**THE INFLUENCE OF ATTENTION AT ENCODING
ON DIRECT AND INDIRECT REMEMBERING**

By

Penny A. MacDonald

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Graduate Department of Psychology
University of Toronto

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Penny A. MacDonald

Graduate Department of Psychology

University of Toronto

Abstract

The relation between attention at encoding and direct (i.e., recognition) and indirect (i.e., rapid reading) remembering was investigated. In Experiments 1 and 2, a subtle attentional manipulation at study reduced direct but not indirect remembering. In Experiment 3, however, presenting two words simultaneously at study, with the instruction to attend to one (i.e., target) and to ignore the other (i.e., distracter), eliminated this dissociative effect of attention. Distracters were not remembered directly or indirectly, although targets were remembered well. Mere exposure is not sufficient to produce indirect remembering: Stimuli need to be attended. Experiments 4A, 4B, and 5 investigated factors that modulate the relation between attention at encoding and direct and indirect remembering. When stimuli are separated, ignoring an equally salient stimulus in favor of processing another stimulus may prevent even the minimal attentional requirements of indirect remembering from being met, let alone the more stringent requirements of direct remembering.

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The interplay between attention and implicit and explicit memory will be the focus of this thesis. Although controversy surrounds the precise definition of implicit and explicit memory, explicit memory (i.e., direct remembering) will refer to the intentional and instructed use of memory that is under the strategic control of the participant. In contrast, implicit memory (i.e., indirect remembering) will refer to any unintentional and uninstructed use of memory that is not under the strategic control of the participant. These definitions approximate the definitions held by most contemporary memory investigators (for reviews, see Engelkamp & Wippich, 1995; Richardson-Klavehn & Bjork, 1988; Roediger, Guynn, & Jones, 1994; Roediger & McDermott, 1993).

Direct and Indirect Tests of Memory

Explicit remembering is generally measured by direct tests (Johnson & Hasher, 1987). In these tests, participants are instructed to refer to previous study episodes or events. To perform correctly on these tasks, participants must make contact with memories encoded during the study phase. Free recall and recognition memory tests are hallmark examples of direct tests. In free recall, participants are given instructions to recollect unaided as many items as they can from a previous study episode. In recognition memory tests, participants are asked to select the items that they recognize from a previous study episode from among items that are being presented for the first time in the experiment.

Implicit remembering is generally measured by indirect tests (Johnson & Hasher, 1987). In these tests, participants are not asked to refer back to a prior episode. Normally, the relevance of the prior episode or study phase is concealed from participants, although the prior episode is relevant to the task at hand. In these tasks, indirect remembering is revealed by facilitated (i.e.,

faster and/or more accurate) performance for items that were previously presented compared to items not previously presented. This facilitated performance is referred to as priming or repetition priming.

There are numerous examples of indirect tests of memory. The word fragment completion task (Tulving, Schacter, & Stark, 1982) involves presenting words with letters omitted and requiring participants to fill in the missing letters. When the fragmented word was previously presented, participants more often offer correct completions compared to novel fragmented words. The lexical decision task (Meyer & Schvaneveldt, 1971) has also been used to assess indirect remembering, with latency to judge whether the presented item is a word as the dependent measure. Here, words that were recently seen are more quickly identified than are new words (e.g., Smith, MacLeod, Bain, & Hoppe, 1989; Szymanski & MacLeod, 1996). In the masked word identification task (also referred to as the perceptual identification task; Jacoby & Dallas, 1981), words -- some of which were previously studied, some not -- are presented to participants very briefly and then masked. Participants identify more studied words than unstudied words despite the fact that they are not instructed to use memory or to refer back to the study list (e.g., Masson & MacLeod, 1992). A final example of an indirect test is the rapid reading procedure (sometimes called pronunciation or naming; e.g., Scarborough, Gerard, & Cortese, 1979) in which latencies to read words that were previously presented are normally shorter than are latencies for reading new words in the experiment (e.g., MacLeod, 1996; MacLeod & Masson, 1997). All of these tests have been used as indirect measures of memory, along with an ever-growing battery of others.

Memory Dissociations: A Quick Summary

Direct and indirect remembering have been distinguished on the grounds that certain manipulations affect performance on direct tests but not on indirect tests, and vice versa. Such direct/indirect memory dissociations, in fact, abound in the literature. In this section, some of these dissociations will be noted. These dissociations have been taken as evidence that there are at least two types of remembering. The belief is that by understanding these functional dissociations, the specific role or purpose of each way of remembering will be elucidated.

The original finding that attracted attention to the issue of direct/indirect memory distinctions was the dissociated performance of amnesics on direct and indirect tests of memory. That is, amnesics demonstrated profound impairments on direct tests of memory but showed no such impairment on indirect tests of memory (Graf & Schacter, 1985; Musen, Shimamura, & Squire, 1990; Winnick & Daniel, 1970). Another difference is that massed repetitions at study improve performance on direct but not indirect tests (Challis & Sidhu, 1993). Changes in modality from study to test reduce priming on indirect tests but do not affect performance on direct tests (Hayman & Rickards, 1995). A dissociation also exists in the time course of implicit and explicit memory: Performance on indirect tests does not diminish over time as rapidly as does performance on direct tests (DeSchepper & Treisman, 1996; Parkin, Reid, & Russo, 1990; Tulving, 1985).

Levels of processing, or encoding manipulations, also affect direct and indirect tests differently. In levels of processing manipulations, participants are normally asked to perform an orienting task at study that determines how deeply material is encoded (Craik & Lockhart, 1972). When participants are asked to orient to surface characteristics, such as the letters in words,

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encoding is deemed shallow; when participants are asked to orient to the meaning of the stimuli, such as whether the words represent pleasant concepts, encoding is deemed deep. These types of manipulations greatly affect direct remembering (i.e., deeper processing improves performance on direct tests) but do not similarly affect indirect remembering (i.e., deeper processing does not improve performance on indirect tests; Craik, Moscovitch, & McDowd, 1994). This dissociation, however, has been challenged (Brown & Mitchell, 1994; Challis & Broadbeck, 1992). It has also been demonstrated that reading a word at study versus generating the word from a definition increases priming on an indirect test of memory whereas the reverse occurs on direct tests of memory for at least some tests (Blaxton, 1989; Winnick & Daniel, 1970). Directed forgetting encoding manipulations have also demonstrated differential effects on direct and indirect tests. To-be-remembered items are remembered much better than to-be-forgotten items on direct tests, but the two types of items generally produce equivalent priming on indirect tests (see, e.g., Basden, Basden, & Gargano, 1994; MacLeod & Daniels, 1997).

Finally, more recent investigations have focused on the role of attention in direct and indirect tests of memory. Attentional manipulations at encoding have also been found to affect direct but not indirect remembering (Debner & Jacoby, 1994; DeSchepper & Treisman, 1996; Jacoby, 1991; Szymanski & MacLeod, 1996). Research shows that dividing or diverting attention from items at study greatly impairs performance on subsequent direct tests of memory but does not affect performance on indirect tests.

These dissociations suggest that there are definite distinctions between performance on direct and indirect tests of memory. The goal of the present study is in fact to further investigate distinctions between direct and indirect remembering. Despite numerous replications of these

findings, many of these dissociations remain controversial, as counterexamples proliferate. The aim of the current study is to explore further the effect of attentional manipulations at encoding on direct and indirect measures of memory. Before describing the experiments, however, I will review in greater detail previous investigations of the effect of attention at study on direct and indirect tests of memory.

Attention and its Effect on Performance on Direct and Indirect Tests of Memory

Research has begun to emphasize the interplay between attention and memory as measured by different types of tests. In a quite early instance, Eich (1984) used a dichotic listening procedure, having participants shadow prose on the attended channel while hearing word pairs consisting of a homophonic noun preceded by an adjective that biased its interpretation (e.g., taxi-FARE) on the unattended channel. Although on a subsequent recognition memory test participants did not recognize the words from the unattended channel, they demonstrated the appropriate bias in an oral spelling test (e.g., the spelling “fare” rather than the spelling “fair”). This finding reveals preserved priming on an indirect test for items that were not attended, despite no evidence of memory for these items on a direct test.

