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Manipulation of Attention at Study Affects an Explicit but Not an Implicit Test of Memory

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We investigated the impact of attention during encoding on later retrieval. During study, participants read some words aloud (ignoring the print color) and named the print color of other words aloud (ignoring the word). Then one of two memory tests was administered. The explicit test—recognition—required conscious recollection of whether a word was studied. Previously read words were recognized more accurately than were previously color named words. This contrasted sharply with performance on the implicit test—repetition priming in lexical decision. Here, words that were color named during study showed priming equivalent to words that were read during study; both were responded to faster than unstudied words. Thus, an attentional manipulation during study had a strong effect on an explicit test of memory, but almost no effect on an implicit test. Focal attention during study is crucial for remembering consciously but not necessarily for remembering without awareness.

The goal of the present research was to investigate the impact of degree of attention to words at the time of study on subsequent memory for those words at the time of test. The idea for this experiment grew out of the juxtaposition of the literature on explicit and implicit memory and the literature on attention. Our aim was to bring together these areas of research to examine the implications of attentional variation during study on later memory test performance.

Remembering is not a unitary phenomenon; rather, there are different ways of remembering (cf. Richardson-Klavehn & Bjork, 1988; Schacter, 1987). One key contemporary distinction is between explicit and implicit remembering, terms coined by Graf and Schacter (1985). The major difference between these two types of remembering is their degree of dependency on consciousness at the time of retrieval (Graf & Schacter, 1985; Schacter, 1987). Explicit remembering is the conscious retrieval of a prior stimulus or event, whereas implicit remembering occurs when a previously encountered stimulus or event affects behavior, but without requiring conscious knowledge of having experienced that stimulus or event before.

IMPLICIT AND EXPLICIT REMEMBERING

Amnesic patients clearly show the distinction between explicit and implicit memory (see Roediger & McDermott, 1993; Shimamura, 1986). For example, amnesics have been shown to be able to learn many motor skills, yet each time they perform the motor skill, they deny that they have ever done it before (Milner, Corkin, &

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Teuber, 1968). Memory for verbal material has also been demonstrated in amnesics, but again their remembering is evident almost exclusively on implicit tests of memory, and they are unaware that the material being tested was presented to them before (Warrington & Weiskrantz, 1968). Their reprocessing of previously encountered verbal material is enhanced—or primed—but they do not realize it.

Augmenting this implicit/explicit dissociation shown in amnesic patients, many experiments have now pointed toward a dissociation between implicit and explicit tests of memory in normal individuals as well (Richardson-Klavehn & Bjork, 1988). Because implicit tests do not require conscious remembering of a specific episode, whereas explicit tests do require such awareness, it is to be expected that the two types of tests will react differently to a number of manipulations. Among those already investigated are semantic elaboration (Richardson-Klavehn & Bjork, 1988), levels of processing (Jacoby, 1983; Roediger & McDermott, 1993; Winnick & Daniel, 1970), surface feature differences (Graf, Shimamura, & Squire, 1985; Jacoby & Dallas, 1981; Roediger & Blaxton, 1987), and attentional variations (Gardiner & Parkin, 1990; Hawley & Johnston, 1991; Parkin & Russo, 1990; Parkin, Reid, & Russo, 1990).

It is well established that greater semantic elaboration at study leads to better performance on explicit tests, yet most implicit tests show no such benefit (Richardson-Klavehn & Bjork, 1988). Graf and Mandler (1984) showed that, even for identical test materials, different instructions given to participants at the time of test could still dissociate implicit from explicit remembering. They manipulated processing at study by asking people either to rate their liking or to count certain physical features of stimulus items. Then these same individuals received a stem completion test consisting of the first three letters of each item (i.e., REA for REASON). One group received instructions consistent with an implicit test of memory (i.e., try to complete the stem with the first word that comes to mind), whereas the other group received explicit memory test instructions (e.g., try to think of a word just studied that completes the stem). Graf and Mandler found that explicit test performance was enhanced the more elaboratively the item had been processed at study, but implicit test performance showed no corresponding benefit.

