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Selective Attention during Retrieval Harms Initial Recognition Memory Performance but not Subsequent Retrieval Events

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Abstract

Previous research provides conflicting results regarding attention's role during memory retrieval. Some studies show that divided attention has no effect at all on performance (Baddeley, Lewis, Eldridge & Thompson, 1984, Anderson, Craik & Naveh-Benjamin, 1998, Clarke & Butler, 2008, Dudukovic, DuBrow & Wagner, 2009) while other studies show a detriment in performance during divided as opposed to full attention during a memory test (Troyer, Winocur, Craik & Moscovitch, 1999, Hicks & Marsh, 2000, Lozito & Mulligan, 2006, Dudukovic,et al., 2009). The present study explores the way selective attention during retrieval affects recognition memory and subsequent retrieval events. The results of two experiments show that selective attention during memory retrieval reduces hit rates during initial testing, but that difference in performance between full and selective attention conditions is diminished on subsequent tests. Implications for attention's role in memory as well as relations to the testing effect are discussed.

Introduction

At any moment there is a vast amount of environmental stimuli to which one could attend. Attention allows certain stimuli to be concentrated on, while other information essentially ignored (Driver, 2001). A consequence of attention is that it can impact memory performance. Research on the role of attention during retrieval has mainly been explored through tests of divided (as opposed to selective) attention, and conflicting results have left this area of research without a final verdict. Some studies on divided attention during retrieval have shown no effects on recognition memory performance (Baddeley, Lewis, Eldridge & Thompson, 1984, Anderson, Craik & Naveh-Benjamin, 1998, Clarke & Butler, 2008, Dudukovic, DuBrow & Wagner,2009) while others have shown decrease memory performance either in decreases in hit rates and/or increases in false alarm rates when attention during retrieval is divided (Troyer, Winocur, Craik & Moscovitch, 1999, Hicks & Marsh, 2000, Lozito & Mulligan, 2006, Dudukovic,et al., 2009). The inconsistency of the effect of attention on retrieval is in contrast to the more consistent finding that dividing attention at encoding is harmful for retrieval (Craik et al., 1996, Troyer, et al., 1999, Crabb & Dark, 1999). Studying reduced attention during recognition can help clarify the automaticity of memory retrieval, and provides evidence for whether memory retrieval is mediated by familiarity or recollection. If reduced attention during retrieval has no effects on recognition memory performance then it is assumed that retrieval is an automatic process relying on familiarity; however, if reduced attention during retrieval does lead to reduced memory performance, then it suggests that memory retrieval is effortful and relies more on recollection (Jacoby, 1991).

Further complicating the effect of divided attention on retrieval is the results of recent research investigating the role of divided attention during retrieval on subsequent retrieval events. In a study by Dudukovic et al. (2009), participants studied a list of pictures and were immediately given a recognition memory test. In one portion of the test, a standard recognition memory test was given (full attention). For the other portion, participants responded to test items while also engaging in an auditory detection task (divided attention). After a two-day delay, participants were given a second memory test with no attentional manipulation. This study found conflicting results for the impact of divided attention during retrieval; in one experiment they found reduced memory performance, and in the other they found that divided attention during retrieval had no effect on memory performance. This study however, did show consistent effects on subsequent testing, where stimuli that were originally tested under full attention had higher hit rates than stimuli that were originally tested under divided attention. In addition, this study also found that false recognition for foils was greater when attention was full as opposed to divided, suggesting that reduced attention during retrieval doesn't necessarily have to hurt memory performance since divided attention during retrieval can protect against memory errors.

Dudukovic, et al. (2009) briefly suggest in their discussion that their results support the testing effect; the idea testing improves memory performance over simply restudying. Research on testing effects have shown that both recall (Roediger & Karpicke, 2006, Halamish & Bjork, 2011) and recognition (Roediger & Marsh, 2005, Chan & McDermott, 2007, Butler & Roediger, 2008) memory performance benefits more from testing than restudying. A wide variety of research has been done on various factors that influence testing effects. For example, research has been conducted on the benefits of feedback during testing (Butler & Roediger, 2008), the negative impact of answering incorrectly on testing (Roediger & Marsh, 2005) and the practical implications of testing effects in classroom settings (McDaniel, Anderson, Derbish & Morrisette, 2007, Butler & Roediger, 2007). At the present time, however, little research has been done directly studying the effects of reduced attention during initial retrieval on subsequent retrieval events. The present study addresses this gap in the literature by employing a within subjects design to understand how reduced attention affects testing and restudy effects.