Parkin, Reid, and Russo (1990) examined the effect of divided attention at study by asking participants in a full attention condition to complete a sentence verification task only and participants in a divided attention condition to perform sentence verification and tone monitoring tasks simultaneously at study. The sentence verification task involved reading sentences and judging whether they made sense; the tone monitoring task consisted of listening to a series of tones occurring every 3 to 7 s and indicating for every tone whether it was high, medium, or low frequency. After a 24-hr delay, participants performed a recognition test and a word fragment

completion test. Parkin et al. found much poorer recognition of test items for participants who had studied under divided attention conditions compared to those who had studied under full attention conditions. On the word fragment completion test, however, divided attention had no effect on subsequent performance: Both groups showed equivalent priming for studied words. These results suggest that implicit remembering occurs despite constraints on attentional resources at study. Divided attention at study is not so kind, however, to performance on direct tests, which suffers substantial impairment. This conclusion was strengthened by the corresponding findings of Parkin and Russo (1990) using picture completion as both the direct and the indirect measure of memory.

DeSchepper and Treisman (1996) indirectly tested memory for novel shapes using the negative priming paradigm (see Fox, 1995, for a review). In the typical negative priming study, two items appear on each trial and the participant must respond to one of them. In the control condition, normally no relation exists between the targets and distracters on the two consecutive trials, called the prime trial and the probe trial. The ignored repetition condition is the crucial one: Here, the distracter from the prime trial becomes the target on the probe trial. Responses to the probe target in this condition are typically slower and more error prone compared to those in the control condition. The difference between the latencies (or the error rates) in the ignored repetition condition and the control condition is negative priming.

In their study, DeSchepper and Treisman (1996) presented participants with overlapping novel shapes in red and green. On each trial, participants were to ignore the red shape and to say whether the green shape matched a third shape presented to the right of the overlapping items. Negative priming persisted undiminished over lags of up to 200 intervening items between the

corresponding prime and probe trials, providing evidence of memory for the ignored distracters. Indeed, even over delays of 1 day, 1 week, and 1 month, they found that if participants showed negative priming during the original presentation of items they also showed comparable negative priming later. [In fact, the participants who showed facilitation at time 1 also showed facilitation at time 2 over all delays, with the facilitation actually increasing for longer delays.] These findings further suggest that memory, as measured by an indirect test, persists for ignored distracters over both short and long delays. On a recognition test, however, the same participants showed no memory for the unattended shapes and little memory for the attended ones. Again, a dissociation is evident between performance on direct and indirect tests of memory caused by selective attention at study.

Szymanski and MacLeod (1996) also examined the effect of selective attention at study on subsequent direct and indirect memory tests. During the study phase, participants read some words aloud and named the print color of others. In the color-naming study phase, the word was the ignored dimension whereas the color was the attended dimension. At test, participants either performed a direct recognition test or an indirect lexical decision test. In both tests, words from the study phase appeared among new words. Szymanski and MacLeod found that words that were read at study were better recognized than words that were color-named at study. The repetition priming in the lexical decision task, however, was equivalent for both words that were read and words that were color-named at study. Szymanski and MacLeod concluded that successful implicit remembering occurs once a low attentional threshold is met, and that further attention confers little additional benefit. Their study provides yet another illustration of dissociated performance on direct and indirect tests of memory.

These recent investigations of the effect of attention on explicit remembering have even challenged such classic findings as the “cocktail party phenomenon.” This is one of cognitive psychology's best known results: that people will detect their own name on an irrelevant channel even when their attention is engaged somewhere else, presumably because their name has personal relevance (Moray, 1959). Wood and Cowan (1995b) attempted a direct replication of Moray's (1959) finding. The study consisted of a dichotic listening experiment in which participants were instructed to attend to and shadow the information coming in one ear (i.e., the attended channel) while ignoring the information coming in the other ear (i.e., the unattended channel). The participant's name was then inserted on the irrelevant channel.

Participants were later asked questions about the contents of the irrelevant channel, including a question about whether they remembered hearing their name. They discovered that only 34.6% of participants had actually detected their own name. Furthermore, this detection only occurred for participants who displayed shifts of attention to the irrelevant channel during the shadowing task, as indexed by errors in shadowing shortly after the participant's name was presented. This suggests that, without attention, even highly salient information is not encoded sufficiently for explicit remembering to occur. Success on this explicit memory test occurred only when participants devoted attention -- against instructions -- to the irrelevant channel.

Although many studies have found the pattern of preserved priming on an indirect test despite impaired performance on a direct test following reduced attention at study, recent evidence has emerged indicating that the effect of attention at encoding on direct and indirect remembering is not as straightforward as it first seemed. In another article, Wood and Cowan (1995a) investigated both direct and indirect tests of memory for information entering via an

irrelevant channel. In a series of selective listening experiments, participants were asked to ignore passages presented to one ear while attending to and shadowing passages presented to the other ear. Throughout the selective listening task, backward speech was embedded in the passage presented to the irrelevant channel. Participants were later asked to indicate whether they could recall anything odd happening on the unattended channel. Although some participants did remember hearing a switch to backward speech --and this number increased by further differentiating the voices in the attended and unattended channels --their recollection occurred at a cost to on-line shadowing. For participants who detected the shifts, however, errors in shadowing occurred about 15 s following the shift from forward to backward speech in the irrelevant channel. Evidently, remembering did not occur in the absence of attention at study. In addition, both direct and indirect tests of memory revealed little to no memory for the content of the unattended message in which the backward speech had been embedded. These findings suggest that success on both direct and indirect tests requires attention at encoding.

Phaf (1994, Experiment 10) also investigated the effect of attention at encoding on direct and indirect remembering. Participants were presented two words simultaneously on each trial, one to the left and one to the right of fixation. After a 200 ms delay, an arrow appeared pointing to one word, instructing participants to read it aloud. Participants were to attend only to the cued word, and were urged to ignore the other word.

Three tests were later administered to three different groups. One group did an indirect word-stem completion test, with unique three-letter cues corresponding to studied or unstudied words. Another group did an indirect masked word identification test, where each test word briefly appeared inside a mask. Finally, a third group did a direct free recall test. The free recall

test group showed essentially no memory for the ignored words, consistent with the need for prior attention on direct tests. More surprisingly, however, both indirect test groups also demonstrated impairment in performing an indirect test for words that were ignored at study. Even though there was still reliable priming for the ignored words, participants showed more priming for attended words than for ignored words. These findings suggest that attention may play a role in both direct and indirect remembering.

The most common finding is that there is virtually no effect of decreased attention to items at study on later indirect tests despite seriously detrimental effects on later direct tests (Anooshian, 1989; Eich, 1984; DeSchepper & Treisman, 1998; Szymanski & MacLeod, 1996). Although this pattern is not uncontested, it suggests that success on indirect tests does not depend on attention at encoding despite the fact that success on direct tests depends greatly on it. The following contention expresses this view about indirect remembering: "...the memory processes underlying priming effects are not open to conscious inspection and should not be disrupted by experimental manipulations that reduce the subjects' degree of conscious involvement with the initial learning task" (Parkin et al., 1990, p. 510). Others also argue that indirect remembering is independent of attention and that automatic sensory registration or data-driven processing is sufficient to facilitate reprocessing of studied items on indirect tests (Hayman & Tulving, 1989; Roediger, 1990).

The objective of the present study was to further explore this interplay between attention and memory. Specifically, the current experiments investigated two important issues: (a) the dependence of direct remembering on attention at encoding, and (b) the independence of indirect remembering of attention at encoding. The aim was to further clarify the contribution of attention

at study to subsequent remembering. Do all reductions in attention at encoding, no matter how slight, produce declines in performance on direct tests? Do all reductions in attention at encoding, no matter how extreme, fail to affect indirect remembering? Thus, the intention was to explore the attentional requirements for each type of remembering. Experiments 1 and 2 investigated whether direct remembering would be affected by even a subtle attentional manipulation. The goal was to examine the sensitivity of direct remembering to even slight reductions of attention to items at encoding. In Experiment 3 the primary objective was to create a dramatic attentional manipulation at study to determine whether indirect remembering would be reduced if the manipulation of attention was extreme enough. Finally, Experiments 4A, 4B, and 5 investigated variables that influence attention at encoding, and their effect on subsequent direct and indirect remembering was examined. The purpose of the latter three studies was to discover the source of the discrepant findings in Experiment 3 and in Szymanski and MacLeod (1996).

Experiment 1

The aim of Experiment 1 was to investigate the effect of a subtle attentional manipulation at encoding on direct and indirect remembering. In most previous studies, attention to items has been limited either by competing stimuli (i.e., selective attention situations) or by competing responses (i.e., divided attention situations). In these cases, the attentional limitations to processing of tested items have been quite severe and usually have resulted in seriously impaired performance on direct tests (Anooshian, 1989; DeSchepper & Treisman, 1996; Eich, 1984; Inhoff & Brihl, 1991; Szymanski & MacLeod, 1996; Wood & Cowan, 1995a). The central question in the present experiment was how sensitive is direct remembering to decreases in attention at encoding?