When comparing priming for words that were simply read at study to that for words that were generated (i.e., meaning had to be processed), Jacoby (1983) found that generation produced better performance on an explicit recognition test, whereas reading produced better performance on an implicit masked word identification test. In an earlier demonstration of this, Winnick and Daniel (1970) manipulated encoding at study: Participants either read a word, generated a word from a picture, or generated a word from its definition. A test of tachistoscopic word identification showed that only reading led to better identification; the two generation conditions did not benefit performance relative to unstudied control items. However, on recall, a test of explicit remembering, performance was markedly better for the generation conditions compared to the reading condition. In short, processing of meaning had a large effect on an explicit test, but not on an implicit test; the reverse was true for processing of physical form.[2]

[2] Note that Masson and MacLeod (1992) replicated the advantage for generated over read words in explicit recognition, but generally found no difference for generated and read words in implicit masked word identification. This equivalence in masked word identification was true for many types of verbal materials but intriguingly not for antonyms, Jacoby's materials, where Masson and MacLeod replicated Jacoby's pattern.

ATTENTION AND REMEMBERING

What role does attention play in memory? This is no doubt too broad a question to answer simply. Since the pioneering work of Cherry (1953) on the ''cocktail party phenomenon,'' it has been widely held that attending to information makes that information more likely to be remembered later, but that attention is not necessary for later mamory. The latter claim rests on the observation that information on a channel designated as unattended occasionally is picked up. Of course, these claims had to do with explicit remembering only. But very recently, even this long-standing belief has been questioned. Wood and Cowan (1995) have revisited the cocktail party phenomenon and have concluded that information from the unattended channel is only remembered when listeners switch attention to that channel, against instructions. Otherwise, only the information on the attended channel is remembered, placing attention in the role of critical gatekeeper for memory. Again, though, this refers to explicit remembering: How crucial is attention to implicit remembering?

Using the ''Remember/Know'' distinction, Gardiner and Parkin (1990) showed that dividing attention during study reduced conscious recollection of words during a later recognition test, but that recognition without conscious recollection was not affected. It appears, then, that conscious retrieval depends critically on the amount of attention devoted to an item during study but unconscious retrieval may not. In a similar vein, Parkin et al. (1990) showed a dissociation between explicit and implicit tests of memory when attention during study was manipulated. Having people perform a distracter task during study (divided attention) as opposed to not performing the distractor task (focused attention) reduced recognition but did not affect priming in fragment completion. Thus, again, explicit remembering depended critically on how much attention the person paid to the stimulus during study but implicit remembering did not.

The effect of divided versus focused attention on later memory performance has also been demonstrated with picture stimuli. An experiment by Parkin and Russo (1990) showed savings in picture completion after one day regardless of whether the item was initially seen under full or divided attention. However, the divided attention group was considerably worse than the focused attention group on a test of free recall for the pictures. Again, for conscious remembering, the item benefited from being studied under focused attention conditions; if attention was directed away from the study material, performance on an explicit test of memory suffered. This contrasts with performance on their implicit test of memory, where manipulation of attention had little effect.

In sum, previous studies manipulating elaborative processes at study have shown that performance on an implicit test of memory was about the same for stimuli that were simply read as for stimuli processed for meaning (Graf & Mandler, 1984; Masson & MacLeod, 1992). As well, Parkin and his colleagues (Gardiner & Parkin, 1990; Parkin & Russo, 1990; Parkin et al., 1990) have reported that different amounts of attention devoted to stimuli during study also did not lead to different levels of performance on a subsequent implicit test of memory (but see Hawley & Johnston, 1991, for a counterexample). Unlike explicit remembering, implicit remembering appears to be quite insensitive to attentional variations during study, based on the few available studies.

