Response Made at Test 1: Yes, No) x 3(Stimulus Pairing: None, Same, Different) x 2(Test Order: FA First, SA First) mixed design ANOVA were conducted for Test Phase 2, with Test Order being the only between subjects variable. All main effects and interactions will not be discussed, as the four-way (Status x Response x Stimulus Pairing x Test Order) interaction was significant [F(2,240)= 5.708, p=.004, η_p^2=.045] and represents the data of greatest interest. In order to follow-up this complicated interaction, a 2(Status: Target or Lure) x 3(Stimulus Pairing: None, Same, Different) x 2(Test Order: FA First, SA First) ANOVA was conducted for stimuli that participants made responses to during Test Phase 1, and for stimuli that participants did not make responses to during Test Phase 1. Critically, I was concerned with interactions involving Test Order. There was a significant three-way (Status x Stimulus Paring x Test Order) interaction for stimuli that participants made a recognition memory response to during Test Phase 1 [F(2,240)= 3.506, p=.032, η_p^2=.028] but there were no significant interactions or main effect involving Test Order for stimuli that participants did not make a recognition memory response to during Test Phase 1 (ps>.088).

Overall, this finding suggests that the effects of Test Order, observed during Test Phase 1, transfers to Test Phase 2, but only for stimuli that participants made a recognition memory responses to during Test Phase 1. To follow-up the significant interaction for stimuli for which participants made recognition memory responses, One-way ANOVAs were conducted for Targets and Lures that participants made responses to during Test Phase 1 (FA, SAS, SAD) for both Test Orders (FA first, SA first), for a total of four One-Way ANOVAs. There were no differences in Stimulus Pairing (for Targets or Lures) when participants complete the SA test first during Test Phase 1 (ps>.534). When participants completed the FA test first during Test Phase 1, there were differences for Targets [F(2,114)= 12.503, p<.001, η_p^2=.180], but not Lures (p=.186). The difference for Targets was due to the difference between FA (M= .83, SD=.15) and SAD (M= .71, SD=.20) stimuli [t(57)= 4.828, p<.001, d=.68] as well as the difference between FA (M= .83, SD=.15) and SAS stimuli (M= .73, SD=.20) [t(57)= 4.062, p<.001, d=.57] (Figure 3A). This indicates that selective attention during an initial test impairs memory on future tests as well but only when the FA test occurs first.