Although many studies have reduced attention at encoding and surveyed decreases in direct remembering, the issue of the attentional requirements at encoding for direct remembering has not been adequately addressed. If the attentional manipulation is slight, direct remembering may be unaffected, paralleling indirect remembering. Alternatively, performance on direct tests may respond to even slight alterations in attention at encoding, preserving the common direct/indirect memory dissociation. The correspondence between performance on direct tests and decreases in attention to items at encoding is not altogether defined because previous investigations of this issue have tended to examine the effect of more serious attentional limitations at study. Addressing this issue will yield a more complete picture of the interaction between attention at encoding and direct remembering.

The objective of the experimental manipulation was to decrease the attention paid at study to some items relative to other items without presenting a competing stimulus or requiring a competing response. This manipulation involved instructing participants to read aloud individual words that appeared in red but to respond 'pass' to words that appeared in white. The expectation was that, despite the absence of explicit instructions to ignore the white words or to decrease attention to them, participants would consider the red words more important and thus attend to them more than to the white words. Thus, color signalled the degree of attention to be paid to a word as well as how to respond appropriately to it. For red words, in addition to identifying its color, the word had to be identified and read out loud for proper responding. For white words, however, the only necessary action was to determine the color of the stimulus, after which processing could be halted and the response 'pass' could be provided. Both red and white words appeared on the screen in full view of participants until a response was made.

Method

Participants. Twenty introductory Psychology students at the University of Toronto at Scarborough participated in the experiment in exchange for bonus credit in their course.

Stimuli. A set of 120 words, each with an estimated frequency of 30 or above out of a million, served as the materials for all experiments (Thorndike & Lorge, 1944). These words appear in the Appendix. All participants received a uniquely randomized set of words for the study phase, the direct and indirect test phases. The words in all phases of the experiment subtended $.4^\circ$ of visual angle when viewed at a distance of 57 cm (the approximate viewing distance in the experiment).

Apparatus. An IBM 486 compatible microcomputer with a 14-in color VGA monitor was used for testing. The controlling program was written in QuickBasic 4.5 using the routines provided by Graves and Bradley (1987, 1988) to achieve millisecond timing accuracy. Response times were measured as the interval between the stimulus onset and the participant's oral response into a microphone that was interfaced to the computer. Accuracy was scored on-line by the experimenter.

Procedure. Participants were informed that they were taking part in a study of reading and reading speed. The experiment consisted of three phases in which all participants took part: (a) study phase, (b) indirect test, and (c) direct test. During the study phase, participants saw 80 words, half printed in red and half printed in white, randomly intermingled. They were to read aloud the words that appeared in red at an average reading pace, but to respond 'pass' to words that were printed in white. Other than these directions, participants were given no further instructions as to the processing of the words, nor were they informed that they would be tested

on their memory for these words.

On each study trial, an orienting stimulus (*****) appeared in the centre of the computer screen for 500 ms, followed by a blank screen for 500 ms. The colored word stimulus remained on the screen until the participant spoke his or her response. The experimenter advanced to the next trial by pressing the key that corresponded to the accuracy of the participant's response (i.e., whether they read the red words correctly or incorrectly, or whether they responded 'pass' to the white words).

On the indirect test of memory, 20 of the red words and 20 of the white words randomly selected from the study phase were presented mixed together with 20 new words. The other 20 red words and the other 20 white words from the study phase appeared on the direct test of memory, mixed with 20 new words. In this way, there was no overlap of the words presented on the direct and indirect tests, permitting within-subject testing. The indirect test always preceded the direct test because the risk of contamination between tests is less in this direction.

The indirect measure of memory was rapid reading (MacLeod, 1996; MacLeod & Masson, 1997). In this task, participants are asked to read aloud each word that appears on the screen as quickly as they can, speaking their responses into the microphone. The latency of their reading response is the dependent measure, with the time difference between studied words and new words providing an index of implicit remembering. It is well established that previously studied words are read more quickly than are words not previously encountered in the experiment (Balota & Chumbley, 1984; Scarborough et al., 1979). In the present experiment, the objective was to compare memory for words to which participants had responded 'pass' at study with memory for words that had been read aloud.

As in the study phase, each stimulus on the indirect rapid reading test was preceded by an orienting stimulus (*****) for 500 ms and a blank screen for 500 ms. The word remained on the screen until the participant's oral response into the microphone sent an interrupt to the computer. The word 'Ready?' then appeared on the screen as an indication to the experimenter to score the accuracy of the participant's response. During the indirect test, the words that had appeared in white during the study phase were again presented in white and the words that had appeared in red were again presented in red. This was done so that the words would be physically identical at study and at test. Previous studies have shown that even slight alterations in the appearance of a word from study to test can alter any benefit of reprocessing (e.g., Snodgrass & Hirshman, 1994). As for the 20 new words, half appeared in red and half appeared in white. Stimulus color for these new words was randomized anew for each participant.

The direct test of memory was a recognition test. The 40 previously studied words were also presented in the same color at test as they had appeared at study. Half of the 20 new words were presented in red; half were presented in white. The participant's task was to identify the words that had been previously encountered in the study list, regardless of whether a word had been in red or in white. Participants were informed that none of the words from the rapid reading test would be included on the recognition test. A trial proceeded as follows: (a) An orienting stimulus (*****) was presented for 500 ms, (b) a blank screen appeared for 500 ms, (c) the test word was presented in either red or white, and (d) the participant pressed the key marked 'O' for old or the one marked 'N' for new. The 'O' sticker covered the "" key; the 'N' sticker covered the "a" key. Participants were informed that they were not being timed in making their old/new decisions.

Results

Indirect test. A one-way repeated measures analysis of variance (ANOVA) was conducted on the mean latencies from the indirect rapid reading test, with the encoding condition (read at study, ‘pass’ at study, and new) as the lone within-subject variable. The mean latencies used in the analyses and shown in the first column of Table 1 included only words that were responded to correctly at study and at test. The ANOVA was significant, $F(2, 38) = 4.88$, $MSe = 606.60$, $p < .025$. A planned contrast comparing the mean latencies for new words to those for both types of old words combined (i.e., both read and “pass” words at study) was also significant, $F(1, 19) = 14.76$, $MSe = 2408.03$, $p < .001$, indicating longer latencies for new words. This priming effect of 14 ms attests to the fact that words that appeared in the study list were indirectly remembered. The second orthogonal contrast comparing the mean latencies for words read at study (i.e., the red words) versus those passed on at study (i.e., the white words) was nonsignificant, $F < 1$. This indicates that words that were studied, regardless of whether they were read aloud, were remembered implicitly equally well. Because accuracy on this task was extremely high, such that most participants made no errors at all, error analyses are not reported. Indeed, the second column of Table 1 shows that errors essentially never occurred.

Insert Table 1 about here

Direct test. A second one way ANOVA, with encoding condition (read aloud vs pass response) as the within subject variable, was performed on the d' scores for the recognition test. There was a significant difference between the d' scores, $F(1, 19) = 68.17$, $MSe = 0.19$, $p < .001$,

with better recognition for words that were read aloud at study than for those to which participants had responded “pass” at study.

Discussion

There was a dissociation in participants’ performance on the direct and indirect tests in Experiment 1. Not surprisingly based on previous studies (DeSchepper & Treisman, 1996; Eich, 1984; Szymanski & MacLeod, 1996), the attentional manipulation did not affect priming on the indirect rapid reading test of memory. Even this subtle attentional manipulation, however, did reduce performance on the direct recognition test. This pattern of results is most common (e.g., Debner & Jacoby, 1994; DeSchepper & Treisman, 1996; Szymanski & MacLeod, 1996).

The key finding was that despite what appeared to be only slight attentional biasing (i.e., read some words aloud and respond ‘pass’ to other words), performance on a direct test of memory was significantly affected. It appears that direct remembering is highly sensitive to attentional manipulations at encoding. The greater the attentional resources directed toward the stimulus at encoding, the better the performance on a subsequent recognition test. In the present study, participants were not prevented from attending to the words to which they were supposed to respond ‘pass.’ They were further not explicitly instructed that these words were less important. In fact ‘pass’ words could have been processed identically to read words apart from overt responding. Despite all this, words to which participants responded ‘pass’ were less well remembered on a direct test.