RATIONALE FOR THE PRESENT EXPERIMENT

The present experiment was designed to explore further this dissociation between explicit and implicit tests of memory after a manipulation of attention at study. We hoped to generalize the result to a different implicit test, in particular to a test that used latency rather than accuracy as the dependent measure. A speeded response should be less vulnerable to the intrusion of conscious recollection strategies into a nominally implicit test. Such conscious intrusion might reasonably be expected to be influenced by the degree of attention at study, too, so we thought it preferable to try to minimize that possibility.

During study, students encoded words under two conditions: reading the word aloud or saying the color of print of the word aloud. We expected that a word would be attended to less when the study task was color naming as opposed to reading the words, because color naming would divert attention away from the word. For an explicit test of memory, poorer performance was expected for words attended to less during study, consistent with the vast literature. Like Parkin and his colleagues, we used a recognition test. We predicted that words that were read before would be responded to more accurately than words that were color named before. For the implicit test, no difference was expected in memory test performance after the different study conditions. We chose repetition priming in lexical decision as our implicit measure because this permitted a speeded measure of implicit remembering. We expected that words from both study conditions—read and color named—would lead to faster performance than words that had not been studied. Priming would not be affected by attention at study.

In summary, an interesting dissociation between explicit and implicit tests of memory should appear for words that were color named (i.e., the words themselves were ignored) during study. For the color named words, performance on an explicit test should be much worse in terms of accuracy and speed of response as compared to words that were read. However, on an implicit test, priming for words in both study conditions should be about equal. Put simply, the argument is that attention matters for explicit but not for implicit remembering.

METHOD

Participants

Forty undergraduates from the University of Toronto, Scarborough Campus, took part in the experiment for bonus credit in their Introductory Psychology course. They were divided into two equal groups of 20 for the two different memory tests.[3]

Apparatus

Participants were tested on IBM-compatible 286 computers equipped with Tatung CM-1496 14-in. VGA color monitors. Spoken input to the Realistic Highball-7 mi-

[3] Half of each group was tested in one academic term; the other half was tested in another academic term. Tests comparing the two subgroups revealed no reliable differences between them.

crophone was amplified with a Realistic SA-150 stereo amplifier and input to the computer through a specially modified keyboard, causing an interrupt that permitted response timing. All programs were written in QuickBASIC 4.5, with millisecond accuracy timing routines taken from Graves and Bradley (1987, 1988). The screen background color was black (palate No. 0), and instructions were presented in white (palate No. 15). For stimulus presentation, the colors green (palate No. 2), blue (palate No. 9), red (palate No. 12), and yellow (palate No. 14) were used.

Materials

There were 216 items, consisting of 108 six-letter words and 108 six-letter nonwords. The nonwords were created by changing one to three letters of real English words. All nonwords were judged to be pronounceable and were created from words similar in major characteristics to the set of 108 critical words but not contained in that set. All of the words and nonwords are listed in Appendix A. Also, 20 number words (e.g., four, thirteen) were selected for the practice session.

Study Procedure

The study phase was a modified Stroop (1935) task. Instead of the familiar color words, regular noncolor words (e.g., carpet) were printed in the colors red, green, blue, or yellow. Participants received two blocks of words with different instructions. For one block, they were to read each word aloud, ignoring its color; for the other block, they were to ignore each word and instead say aloud the word's color of print. Participants were encouraged to make each response as quickly as possible and were aware that vocal response times were being recorded. Stimuli were presented in the middle of the computer screen (i.e., centered on the line located half way down the page) in lowercase letters, and each stimulus stayed on the screen until the participant responded.

The Word Reading block consisted of 36 words; the Color Naming block consisted of 36 words plus 12 xxxxxx control trials. In both blocks, the delay between successive words was 250 ms, measured from the onset of the response to the onset of the next item. The blocks were counterbalanced, with half of the participants doing word reading first and half of the participants doing color naming first. Before beginning the study phase, participants had received two practice blocks of 10 number words each (e.g., ''seven'' in green, ''four'' in red), one block for reading and the other block for color naming.

Test Procedure

Type of memory test was a between-groups factor. For the memory tests, words were not printed in color, but instead appeared in white on a dark background in the middle of the computer screen. Again, each word was printed in lowercase letters and stayed on the screen until the participant responded.