A modified version of the methodology of Dudukovic et al (2009) was used in the present study to investigate the way selective attention during retrieval affects recognition memory performance and subsequent memory performance. The first goal of the present research therefore was to understand how selective attention during recognition would affect immediate recognition. Most research on the effects of attention during retrieval has used tasks of divided attention, however, Hicks and Marsh (2000) lay out some important criteria factors that must be considered in order to determine whether divided attention during retrieval to impact memory performance and find that the characteristics of the secondary task used often leads to differential outcomes of divided attention at retrieval. For instance, Hicks and Marsh (2000) found that reductions in memory performance with divided attention depends upon the difficulty of the secondary task. For this reason, we used a selective attention task to eliminate the possibility of specific secondary task characteristics influencing the outcome of reduced attention during retrieval. Although selective attention and divided attention tasks are fundamentally different, switching to a selective attention task will still provide evidence for how reduced attention during retrieval affects memory performance, but concerns over the characteristics of the secondary task will be removed. Selective attention tasks require participants to respond to only some of the stimuli presented, while ignoring distracter stimuli also present during task completion. Unlike tasks of divided attention, there is no secondary task other than to ignore the non-target stimuli. For example, Ballesteros, Reales and Garcia (2007) used overlapping, different colored pictures and told participants to only respond to one of the colors. In the present study, we modified the Ballesteros stimuli from pictures to words. Participants view multiple words on the screen but only respond to one of the words. Both the stimuli used by Ballesteros et al (2007) and the present stimuli are selective attention tasks, however the stimuli was changed from pictures to words due to the surprisingly low false alarm rates found by Dudukovic et al. Hicks and Marsh (2000) discuss that a majority of the negative effects of reduced attention come from increases in false alarms. Since previous research has established that words are more difficult to remember than pictures (Pavio, 1980), the present study uses words instead of pictures to increase the false alarm rates to something closer to Hicks and Marsh's findings.

The second goal of the present study was to understand how selective attention during retrieval impacts subsequent retrieval events and how reduced attention during initial testing impacts the testing effect. Memory tests are an opportunity for both retrieval and re-encoding, and as discussed above, research has determined that when stimuli are tested rather than simply studied, memory performance is better on future tests. In the present study, selectively attended stimuli act as "tested" material, while selectively ignored stimuli during initial testing acts as "studied" or additionally exposed material. Because of this, we can directly compare, within subjects, the influence of testing and restudying on memory performance. The present study investigated both how target test words are remembered during retrieval, and also how foils are falsely remembered (Experiment 2).

By using a selective attention task, we can begin tease apart the theoretical underpinnings of how retrieval is influenced by memory. Using a selective attention task also allows us to directly compare, within subjects, the differences in memory performance after studying vs. testing. Because of the conflicting findings or lack of research in these areas, no specific hypothesizes were made regarding the results of this study. However, we predict that if selective attention is similar to divided attention, memory performance on subsequent retrieval events will be higher for stimuli tested under full attention as opposed to selective attention. If selective attention is different from divided attention, then stimuli initially tested under full attention and selective attention will not differ in their subsequent retrieval memory performance.

Method

Participants

In Experiment 1, 44 Seton Hall University students participated for course credit. Fifty-six students received credit for participation; however 12 participants' data were removed from final analysis due to programming errors. For Experiment 2, 59 Seton Hall University students participated for course credit. Seventy-two students received credit for participation; however 13 participant's data were removed from the analysis due to programming errors. Each participant was tested individually.

Stimuli

A total of 300 words were used in this study. Each word was a noun that ranged from three to seven letters in length, and had a concreteness rating of 600 to 700. This is a high level of concreteness and means that each word produced high imagery. All words were generated through the University of Western Australia's MRC Psycholinguistic database (Wilson, 1988).

Procedures

Both experiments consisted of three phases: Study Phase, Test Phase 1 and Test Phase 2. During the Study Phase, participants viewed 120 words individually for 500ms each. They were instructed to learn the words for an upcoming memory test.

