

Separating Conscious and Unconscious Influences of Memory: Measuring Recollection

Larry L. Jacoby, Jeffrey P. Toth, and Andrew P. Yonelinas

How can conscious and unconscious influences of memory be measured? In this article, a process-dissociation procedure (L. L. Jacoby, 1991) was used to separate automatic (unconscious) and consciously controlled influences within a task. For recall cued with word stems, automatic influences of memory (a) remained invariant across manipulations of attention that substantially reduced conscious recollection and (b) were highly dependent on perceptual similarity from study to test. Comparisons with results obtained through an indirect test show the advantages of the process-dissociation procedure as a means of measuring unconscious influences. The measure of recollection derived from this procedure is superior to measures gained from classic test theory and signal-detection theory. The process-dissociation procedure combines assumptions from these 2 traditional approaches to measuring memory.

Dissociations between performance on direct and indirect tests of memory supply examples of effects of the past in the absence of remembering (for reviews, see Hintzman, 1990; Richardson-Klavehn & Bjork, 1988). In an indirect test, subjects are not asked to report on memory for an event as they would be in a direct test, such as in a test of recognition or recall; rather, they engage in some task that can indirectly reflect memory for the occurrence of that event. Word stem- and fragment-completion tasks are among the most popular indirect tests of memory (e.g., Graf & Mandler, 1984; Tulving, Schacter & Stark, 1982; Warrington & Weiskrantz, 1974). For a stem-completion task, subjects might read the word *scalp* and then be presented with the stem *sca*— with instructions to complete that stem with the first word that comes to mind. Evidence of automatic influences of memory that are dissociated from performance on a direct test is provided by the finding that prior presentation of a word increases the likelihood of that word being used to complete a stem, even though a direct test reveals no memory for the prior presentation of the word. Some of the most striking examples of dissociations come from the performance of patients suffering a neurological deficit. Korsakoff amnesics, for example, show near-normal effects of memory in their performance of a stem-completion task, even though

their performance on direct tests of memory is severely impaired (for a review, see Shimamura, 1986).

Dissociations have been interpreted as evidence for the existence of anatomically distinct memory systems (e.g., Squire & Zola-Morgan, 1988; Tulving & Schacter, 1990). Performance on direct tests is said to rely primarily on an explicit/declarative memory system that is affected in amnesia, whereas performance on indirect tests relies primarily on an implicit/nondeclarative memory system that is intact in amnesia. Other researchers have argued against the necessity of postulating separate memory systems, instead, they have explained memory dissociations as reflecting differences in the types of processing required by direct and indirect tests. For example, Roediger (1990; Roediger, Weldon, & Challis, 1989) advanced a transfer-appropriate-processing view by arguing that memory dissociations reflect differences in the extent to which direct and indirect tests rely on data-driven versus conceptually driven processing.

In this article, we do not enter into the debate over the necessity of postulating multiple memory systems to account for task dissociations. Rather, we question the practice of identifying processes with tasks as is done when interpreting task dissociations from either a multiple-memory-systems perspective or from a transfer-appropriate-processing perspective. Many researchers who are against this practice have noted that performance on indirect tests is often contaminated by intentional uses of memory (e.g., Jacoby, 1991; Reingold & Merikle, 1990; Richardson-Klavehn & Bjork, 1988). For example, in the stem-completion task, subjects may sometimes intentionally use memory for words presented earlier to complete stems. That is, the processes underlying performance on an indirect test of stem completion are sometimes the same as those underlying performance on a direct test of recall cued with word stems. The possibility of contamination of this sort produces problems for interpreting performance on indirect tests. The severity of those problems is illustrated by the controversy surrounding claimed demonstrations of unconscious perception. Some researchers have dismissed effects on indirect tests of perception as evidence of unconscious perception by arguing that

Larry L. Jacoby, Jeffrey P. Toth, and Andrew P. Yonelinas, Department of Psychology, McMaster University, Hamilton, Ontario, Canada.

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Correspondence concerning this article should be addressed to Larry L. Jacoby, Department of Psychology, McMaster University, Hamilton, Ontario, Canada L8S 4K1. Electronic mail may be sent to jacobyl@mcmaster.ca.

those effects arise from the contamination of performance by aware perception (e.g., Holender, 1986, and accompanying commentaries). The same arguments apply to interpreting performance on indirect tests of memory.

In this article, we turn the tables on those who have appealed to the possibility of contamination of performance on indirect tests to argue against the existence of unconscious influences. These critics have generally taken performance on direct tests at face value while questioning the source of effects on performance of indirect tests (e.g., Holender, 1986). We grant that performance on indirect tests is sometimes contaminated by intentional use of memory. However, we focus on the converse case: the contamination of performance on a direct test by unconscious, or automatic, influences of memory. We show that reliance on standard means of measuring recollection leads to serious errors in conclusions that are drawn. For example, because of failure to take unconscious influences of memory into account, standard procedures can greatly overestimate the probability of recollection. This is particularly problematic when measuring the ability of memory-impaired people to engage in recollection.

Standard Procedures for Measuring Recollection

How should one measure an amnesic's ability to recollect memory for a prior experience? Suppose one attempted to do so by using the direct test of presenting word stems as cues for recall of words studied earlier. Amnesics' performance on tests of recall cued with word stems or with fragments is nearly as good as that of subjects with normally functioning memory (e.g., Graf, Squire, & Mandler, 1984). Indeed, H. M., a famous amnesic, showed a level of recall cued with fragments that was above that of control subjects (Gabrieli, Milberg, Keane, & Corkin, 1990). Does this high level of performance mean that amnesic's ability to recollect a prior event is normal in some situations? An argument of this sort was made by Warrington and Weiskrantz (1974), who suggested that amnesia results from a deficit in retrieval processes that is marked by extreme susceptibility to interference. Warrington and Weiskrantz invented word and picture fragment-completion tasks as a means of providing sufficient cues to minimize interference and showed that with these tasks, amnesics' ability to remember is near that of people with normal memory.

Alternatively, amnesics may achieve their high level of performance by some means other than recollection. If asked, amnesics will claim not to remember that a list of words was presented earlier and will attribute any success recalling those words to guessing. That is, amnesics will claim to have completed word stems with the first word that came to mind without being aware that their completions were the words that they were instructed to recall. Indeed, amnesics' cued-recall performance does not differ greatly from what would be observed if they were given an indirect test of memory by being instructed to complete stems with the first word that came to mind (Graf et al., 1984). Automatic influences of memory may increase the probability of correct guessing on tests of cued recall. Such "informed guessing" would inflate

estimates of recollection and may sometimes be largely responsible for accurate memory reports produced by amnesics (e.g., Gabrieli et al., 1990).

Many experiments comparing performance on direct and indirect tests do not provide a measure of guessing for performance on the direct test (e.g., Graf & Mandler, 1984). In contrast, Weldon, Roediger, and Challis (1989) examined the influence of guessing by testing with fragments that could not be completed with any of the words presented earlier. Although instructed to produce only studied words, subjects sometimes produced false recalls by completing those baseline fragments, "recalling" words that were not presented earlier. To correct the probability of cued recall for guessing, Weldon et al. (1989) subtracted the probability of false recall from the probability of correct recall. Light and Singh (1987) used the same procedure for recall cued with word stems. That means of correcting for guessing is based on the assumption that prior presentation of a word contributes only to its later recollection, not to the probability of guessing with an old word. However, to the extent that stem-completion performance is affected by automatic influences of memory (i.e., informed guessing), performance on stems that can only be completed with new words underestimates the true probability of guessing, and so subtracting false recalls from correct recalls overestimates the probability of recollection.

Using Opposition to Measure Recollection

Performance on tests of cued recall overestimates the probability of recollection because both informed guessing and recollection serve as bases for correct responding. A more conservative means of measuring recollection would be to place the two bases of responding in opposition. In the experiments reported here, we did so by instructing subjects to complete stems with words that were not presented earlier. If subjects were given this instruction, the automatic influence of memory would still be to make old words more likely than new words to be given as completions. However, recollection would oppose that effect by serving to exclude words presented earlier. The probability of recollection could be measured as the difference between responding with old and new words: To the extent that recollection is possible, subjects will be less likely to respond with an old word than with a new word. However, the measure underestimates the true probability of recollection because of the opposing effects of automatic influences of memory.

Although the opposition of consciously controlled processes with automatic processes does not provide a pure measure of recollection, it can be used as a methodological tool to identify factors which selectively influence the two forms of processing. For example, it has been argued that attention to an event is required for later intentional use of memory but not for automatic or unconscious influences of memory (Dixon, 1981; Eich, 1984; Grand & Segal, 1966; Koriat & Feuerstein, 1976; Parkin, Reid, & Russo, 1990). In a series of false-fame experiments (Jacoby, Woloshyn, & Kelley, 1989), automatic and intentional influences of memory were set in opposition so as to better examine differential effects of dividing attention.