Lexical decision. Twenty participants did a lexical decision test. In addition to all of the 72 words presented during the study phase, 36 new words and 36 pronounceable nonwords (which resembled real words as closely as possible) were presented. Items were presented in the middle of the computer screen, and the participant's task was to decide as quickly as possible whether each item was a real English word. The item stayed on the screen until the participant responded. If the presented word was a real English word, the participant was to press the ''/'' key; otherwise, the correct response was the ''z'' key. Both latency and accuracy were recorded.

Recognition. Twenty participants did a recognition test, which included all 72 of the words that occurred during the study phase plus an additional 36 new words. A word was presented on the screen, and the participant had to decide whether that word had appeared before during the study phase. If the participant thought that the presented word had been seen before, he or she was to press the ''/'' key; otherwise, the ''z'' key was to be pressed. Both latency and accuracy were recorded.

RESULTS

The Study Phase

Before turning to the data of primary interest—the memory test data—we examine the data from the study phase. We initially analyzed these data using a 3×2 mixed analysis of variance (ANOVA), the factors being Study Task (word reading, color naming words, and color naming xxx's) and Test Group (recognition and lexical decision).[4] Test Group should not have affected performance in the study phase, and it in fact did not, nor did it interact with Study Task, both Fs < 1. Therefore, we collapsed over Test Group and analyzed just the Study Task. There was a significant effect of encoding condition, $F(2, 78) = 6.60$, $MSe = 4833.02$, $p < .01$. Planned comparisons revealed that word reading ($M = 744$ ms; $SEM = 26$) was faster than color naming of either words ($M = 782$ ms; $SEM = 24$) or xxx's ($M = 799$ ms; $SEM = 31$), $F(1, 39) = 12.66$, $MSe = 27333.82$, $p < .001$, which did not differ reliably from each other, $F(1, 39) = 1.20$, $MSe = 10220.82$, $p > .20$. It is worth noting, therefore, that a stimulus word actually appeared on the screen for less time in the word reading than in the color naming condition.

The usual pattern—word reading being faster than color naming because reading is a more automatic activity (cf. Fraisse, 1969; MacLeod & Dunbar, 1988)—was observed. It is not clear why people were a little slower at color naming control strings as opposed to words, but this may result from the relative infrequency of control trials in our study, which made them somewhat surprising when they did appear. Critically, though, there was no suggestion that the words interfered with color naming, implying that they attracted very little attention.

[4] In fact, the trials during the study phase were divided into only two blocks: color naming and word reading. We have subdivided the color naming trials into those involving words and those involving control xxx's to facilitate subsequent comparisons.

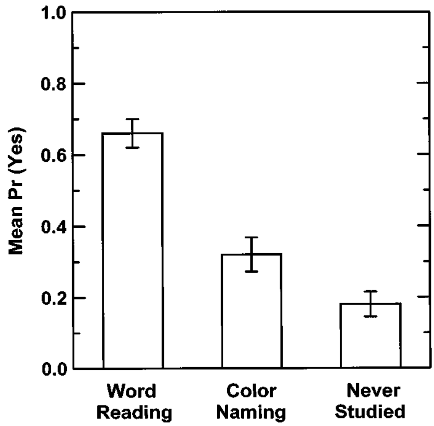

FIG. 1. The mean proportion of ''Yes'' responses during the recognition test. ''Yes'' responses are hits for studied words, including words read during the study phase and words color named during the study phase. ''Yes'' responses are false alarms for words that were never studied. The error bars represent the standard error for each mean.