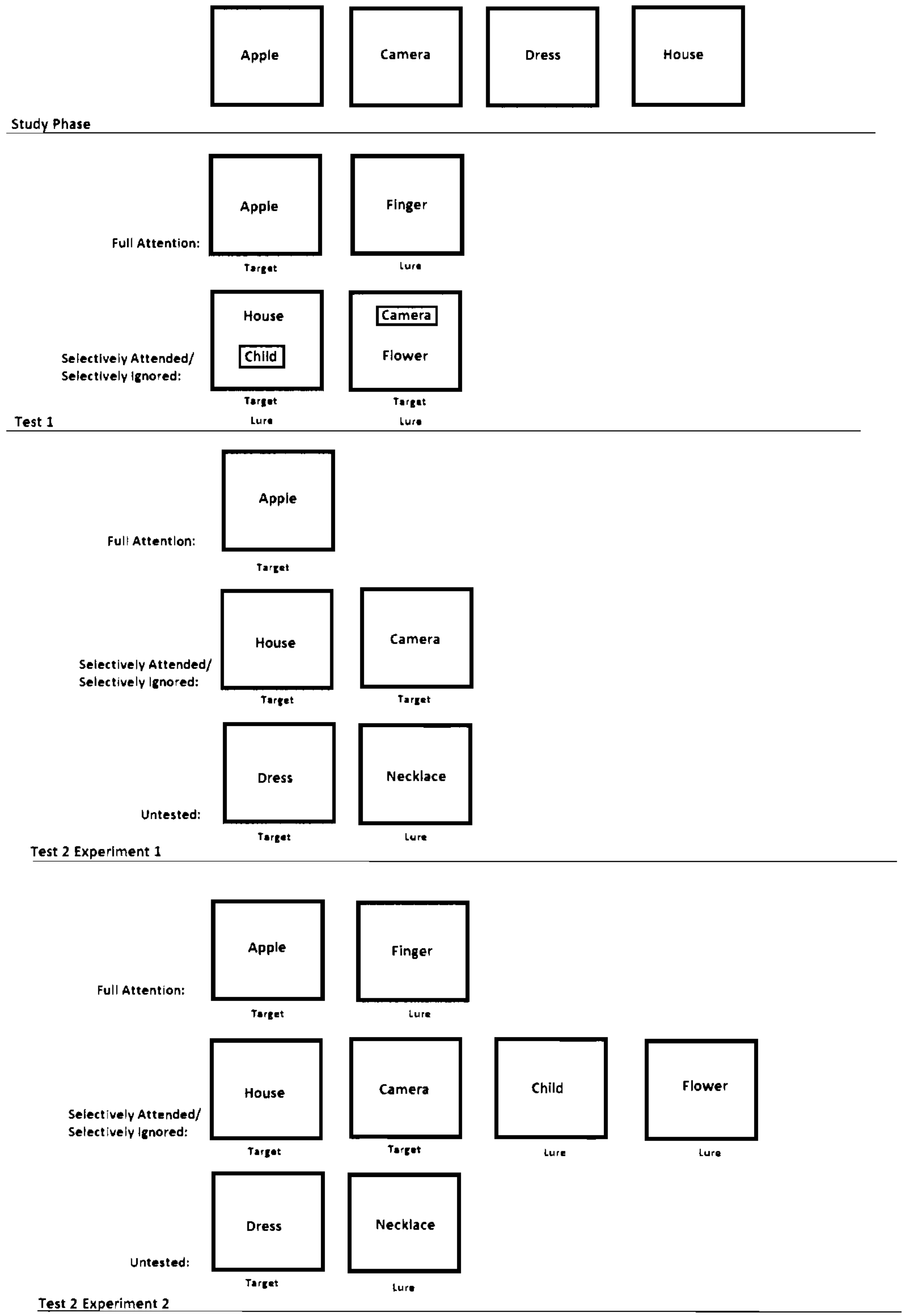
After the study list was complete, participants immediately completed Test Phase 1 where they were told that they would now be tested on the list of words they just studied. They were also told that sometimes one word would appear on the screen and sometimes two words would appear on the screen, but they should only respond "yes" or "no" to the word surrounded by a box. Participants were not explicitly told to ignore the stimuli that were not being tested. During Test Phase 1, each word appeared and after

500ms a word was surrounded by a box. During full attention trials, one word appeared on the screen. During selective attention trials, two words would appear on the screen and then a box appeared around one of the words. The word in the box was the target word (later referred to as Selectively Attended condition) and the word outside the box was not responded to (later referred to as Selectively Ignored condition). During Test Phase 1, there were 120 trials using 200 different words. There were 40 targets and 40 lure words in the Selective Attention condition, 40 target and 40 lure words were in the Selectively Ignored condition, and 20 target words and 20 lure words were in the Full Attention Condition. Two different word lists were used to counterbalance words between participants. Each word in the two lists was counterbalanced so that each word was viewed in each of the attention categories mentioned above an equal number of times across participants. The presentation orders of the study and test words were freshly randomized for each participant and thus full and selective attention trials were intermixed.