In the first phase of one of those experiments (Jacoby et al., 1989, Experiment 2), subjects read a list of nonfamous names under conditions of either full or divided attention. Those names were then mixed with new famous and new nonfamous names and presented for a test of fame judgments. Subjects were correctly informed that all of the names they had read in the list were nonfamous, so if they recognized a name on the fame test as one from the first list, they could be certain that the name was nonfamous. Thus, conscious recollection of a name from the list opposed the increase in familiarity the name gained from being read on the list.

Results showed that when full attention was given to the reading of names, old nonfamous names were less likely to mistakenly be identified as famous than were new nonfamous names. In this case, subjects could recollect that old nonfamous names were read earlier and, consequently, were able to be certain that those names were nonfamous. In contrast, subjects who read the names with divided attention were far less likely to recognize a name as one they had studied, and so they were more likely to mistakenly identify old nonfamous names as famous than new nonfamous names. The increase in the probability of calling a name famous must be a result of an automatic influence of memory, because intentional use of memory would produce an opposite effect.

In Experiment 1, we manipulated attention during the study presentation of words in an attempt to produce an effect on stem-completion performance that parallels the false-fame effect. Dividing attention during study was expected to reduce later recollection and make it more likely that, counter to instructions, subjects would complete stems with old words. If subjects were given instructions to exclude old words, any increase in the probability of completing a stem with a particular word that is produced by its prior presentation must originate from automatic (unconscious) influences of memory, because consciously controlled processes (recollection) would produce an opposite result.

The Process-Dissociation Procedure

Because of automatic influences of memory, it is likely that the probability of recollection is overestimated by cued-recall performance and is underestimated by performance on a test for which subjects are instructed to exclude old words as completions. In our study, we use the process-dissociation procedure (Jacoby, 1991) to combine results from the exclusion and inclusion tests so as to gain a more accurate measure of recollection. For the process-dissociation procedure, we use a commonsense approach of measuring intentional control (recollection) as the difference between performance when one is *trying to* as compared with *trying not to* engage in some act. If one is as likely to do something when trying not to do it as when trying to do it, clearly one has no control. We illustrate the process-dissociation procedure by considering the stem-completion task.

Suppose that for an inclusion test subjects were instructed to complete stems with recalled words or, if they could not do so, to complete stems with the first word that came to

mind. Furthermore, suppose that for an exclusion test subjects were instructed to complete stems with words that were not presented earlier. If recollection were perfect, subjects would always complete stems with old words for the inclusion test and never complete stems with old words for the exclusion test; that is, responding would be under complete intentional control. At the other extreme, an amnesic who was fully incapable of recollection would show complete lack of intentional control by being as likely to respond with an old word when trying not to (exclusion test) as when trying to (inclusion test). Although showing no controlled (intentional) use of memory, the amnesic might still show automatic influences of memory by being more likely to complete stems with old words than with new words for both the exclusion test and the inclusion test. Manipulations such as dividing attention during the study presentation of words might produce a pattern of results for subjects with normal memory that is similar to that described for amnesics.

Translating these arguments into a set of simple equations that describe performance in the inclusion and exclusion test conditions provides a means of estimating the separate contributions of recollection and automatic influences. Stated formally, the probability of responding with a studied word in the inclusion test condition is the probability of recollection (R) plus the probability of the word automatically coming to mind (A) when there is a failure of recollection, $A(1 - R)$:

$$\text{Inclusion} = R + A(1 - R). \quad (1)$$

For the exclusion test, a studied word will be produced only when it automatically comes to mind and there is a failure to recollect that it was presented earlier:

$$\text{Exclusion} = A(1 - R). \quad (2)$$

The probability of recollection can be estimated as the probability of responding with a studied word in the inclusion condition minus the probability of responding with a studied word in the exclusion condition:

$$R = \text{Inclusion} - \text{Exclusion}. \quad (3)$$

Once an estimate of conscious recollection has been obtained, unconscious (or automatic) influences can be estimated by simple algebra:

$$A = \text{Exclusion} / (1 - R). \quad (4)$$

The use of Equation 4 to estimate the probability of an old word originating from an automatic basis of responding results in an estimate that reflects both automatic influences of memory (M) and the baseline probability of completing a stem with a particular word (B). We assume that these two effects are additive:

$$A = M + B. \quad (5)$$

Given this assumption, one can estimate automatic influences of the study experience by subtracting baseline from the estimate of A gained by the use of Equation 4. The probability of using a particular word as a completion for a stem

when that word was not presented for study serves as a baseline against which the effects of prior presentation can be assessed. An assumption made when using these equations is that the criterion for responding is the same for inclusion and exclusion tests. One can check the validity of that assumption by comparing baseline performance for the two test conditions.

The rationale for subtracting baseline is the same as that for subtracting baseline from performance for old items on an indirect test of memory so as to measure priming (e.g., Weldon et al., 1989). However, because we assume that recollection serves as a basis for responding that is separate from automatic influences, we subtract baseline from the estimate of A rather than from overall performance. As discussed later, an alternative approach would be to apply signal-detection theory (Swets, Tanner, & Birdsall, 1961) to describe automatic influences of memory. For the experiments reported here, the choice between approaches does not influence the conclusions drawn. This is true because for the comparisons that are of greatest interest, baselines do not differ across conditions. Consequently, subtracting baseline amounts to subtracting a constant and will not change the pattern of results, nor would the application of signal-detection theory.

We call this approach the *process-dissociation procedure* because we are looking for factors that produce dissociations in their effects on the estimates of the different types of processes. It is important to us that we find such dissociations. One of the strongest assumptions underlying the procedure is that automatic and intentional uses of memory are independent. If this assumption is valid, then we should be able to identify factors that have large influences on one process but leave the other process unchanged. The strategy is analogous to that used by proponents of signal-detection theory to justify the assumed independence of discriminability and bias. For signal-detection theory, if discriminability and bias are independent, it should be possible to vary bias and leave d' (the estimate of discriminability) unchanged, or vice versa (e.g., Snodgrass & Corwin, 1988). For our approach, dividing attention might produce such differential effects. As suggested earlier, divided, as compared with full, attention to the study presentation of words would be expected to reduce the later probability of recollection. In contrast, automatic influences of memory might be left invariant. A process dissociation of that form would provide strong support for our assumption of independence of automatic and intentional influences. Experiments 1a and 1b were done to determine whether dividing attention during study produces a process dissociation of this sort.

In the General Discussion, we further consider the assumptions underlying the process-dissociation procedure as well as its general applicability. The procedure is as important for measuring automatic influences as it is for measuring recollection. Estimating the separate contributions of automatic influences and consciously controlled use of memory within the confines of a single task holds important advantages over identifying different processes with different tasks as is done in the use of the indirect-direct test distinction (Jacoby, 1991; Jacoby & Kelley, 1991). When reporting the particular experiments, we compare conclusions drawn about auto-

matic influences based on the use of the process-dissociation procedure with conclusions based on the use of indirect tests of memory.

Experiments 1a and 1b

Experiments 1a and 1b used the process-dissociation procedure to examine differential effects of dividing attention on recollection and automatic influences as bases for stem-completion performance. Dividing attention during the presentation of an item was expected to reduce later recollection but leave automatic influences unchanged, thereby providing support for the assumption that the two bases for responding are independent. The two experiments differed only in the materials that were used. The word lists and word stems were such that target words were more likely to be given as completions in Experiment 1b than in Experiment 1a. That is, the stems used in the two experiments differed in their base rate for completion. Comparison of results across the two experiments allows us to check the validity of our assumption that automatic influences of memory are additive with base rate. If this assumption is valid, the difference between estimated automatic influences for studied items and base rate should be constant across the between-experiments manipulation of base rate.

In the first phase of both experiments, subjects were instructed to remember a list of aurally presented words. The manipulation of attention was in Phase 2 and was centered on the visual presentation of a second list of words. Subjects in a full-attention condition were told to read the words aloud and remember them for a later test of memory. Subjects in the divided-attention condition read aloud the same list of words while simultaneously engaging in a listening task. For the listening task, a long series of numbers was presented, and subjects were to indicate when they heard a target sequence of three consecutive odd numbers (Craik, 1982). Subjects were told that the task of reading words aloud was designed to interfere with performance on the listening task; no mention was made of the fact that subjects' memory for the read words would be tested later. Inclusion and exclusion tests of the sort described earlier were given in Phase 3 of the experiments.