It should be kept in mind that participants were informed that they were participating in a study of reading and reading speed. They had no reason to expect any words to reappear on a subsequent test of memory, either direct or indirect. It seems likely, then, that in the interest of

efficient performance, participants processed both types of words as far as was required: Red words requiring color, lexical, phonological, and likely semantic processing, white words needing only to be processed for color. The processing needed to ascertain the color of a word at encoding appears less successful in engaging the processes that enhance subsequent effortful retrieval. By contrast, this processing is sufficient to enhance subsequent rereading of the word as evidenced by intact priming.

On direct tests, the greater the contextual information that is available from study (e.g., response information), the more familiar the word will feel. Indeed, having previously said a word aloud may contribute to participants' success in identifying a studied word as old. Such a strategy would assist recollection of the red words but leave the white words undifferentiated from the new words on the recognition test. In the present case, the encoding of the white words involved no overt response, and therefore the context at recognition was less informative. The possibility exists that direct tests require greater overlap in all stages of reprocessing from study to test for successful performance. On indirect tests, the earlier stages of processing (e.g., visual scanning of displays, data driven processing) may be of greater importance in enhancing subsequent performance. The latter is consistent with the views mentioned earlier, espoused by Hayman and Tulving (1989), and by Roediger (1990). It is also consistent with the idea of indirect tests relying primarily on recovery of the "initial interpretive encoding" in the Masson and MacLeod (1992) account.

There is one caveat. Participants were instructed to say 'pass' when they encountered white words in the study list. It is possible that the production of this incompatible response may have interfered with further processing of the item. That is, we may have explicitly imposed

restrictions on processing by requiring this irrelevant response. To be sure that the present result was not simply due to interference in processing from the 'pass' response, Experiment 2 was conducted. The main goal was to provide a relative attentional manipulation that did not prevent full processing of white words.

Experiment 2

The objective of Experiment 2 was to re-examine the effect of an attentional manipulation at encoding on performance of direct and indirect tests of memory. The main goal of Experiment 2 was to ensure that the result on the direct test of Experiment 1 was not simply due to impeded encoding of white words because of the irrelevant 'pass' response that was made during study of these items. In the present experiment, participants were simply instructed to read red words aloud but not to read white words aloud.

Method

Participants. Another 20 students from introductory psychology at the University of Toronto at Scarborough participated for bonus credit in their class.

Stimuli. The stimuli were identical to those used in Experiment 1.

Apparatus. The apparatus was identical to that used in Experiment 1.

Procedure. Participants again performed all three phases of the experiment: the study phase, the indirect test phase, and the direct test phase. Participants made no response to words appearing in white in the study phase, rather than responding 'pass'. This detail excepted, Experiment 2 was identical to Experiment 1.

Results

Indirect test. The analyses were identical to those conducted in Experiment 1. Table 2 presents the data summary. The ANOVA comparing mean latencies in the rapid reading test as a function of encoding condition (words read aloud at study, words not read aloud at study, and new words) revealed a significant difference, $F(2, 38) = 5.12$, $MSe = 433.32$, $p < .025$. A planned contrast of the mean latencies for new words with the combined mean latencies for studied words (i.e., red words and white words) was significant, $F(1, 19) = 8.22$, $MSe = 3233.63$, $p < .025$, revealing longer latencies for new words relative to the two types of old words. There was about 18 ms of priming --very similar to the 14 ms effect in Experiment 1-- for words that had appeared in the study list. The orthogonal contrast of mean latencies for words that were read at study versus those that were not read at study was nonsignificant, $F(1, 19) < 1$, indicating equivalent repetition priming for each type of old word.

Insert Table 2 about here

Direct test. The one-way ANOVA comparing d' scores was significant, $F(1, 19) = 117.42$, $MSe = 0.14$, $p < .001$, reflecting more accurate recognition memory for words read aloud at study (i.e., the red words) than for words not read aloud at study (i.e., the white words). This finding replicates the finding on the direct test in Experiment 1.

Discussion

The results of Experiment 2 are completely in accord with those of Experiment 1. The results on the indirect rapid reading test revealed performance unaffected by attentional manipulations at encoding whereas the direct test showed better recognition for words that had

received more attention at encoding than for words that had received less attention. That is, recognition was better for words read aloud than for those not read aloud at study. As was suggested earlier, perhaps a stimulus-response coupling at encoding provides greater context leading to better identification of old items on direct tests. This context might be used to evaluate prior experience, with the participant especially confident of prior study for words that he or she could recollect having spoken during study.

In the present study, despite the fact that there was no explicit instruction to devote more attention to words that were read aloud compared to words that were not, attention may have been implicitly directed to red words and away from white words. In both Experiments 1 and 2, given that participants were not aware of the subsequent tests of memory, it was an efficient strategy to differentially process words as far as their respective encoding task required.

The results of both Experiments 1 and 2 are consistent with the prevalent pattern of differential performance on direct and indirect tests of memory as a result of attentional manipulations at encoding. Based on these findings, direct remembering is highly sensitive to attention at encoding. The goal of Experiment 3 was to test the second hypothesis generated by this common pattern of dissociation. That is, the objective was to investigate whether indirect remembering is truly independent of attention at encoding.

Experiment 3

The aim of Experiment 3 was again to limit attention to some words at study and to observe how this affected performance on both direct and indirect tests, with the specific goal of altering performance on the indirect test. The intent was to investigate whether indirect remembering could be affected at all by reductions in attention at study or whether encoding for

this type of remembering truly occurred automatically without attention to items at encoding (Hayman & Tulving, 1989; Parkin et al., 1990; Schmitter-Edgecombe, 1996). To effectively test this hypothesis, a dramatic attentional manipulation was required. In Experiment 3, the attentional limitation was achieved by presenting two words at the same time and requiring participants to attend to one, the target, and to ignore the other, the distracter. This was explicit in the instructions to participants. Thus, Experiment 3 differed from Experiments 1 and 2 in two fundamental ways: (1) Targets and distracters were presented simultaneously at study, and (2) participants were explicitly instructed to attend to targets and to ignore distracters. This selective attention manipulation ensured that even less attention would be allocated to distracter words.

Method

Participants. Forty students from introductory psychology at the University of Toronto at Scarborough participated for bonus credit in their psychology class.

Stimuli. The stimuli were identical to those used in Experiment 1. In the study phase of Experiment 3, the entire display --red word, white word and space between each word-- subtended 1.2° of visual angle when viewed at a distance of 57 cm (the approximate viewing distance in the experiment). Each word, as well as the space separating the words in the display, subtended $.4^{\circ}$ of visual angle when viewed at this distance.

Apparatus. The apparatus was identical to that in Experiment 1.

Procedure. The major change in Experiment 3 was that participants were presented with two words at a time on each trial during the study phase. The study list now consisted of 40 pairs of words, with each pair containing one red word and one white word. Top-bottom position was randomized, with the red word equally likely to be in either position. Half of the participants were

instructed to read the word in red and to ignore the word in white, the other half were instructed to read the word in white and to ignore the word in red. The procedure was actually very similar to a negative priming experiment (see, e.g., Fox, 1995, for a review) with two differences: (1) In the present study, none of the words were repeated, and (2) participants were not instructed to respond as quickly as they could but rather to read the red words at an average reading pace, as in the two previous experiments. The two words on each trial remained on the screen until the participant spoke a response into the microphone. All other procedures in Experiment 3 were identical to those of Experiment 1.

Results

Indirect test. Table 3 presents the data summary. A 2 X 3 mixed ANOVA was conducted on the mean latencies from the rapid reading test with color attended at study (red vs. white) as the between subject factor and encoding condition (attended vs. ignored vs. new) as the within subject factor. The main effect of color attended was marginally significant, $F(1, 38) = 3.64$, $MSe = 28759.86$, $p = .064$, indicating that participants who had attended to the white words in the study phase were faster overall to respond in the rapid reading test relative to participants who had attended to the red words in the study phase. The main effect of encoding condition was highly significant, $F(2, 76) = 16.86$, $MSe = 1004.84$, $p < .001$. The planned contrast collapsed across color attended, comparing mean latencies for the new words to those for the two types of studied words (attended and ignored) combined. This was significant, $F(1, 39) = 5.99$, $MSe = 3969.98$, $p < .020$, revealing longer latencies for new words than for studied words. This result, however, should be viewed in light of the next comparison. The second orthogonal contrast collapsed across color attended, comparing the mean latencies for the two types of studied words

(attended and ignored). This, too, was highly significant, $F(1, 39) = 22.74$, $MSe = 2631.51$, $p < .001$. Words that were attended during study produced priming whereas words that were ignored did not. To complete the picture, an additional post hoc comparison of the mean latencies for words that were ignored with those for new words, collapsed across color attended, was nonsignificant, $F(1, 39) = 1.59$, $MSe = 1287.21$, $p > .200$. This confirms that no advantage in reprocessing was conferred to words that were ignored during study; indeed, if anything, there appears to be 7-8 ms of negative priming for the ignored words. In Experiment 3, then, only words that were attended during study were primed on the indirect test. Finally, the Color Attended x Encoding condition interaction was not significant, $F < 1$.