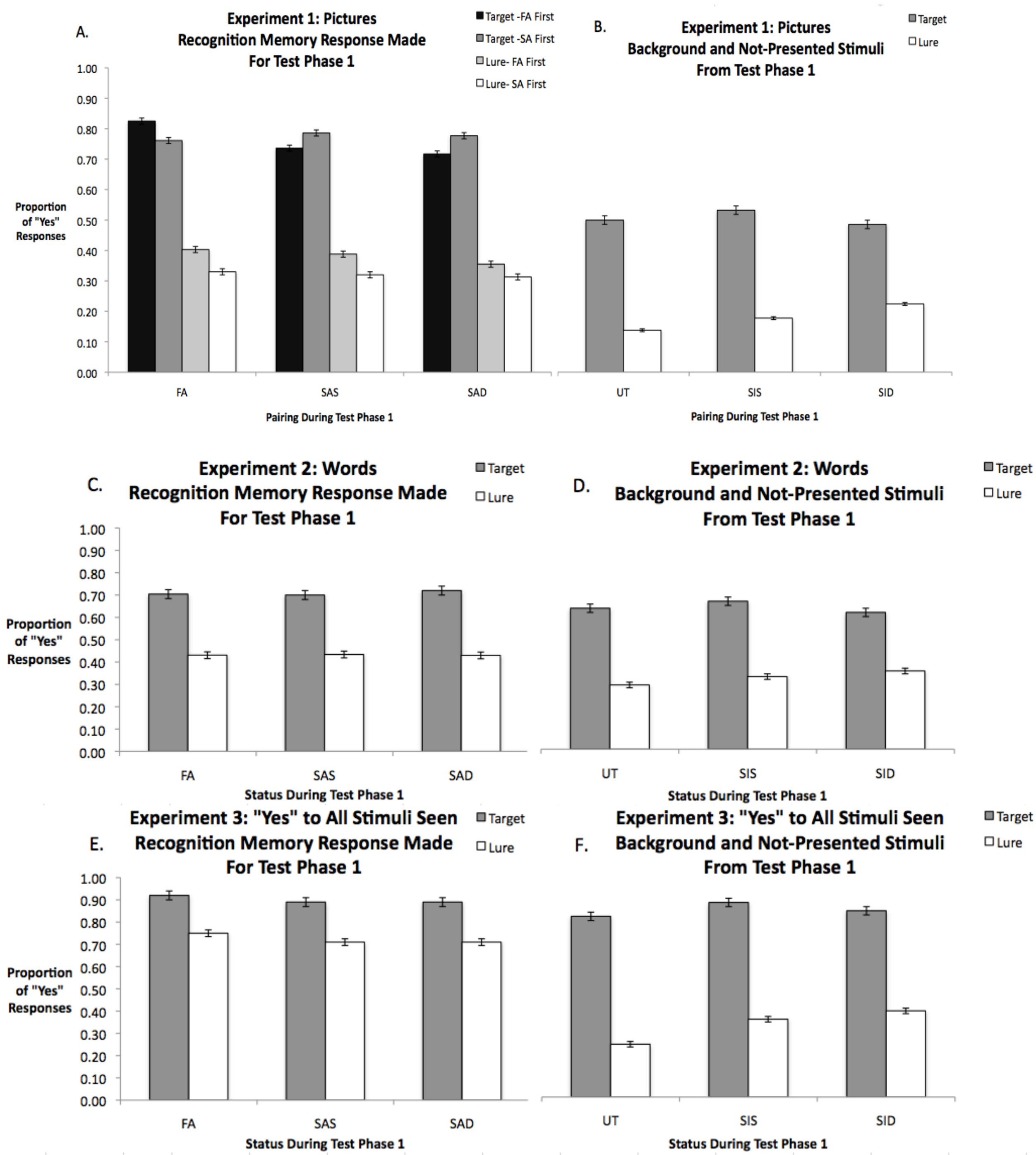

Figure 3. Means and standard errors for Test Phase 2 are displayed. Full data are displayed for Experiment 1 because of the effect of test order. This variable did not have an effect in Experiments 2 or 3, so it is not displayed.

Since there were no differences in Test Order for stimuli that participants did not make a recognition memory response to during Test Phase 1 (SID, SIS, UT), Test Order was excluded as a variable for follow-up tests (Figure 3B). Two repeated measures ANOVAs were conducted to measure differences among stimuli that participants did not respond to during Test Phase 1 (SID, SIS, UT). There were significant differences in Stimulus Pairings for Targets [$F(2,240)= 3.999$, $p=.020$, $\eta_p^2=.032$] and Lures [$F(2,240)= 13.891$, $p<.001$, $\eta_p^2=.104$] that participants did not respond to during Test Phase 1 . The effect for Targets was due to differences between SID ($M= .52$, $SD=.20$) and SIS ($M= .57$, $SD=.19$) Targets [$t(120)=-2.716$, $p=.008$, $d=.256$], which indicates a difference between Same and Different pairings for ignored items (Figure 3B). Different pairings (Target/Lure) resulted in lower hit rates and higher false alarm rates compared to Same pairings (Target/Target). There were no differences between UT ($M= .54$, $SD=.22$) and SIS ($M= .57$, $SD=.19$) ($p=.042$). This suggests that making a response to a Lure, if paired with an ignored Target, results in impaired memory performance when later asked to recognize the initially ignored Target.

For Lures there were differences between SIS ($M= .19$, $SD=.13$) and UT ($M= .15$, $SD=.13$) [$t(120)=-2.934$, $p=.004$, $d=.237$], SID ($M= .24$, $SD=.19$) and UT ($M= .15$, $SD=.13$) [$t(120)=-5.410$, $p<.001$, $d=.617$] (Figure 3B). The differences for ignored and untested Lures parallel the results for Targets. Participants were more likely to endorse ignored stimuli compared to totally novel stimuli, and participants were less likely to false alarm to a stimulus if it was originally paired with another Lure as opposed to a Target.