After Test Phase 1 was completed, participants completed a word search puzzle for 10 minutes. After this delay, participants completed Test Phase 2. During this test phase, 240 words were presented individually and participants were asked to respond "yes" if they believed the word to have been on the study list and "no" if they did not think the word appeared on the initial study list. All 120 words from the original study list were presented. The target test words were categorized based on their status during Test Phase 1 (Full Attention, Selective Attention, Selectively Ignored or Untested).

In Experiment 1, a total of 120 novel words, or words that were never presented during the experiment, were also tested in Test Phase 2. In Experiment 2, all 120 studied words were tested as well as lure items from each category in Test Phase 1 (20 Full Attention, 40 Selectively Attended, 40 Selectively Ignored) as well as 20 completely novel words. A schematic diagram of the procedures is displayed in Figure 1.

Figure 1. The experimental design for Study, Test 1 and Test 2.



Design

The experimental design of Experiment 1, Test Phase 1 was a 2 (Stimuli: Target or Lure) x 4 (Presentation: Full Attention, Selective Attention, Selectively Ignored, or Novel) within subjects design. The experimental design of Test Phase 2 was a five-level within subjects design with a factor of test 1 item status (Full Attention, Selective Attention, Selectively Ignored, Untested, and Novel).

The experimental design of Experiment 2, Test Phase 1 was a 2 (Stimuli: Target or Lure) x 2 (Presentation: Full Attention or Selective Attention) within subjects design. The experimental design of Test Phase 2 was a 2 (Stimuli: Target or Lure) x 4 (Presentation: Full Attention, Selective Attention, Selectively Ignored, or Untested) within subjects design.

Results

Experiment 1

For Test 1, the proportion of "yes" responses was the dependent variable. For target words, the proportion of "yes" responses is the hit rate, and for lures the proportion of "yes" responses is the false alarm rate. A significance level for initial analysis was set at .05, and post-hoc and planned comparisons significance levels were set at .01 and unless otherwise indicated below, results described were at or below these levels of significance.

Means as a function of attention and status are presented in Figure 2. A 2 (Status: Target or Lure) x 2 (Attention: Full or Selective Attention) repeated measures ANOVA was conducted. There was a main effect of status $F(1,43)=268.08$, $\eta^2=.86$; participants were more likely to say "yes" to target items than to lure items. There was no significant main effect of Attention, $F(1,43)=2.49$, $p=.12$, $\eta^2=.06$. There was a significant interaction between Attention and Status $F(1,43)=5.95$, $\eta^2=.12$. To interrupt this interaction, planned contrasts as a function of attention for each status were conducted. There was no difference for lure items, $t(43)=.43$, $p=.67$. In contrast, full attention target words ($M=.62$) had higher hit rates than selectively attended target items ($M=.55$), $t(43)=2.81$. On initial testing, selective attention does decrease memory performance in comparison to full attention. Means and standard deviations are presented in Table 1.

Figure 2. The proportion of "yes" responses for target words (hit rates) and lures (false alarms).

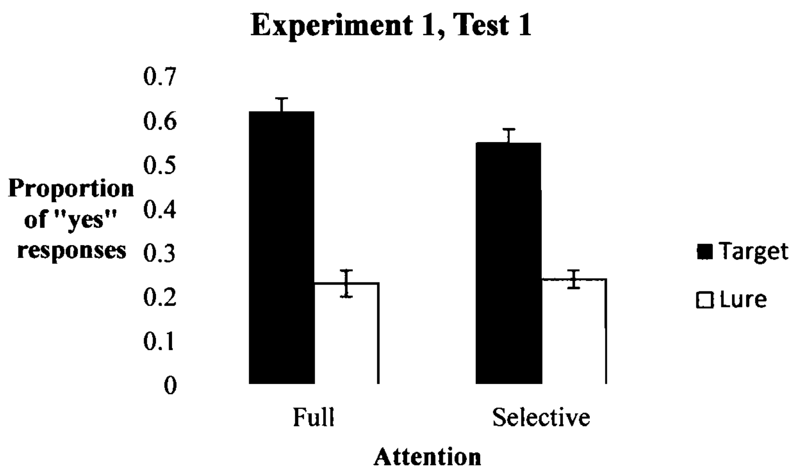


Table 1. Means and standard deviations for Experiment 1 Test 1.