Insert Table 3 about here

Direct test. A 2 x 2 mixed ANOVA examining recognition d' was conducted with color attended at study (red vs. white) as the between subject factor and encoding condition (attended vs. ignored) as the within subject factor. Color attended did not influence performance on the direct test, $F(1, 38) = 2.15$, $MSe = 0.43$, $p > .150$. The main effect of encoding condition, however, was highly significant, $F(1, 38) = 225.40$, $MSe = 0.25$, $p < .001$, reflecting the fact that words that were attended during study were far better recognized than words that were ignored. In fact, the mean d' score for ignored items reveals no recognition at all on the direct test. The Color Attended x Encoding condition interaction was not significant, $F < 1$.

Discussion

In Experiment 3, performance was better on both types of tests for the words that were attended during the study phase. The dissociation due to attention at encoding on performance of

the direct and indirect tests disappeared in Experiment 3. In contrast to previous findings of priming for distracters on indirect tests following selective attention study phases (DeSchepper & Treisman, 1996; Szymanski & MacLeod, 1996), the present study revealed no priming for distracters. This challenges the prevalent contention that indirect remembering occurs unconstrained by attention at encoding. Not surprisingly, the distracter words were no longer recognized as old items on the direct test when target and distracter words were presented simultaneously in the study phase.

The study phase in Experiment 3 was similar to those used by Phaf (1994), by Szymanski and MacLeod (1996) and by DeSchepper and Treisman (1996). Although the simultaneous presentation of spatially separated items in Experiment 3 more closely resembles DeSchepper and Treisman's study phase, their stimuli were novel shapes, which are quite different from familiar words. In fact, differential findings between studies employing word stimuli and DeSchepper and Treisman's studies using novel shapes have appeared in the negative priming literature. As one illustration, negative priming occurs for novel shapes even with large stimulus sets (DeSchepper & Treisman, 1995) whereas for words it only occurs with very small stimulus sets (Malley & Strayer, 1995). Therefore, it does seem that processing of these novel shapes is quite different from processing of words, a topic worthy of further research.

The discrepancy in results obtained in Experiment 3 and by Szymanski and MacLeod (1996) is more unexpected. They employed words and colors in a selective attention study phase modelled after the Stroop task (Stroop, 1935). In this case, a color is pitted against a word, where the color is the target and the word is the distracter, quite contrary to the automatic tendency of participants to read the word. Two critical differences distinguish the study phase in

the present Experiment 3 from that used by Szymanski and MacLeod. First, Experiment 3 pitted two words against each other. Unlike in the Stroop task, where the target color is less salient and presumably less attention-capturing than the distracting word (Melara & Mounts, 1993), both dimensions were equally salient and capable of capturing attention in Experiment 3. In the Stroop task, there is a tendency to orient to words, ensuring some processing of the distracting dimension. In Experiment 3, although at the outset there was an equal probability of orienting to either the red word or the white word, the instruction to attend to the word in one color and to ignore the word in the other color introduced an intentional set that biased attending to the target word. The goal-directed behaviour of participants, in the absence of any involuntary stimulus-driven orienting, greatly reduced the probability that the distracter word would be attended. This was indeed the goal of Experiment 3.

The second difference arose in the manner that the two dimensions were displayed in each of these experiments. In Szymanski and MacLeod's (1996) study, the two dimensions (i.e., the attended and the ignored) were perceptually integrated whereas in Experiment 3, the attended and ignored words were separated. The integration versus separation variable is known to affect performance on a Stroop task (cf. MacLeod, 1997). Spatial separation normally decreases the Stroop effect, presumably due to decreased attentional capture from the word when it is spatially separated from the color. This is another possible explanation for the discrepant results.

The variables of distracter salience and spatial separation of targets and distracters almost certainly influence performance by altering the amount of attention that the distracter receives. The failure to replicate the pattern obtained by Szymanski and MacLeod (1996) in no way invalidates either finding. It may simply be the case that the study phase in Experiment 3 provided

an instance of a more powerful attentional manipulation. The objective of Experiments 4A, 4B, and 5 was to disambiguate the source of this discrepancy by further exploring the impact of the variables of distracter salience and spatial separation of targets and distracters on direct and especially on indirect remembering.

The principal finding in Experiment 3 is that, like direct remembering, indirect remembering requires attention at encoding. The attentional requirements for successful indirect remembering are simply less demanding than those for successful direct remembering. The present results are not alone in suggesting this (Phaf, 1994, Experiment 10; Wood & Cowan, 1995a). Perhaps Experiment 3 provides a visual analog to the dichotic listening encoding procedure employed by Wood and Cowan (1995a). In both cases, there was spatial separation of targets and distracters as well as equally salient material presented as target and distracter information. Both provide instances where attention to distracters is extremely limited, resulting in the absence of remembering for these distracters on both direct and indirect tests.

The study phase in Phaf (1994, Experiment 10) was also similar to the encoding phase of Experiment 3 in that targets and distracters were equally salient words, presented in spatially separate locations. Despite this similarity, however, Phaf did find some priming on his indirect tests for ignored words whereas no such priming was evident in the present Experiment 3. A significant procedural difference that may have accounted for this discrepancy was that both words appeared on the screen for 200 msec before the target was indicated in Phaf's study. Just due to chance, on some of the encoding trials, the nominally ignored word was likely attended during the 200 msec of uncertainty prior to the cue, thereby mixing the attended and ignored

words in the nominally ignored condition. In Experiment 3, by contrast, the print color immediately indicated the target word, providing no reason to examine the ignored word.

Before proceeding to Experiment 4A, one further explanation for the current findings should be considered. Perhaps distracters did not even undergo visual processing. If this was the case, then neither direct nor indirect remembering of distracters would be expected. It seems unlikely, however, that this was the case. First, targets and distracters were presented in very close proximity, separated only by a space subtending a visual angle of $.4^{\circ}$, appearing immediately above or below one another. It seems improbable that participants could completely avoid visually processing distracters while selecting and identifying target words. Keep in mind that targets occurred randomly in either the top or the bottom location¹ so that participants could not predict the target location or know where to focus their attention at the outset.

In a situation identical to that described in Experiment 3 (i.e., red target words appearing above or below white distracter words), MacDonald, Joordens, and Seergobin (1997) obtained negative priming for previously ignored white words that became red targets on a subsequent trial, confirming that indeed the white words were processed at some level. As well, Debner and Jacoby (1994) found unconscious perception and memory on a word fragment completion test occurring immediately after every trial, for words that were flanked by numbers at study when the participants' task was to sum the numbers. Similar to the experience of participants in the present experiment, the authors reported that "The phenomenological experience in this task is often

¹ Analyses were performed on the effect of presentation location of targets and distracters on subsequent direct and indirect remembering. Although targets presented on the top were read faster than those appearing on the bottom at study, presentation location did not affect performance on the rapid reading test or on the recognition memory test. Therefore, these analyses for the present and subsequent experiments were not included.

reported as being one of not ‘seeing’ the flashed word because of attending to the numbers” (p. 310). These examples provide compelling evidence that spatially separated distracters are processed sufficiently to affect immediate subsequent processing, although apparently the attention received by these items is insufficient to support long-term direct or indirect remembering. Finally, Lambert, Beard, and Thompson (1988) have presented evidence that semantic information about a word is encoded for distracters presented as far away as 4° from a centrally attended fixation. Given that targets and distracters were separated by a distance subtending only .4° of visual angle in the present study, the argument that distracters were simply not visually processed seems highly unlikely. Further investigations of this issue are planned nonetheless.