Overall, the results of Experiment 1 indicate that selective attention during initial testing impaired immediate and later retrieval. However, this is only true when participants originally completed the FA test first during Test Phase 1. This indicates that Test Order matters for initial and subsequent testing, but only for stimuli that participants made a recognition memory response to during the initial test. Test Order had no effect on stimuli that were originally ignored during the initial test. The results of the experiment also indicate that the status of the ignored item plays a role in the participants' ability to remember the attended stimulus and suggests that participants do not completely ignore the background stimulus. Further evidence for memory of the ignored stimuli was obtained because ignored Lures produced higher false alarm rates compared to untested Lures, suggesting that participants are processing and remembering the ignored stimuli. Additionally, being tested on a Lure that was paired with a Target during Test Phase 1 increases the likelihood that a participant will falsely endorse that Lure as a studied item.

Table 2. *Means for Test Phase 2 of Experiments 1-3*

Status	**Experiment 1**				**Experiment 2**		**Experiment 3**	
	FA First Target	SA First Target	FA First Lure	SA First Lure	Target	Lure	Target	Lure
FA	.83	.76	.40	.33	.70	.43	.92	.75
SAS	.74	.79	.36	.32	.70	.43	.89	.71
SAD	.72	.78	.39	.31	.72	.43	.89	.71
UT	.54		.15		.50	.23	.65	.19
SIS	.57		.19		.53	.26	.70	.28
SID	.52		.24		.49	.28	.67	.31

Experiment 2. As with Experiment 1, a 2(Status: Target or Lure) x 2(Recognition Memory Response Made during Test 1: Yes, No) x 3(Stimulus Pairing: None, Same, Different) x 2(Test Order: FA First, SA First) mixed design ANOVA was conducted for Test Phase 2, with Test Order being the only between subjects variable. I was interested in any possible interactions between Test Order and other variables. There were no significant main effects or interactions involving Test Order, thus, this variable was dropped from further analysis. Four repeated measures ANOVAs were conducted to measure differences among stimuli that participants made recognition memory responses to during Test Phase 1 (FA, SAD, SAS) (Figure 3C) as well as for stimuli that participants did not make recognition memory responses to during Test Phase 1 (SID, SIS, UT) (Figure 3D) to follow up the trending significant three way

interaction among Status, Response, and Stimulus Pairing, [$F(2,240)=2.648$, $p=.073$, $\eta_p^2=.022$] and parallel the analyses of Experiment 1. This was done for both Targets and Lures, for a total of four repeated measures ANOVAs per experiment.

As a reminder, the stimuli during Test Phase 2 in Experiment 2 were switched to words. This was done to increase task difficulty in order to test the robustness of the effects of selective attention on memory that were observed in Experiment 1 and possibly exacerbate differences between full and selectively attended stimuli. After the four repeated measures ANOVAS were conducted, there were only differences among Lures that participants did make a recognition memory response to during Test Phase 1 [$F(2,240)= 3.960$, $p=.020$, $\eta_p^2=.032$]. All other ANOVAS for Experiment 2 were not significant (*p*s >.126). The effect for Lures that participants did not make a recognition memory response to during Test Phase 1 was due to the significant difference between SID ($M=.28$, $SD=.19$) and UT ($M=.23$, $SD=.16$) Lures [$t(120)=-2.839$, $p=.005$, $d=.092$] (Figure 3D). It is important to note that the difference between SID and UT Lures is identical across Experiments 1 and 2. Participants are more likely to falsely endorse a Lure as being a previously studied item when it was originally paired with a Target (Different Pairing), compared to being paired with a Lure (Same Pairing). This is also further evidence that participants do not completely ignore the background stimuli during Test Phase 1.

In Experiment 1, differences between full attention and selectively attended stimuli were observed during Test Phase 2, when participants were originally tested on the full attention stimuli first. However, in Experiment 2, that difference disappeared when the stimulus type changed from pictures to words. This difference in the pattern of results can be attributed to the increase in difficulty from Experiment 1 to Experiment 2. However, this manipulation appears to have removed effects of selective attention. It could be argued that the lack of results at Test Phase 2 could also be due to there being no effects of selective attention during Test Phase 1 in Experiment 2. However, the results of Dudukovic et al., (2009) suggests that initial effects of selective attention are not necessary to elicit effects of selective attention on future tests.

Experiment 3. As with Experiments 1 and 2, a 2(Status: Target or Lure) x 2(Recognition Memory Response Made during Test 1: Yes, No) x 3(Stimulus Pairing: None, Same, Different) x 2(Test Order: FA First, SA First) mixed design ANOVA were conducted for Test Phase 2, with Test Order being the only between subjects variable. There were no significant main effects or interactions involving Test Order, thus, this variable was dropped from further analysis.