Recognition: The Explicit Test

We begin the critical test data with those from the explicit recognition test. Our focus here is the accuracy data, though we also recorded latencies and will present them as well. Figure 1 displays these accuracy data: the means and standard errors for ''yes'' responses in each of the three test conditions. ''Yes'' responses are hits for words that were read or color named during the study phase, but false alarms for new words that were never studied. The probability of a ''yes'' response differed significantly for the three types of test words, $F(2, 38) = 66.23$, $MSe = .019$, $p < .001$. Planned comparisons showed that ''yes'' responses to words read during study were significantly greater than they were to color named words or new words, $F(1, 19) = 76.71$, $MSe = .180$, $p < .001$. Furthermore, ''yes'' responses to words color named during study were significantly higher than those to new words, $F(1, 19) = 24.31$, $MSe = .015$, $p < .001$. Thus, recognition of words read during encoding was better than that of words color named during study, but performance on the color named words still reliably exceeded chance. People clearly had some memory for words that they had color named before, albeit poor relative to their memory for words that they had read before.

The difference in recognition response times was not reliable, $F(2, 38) = 2.37$, $MSe = 18133.69$, $p = .11$, though it was suggestive of ''yes'' responses to previously color named words ($M = 988$ ms; $SEM = 44$) being slower than those to previously read words ($M = 908$ ms; $SEM = 49$) or to new words ($M = 907$ ms; $SEM = 31$). It is worth noting that the variance in these latencies was quite high.

Recognition is an explicit memory test. It has been shown in prior studies that words not attended to earlier are consciously retrieved only very poorly later on (Gardiner & Parkin, 1990; Parkin & Russo, 1990; Parkin et al., 1990). The present results further support this finding: Words that were ignored during study—color named words—were recognized not at all well during the memory test. This was

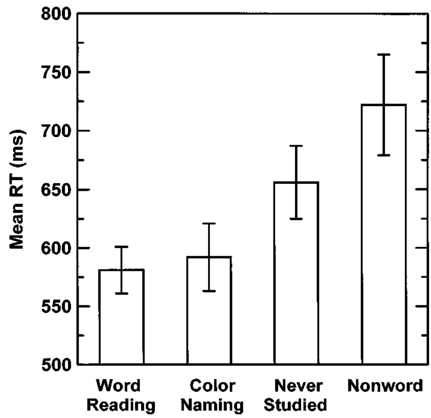

FIG. 2. The mean response times in milliseconds for each of the four types of words on the lexical decision test—words read during study, words color named during study, words not studied at all, and control nonwords. The error bars represent the standard error for each mean.

true despite the fact that words were displayed for a longer period in the color naming than in the word reading study task.

Lexical Decision: The Implicit Test

Accuracies usually are not very informative for lexical decision, because participants are very accurate about judging whether an item is a real English word. In the present sample, all individual subject accuracies were in the range of .91 to 1.00. The mean accuracies for words seen before (words read and words color named) were both .99, whereas the mean accuracy for new words was .98. This tiny difference was consistent across subjects and the variance was very small, so the result reached statistical significance, $F(2, 38) = 6.39$, $MSe = .000$, $p < .01$. Planned comparisons showed that decisions about the previously seen words were more accurate than those about the new words, $F(1, 19) = 10.60$, $MSe = .002$, $p < .01$, but that the two types of studied words displayed equivalent accuracy, $F < 1$.

The main data are the latency data. We excluded the nonword data from analysis, though they are shown in Fig. 2. The mean response times in lexical decision were significantly different for the three conditions involving words, $F(2, 38) = 13.33$, $MSe = 2433.04$, $p < .001$. Planned comparisons indicated that words encountered before (i.e., words either read or color named) were significantly faster than new words, $F(1, 19) = 25.02$, $MSe = 15302.77$, $p < .001$. Most critically, color named words and words read before did not differ from each other in decision time, $F < 1$.

Lexical decision is an implicit memory test in that repetition priming does not require awareness. Previous research has shown that priming as measured during an implicit memory test can occur even if the words have been studied at a shallow level (e.g., Jacoby & Dallas, 1981) or have been ignored (e.g., Parkin et al., 1990). The present results support and extend those findings. No apparent difference in response times was present for words read (i.e., attended) as compared to words color named (i.e., ignored) during initial encoding. Therefore, merely encountering the physical characteristics of the words can produce priming, and that priming can reach the same level as for a word intentionally processed.