By confounding divided attention with the absence of instructions to remember, we hoped to fully eliminate the possibility of later recollection in the divided-attention condition so as to mimic results one would expect to be produced by total amnesia. Accomplishing this goal would allow us to compare the measure of recollection provided by the process-dissociation procedure with standard measures of recollection. A dramatic result would be a finding of zero recollection as measured by the process-dissociation procedure along with a level of automatic influences that was the same as that in the full-attention condition. In contrast, the use of standard measures of memory would mistakenly show recollection to be above zero because the standard measures failed to take automatic influences of memory into account.

Differential effects of dividing attention during study were of primary interest in the experiments. The manipulation of attention involved only the read words. The auditory input

list presented in Phase 1 was included to allow a preliminary assessment of the effects of modality of presentation on later consciously controlled and automatic uses of memory. The assessment is only preliminary because modality of presentation was confounded with delay between study and test. On the basis of the results of experiments using indirect tests (e.g., Jacoby & Dallas, 1981), we expected automatic influences of memory to be largely modality specific. Because the test was a visual one, we expected reading a word at study to produce larger automatic influences than hearing a word. Effects of variation in the physical details of the previously presented words were further investigated in Experiments 2–4.

Method

Subjects and design. Thirty-six subjects participated in each of the two experiments in return for credit in introductory psychology courses. In each experiment, half of the subjects were randomly assigned to either the full- or divided-attention condition manipulated during study of the visually presented words. Word stems presented at test corresponded to words that were read earlier, words that were heard earlier, and words that had not been presented (new words). Two different-colored word stems were used to indicate the required test response: Green stems indicated an inclusion response, whereas red stems indicated an exclusion response (see later).

Materials. Words used in Experiment 1a comprised a pool of 116 five-letter nouns of low, medium, and high frequency as indexed by Thorndike and Lorge (1944). Seventy-two of these words were divided into three sets of 24 words, which were rotated through each of the three experimental conditions: words to be heard, words to be read, and new words. Each of these sets was further divided into two sets of 12 words each, one set to be tested in the inclusion condition and the other set to be tested in the exclusion condition. Each set had an equal distribution of both word frequency and the probability of completing the corresponding stems when new. To avoid primacy and recency effects, we presented five items at the beginning and end of both the heard and read lists. These buffer items stayed constant across all formats.

The test list contained three-letter stems corresponding to the 24 heard words, 24 read words, and 24 new words. In addition, the test contained 24 stems corresponding to filler items; these items were used to equate the number of stems corresponding to old and new items and were not included in the analysis. Each of the three-letter word stems used at test was unique within the experiment but not within the language; that is, each stem could be completed with more than one five-letter word (e.g., mer—: mercy, merit, merge, and merry). For each word type (i.e., read, heard, and new), half of the stems were presented in green, and half were presented in red. Five practice items were added to the beginning of the test list (four previously presented buffers and one new item). In all phases of the experiment, order of presentation was random with the restriction that not more than three items representing the same combination of conditions could be presented in a row, and all conditions were presented evenly throughout the list.

The listening task used in the divided attention condition was one previously used by Craik (1982). In this task, subjects monitored a tape-recorded list of digits to detect target sequences of three odd numbers in a row (e.g., 9, 3, 7). The digits were random with the exception that a minimum of one number and a maximum of five numbers occurred between the end of one target sequence and the beginning of the next target sequence. Digits were recorded at a 1.5-s rate.

The materials and list-construction criteria for Experiment 1b were the same as those for Experiment 1a, except for the following changes. First, the items were selected to have a higher average completion rate when new. On the basis of previous studies, the average completion rate was 30%. Second, the number of items studied and tested was increased. Study lists (read and heard) were increased to 32 items; the test list contained three-letter stems corresponding to these 64 critical items plus 32 new stems and 32 filler stems.

Procedure. Words were presented and responses were collected on a PC-compatible computer interfaced with a color monitor. The character size of the stimuli was approximately 3×5 mm. Words were presented in lowercase letters in the center of the screen.

In the first phase of each experiment, subjects heard a list of words, recorded at a 2-s rate, and were instructed to repeat the words aloud and remember them for a later memory test. In the second phase, subjects saw a list of words on the computer screen. Each word appeared for 1.5 s, followed by 0.5 s of blank screen. Words were presented in white letters on a black background. The subjects in the full-attention condition were instructed to read the words aloud and to try to remember them for a later memory test. Subjects in the divided-attention condition were told that they were to do two tasks at once: a listening task and a reading task. They were informed that it was very important not to miss a target sequence in the listening task. Subjects responded by pressing a key whenever they detected a target sequence. They were informed that while doing the listening task they would be presented with a list of words, one at a time, on the computer screen. They were to read each word aloud but not to let this disrupt their performance on the listening task.

In the final phase of the experiment, word stems were presented, one at a time, as the initial three letters of a word followed by two dashes. Word stems appeared in either green or red and were randomly presented. Subjects were told that if the stem appeared in green, they were to use it as a cue to help them remember a word that was presented earlier in the experiment (either read or heard). If they could not think of an old word, they were to complete the stem with the first word that came to mind. Subjects were told to also use red stems as a cue for remembering words presented earlier but that they were to complete those stems with a word that was not presented earlier in the experiment. No proper names or plurals were allowed as completions for the stems. If the subject's response met these criteria, the experimenter pressed a key to remove the word stem from the screen and then pressed another key to present the next word stem. Otherwise, subjects were informed of their error and were told to attempt to give a satisfactory completion for the word stem. In Experiment 1a, subjects were allowed a maximum of 20 s to complete each stem but could say "pass" at any time during the 20 s if they felt they could not complete the stem. In Experiment 1b, the response deadline was reduced to 15 s, and the option of passing was not provided. If the word stem had not been completed after the allotted time, a beep sounded, and the experimenter initiated the next trial.

The significance level for all tests was set at $p < .05$. Tests revealing significant main effects are not reported when variables producing those main effects entered into significant interactions.

Results and Discussion

In the divided-attention condition, the probabilities of failing to detect a target sequence for the listening task were .17 in Experiment 1a and .15 in Experiment 1b. For Experiment 1a, completion rates for stems corresponding to new words

in the inclusion and exclusion tests were .14 and .14 in the full-attention condition, and .10 and .17 in the divided-attention condition. The corresponding probabilities for Experiment 1b were .37, .35, .31, and .35. For both experiments, analyses revealed that differences among base rates did not approach significance, providing support for our assumption that the criterion for responding did not change across conditions. Consequently, scores were collapsed across the test and across attentional manipulations to yield base rate values of .14 for Experiment 1a and .35 for Experiment 1b.

Proportion of stems completed with old words. Table 1 presents the proportion of stems completed with old words under each experimental condition. The three-way interaction (Test \times Attention \times Modality) was significant in both experiments, $F(1, 34) = 4.171$, $MS_e = .016$, for Experiment 1a, and $F(1, 34) = 5.889$, $MS_e = .012$, for Experiment 1b. Manipulation of full versus divided attention did not affect the probability of heard words being given as completions; this was expected because attention was not manipulated for the heard words. In contrast, dividing attention decreased the probability of completing a stem with a read word in the inclusion condition and increased the probability of using a read word in the exclusion condition. This pattern of results provides evidence that conscious recollection of read words was greatly reduced under conditions of divided attention.

Measuring recollection: A process dissociation produced by dividing attention. The inclusion test corresponds to a standard test of cued recall with instructions to guess when recollection fails. Subtracting base rate from the probability of recalling old words for the inclusion test would lead to the conclusion that dividing attention during study produced a low but nonzero probability of recollection (.13 in Experiment 1a and .11 in Experiment 1b). In contrast, use of the process-dissociation procedure shows that the probability of recollection was truly zero for the divided-attention condition; the probability of responding with an old word was the same whether subjects were trying to (inclusion test) or trying not to (exclusion test) respond with old words. The effects of memory that remained in the divided-attention condition originated from automatic influences. These remaining effects of memory reflect an automatic influence because the effects were the same regardless of whether an exclusion or

an inclusion test was given; that is, subjects did not show the selectivity of responding that would be supported by true recollection.

In the process-dissociation procedure, the probability of recollection is estimated by subtracting the probability of completing a stem with an old word in the exclusion condition from that of completing a stem with an old word in the inclusion condition. As shown in Table 2, divided, as compared with full, attention during study reduced the probability of later recollection in both Experiments 1a and 1b, $F_s(1, 34) = 6.92$, and 13.98 , $MS_e = .045$ and $.040$, respectively. For both experiments, the probability of recollection in the divided-attention condition was zero.