In order to facilitate comparisons with Experiments 1 and 2, the same four repeated measures ANOVAS were conducted to look for differences in Stimulus Pairing as a function of Study Phase presentation and responses at Test 1. As a reminder, only the Untested Lures had "no" as a correct response because they were not presented during the Study Phase or first test (See Table 1). There were differences among Targets [$F(2,240)= 3.341$, $p=.037$, $\eta_p^2=.027$] and Lures [$F(2,240)= 4.177$, $p=.016$, $\eta_p^2=.034$] that participants made a recognition memory response to during Test Phase 1 (Figure 3E). There were also differences among Targets [$F(2,240)= 4.163$, $p=.017$, $\eta_p^2=.034$] and Lures [$F(2,240)= 19.803$, $p<.001$, $\eta_p^2=.142$] that participants did not make a recognition memory response to during Test Phase 1 (Figure 3F). That is, all four repeated measures ANOVAs were significant. Again, paired sample *t*-tests were conducted to specify the differences. There were no differences between FA ($M=.92$, $SD=.12$) and SAD ($M=.89$, $SD=.15$) or SAS ($M=.89$, $SD=.14$) Targets (*p*s>.020). For ignored stimuli, there were differences between SIS ($M=.71$, $SD=.19$) and UT ($M=.66$, $SD=.20$) Targets [$t(120)=-3.080$, $p=.003$, $d=.285$] (Figure 3F), which indicates that participants remembered ignored Targets (presented at the Study Phase and as a blue background object) better than Untested Targets (presented only during the Study Phase).

For Lures, there were no differences between FA stimuli ($M=.75$, $SD=.24$) and SAD stimuli ($M=.71$, $SD=.28$) ($p=.021$). However there were differences between FA ($M=.75$, $SD=.24$) and SAS ($M=.71$, *SD*=.25) Lures [*t*(120)=2.573, *p*=.011, *d*=.163] (Figure 3E), in that participants better remembered Lures initially tested under full attention as opposed to selective attention, but this is only true when two Lures were originally paired together during the initial test.

Similar to the results of the first two experiments, participants recognized SID (*M*=.31, *SD*=.23) [*t*(120)=-6.056, *p*<.001, *d*=.606] and SIS (*M*=.28, *SD*=.19) [*t*(120)=-5.234, *p*<.001, *d*=.512] Lures, as having appeared during the initial test phase compared to Untested Lures (*M*=.19, *SD*=.16) which appeared for the first time during Test Phase 2 (Figure 3F). It is important to note that the Untested Lures were the only items to which participants should have responded "no". As suggested in Experiment 1 and 2, these results support the argument that participants are not completely ignoring all the background stimuli presented during the initial test.

Overall, the results of the Experiments 1-3 indicate that selective attention selectively impairs memory performance for both attended and ignored stimuli. These results suggest that responding to a stimulus results in better memory later on, as opposed to ignoring the stimulus, or not seeing the stimulus at all. This could be attributed to several factors. Since the stimuli are completely overlapped, it is technically impossible for participants not to notice the background stimulus (Chelazzi et al., 2010). In a true selective attention paradigm, even if participants are not attending to the ignored stimulus, they will recognize some characteristics of the stimulus (such as color and general shape). However, the actual stimulus may not be completely identified (Butler & Klein, 2009). As our results indicate, participants are recognizing previously ignored items, to some extent. Thus, a possible explanation is that while participants do not fully recognize the object or where they originally saw it, the previous processing of features and shape leads to a greater sense of familiarity for that object (Butler & Klein, 2009) compared to untested stimuli, and in turn leading to more "yes" responses compared to novel stimuli. However, while this does lead to more "yes" responses, participants are still better at recognizing selective attended stimuli compared to selectively ignored stimuli. For example, suppose a participant was tested on a picture of a cake overlapped with a picture of a hammer. The participant made a response to “cake” and ignored “hammer”. The participant is then likely to remember having seen “cake” when asked about it later on. If then shown a picture of “mountain”, which they had not previously seen before, they are more likely to respond “yes” to “cake” as well as to “hammer” than they are to respond “yes” to “mountain”. The reason they will have higher “yes” responses to “hammer” compared to “mountain” is because they have seen “hammer” before. If the participant truly ignored “hammer”, they will not have a memory of studying or being tested on it, but they will have an increased sense of familiarity because of the perceptual features that they processed (Butler & Klein, 2009). However, they will still be better at recognizing “cake” than “hammer” because they made a response to it (Wheeler, 2003).