DISCUSSION

The results of the lexical decision task support the notion that substantial priming occurs even if the word itself was ignored because another dimension of the stimulus was the focus of attention during encoding (Parkin et al., 1990; Roediger & McDermott, 1993). Furthermore, this is true on a speeded measure of priming, where conscious recollection is much less likely—or useful—than in accuracy measures. Simply being exposed to the physical characteristics of the word during encoding engages processing that can be accessed without requiring awareness later on. Indeed, our study provides no evidence that initial attention confers any benefit on subsequent implicit memory performance.

Without question, though, the initial encoding of an unattended word is much more difficult to access consciously later on than is the encoding of an attended word, as the results from our explicit recognition test show (Gardiner & Parkin, 1990; Parkin & Russo, 1990; Parkin et al., 1990). In the present experiment, explicit retrieval was much more probable if the word was attended to (i.e., read) during study: The ability to consciously retrieve a word dropped considerably when that word was color named and hence not directly attended to during the study task.

The experiment reported here is, in a sense, the inverse of a recent series of experiments reported by MacLeod (in press). In those experiments, participants studied a list of words and then performed two speeded implicit tasks in which half of the words were studied and half were new. There was no evidence of priming on the color naming task, despite clear facilitation for studied words on the word reading (naming) task. How do these two sets of results fit together? It appears from our study that some attention is paid to the word when people color name at study, and this is sufficient to prime a word-directed implicit test like lexical decision. However, directing attention to the word at study, as in the MacLeod (in press) study, does not result in priming on a later implicit color naming task, where attention is directed away from the word. Attentional specificity appears to be crucial on these sorts of implicit measures of memory.

The goal of examining the role of initial attention in performance on subsequent explicit and implicit tests of memory has been achieved. This experiment helps us to understand how attention affects different memory situations. Put simply, focal attention to a word seems to be crucial for remembering explicitly. However, focal attention does not seem critical for remembering when measured by an implicit test of memory such as lexical decision. Even words that were processed only in the course of being ignored during a color naming task produced priming at the same level as words that were intentionally read. Explicit remembering requires a reasonable degree of initial attention, as Wood and Cowan (1995) have recently argued. In contrast, even minimal attention at the time of encoding seems to be sufficient to result in substantial priming during implicit remembering. Clearly, then, implicit and explicit remembering dissociate with respect to attention, adding further force to what has become a pivotal distinction in the memory literature.

APPENDIX A: STIMULI USED IN THE EXPERIMENT

Words

Agency anchor arctic author avenue barley basket beauty beetle bottle branch breeze bridge buffet camera candle carpet castle cattle cereal collar column comedy copper corner cotton degree dinner doctor dollar drawer editor energy engine estate excuse fabric figure flavor flight forest friend gallon gamble garden grease hammer handle harbor helmet hermit infant island jacket jungle kettle kitten ladder lawyer letter liquor lumber market meadow meteor minute mirror museum napkin nephew nickel office orange oxygen parcel pencil picnic pillow planet pocket puzzle rabbit recipe record ribbon rubber saddle sailor school screen shield shower singer spash spring square street studio supper tablet tennis throne ticket tunnel turtle valley violin walnut.

Nonwords (Lexical decision only)

akenry anoher artloc aupher alenee borgey balkey betumy belome betese bronek bronke bliden bulfot cemeka conzle corpot cestel catloe coreke crelak calune cemeky cappor cotene colten dogele diener doyter dulkar drower edytow enorge eginke eltake exlume fagril foguke flaver flogen furelt fieked golgen gimbel gafden gleame homter hondee horber hilmut harmut imfont infome jalkot jemgen katefe kiltan lodfer lafyor lotyer loquer lambir merfet mekiwe mateor monune merfar mosoum nafkon nopfew nolkel olfoce oganfe ogagen pornel ponwil pinnoc palliw pfanot polkot pozule robbut redife racond rofene robner sodele spilke sunyol safeme silund shawer sanfer sparsu simege slunge sprest sudifo sunpar toblyt temnif thyome tilkst tonfel torble vanlay vinlon wolnet.

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