Dividing attention during study was expected to reduce the probability of recollection but leave automatic influences invariant. A process dissociation of this sort would provide support for our assumption that automatic and intentional influences independently contribute to performance. The equations described earlier were used to estimate automatic influences for words that were read (see Table 2). An analysis of the estimates of automatic influences revealed that dividing attention had no effect on the automatic use of memory ($F_s < 1$, for both experiments). One problem with the estimates of automatic influences in Experiment 1a concerns the low completion rate. The equations are mathematically constrained such that a subject scoring perfectly in the exclusion condition (i.e., zero) will have an estimate of zero for the automatic component. The consequence of such floor effects is an underestimation of the overall automatic contribution to performance. Although this problem was directly addressed in Experiment 1b by using more easily completed stems, we recalculated the estimates of automatic influences for Experiment 1a by removing all zeros. This changed only the estimate of automatic influences for read items in the full-attention condition (see Table 2) and produced identical estimates across the attentional manipulation.

Did reading a word produce significant automatic influences of memory? To answer this question, we compared estimates of automatic influences for read words with new-item performance (base rate). The estimate of automatic influences for read words was higher than the baseline com-

Table 1
*Probability of Responding With an Old Word
In Experiments 1a and 1b*

| Attention | Read | | Heard | |
|---------------|-----------|-----------|-----------|-----------|
| | Inclusion | Exclusion | Inclusion | Exclusion |
| Experiment 1a | | | | |
| Full | .38 | .19 | .26 | .17 |
| Divided | .27 | .26 | .24 | .16 |
| Experiment 1b | | | | |
| Full | .61 | .36 | .47 | .34 |
| Divided | .46 | .46 | .42 | .37 |

Note. The base rate for Experiment 1a was .14 and for Experiment 1b, .35.

Table 2
*Estimates of Recollection and Automatic Influences
for Experiments 1a and 1b*

| Attention | Estimate | |
|---------------|--------------|------------------|
| | Recollection | Automatic |
| Experiment 1a | | |
| Full | .20 | .21 ^a |
| Divided | .00 | .27 |
| Experiment 1b | | |
| Full | .25 | .47 |
| Divided | .00 | .46 |

Note. The base rate for Experiment 1a was .14 and for Experiment 1b, .35.

^a The estimate of automatic influences for read items in the full-attention condition, after removing all zeros, was .27.

pletion rate in both Experiment 1a, $F(1, 34) = 18.969$, $MS_e = .009$, and Experiment 1b, $F(1, 34) = 31.331$, $MS_e = .009$.

In summary, dividing attention during study reduced the probability of recollection to zero but left automatic influences perfectly invariant. This dissociation strongly supports the assumption that unconscious influences are independent of a person's ability to engage in intentional use of memory. The effect of dividing attention is similar to what would be expected in amnesia (cf. Craik, 1982). For total amnesics, we would expect recollection to be absent ($R = 0$), and so the probability of their completing a stem with an old word should be the same in both the inclusion and the exclusion test conditions. Results consistent with this prediction have recently been obtained (Cermak, Verfaellie, Sweeney, & Jacoby, 1992).

Note that in the divided-attention condition subjects were required to read words aloud, making it impossible for them to totally ignore the presentation of those words. Allowing people to fully ignore presented words would likely result in a reduction of automatic influences as well as the loss of the possibility of later recollection. Conversely, had an easier secondary task been used, later recollection would probably not have been brought to a zero level. The finding of zero-level recollection is dramatic, but it is not essential for our purposes. By using the process-dissociation procedure, we showed that the standard procedure of correcting cued recall for guessing overestimates the probability of recollection because of its failure to take automatic influences into account. Our procedure makes it unnecessary to fully eliminate intentional uses of memory to examine those unconscious influences.

Some researchers might object that our inclusion test condition does not correspond to a standard test of cued recall but rather is a mix of a direct test and an indirect test. Furthermore, it might be claimed that had we used a more standard cued-recall test by instructing subjects to report only words that they were certain were old, we would have likely found that performance was near zero, showing that cued-recall performance does provide a good measure of recollection. However, instructing subjects not to guess cannot be relied on to eliminate guessing and thereby provide a pure measure of recollection. Guessing reflects the same types of processes as are involved in indirect tests, and so cued recall probably always reflects a mixture of the processes involved in direct and indirect tests. By encouraging guessing and using the process-dissociation procedure, we allow the effects of guessing to be better measured.

Transfer across modality. Estimates of recollection and of automatic influences were computed for words presented aurally in Phase 1. The probabilities of recollection were .09 in Experiment 1a and .10 in Experiment 1b. An analysis of the estimated probabilities for heard words did not reveal a significant effect of the manipulation of full versus divided attention in either of the two experiments. This is not surprising because attention was divided only during the presentation of read words.

Automatic influences for heard words in Experiment 1a (.18) and Experiment 1b (.39) were smaller than for read words, $F_s(1, 34) = 7.50$ and 7.56 , $MS_e = .009$ and $.015$, for

Experiments 1a and 1b, respectively. Estimated automatic influences for heard words were compared to the base rate in each of the experiments to assess the significance of cross-modality transfer. Estimated automatic influences were only slightly above base rate in both Experiment 1a (.18 vs. .14) and Experiment 1b (.39 vs. .35). The effect was just significant in Experiment 1a, $F(1, 34) = 4.07$, $MS_e = .006$, and was nonsignificant in Experiment 1b, $F(1, 34) = 3.00$, $MS_e = .101$.

Experiments using indirect tests such as perceptual identification and fragment completion have generally shown effects of changing modality between study and test. For visual word identification, reading a word substantially increases its later identification, whereas hearing a word can confer no advantage in later identification (Jacoby & Dallas, 1981). For visual stem- and fragment-completion performance, reading a word, more so than hearing a word earlier, increases the probability of the word later being given as a completion. However, words that were heard earlier are often found to enjoy a large advantage over new words (e.g., Graf, Shimamura, & Squire, 1985). In contrast, results from Experiment 1a and 1b showed that hearing a word earlier did little to produce automatic influences of memory; that is, automatic influences were almost totally modality specific.

Even the small benefit gained from hearing a word earlier can be explained as truly modality specific. Given a word stem as a cue, subjects might sometimes pronounce that stem, thereby, gaining access to memory of the previously heard word (Donaldson & Geneau, 1991). The significant transfer across modalities that is observed when indirect tests of memory are used might reflect the contamination of those tested by recollection. Experiments 3 and 4 provide evidence in favor of this possibility.

Invariance of automatic influences of memory across differences in base rate. In comparing across experiments, we find that the estimates of automatic influences are elevated in Experiment 1b; however, this is simply due to the fact that we increased the ease (i.e., base rate) of completion. Subtracting the base rate from the old item values gives estimates of automatic influences originating from the prior study experience: The estimates for the read words are virtually identical for the two experiments (.13 vs. .12), and the estimates for the heard words are identical (.04) across experiments.

The invariance of automatic influences of memory across base rates provides support for our assumption that the effects of study are additive with base rate. Although the procedure was not done in a systematic fashion, the differences in base rate were produced by varying the dominance of the target word as a completion for a stem and by varying the number of possible completions for stems. Nelson, Schreiber, and McEvoy (1992) reviewed a large number of experiments to show that the effects of the number of possible completions (set size) and the effects of the dominance of a completion (strength) are often independent of other factors, such as whether a direct or an indirect test of memory is given. Nelson et al. (1992) referred to the effects of set size and strength as reflecting *implicit memory*, although their use of the term is very different from the way other researchers have used it (e.g.,

Schacter, 1987). For example, Nelson et al. (1992) did not identify implicit memory with performance on an indirect test. In fact, their use of the term implicit memory seems to be closer to what we mean by "automatic" or "unconscious" influences of memory. Regardless, our finding that the effect of prior experience on automatic influences is independent of base rate is consistent with results reported by Nelson et al. (1992).

Experiment 2

The results of Experiments 1a and 1b showed that hearing a list of words produced little automatic influence on visual stem-completion performance. For the read items, it is also possible that changes in the physical form of the read items resulted in a decrease in automatic influences. In Experiments 1a and 1b, read words were presented at study in white against a black background; however, in order to cue the required test response, test stems were presented in either green or red. Experiment 2 directly manipulated color from study to test to assess the possibility that changes in this physical property reduced the contribution of automatic influences of memory in Experiments 1a and 1b.