	Full Attention		Selective Attention	
	M	SD	*M*	SD
Target	.62	.17	.55	.14
Lure	.23	.19	.24	.14

Means as a function of attention and status are for Test 2 of Experiment 2 are presented in Figure 3. A 5-level repeated measures ANOVA with a factor of status (Full Attention, Selective Attention, Selectively Ignored, Untested, and Novel) was conducted. The effect was significant, $F(4, 172)= 74.39$, $\eta^2=.78$. Planned comparisons revealed that there was no difference in hit rates between full attention ($M=.61$) and selective attention ($M= .59$) items, $t(43)=.98$, $p=.33$. Full attention items were remembered better than selectively ignored ($M= .52$) items, $t(43)=3.93$. Similarly, selectively attended items were better remembered than selectively ignored items, $t(43)=3.56$. Selectively ignored items were better remembered than items that were untested (M= .42) during Test 1, $t(43)$=5.16. Lastly, items that were not tested were recognized at higher rates than novel items (M=.24), $t(43)$=10.09. Overall, full and selective attention did not alter memory performance, however, when words were re-exposed in the selectively ignored condition, memory performance was better than no second exposure at all. Means and standard deviations for Test 2 are presented in Table 2.

Figure 3. Proportion of "yes" responses for full attention, selective attention, selectively ignored, and untested target words (hit rates) and novel words (false alarms).

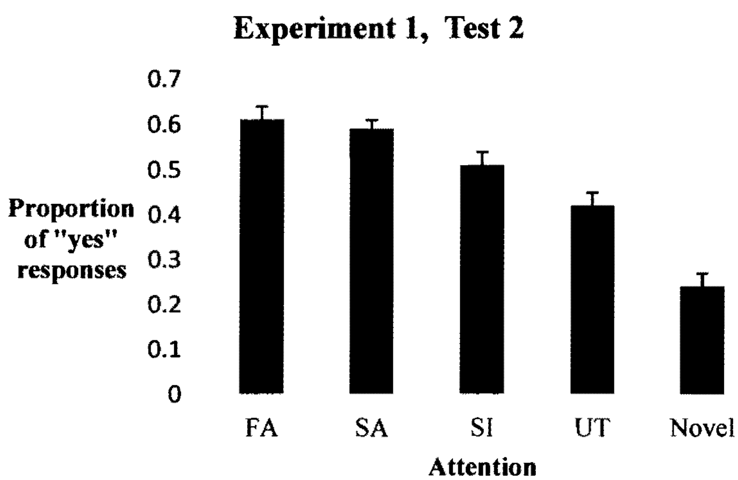


Table 2. Means and standard deviations for Experiment 1, Test 2.

	Full Attention		Selective Attention		Selectively Ignored		Untested		Novel	
	M	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Condition	.61	.17	.59	.16	.52	.17	.42	.17	.24	.18

Experiment 2

In Experiment 2, lures from Test 1 were represented on Test 2 to test the effects of selective attention during retrieval on false recognition of foils. For Test 1, the proportion of "yes" responses was the dependent variable. Again, significance levels for initial analyses were set at .05 and post-hoc and planned comparisons significance levels were set at .01 and *p*-values that meet this criterion are not reported. Means as a function of attention and status are presented in Figure 4. A 2(Status: Lure or Target) x 2 (Attention: Full or Selective Attention) repeated measures ANOVA was conducted. There was a main effect of status, $F(1,58)=202.48$, $\eta^2=.78$, showing that participants said "yes" more often to target items than lure items. There was also a main effect of attention, $F(1,58)=15.00$, $\eta^2=.21$. Participants said "yes" more to full attention items than selective attention items. The main effects of status and attention were qualified by an interaction between status and attention, $F(1,58)=5.64$, $\eta^2=.02$. Planned comparisons revealed that false alarm rates were the same for full and selectively attended items, $t(58)=1.51$., $p=.14$. Hit rates were higher for full attention ($M=.64$) than selectively attended ($M=.56$) items, $t(58)=4.05$. These results mirror those of Experiment 1, Test 1 and show that selective attention during retrieval has a negative impact on memory performance. Means and standard deviations are presented in Table 3.