Experiment 4A

The aim of Experiment 4A was to make distracters more salient than targets, using a perceptual manipulation. The intent was to create a situation that more closely resembled the typical Stroop situation. In the Stroop task, the dimensions (i.e., word and color) are not equally salient or “naturally” capturing of attention (see, e.g., Melara & Mounts, 1993). Although participants are instructed to attend to the color, this dimension is not the most salient dimension of the display. The word dimension, which is the distracter, actually captures participants' attention at the outset, ensuring that it is attended despite instructions to the contrary.

In Experiment 4A, the goal was to investigate performance on direct and indirect tests of memory after a selective attention study phase in which the distracters were made more prominent than their target counterparts. This unequal salience was attempted through the manipulation of color. In Experiment 4A, distracters appeared in various bright colors that changed from trial to

trial, whereas targets appeared in a very dark blue color against a black background, making them difficult to perceive. If the results in Experiment 3 indeed occurred because two equally salient stimuli were pitted against one another at study, then the manipulation in Experiment 4A should restore the functional dissociation between performance on the direct and indirect tests of memory, reconciling the findings in the present study with those of Szymanski and MacLeod (1996). That is, participants should show equivalent priming on the rapid reading test but impaired performance on the recognition memory test for words that were distracters at study compared to words that were targets. On the other hand, if the fact that two equally salient stimuli were pitted against one another at study was not a contributing factor to the findings in Experiment 3, the manipulation in Experiment 4A should not alter these findings. That is, distracters should not be remembered either directly or indirectly in Experiment 4A.

Method

Participants. Forty students from introductory psychology at the University of Toronto at Scarborough participated for bonus credit in their class.

Stimuli. The stimuli were identical to those described in Experiment 3.

Apparatus. The apparatus was also identical to that used in Experiment 1.

Procedure. Two words, one printed in either bright green, bright blue, bright yellow, bright pink, or white, the other printed in dark blue, were presented simultaneously to participants during the study phase against a black background. Participants were instructed to read the word that appeared in dark blue, ignoring the word that appeared in the bright color. The bright words were designed to be much more visible and salient to participants, despite the fact that they were cast as distracters in the study phase. The two words remained on the screen until the participant

responded into a microphone, as in Experiment 3. Again the direct and indirect tests of memory proceeded as in previous experiments.

Results

Indirect test. Table 4 summarizes the results of Experiment 4A. The one-way repeated measures ANOVA of the mean latencies in the rapid reading test for each encoding condition (attended, ignored, and new) was significant, $F(2, 78) = 20.46$, $MSe = 253.01$, $p < .001$. The planned comparison of the mean latencies for the new words with the mean latencies for the two types of studied words combined, $F(1, 39) = 16.31$, $MSe = 1535.97$, $p < .001$, revealed significantly shorter latencies for studied items relative to new items. The second orthogonal and a priori contrast, comparing the two types of studied items (i.e., attended and ignored), was also significant, $F(1, 39) = 24.71$, $MSe = 500.05$, $p < .001$, with attended words being read faster than ignored words. A nonorthogonal contrast of the latencies for words that were ignored at study with words that were new in the experiment, however, was not significant, $F < 1$. There was, however, no longer any suggestion of negative priming. Again, as in Experiment 3, words that were attended during the study phase produced reliable priming on a subsequent indirect test whereas words that were ignored did not.

Insert Table 4 about here

Direct test. A one-way ANOVA was performed on the d' scores for the words that were attended versus ignored at study. A highly significant difference was found, $F(1, 39) = 201.78$, $MSe = 0.20$, $p < .001$, reflecting the fact that words that were attended during the study phase

were better recognized than words that were ignored. In fact, referring to Table 3 reveals once again no recognition of the words that were ignored at study.

Discussion

The results of Experiment 4A were not in line with the results obtained by Szymanski and MacLeod (1996), but did replicate the pattern in Experiment 3. There was neither direct nor indirect remembering of words that were to be ignored at study despite attempts to make these words more salient than targets. Perhaps the discrepancy between the findings of Experiment 3 and those of Szymanski and MacLeod (1996) was not due to the differential relative salience of distracters compared to targets. That is, making distracters more attention-capturing than targets, reminiscent of a typical Stroop situation, does not increase subsequent indirect or direct remembering for those items

Alternatively, the present salience manipulation may not have been powerful enough to bias orienting to distracters. That is, the attention garnered by distracters because of their brighter color was not equal to the attention garnered by words relative to colors in the Stroop situation. Although there is evidence that salient colors can capture attention (Theeuwes, 1994), Jonides and Yantis (1988) and Theeuwes (1990) failed to demonstrate attentional capture from a conspicuously colored item in a visual search task. In the present case, particularly because the task selection was based on color, the involuntary stimulus-driven orienting to the more salient color may not have been potent enough to override voluntary target selection. Top-down and bottom-up processing were at odds on the same dimension. A more compelling attentional biasing toward distracters was needed. This was the purpose of Experiment 4B.

Experiment 4B

The goal of Experiment 4B was to ensure that distracters would be more salient and attention capturing than targets at the outset of each trial. In Experiment 4A, color was used to increase the stimulus-driven attentional capture of distracters. This manipulation appeared to be unsuccessful in eliciting prepotent orienting responses to distracters. Yantis and Jonides (1996), however, conclude that "... abrupt visual onset may have a privileged status in its ability to capture attention in a stimulus-driven fashion compared to certain other salient visual properties" (p.1506). Experiment 4B capitalized on this tendency to orient toward objects appearing suddenly in a previously blank space. Because synchronous presentation of targets and distracters was desirable in the present study, so as to avoid any confound with presentation duration, an abrupt onset cue (*****) appeared in the location of the distracter just prior to its presentation. The sequence of cue, blank screen, and presentation of distracter all occurred in less than the approximate pause time required to fixate and initiate a subsequent saccade (i.e., 200 ms; Salthouse & Ellis, 1979). These measures were implemented to ensure that distracters would be attended while maintaining an encoding situation similar to that of Experiment 3.

One objection to the present manipulation is immediately evident. The pre-cueing manipulation informs participants of the location of both targets and distracters. That is, in advance of the presentation of the target, participants can prepare to process it by suppressing the prepotent response to orient to the abrupt onset cue. If participants are so inclined, the present experiment can be performed as an antisaccade task (Hallett, 1978). Fortunately, for the present purpose, the antisaccade task is comparable to the Stroop task in terms of the difficulty with which participants successfully suppress prepotent responses (Roberts, Hager, & Heron, 1994).

In addition to this fact, participants may not have been motivated to attempt this suppression given that latency to respond was not emphasized in the study phase of the experiment.

In addition to the abrupt onset cueing manipulation, secondary measures for increasing the salience of distracters were also employed. Distracters were flanked by arrows that pointed to them. As well, distracters were presented in a bright white color against a black background. Targets, on the other hand, were presented in red.

Method

Participants. Students from introductory psychology at the University of Toronto at Scarborough participated for bonus credit in their class. As well, some participants were recruited through a paid pool and were paid \$5.00 in exchange for their participation. There were 20 participants in all.

Stimuli. The stimuli were the same as those used in Experiment 3.

Apparatus. The apparatus was also identical to that used in Experiment 1.

Procedure. Against a black background, two words, one printed in bright white (distracter) the other printed in red (target), were presented simultaneously to participants during the study phase. A row of asterisks corresponding in length to the distracter word appeared in its location for 50 ms, 50 ms prior to the simultaneous presentation of the bright white and red words. The bright white words were also flanked by two bright white arrows that pointed toward them, drawing further attention to these distracters. Participants were asked to read the red words and to ignore the bright white words. All other aspects of the study phase as well as the direct and indirect tests of memory proceeded as in previous experiments.

Results

Indirect test. Table 5 presents the findings of Experiment 4B. A repeated measures ANOVA was performed on the reading latencies in Experiment 4B. The result of this analysis was a marginally significant difference in reading times over the three encoding conditions (attended, ignored, and new), $F(2, 38) = 2.80$, $MSe = 143.50$, $p = .074$. Further comparisons revealed that the studied words combined (attended and ignored) were read faster than the new words, $F(1, 19) = 4.86$, $MSe = 926.53$, $p < .050$. The difference between old words (attended vs ignored), however, was not significant, $F < 1$. A pairwise comparison of the attended studied words and the new words was significant, $F(1, 19) = 4.58$, $MSe = 327.61$, $p < .050$, reflecting priming for the attended words. The pairwise comparison of the ignored studied words and the new words was marginally significant, $F(1, 19) = 3.01$, $MSe = 268.24$, $p = .099$, revealing some priming for the ignored words. These findings indicate greater priming for attended words, although a small, marginally significant priming effect was also revealed for ignored words.