Method

Subjects and design. Eighteen subjects participated in return for credit in introductory psychology courses. At study, subjects read a list of words, half of which were displayed in green, the other half in red. At test, green word stems and red word stems were presented that corresponded to words read earlier and words that had not been presented (new words). For read items, half of the stems were presented in the same color as that used at study (matched condition), whereas the other half were presented in the other color (mismatched condition). As in Experiments 1a and 1b, the different-colored word stems also served to indicate the required test response: Green stems indicated an inclusion response, whereas red stems indicated an exclusion response.

Materials and procedure. The materials and procedure were the same as those used in Experiment 1b, with the exception that attention was not manipulated and items were presented at study in red or green, intermixed within the study list. There were 96 critical words, which were separated into three sets of 32. These sets were rotated through conditions such that each set served an equal number of times as studied-in-green, studied-in-red, or not studied (i.e., new). Words within a set were also rotated such that each word served an equal number of times in the matched (e.g., studied-in-red and exclusion test) and mismatched conditions (e.g., studied-in-red and inclusion tests). Study lists contained 74 words: 32 presented in green, 32 presented in red, and 5 primacy and 5 recency buffers presented in green and red. Test lists contained 128 stems corresponding to the 64 studied words, 32 new words, and 32 fillers. For stems corresponding to study items, half matched the color used at study, whereas the other half did not match. All words and stems were presented in lowercase under conditions of full attention.

Results and Discussion

Proportion of stems completed. In the inclusion condition, completion performance on matched (i.e., same color) and mismatched stems was .63 and .62, respectively; the

corresponding values in the exclusion condition were .39 and .40, respectively. An analysis of the studied items revealed only a main effect of test, $F(1, 17) = 24.54$, $MS_e = .040$. New item performance was identical in the inclusion and exclusion conditions (.32).

Separating controlled and automatic influences. Because performance in the inclusion and exclusion conditions was nearly identical for matched and mismatched stems, estimates of recollection and automatic influences were also nearly identical (for recollection: matched = .24, mismatched = .22; for automatic influences: matched = .51, mismatched = .52). Obviously, a mismatch in color from study to test had no impact on performance. However, to facilitate comparisons with the other experiments, estimates of recollection and automatic influences are presented in Table 3 and are collapsed across the color manipulation.

Logan (1991) has presented evidence suggesting that changes in stimulus color may have small influences on automatic processes but only after a large number of presentations (e.g., the same word in the same color for 16 trials); after a single presentation, a change in color had no effect. This finding and the results of Experiment 2 are sufficient to convince us that the color change in Experiments 1a and 1b had no appreciable effect on automatic influences of memory. In Experiments 3 and 4, we investigated the issue of perceptual specificity more directly by manipulating the visual form in which studied items were presented.

Experiments 3 and 4

Experiments 1a and 1b showed that measuring memory by performance on a direct test can overestimate recollection. The next case we consider shows an even more serious error in conclusions that can result from reliance on such standard procedures. A manipulation can have effects on recollection that are fully offset by its opposite effect on automatic uses of memory. If given such offsetting effects, reliance on standard procedures for measuring memory can lead to the mistaken conclusion that the manipulation had no effect.

One of the most general conclusions to come from research using indirect measures of memory is that these measures are very sensitive to changes in perceptual characteristics from study to test. For example, presenting words in their normal form to be read does more to enhance their later perceptual identification than would presenting the words as anagrams to be solved (Allen & Jacoby, 1990). Results of this sort have

Table 3
Estimates of Recollection and Automatic Influences for Experiments 2, 3, and 4

| Experiment | Recollection | | Automatic | | New |
|------------|--------------|---------|-----------|---------|-----|
| | Read | Anagram | Read | Anagram | |
| 2 | .24 | — | .52 | — | .32 |
| 3 | .33 | .57 | .73 | .59 | .56 |
| 4 | .31 | .45 | .32 | .16 | .23 |

Note. Base rates did not differ across test conditions and were collapsed over this factor.

led researchers to propose that indirect tests such as word identification and stem completion are predominantly data driven (Jacoby, 1983; Roediger, et al., 1989) or mediated by modality-specific representations (Kirsner & Dunn, 1985; Kirsner, Milech, & Standen, 1983). The read/anagram manipulation has an effect on recognition memory performance that is opposite to that on perceptual identification performance (Allen & Jacoby, 1990). The recognition advantage for anagram solutions serves as an example of findings that words generated in response to questions are better remembered on direct tests than are words that were simply read (e.g., Slamecka & Graf, 1978; Jacoby, 1978).

Consider predictions that would be made for the effect of the read/anagram manipulation on recall cued with word stems. Results from experiments using direct tests lead to the prediction that words presented as anagrams would hold an advantage in cued recall over words that were read. However, to the extent that subjects guess and those guesses reflect automatic influences, results from experiments using indirect tests predict that words that were read would hold an advantage over words presented as anagrams. Because of the opposite effect on automatic influences, the advantage for recollection of anagrams over read words is likely underestimated by cued-recall performance. Indeed, the two effects might fully offset one another so that the read/anagram manipulation produces no difference in cued-recall performance.

In Experiments 3 and 4, subjects were presented with a list that contained both words to be read and anagrams to be solved. Memory for these words was then tested using word stems under both inclusion and exclusion instructions. Given the results for cross-modality transfer from Experiments 1a and 1b, we expected read words, but not anagrams, to produce automatic facilitation in stem-completion performance. Opposite to the effect on automatic influences, we expected better recollection of words presented as anagrams than words that were read.

Our prediction for automatic influences contrasts with results reported by Jacoby (1991). Jacoby (1991) used the process-dissociation procedure to separate recollection and familiarity (an automatic influence of memory) as bases for recognition-memory judgments. He found that words presented as anagrams held an advantage over words that were read in both recollection and familiarity. In contrast, we expected better recollection but less automatic facilitation for anagrams than for read words in stem completion. The reason for expecting greater specificity of automatic influences for stem completion than for recognition relates to the difference in cues for retrieval provided by the two sets. Stem completion is more likely to be reliant on perceptual cues (data-driven processing) than is recognition memory (cf. Allen & Jacoby, 1990).

Another issue addressed in Experiments 3 and 4 concerns the adequacy of using indirect tests as measures of unconscious, or automatic, influences. In each of the experiments, we compare performance on an indirect test to that obtained from an inclusion test condition. We show that performance in those test conditions is very similar; however, reliance on indirect tests would lead to conclusions that are different

from those drawn using the process-dissociation procedure. Experiments 3 and 4 can also be viewed as extending the generality of the process-dissociation procedure. In Experiments 1 and 2, test instructions (i.e., inclusion and exclusion) were manipulated within subjects, and cues for these instructions occurred randomly within a single memory test. In Experiment 3, test instructions were also manipulated within subjects, but the two test conditions were blocked such that subjects completed the inclusion test before being given the exclusion test. In Experiment 4, test instructions were manipulated between subjects to avoid any possibility that within-subject designs result in across-test interference. Finally, to extend the generality of our findings, Experiment 3 used single-completion stems, whereas Experiment 4 used multiple-completion stems.

Experiment 3

Method

Subjects and design. Forty-eight subjects participated in return for credit in introductory psychology courses. Twenty-four subjects were randomly assigned to complete stems under indirect test instructions. The remaining subjects completed stems under both inclusion and exclusion test instructions. Word stems presented at test corresponded to words that were presented earlier as anagrams to be solved, words that were read earlier, and words that had not been presented.

Materials. A pool of 128 five-letter nouns, selected as in the previous experiments, served as the stimuli. Seventy-two of the words with single-completion stems were selected as critical items. These words were divided into three sets of 24 words each such that each set represented one of three experimental conditions: words to be solved (anagrams), words to be read, and new words. Each of these sets was further divided into two sets of 12 words each, one set for the first test list and one set for the second test list. Each set had equal distributions of probabilities for solving the anagrams and for completing the stems when new, which had been calculated with data from previous experiments.

The study lists contained 80 items: 40 words to be read and 40 anagrams to be solved, with 24 of each group being critical items and 16 of each group being primacy and recency buffers. The buffers stayed constant across all formats. Three different study lists were constructed by rotating the critical words through the three experimental conditions (anagram, read, and new) such that, across formats, each word presented each condition equally often. Words were presented as anagrams, with the second and fourth letters in their proper positions and underlined (e.g., pamle, maple). The remaining letters in a word presented as an anagram were randomly rearranged. Constraining the order of the letters made the anagrams easier to solve and, more important, gave each anagram only one solution.

The two test lists consisted of 48 items each. Each list contained stems from 12 words that had been read, 12 that had been solved as anagrams, 12 new words, and 12 fillers. Critical test items served equally often in the inclusion and exclusion test conditions. The fillers were used to balance the test lists for old and new items. The order of items for presentation in all phases of the experiment was random, with the restriction that not more than three items representing the same combination of conditions could be presented in a row and that all conditions were presented evenly throughout the list.