Figure 4. Proportion of "yes" responses for full attention and selectively attended targets (hit rates) and lures (false alarms).

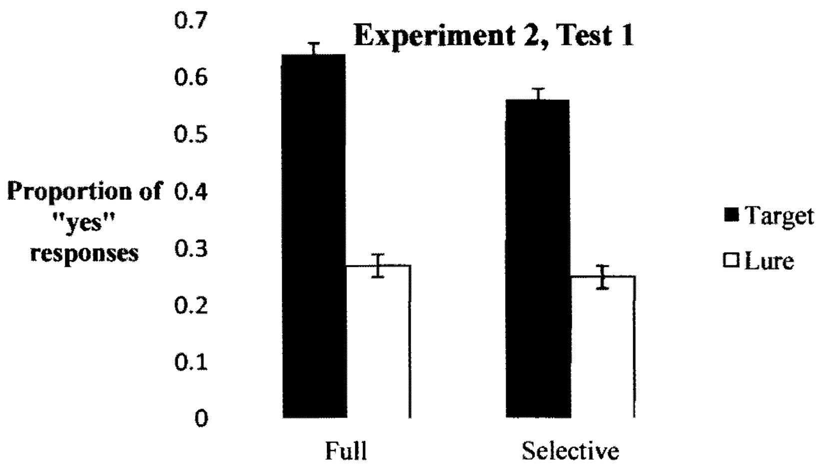


Table 3. Means and standard deviations for Experiment 2, Test 1.

	Full Attention		Selective Attention	
	M	SD	*M*	SD
Target	.64	.18	.56	.17
Lure	.27	.18	.25	.17

Means for Test 2 as a function of attention and status are presented in Figure 5. A 2(Status: target or lure) x 4(Attention: Full Attention, Selectively Attended, Selectively Ignored or Untested) repeated measures ANOVA was conducted. There was a main effect of status, $F(1,58)=87.73$, $\eta^2=.60$ whereby participants said "yes" more often to target items then to lure items. There was also a main effect of attention, $F(3,174)=30.92$, $\eta^2=.48$, where full attention items were more likely to receive a "yes" response than selective attention items. The main effects were qualified by an interaction between status and attention $F(3,174)=4.84$, $\eta^2=.16$. To interpret the interaction separate 1-way ANOVAS were run on each status.

For lure items, the effect was significant $F(1,173)=7.07$, $\eta^2=.21$. There was no significant difference between full ($M= .33$) and selectively attended ($M= .34$) items, $t(58)=.44$, $p=.66$. There was a marginal difference between full ($M=.33$) and selectively ignored ($M= .28$) items, $t(58)=1.98$, $p=.052$. There was a significant difference in false alarm rates between selectively attended ($M=.34$) and selectively ignored ($M=.28$) items, $t(58)=3.26$. There was no difference in false alarm rates between selectively ignored items and novel items ($M=.25$), $t(58)=1.89$, p=.06, however there is a trend towards a significance. This means that false memories for foils are affected by selective attention during retrieval, where selectively attended lures were more likely to be falsely recognized than selectively ignored lures.

For target items, the effect of attention was significant $F(3,174)=41.00$, $\eta^2=.68$. There was no difference in hit rates between full ($M= .57$) and selectively attended ($M= .55$) items, $t(58)=1.63$, $p=.11$. Hit rates for full attention items ($M=.57$) were greater than selectively ignored ($M= .47$) items, $t(58)=5.95$. Similarly, hit rates for selectively attended ($M=.55$) items were greater than for selectively ignored ($M=.47$) items, $t(58)=3.56$. Finally, hit rates for selectively ignored items were greater than for untested items ($M=.40$), $t(58)=5.11$. This experiment replicates the finding in Experiment 1 that subsequent retrieval for items tested under full attention and selective attention do not differ, but that selectively ignored items have higher hit rates than items that were not represented in Test 1. Means and standard deviations are presented in Table 4.