Insert Table 5 about here

Direct test. A one-way repeated measures ANOVA contrasted recognition memory rates for attended and ignored study items using d' scores as the dependent measure. A highly significant difference between the d' scores for attended items and those for ignored items was revealed, $F(1, 19) = 165.21$, $MSe = 0.21$, $p < .001$, reflecting the fact that attended words were recognized quite well whereas ignored words were not recognized at all despite attempts to increase attention to distracters during encoding.

Discussion

It appears that the results of Szymanski and MacLeod (1996) may have differed from the findings in Experiment 3 because their Stroop study phase ensured that distracters were attended. When the distracter words were made more attention-capturing than the target words, paralleling the study phase employed by Szymanski and MacLeod, priming on a subsequent indirect test was revealed for distracters. The fact that the priming was only marginally significant is likely attributable to inadequate power.

As has been the case in all experiments, recognition memory was superior for words that were attended during study versus words that were ignored. Despite the abrupt onset cue which biased orienting toward distracters, to-be-ignored words were not recognized on the direct test. In contrast, targets were recognized quite well.

Experiment 5

Experiment 5 investigated the second possible explanation for the discrepant findings in Experiment 3 and in Szymanski and MacLeod (1996). In Experiment 3, the stimuli at study were spatially separated (i.e., the words appeared above and below one another) whereas in Szymanski and MacLeod's study, the targets and distracters were integrated (i.e., the distracter word was printed in the target color). Experiment 5 examined the effect of spatial separation of words and colors in a Stroop-like study phase on direct and indirect tests of memory.

If the absence of direct or indirect remembering of words that were ignored in the study phase of Experiment 3 was due to the spatial separation of targets and distracters at study, then separating the color and the word in a Stroop-like study phase should produce similar results. This was the primary change made in Experiment 5. It remains that words are more salient than

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colors and, based on the findings of Experiment 4B, this fact alone should produce some priming for the words that were color named. Nonetheless, if spatial separation does in fact modulate the attention given to distracter words, then performance on both direct and indirect tests of memory should be impaired for words that were color-named compared to words that were read at study in Experiment 5. If spatial separation was not a crucial procedural difference causing the divergent findings in Experiment 3 and in Szymanski and MacLeod (1996), then equivalent priming on the indirect test and poorer recognition on the direct test should occur for words that were color-named at study compared to words that were read at study.

Method

Participants. Twenty students from introductory psychology at the University of Toronto at Scarborough participated, receiving bonus credit in their class.

Stimuli. The word stimuli were identical to those used in Experiment 3. In addition, words were presented above or below a colored bar during the study phase. The bar was either red, blue, or green. As in Experiment 3, the entire display (i.e., word, colored bar, and space between word and bar) subtended 1.2° of visual angle when viewed at a distance of 57 cm (the approximate viewing distance in the experiment). The word, the colored bar, and the space between them each subtended $.4^{\circ}$ of visual angle when viewed at this distance.

Apparatus. The apparatus were also identical to that used in Experiment 1.

Procedure. All participants performed two study phases in counterbalanced order. In one study phase, participants were asked to read the word that was presented either in the top or the bottom location and to ignore the colored bar. In the other study phase, participants were asked to name the color of the bar that appeared either in the top or the bottom location and to ignore

the word. Both stimuli remained on the computer screen until participants spoke their responses into the microphone. All other procedural details were identical to those described in Experiment 1.

Results

Indirect test. The summary data for Experiment 5 are presented in Table 6. The one-way ANOVA investigating the effect of encoding condition (read- aloud, color-named, or new) on reading latency was significant, $F(2, 38) = 9.50$, $MSe = 230.03$, $p < .005$. The comparison of mean latencies for both types of studied words combined (read-aloud and color-named) with the mean latencies for new words was significant, $F(1, 19) = 9.91$, $MSe = 2046.87$, $p < .025$, reflecting shorter latencies for studied words compared to new words. The contrast of latencies for read-aloud items and color-named items at study was also significant, $F(1, 19) = 8.33$, $MSe = 237.84$, $p < .025$, indicating shorter latencies for attended study words than for color-named words. Despite this significant difference, priming also resulted for color-named words relative to new words, $F(1, 19) = 6.00$, $MSe = 399.42$, $p < .025$. Therefore significant priming occurred for both types of studied words, with more priming for the items that were read aloud at study.

Insert Table 6 about here

Direct test. The d' scores for the attended words and the color-named words during encoding were significantly different, $F(1, 19) = 96.01$, $MSe = 0.25$, $p < .001$, reflecting the fact that attended words were better recognized than color-named words. In fact, whereas attended words were recognized quite well, color-named words were not recognized better than chance.

Discussion

Using a Stroop-like study phase, both words that were read and words that were color-named demonstrated priming on the indirect rapid reading test of memory. Unlike Szymanski and MacLeod's (1996) finding of equivalent priming for both read and color-named words, however, when colors and words were spatially separated, there was less priming for words that were color-named at study. This finding suggests that indeed spatial separation was a crucial procedural difference between Experiment 3 and Szymanski and MacLeod. As in previous experiments, there was no direct remembering for words that were color-named at study, although words that were read at study were remembered quite well.

The variable of spatial separation likely affects subsequent direct and indirect remembering through the modulation of attention to attended and ignored items at study. That is, unlike in the integrated version of the Stroop task, where both the attended and the ignored dimensions receive focal attention for the duration of the study trial, on the separated version, the ignored dimension certainly receives far less, if any, focal attention during the study trial.

Spatial separation is not the whole story, however. As suggested earlier, the greater salience of the word relative to the color ensures that the to-be-ignored item is attended to some extent. In combination, spatial integration and more salient distracters than targets provide sufficient attention to color-named words that they are indirectly remembered as well as words that are read aloud, although these conditions are insufficient to boost recognition of color-named items beyond chance.

General Discussion and Conclusion

The role that attention plays in memory is complex. The emphasis in the present study was on the influence of attention at the time of encoding on subsequent memory as measured by two predominant categories of memory tests, direct and indirect. Previous work (DeSchepper & Treisman, 1996; Eich, 1984; Parkin et al., 1990; Parkin & Russo, 1990; Szymanski & MacLeod, 1996) led to the conclusion that whereas variation in attention at encoding certainly affected performance on direct memory tests, it had little or no influence on indirect tests. The present work helps to paint a more complete picture of this relation.

In all of the present experiments, the measure of indirect remembering was rapid reading. As an indirect test, rapid reading has the virtues of (1) completely exposing the word and not requiring any problem-solving activity, and (2) being an extremely quick, automatic response, unlikely to be contaminated by conscious recollection (for more on this argument, see MacLeod, 1996; MacLeod & Masson, 1997). The direct test in all of the current experiments was recognition memory.

In Experiments 1 and 2, the attentional limitations at encoding indeed did not affect performance on the indirect measure of memory. Equivalent priming occurred for all items in the rapid reading test regardless of the fact that some items received less attention at encoding. Both Experiments 1 and 2 replicated the predominant pattern of results in that contrary to the invariance in performance on the indirect test, words that received more attention at encoding were better recognized than words that received less attention. The more thorough processing of words that were read aloud at study compared to words that were not read aloud led to better direct remembering. These findings are very much in line with the expected pattern.

Wood and Cowan (1995a), however, have argued that prior studies that have manipulated attention at encoding and then observed the effect of this manipulation on subsequent direct and indirect tests have not completely eliminated attention to the nominally unattended information. I concur. Rather, attention has only been reduced. The remaining attention garnered by distracter items is sometimes sufficient to support priming on indirect tests. This was certainly the case in Experiments 1 and 2 where a more subtle attentional manipulation was sought, and was very likely the case in Szymanski and MacLeod (1996) and Phaf (1994, Experiment 10). Factors in these experiments ensured that to-be-ignored information in fact received some attention at encoding.

Consistent with the previous contention, Inhoff and Brihl (1991) tested memory for supposedly unattended information. In their study, participants were instructed to attend to every other line of text and to ignore the text presented on the remaining lines. Inhoff and Brihl subsequently assessed acquisition of semantic content for both the attended and the unattended passages using multiple choice questions. Subjects accurately reported the semantic details of the attended message and some details of the unattended message but only for portions of text where eye tracking devices recorded fixations to the unattended passage, against instructions. When the questions relating to these portions of the text were removed, evidence of semantic knowledge of the unattended passage disappeared. Therefore, if focal attention was not given to the text, no memory occurred. Despite this precaution, which helped to decrease the contamination of their measure of memory, shifts of attention are not necessarily accompanied by eye movements. Attention can surreptitiously and undetectably vacillate between target and distracter information (Posner & Peterson, 1990; Posner & Snyder, 1975; Posner, Snyder, & Davidson, 1980).