Procedure. In the first phase of the experiment, subjects were required to solve anagrams and to read words. They were informed that words would sometimes be presented in their normal form and that their task was to read those words out loud as quickly as possible. Subjects were told that other words would be presented as anagrams with the second and fourth letters underlined and that those underlined letters were in correct positions with reference to the solution word. It was explained that the underlining of letters was done to make the anagrams easier to solve and to allow only one solution for each anagram. If the word said aloud by the subjects was the correct solution for a presented anagram, the experimenter pressed a key to initiate presentation of the next item. Otherwise, the subjects were informed of their error and were required to continue attempting to solve the anagram. A maximum of 30 s was allowed for the solving of each anagram. Once that time limit elapsed, a beep sounded, and the experimenter told the subject the solution word. Subjects were encouraged to compare the solution word with the anagram to be certain that the solution given was the correct one. After each item had been presented and either read or solved, the experimenter pressed a key to initiate the next trial. Subjects were led to believe that latencies were being recorded for both reading the words and solving the anagrams; in fact, latencies were not recorded. No mention was made of a retention test.

Subjects in the inclusion/exclusion test group received a test block under inclusion test instructions followed by a test block under exclusion test instructions. In the inclusion test condition subjects were told to use each stem as a cue for recall of a word presented earlier (read or anagram). Subjects were also instructed that if they could not think of an old word they were to complete the stem with the first word that came to mind. For the exclusion test condition, subjects were told to treat the stems as akin to a creativity test and to complete these stems with words that had not been presented earlier in the experiment. Because we were using single-completion stems, subjects were also told that if they could only complete a stem with an old word, that is, a word they had read or solved earlier, they were allowed to say "pass." The pass option was used in the exclusion condition to avoid the possibility that studied words would be used in those cases where a novel completion could not be produced. The stimuli and testing procedure for the indirect test group were the same as for the inclusion group, except that subjects were instructed to complete each word stem with the first five-letter word that came to mind.

Results

Proportion of stems completed. Table 4 presents the proportion of stems completed for each experimental condition. Under indirect-test instructions, slightly more read

words were given as completions than were words presented as anagrams (.86 vs. .83); however, the effect was not significant, $F(1, 23) = 1.638$, $MS_e = .004$. Similarly, under inclusion-test instructions the probability of completing stems with read and anagram items did not differ (.82, for both read and anagram). An analysis of critical items (read or anagram) revealed no difference between the indirect and inclusion test conditions ($F < 1$).

An analysis of the inclusion/exclusion data revealed a significant study by test interaction, $F(1, 23) = 26.11$, $MS_e = .013$. Whereas the indirect test and the inclusion condition revealed no difference between read and anagram items, the exclusion test showed a large difference in performance: Words presented as anagrams were much more easily excluded from the completion test than were read words (.25 and .49, for anagram and read, respectively).

Base rates for the inclusion and exclusion conditions were nearly identical (inclusion = .56; exclusion = .55). Also, base-rate performance in the indirect test (.63) was not statistically different from that in the inclusion test, $F(1, 46) = 2.01$, $MS_e = .026$.

Separating controlled and automatic influences. The inclusion test corresponds to a test of cued recall, and performance on that test would lead to the conclusion that the read/anagram manipulation had no effect of memory. However, a very different picture is gained by use of the process-dissociation procedure (see Table 3). Recollection was greater for anagram items than for read items, $F(1, 23) = 26.11$, $MS_e = .026$. The opposite pattern occurred for the automatic component: Estimates were greater for read items than for anagram items, $F(1, 23) = 9.97$, $MS_e = .026$. As in Experiments 1a and 1b, a final analysis was performed comparing estimates of automatic influences with new-item performance to determine the magnitude of the automatic contribution. Words that were read produced a substantial automatic influence of memory, $F(1, 23) = 26.54$, $MS_e = .014$; however, solving anagrams resulted in little, if any, automatic influence ($F < 1$).

Theoretical implications of these results are discussed after the presentation of Experiment 4, which replicated and extended the present findings. Experiment 4 was similar to Experiment 3, with two changes. First, test instructions (inclusion and exclusion) were manipulated between subjects to avoid any possible across-test interference. Second, multiple-completion stems were used.

Table 4
Probability of Responding With an Old Word in Experiments 3 and 4

| Study item | Test condition | | |
|--------------|----------------|-----------|-----------|
| | Indirect | Inclusion | Exclusion |
| Experiment 3 | | | |
| Read | .86 | .82 | .49 |
| Anagram | .83 | .82 | .25 |
| Experiment 4 | | | |
| Read | .51 | .53 | .22 |
| Anagram | .42 | .54 | .09 |

Experiment 4

Method

Subjects and design. Sixty subjects participated in return for credit in introductory psychology courses. Twenty subjects were randomly assigned to each of three test conditions (inclusion, exclusion, and indirect). Word stems presented at test corresponded to words that were presented earlier as anagrams, words that were read earlier, and words that had not been presented.

Materials and procedure. The materials and procedure were similar to those used in Experiment 3. Seventy-two five-letter nouns were used as stimuli. For each subject, 24 words were randomly selected as words to be read, and 24 were selected as anagrams to

be solved. Construction and presentation of anagrams were the same as in Experiment 3. The test list contained three-letter stems corresponding to the 48 studied words plus 24 new words. For each word stem there were at least two possible solutions. Word stems were presented in a random order at test. The procedure for the study and test phases was the same as in Experiment 3, with the exception that all test conditions were manipulated between subjects.

Results

Results for the proportion of word stems completed with old words replicated those of Experiment 3 (see Table 4). In the indirect test condition, the completion rate for items read earlier was numerically larger than for items presented earlier as anagrams (.51 vs. .42), providing some evidence of perceptual specificity; however, as in Experiment 3, the difference was not reliable, $t(38) = 1.889$. Similarly, for the inclusion condition, the probability of completing stems with read items and with anagram items did not differ. As in Experiment 3, an analysis of critical items in the indirect and inclusion conditions revealed no significant effects, although, as shown in Table 4, indirect test instructions resulted in a larger difference between read items and anagram items than did inclusion instructions. In fact, the interaction between test instructions and type of study item nearly reached significance, $F(1, 38) = 3.55$, $.10 > p > .05$, $MS_e = .012$.

In the exclusion condition, read words were more likely to be given as completions than were words presented as anagrams. An analysis of the inclusion and exclusion conditions revealed a significant Study \times Test interaction, $F(1, 38) = 8.57$, $MS_e = .010$. The completion rates for new stems in the inclusion and exclusion conditions were not statistically different (.25 vs. .20), $t(20) = 1.63$. Finally, base-rate performance in the indirect test (.19) was not different from that in the inclusion test, $F(1, 38) = 2.81$, $MS_e = .010$.

Estimates of recollection and automatic influences are presented in Table 3. Because the inclusion test and exclusion test instructions were manipulated between subjects, no statistical analysis can be performed on these estimates. However, an examination of the pattern convinces one that the same effects are apparent here as in Experiment 3: Recollection is greater for words presented as anagrams than for read words, whereas automatic influences are lower for the anagrams than for the read words. Furthermore, words that were read produced automatic influences well above base rate; in contrast, words previously presented as anagrams produced no automatic facilitation. In fact, the estimated automatic influences for words presented as anagrams were actually below base rate. We offer no explanation for the direction of this base-rate effect except to note that its statistical reliability cannot be tested.

Discussion

A memory advantage for words presented as anagrams over words that were read corresponds to a "generation effect" and effects of that sort on performance of direct tests have been thoroughly documented over the past few years

(for a review, see Hintzman, 1990). Our inclusion test (a test of cued recall) failed to show a generation effect: The probability of completing stems with words presented earlier as anagrams was identical to that of completing stems with read words. However, by using the process-dissociation procedure, we showed that generating a word as a solution for an anagram produced an advantage in recollection that was offset by a disadvantage in automatic influences of memory. In the General Discussion, we further contrast different procedures for measuring recollection.

The pattern of results found using the process-dissociation procedure parallels dissociations found between performance on indirect and direct tests of memory. For example, Jacoby (1983) showed that words generated as antonyms of presented words were better recognized conceptually as old but were less likely to be perceptually identified as compared with words that were read earlier. Jacoby interpreted these results as showing that perceptual identification primarily relies on prior data-driven processing, whereas recognition memory primarily relies on prior conceptually driven processing. Roediger et al. (1989) have extended this argument to account for a variety of dissociations between performance on indirect and direct tests. Results of the present experiment show that a dissociation of the form found between tasks can also be found between processes within a task. Consequently, a strong distinction between data-driven and conceptually driven tasks cannot be drawn.