Figure 5. Proportion of "yes" responses for targets (hit rates) and lures (false alarms). Target untested words are those that were not repeated on Test 1, and lure untested words are novel to the experiment.

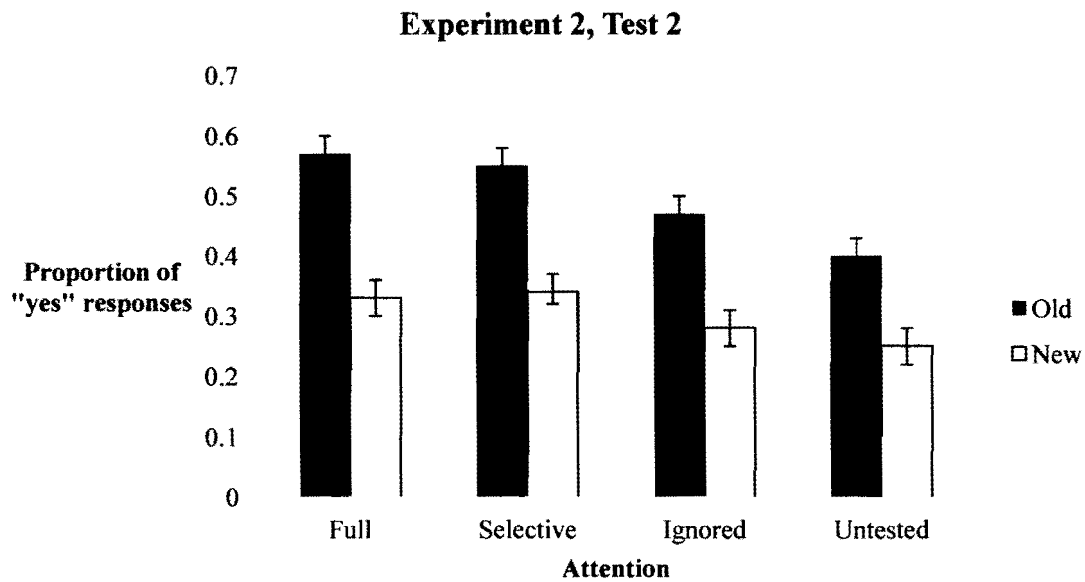


Table 4. Means and standard deviations for Experiment 2, Test 2.

	Full Attention		Selective Attention		Selectively Ignored		Untested/ Novel	
	M	SD	*M*	SD	*M*	SD	*M*	SD
Target	.57	.20	.55	.19	.47	.19	.40	.20
Lure	.33	.20	.34	.19	.28	.20	.25	.23

Discussion

The results of Experiments 1 and 2 show that selective attention during retrieval does not lead to the same results as divided attention during retrieval. Selective attention and divided attention during retrieval differ in three major ways.

First, the results of Test 1 of Experiments 1 and 2 suggest that selective attention during retrieval does have an immediate impact on memory performance. This is in contrast to some (Baddeley, Lewis, Eldridge & Thompson, 1984, Anderson, Craik & Naveh-Benjamin, 1998, Clarke & Butler, 2008, Dudukovic, DuBrow & Wagner,2009) but not all (Troyer, Winocur, Craik & Moscovitch, 1999, Hicks & Marsh, 2000, Lozito & Mulligan, 2006, Dudukovic,et al., 2009) research on the effects of divided attention during retrieval. The results of this study suggest that retrieval is not an automatic process and may rely on more effortful recollection as opposed to familiarity. In discussing this discrepancy in the literature, Hicks and Marsh (2000) suggest that to get effects of divided attention during retrieval, a secondary task has to be difficult. The present study contradicts this to a certain degree, because simply ignoring a second stimulus is presumably not very difficult. We propose that the present findings may indicate that in order to get effects of reduced attention during memory retrieval the perceptual system that is engaged during a secondary task must match that of the primary task (Duncan, Martens & Ward, 1997).

The second difference found between selective attention and divided attention during retrieval is illustrated by the results of Test 2 of Experiments 1 and 2. In this study, selective attention during retrieval does not reduce hit rates on subsequent memory tests, which is in contrast to Dudukovic et al (2009) who found reduced hit rates for items recognized under divided attention during subsequent retrieval tests. In addition, if one considers the initial test to be like a second encoding phase, then it is suggestive that selective attention at encoding is not consequential for retrieval although direct tests should be conducted on this point.