Experiment 3 presented a situation in which the limitation of attention to distracter words was very severe. Because of the simultaneous presentation of both target and distracter words, attention was diverted from distracters to targets, the result of actively ignoring the to-be-unattended information. Priming on the indirect test for ignored distracters now disappeared. This suggests that fluency of reprocessing is not enhanced simply because of exposure to, and resulting visual processing of, a stimulus. It appears that stimuli need to be minimally attended and processed at encoding for subsequent indirect remembering to occur. Ignoring the stimulus in favor of processing another stimulus may have prevented such minimal requirements from being met. Not surprisingly, this harsh limitation of attention to distracters resulted in absolutely no recognition of these items on the direct test. Experiment 3, therefore, provides an instance where the attentional limitation at encoding was serious enough to prevent both direct and indirect remembering. In doing so, it refuted the long held notion that adequate encoding for successful indirect remembering occurs automatically, without attention.

The results of Experiment 3 challenge the notion that indirect remembering occurs for items that were not attended at encoding. They do not correspond to the predominant pattern of findings. Specifically these findings appeared to be at odds with the results of Szymanski and MacLeod (1996). Experiments 4A, 4B, and 5 examined certain procedural differences that may have produced these divergent findings. The factors of distracter salience and of spatial separation of targets and distracters at study were implicated in this discrepancy. It appears that both factors, through their modulation of attention to distracters at encoding, affect participant's success in later indirectly remembering these items. When distracters are inherently more attention-capturing than targets, this ensures that they will be attended to some extent at

encoding, supporting subsequent indirect remembering. Further, if targets and distracters are spatially separated at study, distracters are less likely to receive focal attention, which in turn leads to decreased priming on ensuing indirect tests of memory.

The aim of the current research was to clarify the relation between attention at encoding and later direct and indirect remembering. Clearly, attention at encoding does matter for both types of tests. Contrary to the notion that automatic sensory registration or data-driven processing is sufficient to facilitate reprocessing on indirect tests (Hayman & Tulving, 1989, Roediger, 1990), the present findings suggest that attention and further processing at the time of encoding are required. Although direct remembering is undeniably more sensitive than indirect remembering to attentional manipulations at encoding, as evidenced by Experiments 1 and 2, minimal attentional requirements for successful indirect remembering also exist. Even slight attentional biasing will impact on subsequent direct remembering whereas indirect remembering can abide much greater reductions in attention at encoding. However, when an item receives virtually no attention during encoding, its ability to facilitate later reprocessing is undermined. Previous studies may have failed to reveal this because experimental procedures inadvertently ensured attending to and further processing of nominally unattended or ignored information (Szymanski & MacLeod, 1996; Parkin et al., 1990; Parkin & Russo, 1990). When precautions have been taken to greatly limit focal attention to some items at study, especially by equating the stimulus-driven attention-capturing properties of both targets and distracters and by presenting these items in a spatially separated manner (i.e., Experiment 3; Phaf, 1994, Experiment 10; Wood & Cowan, 1995a), performance is impaired on both direct and indirect tests of remembering.

The interplay between attention and remembering is complicated. Attention at the time of encoding is a necessary component for successful subsequent remembering as measured by both direct and indirect tests. Direct and indirect remembering can no longer be distinguished on the grounds that attentional manipulations affect performance on direct tests but do not affect performance on indirect tests. In fact, challenges to many of the common memory dissociations (Brown & Mitchell, 1994; Challis & Broadbeck, 1992; MacLeod & Masson, 1992) have recently emerged, debunking the myth that certain variables affect performance on one type of test but not on the other. Such simple, straightforward characterisations of direct and indirect remembering are clearly not accurate. The present study hints at the complexity of the relation between attention at encoding and subsequent direct and indirect remembering

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Table 1

Experiment 1: Means and Standard Errors for Correct Response Times (RT in ms) and Error Proportions on the Rapid Reading Test, and for d' Scores on the Recognition Test, as a Function of Encoding Condition

Encoding condition	Rapid reading				Recognition	
	RT		Error		d'	
	Mean	SE	Mean	SE	Mean	SE
Read aloud	573	13.75	.003	0.00	1.77	0.15
Responded "Pass"	573	19.28	.008	0.00	0.63	0.10
New	587	17.37	.003	0.00	---	

Table 2

Experiment 2: Means and Standard Errors for Correct Response Times (RT in ms) and Error Proportions on the Rapid Reading Test, and for d' Scores on the Recognition Test, as a Function of Encoding Condition

Encoding condition	Rapid reading				Recognition	
	RT		Error		d'	
	Mean	SE	Mean	SE	Mean	SE
Read aloud	527	10.44	.000	0.00	2.24	0.14
Not read aloud	526	11.76	.000	0.00	0.96	0.10
New	544	13.02	.000	0.00	---	

Table 3

Experiment 3: Means and Standard Errors for Correct Response Times (RT in ms) and Error Proportions on the Rapid Reading Test, and for d' Scores on the Recognition Test, as a Function of Encoding Condition and Group

Encoding condition	Rapid reading				Recognition	
	RT		Error		d'	
	Mean	SE	Mean	SE	Mean	SE
Attended Red						
Attended	573	18.83	.000	0.00	1.86	0.14
Ignored	618	28.27	.003	0.00	0.11	0.07
New	610	27.39	.003	0.00	---	
Attended White						
Attended	521	18.08	.000	0.00	1.58	0.18
Ignored	555	19.51	.003	0.00	-0.03	0.10
New	548	21.57	.000	0.00	---	

Table 4

Experiment 4A: Means and Standard Errors for Correct Response Times (RT in ms) and Error Proportions on the Rapid Reading Test, and for d' Scores on the Recognition Test, as a Function of Encoding Condition

Encoding condition	Rapid reading				Recognition	
	RT		Error		d'	
	Mean	SE	Mean	SE	Mean	SE
Attended	516	7.44	.005	0.00	1.50	0.11
Ignored	533	8.93	.004	0.00	0.06	0.07
New	537	8.74	.003	0.00	---	

Table 5

Experiment 4B: Means and Standard Errors for Correct Response Times (RT in ms) and Error Proportions on the Rapid Reading Test, and for d' Scores on the Recognition Test, as a Function of Encoding condition

Encoding condition	Rapid reading				Recognition	
	RT		Error		d'	
	Mean	SE	Mean	SE	Mean	SE
Attended	514	8.05	.000	0.00	1.90	0.14
Ignored	516	8.80	.000	0.00	0.02	0.12
New	522	7.72	.000	0.00	---	

Table 6

Experiment 5: Means and Standard Errors for Correct Response Times (RT in ms) and Error Proportions on the Rapid Reading Test, and for d' Scores on the Recognition Test, as a Function of Encoding condition

Encoding condition	Rapid reading				Recognition	
	RT		Error		d'	
	Mean	SE	Mean	SE	Mean	SE
Read-aloud	537	15.93	.000	0.00	1.74	0.15
Color-named	547	17.00	.005	0.00	0.21	0.12
New	558	17.64	.000	0.00	---	

Appendix

The 120 Words Used for Study and for the Direct and Indirect Tests

forest	pocket	traffic	machine	leather	lesson
branch	invention	station	education	history	village
theatre	wagon	minute	factory	direction	century
amount	record	debate	furniture	wheel	address
judge	ticket	account	powder	uniform	teacher
answer	package	quarrel	victory	captain	trousers
shoulder	afternoon	election	ocean	resort	laugh
market	capital	industry	entrance	school	dinner
vacation	clothes	partner	merchant	foundation	stream
garden	kettle	winter	glass	beauty	queen
avenue	evening	language	painting	gravity	friend
engine	basket	treasure	office	plate	campaign
pebble	speech	battery	thread	distance	summer
knock	valley	invitation	guardian	attitude	wheat
whisper	reward	handle	daughter	building	steam
neighbor	travel	attention	peace	harbor	author
kingdom	river	uncle	meadow	nephew	message
arrow	holiday	fashion	turnip	department	island
journey	ladder	sailor	shadow	porch	castle
kitchen	orchard	border	quarter	justice	envelope

APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989

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