The experiments allowed us to compare two very different approaches to the study of unconscious (automatic) processes. In the traditional approach, an indirect test is used to index automatic processes. This approach assumes that performance measures are relatively pure in terms of the psychological processes they evoke. In comparison, the process-dissociation procedure separates the within-task contributions of automatic and consciously controlled processing. Performance on stem completion using indirect test instructions implies significant transfer across visual form (i.e., from anagrams to stems). However, estimates of automatic influences gained from the process-dissociation procedure reveal that there is little, if any, transfer. When the controlled component is removed from performance, we find that items differing in visual form at study and at test result in no automatic influence. It would therefore seem that the apparent transfer from solving anagrams to stem completion under indirect test instructions was due almost entirely to conscious recollection.

Interestingly, in Experiment 3 performance on the indirect test measure looked strikingly similar to that in the inclusion condition in which subjects were specifically instructed to recollect the past. Of course, we cannot be sure that the processes contributing to performance were the same in the two conditions. In fact, the Study (anagram and read) \times Test (indirect and inclusion) interaction in Experiment 4, although not significant, could be interpreted as showing that the processes did differ between the two tests. It is possible that direct test instructions (as in the inclusion condition) reduce the contribution of automatic processes. Alternatively, orientation to the past may result in the apparently paradoxical effect of increasing automatic influences of memory

(Wegner & Schneider, 1989). Reliance on indirect measures does not allow one to determine the magnitude of unconscious influences as a function of factors such as a subject's orientation to the past. In contrast, by providing separate estimates of automatic and controlled influences, the process-dissociation procedure provides a natural framework for investigating such issues. We are currently conducting studies to investigate the effect of orientation to the past on the magnitude of automatic influences of memory.

That solving anagrams results in little or no automatic transfer in stem completion suggests that unconscious influences in a task are very sensitive to the details of prior experience. These results are consistent with an episodic model of memory (e.g., Allen & Jacoby, 1990; Jacoby & Brooks, 1984) but reveal limitations of models that propose multiple levels of representations to account for unconscious influences. For example, findings of nonspecific (e.g., cross-modal) transfer effects have led some researchers to propose that modality-free (i.e., abstract) representations mediate performance on indirect tests (e.g., Kirsner et al., 1983). If nonspecific transfer is due to contamination from consciously controlled processes, as our results suggest, such proliferation of representations is unnecessary.

The lack of automatic influences for words presented as anagrams contrasts with claims that implicit memory is influenced by prior conceptually driven processing. As evidence that dealing with the meaning of words (i.e., conceptually driven processing) is not important for later perceptual identification of those words in isolation, Jacoby and Dallas (1981) showed that a levels-of-processing manipulation that has a large effect on recognition-memory performance has no effect on perceptual-identification performance. Other researchers (e.g., Graf & Mandler, 1984) extended that finding to stem-completion performance. However, although significant "levels" effects are not always found in stem-completion performance, the direction of differences is often the same as that found for direct tests of memory (see Challis & Brodbeck, 1992; Chiarello & Hoyer, 1988). As shown here for the effects of solving anagrams, levels effects and other supposed demonstrations of the effects of prior conceptually driven processing on implicit memory (e.g., Masson & MacLeod, 1992; Hirshman, Snodgrass, Mindes, & Feenan, 1990) likely reflect the intentional use of memory on the indirect test. However, our argument is not that prior conceptually driven processing never enhances automatic uses of memory. When words are tested in the same context as presented earlier, we expect automatic influences of prior conceptually driven processing (Jacoby, in press; Toth & Hunt, 1990).

General Discussion

The advantage of the process-dissociation procedure is that it allows one to separate recollection—an ability that is largely lost after divided attention and because of amnesia—from automatic (unconscious) influences, a use of memory that is uninfluenced by divided attention or, perhaps, by amnesia. Dividing attention during the occurrence of an event can reduce the probability of its later recollection to zero

while leaving automatic influences of memory at the same level as would be produced by full attention. This combination of results provides strong support for the assumption that consciously controlled and automatic processes act as independent bases for responding. Failure to distinguish between the two types of memory effect can lead to seriously mistaken conclusions. The experiments reported here showed that failure to take automatic influences of memory into account can lead to (a) an overestimation of the probability of recollection and (b) the mistaken conclusion that a manipulation had no effect on memory when actually there were offsetting effects.

Measures of Recollection

The standard practice of subtracting recall errors from correct recall so as to remove the effects of guessing (e.g., Weldon et al., 1989) derives from classic test theory and is based on assumptions that are rarely examined. The assumptions underlying this procedure are that guessing is uncorrelated with true recollection and that memory influences only recollection. The assumed independence of recollection and of guessing is used to separate their effects (see Kintsch, 1970, for a description of high-threshold theory). It is assumed that correct recall can be accomplished either by recollecting an old item (R_o) or by producing the old item as a guess (G) when recollection fails ($1 - R_o$):

$$\text{Correct recall} = R_o + G(1 - R_o). \quad (6)$$

In contrast, false recall (FR) of the same item, if it were not presented at study, would require that the item be given as a guess (G) and not be recollected as being new ($1 - R_n$):

$$\text{False recall} = G(1 - R_n). \quad (7)$$

Subtracting false recalls (Equation 7) from correct recalls (Equation 6) to measure recollection, as is standardly done, rests on the assumption that $R_o = R_n$. That is, it is assumed that the probability of recollecting that an item was presented (R_o) is the same as the probability of recollecting that an item was not presented (R_n).

This assumption is probably seldom valid and is particularly problematic when assessing the effects of study manipulations. For example, consider the use of that assumption in examining the effects of reading versus generating an item in recall cued with word stems. An advantage of generated items in correct recall would be described as reflecting a higher probability of recollecting that an item was old (R_o) for generated as compared with read words. The problem comes when one corrects for guessing by subtracting false recalls (base rate) from correct recalls. Reliance on stems that can only be completed with new words to measure false recall forces one to use the same base rate to correct recall of read words and recall of anagrams. Doing so requires the contradictory assumptions that R_n for new words is equal to both R_o for anagrams and R_o for read words but that R_o is different for the two classes of words. What is needed are separate measures of false recall for read and anagram words.

The exclusion condition used in the process-dissociation procedure provides separate measures of false recall for different classes of studied words. The equations for the process-dissociation procedure (Equations 1 and 2) are equivalent to Equations 6 and 7, except for the change from one parameter (R) to two parameters (R_o and R_n) to represent recollection. For the process-dissociation procedure, we assume that the recollection used for inclusion is the same as that used for exclusion. Although the validity of that assumption might sometimes be arguable, it is much more tenable than the standard assumption that $R_o = R_n$. Our use of the exclusion test condition allowed us to see that recollection was different for anagrams and read words (Experiments 3 and 4). That difference would not have been revealed had we relied on a test of cued recall (the inclusion test condition) and corrected for guessing by subtracting base rate from correct recall of anagrams and read words.

Another difference between the process-dissociation approach and classic test theory is that unlike classic test theory, we assume that memory influences guessing. Amnesics as well as people with normal memory often show effects of memory when they claim to be only guessing. By the standard approach, guessing is of interest only in that one must correct for its effects. In contrast, by our view, guessing is informed by automatic (unconscious) influences of memory and is on equal footing with recollection with regard to its importance. Rather than merely correcting for guessing, we examine guessing as a means of specifying the factors that determine the magnitude of unconscious influences.

Signal-detection theory has been another popular means of taking differences in guessing into account when measuring memory. However, signal-detection theory offers no help for separating effects of informed guessing from true recollection. Signal-detection theory does not distinguish between these two effects of memory but rather assumes a single strengthlike basis for performance on direct tests of memory. Like signal-detection theory, we assume that the strength of a word as a completion for a stem is continuously distributed. Prior presentation of a word adds to its baseline strength, thereby producing automatic influences of memory. It may be useful to adopt the assumptions of signal-detection theory rather than simply subtracting baseline performance from estimates of automatic influences. If combined with our approach, signal-detection theory would apply only to automatic influences of memory, not to recollection.