Finally, in addition to different patterns among selective attention and divided attention hit rates, false alarm rates for repeated foils also differed in the present set of experiments. Dudukovic et al (2009) found that when attention was divided during Test 1, false alarms for foils on Test 2 were reduced, essentially providing some protection for memory performance. In the present study we find that selective attention does not reduce false alarm rates for repeated foils. This is another potential fundamental difference between divided attention and selective attention.

This study also provides evidence that selective attention during retrieval does not reduce testing effects. Because selectively attended and fully attended words had comparable hit rates on Test 2, reduced attention by means of selective attention during retrieval does not reduce memory performance. Further evidence for testing effects also come from the decline in memory performance for selectively ignored words relative to selectively attended words. Selectively attended words can be considered "tested" while selectively ignored words can be considered "studied" and the results of both experiments indicate that selectively attended words ("tested" words) have higher hit rates on subsequent testing than selectively ignored words ("studied" words). This pattern shows that any secondary exposure, be it full attention testing, selective attention testing, or simply exposure to stimuli as in the selectively ignored conditions, improves hit rates over words that were untested. Previous studies on the testing effect and recognition have mainly used a recall test as ether Test 1 or Test 2 (Halamish & Bjork, 2011, Chan & McDermott, 2007, Butler & Roediger, 2008), and the current study shows that even a recognition memory test at Test 1 can improve subsequent recognition performance. The results of this study can be useful in classroom settings. Since people are constantly engaging in selective attention to ignore the irrelevant stimuli around us, understanding how reduced attention affects recognition memory can lead to improvements in classroom and study environments. Additionally, these results, like the results of many other studies, suggest that repeated testing in the classroom can lead to improved memory for learned materials.

The use of a selective attention paradigm in adult recognition memory is not as common as that of divided attention. However, because of the complexity of secondary task influences on memory performance, understanding how reduced attention in general during retrieval affect memory performance may be better understood through selective attention tasks. Although Hicks and Marsh (2000) find that secondary tasks must be difficult to evoke reduced memory performance we find here that even a relatively simple task (ignoring a word on a screen) can impact memory performance. Thus, selective attention tasks may provide a new and clearer way of studying the effects of reduced attention during retrieval on recognition memory performance.

The present experiments represent the first steps toward understanding the role of selective attention in recognition memory. Future research should be directed at understanding the cognitive mechanisms underlying these findings. Recollection and familiarity are two proposed mechanisms for recognition memory (for a review, see Yonelinas, 2002), and their role in reduced attention memory performance may provide additional evidence for the discrepancies in the literature regarding reduced attentions affects on memory performance. In addition, direct measurements of recollection and familiarity in the context of reduced attention during retrieval can lead to better understanding of the automaticity of this cognitive function. Future research using a similar methodology to the present study should examine the role of the characteristics which were modified from the Dudukovic et al (2009) study to the present. To understand if selective attention and divided attention tasks do lead to differential results, additional studies using picture studies and increased delays must be conducted. Time delays can have an influence on recognition memory (Nungester & Duchastel, 1982; Roediger & Karpicke, 2006b; Wheeler, Ewers, & Buonanno,2003) and the present studies modification to a 10 minute delay (versus 2 day delay in Dudukovic et al (2009)) may be one reason why we find that reduced attention during Test 1 did not lead to difference in performance between full attention and selective attention conditions during Test 2. Understanding the impact of different time delays on memory could provide more details on the nature of reduced attention on subsequent memory tests.

Finally, the aging literature is abundant with studies of divided attention and memory performance. Generally, it has been reported that divided attention during encoding reduces memory performance more so in older adults than younger adults (Anderson, Iidaka, Cabeza, Kapur, McIntosh, & Craik, 2000), and that divided attention during retrieval affects older adults the same way as younger adults (Naveh-Benjamin, Craik, Guez & Kreuger, 2005). Conducting research on the effects of reduced attention during retrieval on recognition and subsequent recognition in older adults may be a fruitful area of future research. Testing effects have been essentially ignored in the aging population in favor of classroom-aged groups and college age convenience samples. However, understanding testing effects in elderly populations may lead to advances in understanding cognitive rehabilitation and memory training.

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