Collectively, the previous experiments suggest that selective attention during encoding more consistently impairs memory than selective encoding during retrieval. The finding of effects at encoding has been demonstrated previously (Driver, 2001; Mulligan, 2008). Although Experiments 1-3 did not directly manipulate selective attention during encoding, the retrieval phase of memory often acts as a re-encoding phase as well (Butler & Roediger, 2008; Chan & LaPaglia, 2011; Wheeler, 2003). Essentially, Experiments 1-3 manipulated selective attention during retrieval/re-encoding. However, in order to fully justify the claim that selective attention at encoding impairs memory, Experiment 4 was conducted. Since selective attention during encoding has been found to reliably impair memory performance (Ballesterose et al., 2007; Driver, 2001; Lachter et al., 2004; Mulligan, 2008; Rock & Gutman, 1981), it was expected that a direct test of this would find the same result.

Experiment 4

Evidence that selective attention during initial retrieval impairs later retrieval was obtained in the first two experiments. In the first three experiments, the initial test phase can be considered as both a manipulation at retrieval (for Test Phase 1) and at re-encoding (for Test Phase 2). During the initial test, participants were retrieving information under selective attention, but they were also re-encoding the information under selective attention. The results of selective attention during initial testing are not consistent, however the results on subsequent testing did reveal a difference between full and selective attention for the previous experiments. In other words, there has been no consistent effect of selective attention on initial retrieval thus far, but there has been a consistent effect from re-encoding such that consent effects of selective attention have been observed during Test Phase 2. Therefore, the goal of Experiment 4 was to test for differences in recognition memory after attention was manipulated at encoding. If selective attention at encoding impairs memory compared to full attention at encoding, it can be assumed that selective attention during encoding consistently impairs memory, whereas the effects are more variable with regard to selective attention at retrieval.

Method

Participants and Materials

A different sample of 60 participants completed Experiment 4. All materials and stimuli are the same as were used in Experiment 1 and 3.

Procedure

Study Phase. Participants studied 20 individual objects (FA) and 40 overlapped objects (SA) for 500ms each with a 1500ms ISI. The longer ISI (compared to Experiments 1-3) accounted for the difficulty in studying overlapped objects, while still presenting the object for a short period of time (500ms) to allow for comparison across experiments. For the overlapped (selective attention) stimuli, participants were instructed to only pay attention to the black object. The different Study Phases were presented in blocks, and the computer randomly selected which Study Phase appeared first.

Test Phase. Immediately after participants studied the second set of stimuli, there was a 10-minute delay, followed by completion of the Test Phase. This phase was similar to that of the second test in Experiment 1. Participants were instructed to press the “yes” key if they saw the object presented individually during the Study Phase, or overlapped in black during the Study Phase. It was emphasized that participants were to only respond “yes” to objects that were presented in black. Thus, the participants should have responded “no” to any selectively ignored objects or novel Lures.

Results and Discussion

Descriptive statistics are presented in Figure 4. A 2 (Study Order: FA first, SA first) x 4 (Status: FA, SA, SI, Lure) mixed ANOVA was conducted, with Study Order being the only between subjects variable. A Bonferroni correction was used for follow up contrasts, which set the significance level to .013 (2-tailed). There was a main effect of Status [$F(3,180)= 288.504$, $p<.001$, $\eta_p^2=.828$] and an interaction between Study Order and Status [$F(3,180)= 4.033$, $p=.008$, $\eta_p^2=.063$]. To test for differences between different Status stimuli, paired samples *t*-tests were conducted for FA and SA, as well as for SI and Lures for both Study Orders, for a total of 4 paired samples *t*-tests. For participants that studied FA stimuli first, there was a significant difference between FA (*M*=.83, *SD*=.14) and SA (*M*=.72, *SD*=.21) stimuli [$t(33)=2.888$, $p=.007$, $d=.62$], in that participants responded "yes" more to full attention compared to selectively attended stimuli. However, this difference was not observed when participants studied SA stimuli first ($p=.414$). Additionally, there were no differences between SI (*M*=.18, *SD*=.11) and Lures (*M*=.13, *SD*=.10) when participants studied FA stimuli first ($p=.022$) nor for SI (*M*=.22, *SD*=.15) and Lures (*M*=.17, *SD*=.15) when participants studied SA stimuli first ($p=.020$).

Overall, the findings of Experiment 4 support findings in Experiments 1-3. Retrieval was impaired by selective attention at encoding, compared to full attention at encoding. The previous experiments found that selective attention at re-encoding impaired later retrieval. The results of this study confirm that selective attention during encoding (or re-encoding) results in memory impairment during retrieval but only when they follow a full attention test. However the immediate effects of selective attention at retrieval remain uncertain. With regard to Study Order, as with the previous experiments, order was only an important variable for attended stimuli, and not for ignored stimuli or Lures.

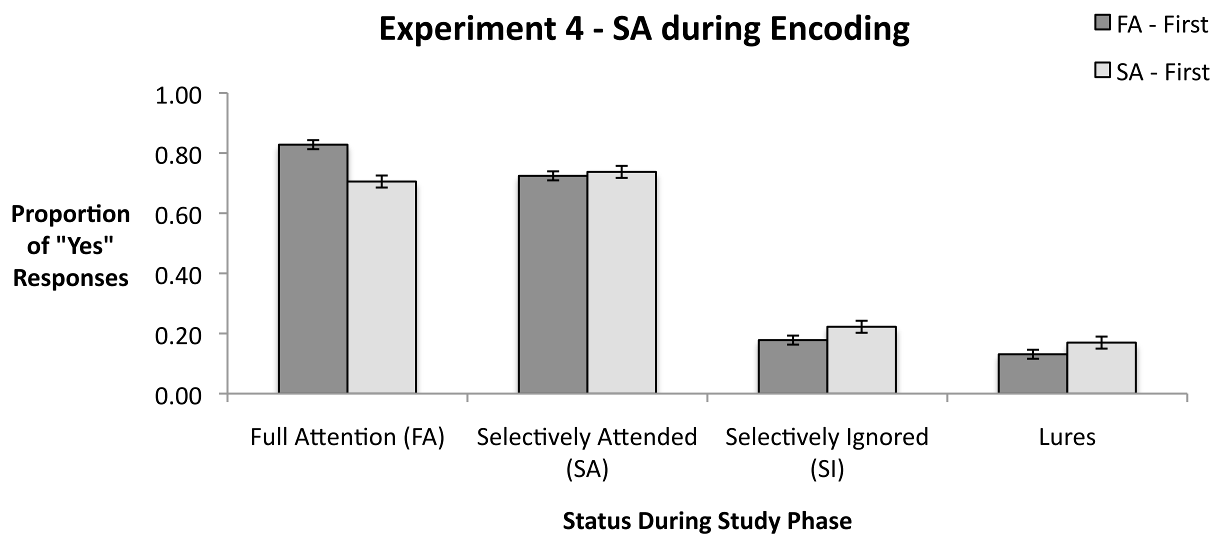

Figure 4. Means and standard errors for Experiment 4 are displayed.

General Discussion

Despite the vast amount of research conducted on selective attention (for reviews see Driver, 2001; Mulligan, 2008), there is no clear evidence of how selective attention at retrieval impairs memory, and how that, in turn, impairs memory on future tests. Four experiments were conducted to attempt to discern these effects. First, with regard to selective attention during initial testing, the effects appear to be variable. Experiment 1 showed that stimuli tested under selective attention resulted in decreased hit rates compared to stimuli tested under full attention. However, in Experiments 2 and 3, no effects of selective attention were observed at initial testing that could be discerned from effects of test order. In addition, the effect size in Experiment 1 was small which may make it difficult to detect consistently. This same explanation has also been used in other studies for why effects of divided attention at retrieval are difficult to detect (Baddeley et al., 1984; Dudukovic et al., 2009).

Despite inconsistent decrements of performance during selective attention memory tests, attention had an impact on later memory tests. Similarly, Dudukovic and colleagues (2009) found that effects of attention are not always present, but can still influence retrieval on a later test. There were three consistent effects of selective attention during Test Phase 2 in the present experiment. First, selective attention during initial testing resulted in impaired memory for stimuli that participants made a recognition memory response to on an initial test (Selectively Attended Stimuli). Second, selective attention during initial testing results in lower hit rates and higher false alarms for stimuli that were ignored during initial testing (Selectively Ignored Stimuli) relative to stimuli that were not presented during the initial test phase. Finally, the type of pairing (Same or Different) during initial testing dictates how participants remembered previously ignored stimuli. Specifically, later hits to background objects decrease when a Lure is tested, and later false alarms to background objects increase when a Target was tested. Each of these findings contributes to the current field of selective attention and memory, and will be discussed separately.

Effects of Attended Stimuli on Subsequent Tests. Unexpectedly, differences among full versus selectively attended stimuli were not significant across Experiments 1-3. Although Experiment 1 found that selective attention during initial testing impaired memory compared to full attention, these differences were not observed for Experiments 2 and 3. Interestingly, these results are exactly in line with the findings from Test Phase 1. In Experiments 1-3, there was an effect of selective attention during initial testing, that effect was also seen in Test Phase 2 (Experiment 1). However, when no effect of selective attention was found during initial testing, there was also no effect during Test Phase 2 (Experiments 2 and 3). One possible explanation for these results is that effects of selective attention are only seen at subsequent testing, if first observed during initial testing. The results of the current experiment support this idea. However, this is in contrast to the results of Dudukovic and colleagues (2009) who found consistent effects of divided attention during subsequent testing, even if there were no effects of divided attention during initial testing. This supports the idea that divided attention and selective attention are two separate processes, and while similar patterns of results are observed across studies, it is still important to think of them as separate attentional processes.

This same pattern of results was also found for Test Order. In Experiment 1, Test Order was found to be an important variable for Test Phases 1 and 2, but only for attended Targets, and only when participants were tested on full attention stimuli first. In Experiments 2 and 3, while there were effects of Test Order for Test Phase 1, there were no differences in the pattern of results of participants that completed full attention first compared to selective attention first, suggesting that Test Order was not an important variable in Experiments 2 and 3. This was also true for the second test phase again, suggesting that an effect must be present during initial testing, in order to elicit an effect during subsequent testing.

Memory for Ignored Stimuli on Subsequent Tests. Although differences between full and selective attention for tested stimuli at later testing only appeared in Experiments 1 and 3, differences between ignored and untested stimuli were found in all four Experiments. Additionally, neither Test Order nor Study Order influenced memory for stimuli that were ignored during the first test phase. It could be argued that participants did not truly ignore the background stimuli because the blue color of the stimuli made the ignored stimuli more salient and thus, more distracting. However, if this argument were true, participants would not show reduced memory for the ignored stimuli relative to the attended stimuli, which was observed in Experiments 1-3. Additionally, a more salient background stimulus should result in a greater selective attention effect than was observed in these experiments because of competition for attention for the target object.

One debate, according to Lachter and colleagues (2004), is *why* participants responded “yes” more to initially ignored than novel stimuli when presented with those stimuli on a later test. They argue that this could be due to two separate factors. The participants could either be paying attention to the ignored stimuli during the initial test (slippage, according to Lachter et al., 2004) or unintentionally processing the perceptual details of the ignored stimuli (leakage, according to Lachter et al., 2004).

Results from a study by Butler and Klein (2009) support the idea that participants were experiencing leakage which led to increased “yes” responses to ignored stimuli. In the Butler and Klein study, participants studied words superimposed on pictures. They were instructed to pay attention to the words for one block of stimuli, and the pictures for another block of stimuli. After the Study Phase, participants were shown words individually for only 30ms and were asked to name the word. This test list contained all the words that were previously presented, and novel Lures. Thus, three stimuli types were present at test: Attended (participants previously studied words and ignored pictures), Unattended (participants previously studied pictures and ignored words), and Lures (new words that were not studied). Butler and Klein found that participants were able to correctly label words that were Attended during the Study Phase better than words that were Unattended during the Study Phase. Additionally, participants were more likely to correctly name both Attended and Unattended words compared to Lure words (Butler & Klein, 2009). These results suggest that participants processed the Unattended stimuli at a perceptual level, but not at an explicit memory level. If participants were not ignoring the Unattended stimuli, and instead consciously processing them (slippage), there would be similar rates of word recognition after a 30ms prime. Additionally, if participants were able to completely ignore the Unattended stimulus, word recognition rates would not differ from novel Lures. However, since the word recognition rate for Unattended words was lower than for Attended words *and* higher than for novel Lures, I can assume that participants were only processing the perceptual details of the ignored stimulus. Thus Lachter and colleague's "leakage" theory explains these results.

Similarly, in the current study, the presentation of the ignored stimuli possibly resulted in increased perceptual familiarity (which resulted in increased "yes" responses compared to untested stimuli). However, since participants did not explicitly process the stimulus, "yes" responses were not as high as for the attended stimuli. Participants seem to be attempting to ignore the background stimuli but have increased perceptual processing of the stimuli due to the presentation during the initial test. This also indicates that the results are indicative of leakage, not slippage (Butler & Klein, 2009; Lachter et al., 2004). Future studies could implement both a source-monitoring task and a confidence rating judgment in order to make more definitive conclusions about the processing of ignored stimuli.

Stimulus Pairing. Another essential aspect of participants' responses to ignored Lures was the type of stimulus pairing, Same (Lure/Lure) or Different (Lure/Target). In the current study, participants had reduced memory performance (higher false alarms) for SID Lures compared to SIS Lures, and Untested Lures. These results indicate that it is not just the presence of the ignored information, but that the *type* of ignored information impairs human memory. The results of Hoffman and Tzelgov (2012) support this idea in that their participants were better able to recognize a background stimulus when it was paired with the same stimulus it was studied with. Hoffman and Tzelgov attributed their results to a shift in context. In a less direct sense, the results of the current experiments suggest the same type of paradigm with regard to pairing. It can be argued that in the current experiments, participants were worse at recognizing ignored Lures, when the context (attended stimulus) was a different stimulus type than the ignored stimulus. For example, when participants were responding to a Lure that was originally paired with a Target, the status of the attended stimulus was different than the ignored stimulus. Later, when the participant is only responding to the ignored Lure, since the original context (the attended stimulus) was a Target, not a Lure, the participant is less likely to make a correct response. However, if the ignored Lure was initially tested with another Lure, there would be no difference in context. Thus, as seen in the current study, participants were more likely to respond "no" to Lures that had previously been paired with another Lure.

It is important to not only focus on the negative influence a Different (Target/Lure) pairing can have, but also the possible protective effects that Same (Target/Target) pairings have. Results of Test Phase 1 in Experiment 1 found that only Different pairings resulted in reduced hit rates, and that stimuli with Same pairings were not significantly different from full attention stimuli. This suggests that when a Target is paired with another Target during a selective attention test, there are no effects of selective attention. Essentially, the status of the background stimulus can have either a protective effect (Same pairing) or impair (Different pairing) memory performance. This was evident at both test phases for Experiment 1. There were no significant differences between SAS stimuli and FA stimuli. SAD stimuli (not SAS stimuli) resulted in impaired memory, compared to FA stimuli, at both initial and later testing, suggesting that if selective attention impairs memory retrieval when presented during encoding (or re-encoding), the status of the background stimulus can protect against the impairment typically seen in later tests. While this effect was not observed for attended stimuli in Experiments 2 and 3, there were effects for ignored Lures. It is important to remember that those ignored Lures served as the background stimuli in SAD pairings during Test Phase 1. Thus, it appears that even if there were no effects of selective attention on initial testing, the status of the background item is important.

This type of stimulus pairing is also important for an applied setting. If students are completing a multiple choice test, a correct answer on 1 multiple choice question might be used as one of the incorrect choices on another question. According to the current results, that manipulation makes it less likely that a student will answer the later question correctly after ignoring it as a distracter item. Future studies should examine this type of manipulation to test if results similar to what was seen in the current study are observed in an applied setting.

Conclusion. Overall, this series of experiments supports previous research that selective attention during encoding impairs memory (Ballesterose et al., 2007; Lachter et al., 2004; Mulligan, 2008; Rock & Gutman, 1981; For reviews see Driver, 2001; Mulligan, 2008). Additionally, participants seem to ignore the background stimuli originally presented during the first test phase. However, the initial presentation of these stimuli increases memory for different perceptual properties, which leads to an increase in “yes” responses compared to novel Lures, especially if the ignored information is a Target. Although most studies are concerned with memory for attended stimuli, it is important to remember that the type of distracting information can also change performance. Future studies in selective attention should examine the role of task difficulty at different levels, as well as randomize the full and selective attention trials during the initial test to rule out effects of Test Order.

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