Redefining Automaticity

We refer to automatic influences rather than to implicit memory when describing our effects because we believe that past theorizing about automaticity has highlighted issues that are important for understanding unconscious influences (Jacoby, 1991). However, by using the process-dissociation procedure, we redefine *automaticity*. Divided attention, fast responding, and lack of awareness as measured by self-report make it unlikely that subjects will engage in intentional, consciously controlled processing, but not so unlikely as to allow those conditions to serve as a satisfactory definition of automaticity (Bargh, 1989; Neumann, 1984). Each of these cri-

teria has been used to design tasks with which automaticity is equated. For example, automaticity has been equated with performance under conditions of divided attention (limited capacity). Such criteria treat automaticity as a property or characteristic of a particular cognitive process. In contrast, we define automaticity solely in terms of the relation between performance in a facilitation paradigm (i.e., inclusion condition) and that in an interference paradigm (i.e., exclusion condition). Automatic influences are defined as remaining the same regardless of whether they facilitate or interfere with performance of a task. Our redefinition of automaticity in terms of the process-dissociation procedure changes the status of conditions such as divided attention from definitional for automaticity to variables whose importance for limiting consciously controlled processing can be documented. It is the converging evidence from experiments varying factors thought to influence automaticity that allows us to be sure that the process-dissociation procedure separates automatic and intentional uses of memory.

Neumann (1984) argued that automaticity is not a characteristic of stimulus-driven processing but rather is an emergent property of the exercise of specific skills in an environment. One clear implication of his view is that automatic processing is context-dependent rather than being invariant across contexts. In our stem-completion experiments, the automatic effect of reading a word earlier arose in the context of completing stems; reading words earlier may have different automatic effects—or no effect at all—in other contexts. That automatic effects are sometimes different across task contexts can be seen by comparing automatic influences in stem-completion performance with those in recognition-memory performance. For stem-completion performance, reading words produces a larger automatic influence than does solving anagrams, whereas the opposite is true for recognition-memory performance (Jacoby, 1991). Because of differences in cues provided for retrieval and differences in task demands, automatic influences on recognition-memory judgments are less reliant on perceptual similarity than are automatic influences on stem-completion performance. Jacoby, Ste-Marie, and Toth (1993) describe additional evidence of the relativity of automaticity and review the results of several experiments using the process-dissociation procedure to show the value of that procedure in providing a redefinition of automaticity.

Alternative Assumptions for the Process-Dissociation Procedure

Most central to the process-dissociation procedure is the goal of separating the contributions of different processes within a task. The particular assumptions that we have adopted to accomplish that goal seem to be well supported by the results of our experiments. However, despite support by the data, our assumption that recollection and automatic influences make independent contributions to performance is likely to be controversial. Here, we consider two alternative assumptions about the relation between automatic and intentional influences.

A generate/recognize model of recall cued with word stems. Jacoby and Hollingshead (1990) gained evidence for a generate/recognize model by showing that the probability of cued recall was satisfactorily predicted as the product of the probability of completing a stem with an old word and the probability of recognizing the completion as old. That is, Jacoby and Hollingshead treated stem completion as a process-pure measure of generation (G) and recognition as a process-pure measure of recognition (R_g) and claimed that cued recall was the product of the two (GR_g). Their model can be extended to describe the probability of producing an old word as a completion in the exclusion test condition. In that test condition, old words should be given as a response only if they are generated as a completion but not recognized as old, $G(1 - R_g)$.

Why were Jacoby and Hollingshead (1990) as successful as they were at predicting cued recall as the product of stem-completion and recognition-memory performance? One answer challenges their assumption that stem-completion performance served as a process-pure measure of generation (i.e., implicit memory or automatic influences). It may have been that stem-completion performance was so contaminated by recollection as to mean that Jacoby and Hollingshead essentially used a measure of cued recall, in the guise of stem-completion performance, to predict cued-recall performance. Alternatively, perhaps the procedure used by Jacoby and Hollingshead was such as to encourage a generate/recognize strategy for accomplishing cued recall. Importantly, by casting models in equations and then looking for process dissociations we provide a means of choosing between models in a variety of situations. For example, the process dissociation produced by manipulating attention in the experiments reported here could not be predicted by a generate/recognize model but was predicted by assuming independence of recollection and automatic influences.

An exclusivity relation between conscious and unconscious influences. In the psychoanalytic tradition, ideas are either conscious or unconscious. Jones (1987) compared models that assume such exclusivity of processes with models that assume independence of processes. The important difference is that by the independence assumption, there is some overlap in the effects of processes, whereas such overlap is denied by the exclusivity assumption. For our inclusion test condition, adoption of the exclusivity assumption would result in the equation being rewritten as $R + A$. In contrast, our Equation 1 assumes independence ($R + A - RA$). It is the overlap in effects of processes represented by $-RA$ that is denied by the exclusivity assumption.

Nelson et al. (1992) have adopted the exclusivity assumption to describe the influence of implicit memory (automatic influences) on recall cued with word stems and word fragments. Nelson et al. do not make use of exclusion test conditions and so do not provide an equation to describe the relation between automatic and intentional influences for such tests. We have been unable to construct a set of equations on the basis of the exclusivity assumption that would allow prediction of the invariance in automatic influences observed in Experiments 1a and 1b. However, the difference

in predictions made by independence and exclusivity models is often very small.

We believe the independence relation between automatic and intentional influences is more plausible than an exclusivity relation. For example, if one were to adopt a view that holds that there are two memory systems, it would seem more plausible to claim an independence relation than to claim that an event could be represented in only one of the two systems. However, the situation is different from the perspective of subjective experience as compared to that of underlying processes. It may be that for subjective experience, an exclusivity relation does hold so that one is either aware or not aware of memory for a particular event (Gardiner & Parkin, 1990).

Conclusions

One of the most exciting consequences of the finding of dissociations has been renewed interest in the relation between cognitive psychology and neuropsychology. For example, Moscovitch (1991) has shown that requiring normal subjects to engage in a secondary task impairs performance on tests of memory that are sensitive to frontal-lobe damage but not on tests that are sensitive to hippocampal damage. Moscovitch's (1991) results are compatible with claims that consciously controlled processes are more dependent on frontal-lobe functions than are automatic processes (see Moscovitch & Winocur, 1992, for a review). However, relating automatic and consciously controlled processes to brain structures requires an adequate measure of each. We believe the measures provided by the process-dissociation procedure are superior to those provided by direct and indirect tests.

The process-dissociation procedure is important for measuring intentional uses of memory such as recollection. It is performance on direct tests of memory that has been the traditional focus of investigations of memory. The measures of memory gained using standard tests do not distinguish between recollection and automatic influences of memory. As argued here, making such a distinction is necessary to truly measure any preserved ability of amnesics to engage in recollection as well as the memory effects of experimental variables. Those interested in performance on direct tests of memory can no longer justifiably ignore evidence of unconscious influences. The same is true when measuring conscious perception. Standard measures of perception fail to distinguish between the contributions of conscious and unconscious perception (Debner & Jacoby, in press). For direct tests of memory and of perception, unconscious influences can lead to informed guesses that must be taken into account when measuring awareness and effects of conscious control.

References

- Allen, S. W., & Jacoby, L. L. (1990). Reinstating study context produces unconscious influences of memory. *Memory & Cognition*, 18, 270-278.
- Bargh, J. A. (1989). Conditional automaticity: Varieties of automatic influences in social perception and cognition. In J. S.

- Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 3–51). New York: Guilford Press.
- Cermak, L. S., Verfaellie, M., Sweeney, & Jacoby, L. L. (1992). Fluency versus conscious recollection in the word-completion performance of amnesic patients. *Brain & Cognition*, 20, 367–377.
- Challis, B. H., & Brodbeck, D. R. (1992). Level of processing affects priming in word fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 18, 595–607.
- Chiarello, C., & Hoyer, W. J. (1988). Adult age differences in implicit and explicit memory: Time course and encoding effects. *Psychology and Aging*, 3, 358–366.
- Craik, F. I. M. (1982). Selective changes in encoding as a function of reduced processing capacity. In F. Klix, J. Hoffman, & E. van der Meer (Eds.), *Cognitive research in psychology* (pp. 152–161). Berlin: Springer-Verlag.
- Debnar, J. A., & Jacoby, L. L. (in press). Unconscious perception: Attention, awareness, and control. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.
- Dixon, N. F. (1981). *Preconscious processing*. New York: Wiley.
- Donaldson, W., & Geneau, R. (1991). *Cross-modal priming in word fragment completion*. Paper presented at the meetings of the Psychonomic Society, San Francisco, CA.
- Eich, E. (1984). Memory for unattended events: Remembering with and without awareness. *Memory & Cognition*, 12, 105–111.
- Gabrieli, J. D. E., Milberg, W., Keane, M. W., & Corkin, S. (1990). Intact priming of patterns despite impaired memory. *Neuropsychologia*, 28, 417–428.
- Gardiner, J. M., & Parkin, A. J. (1990). Attention and recollective experience in recognition memory. *Memory & Cognition*, 18, 579–583.
- Graf, P., & Mandler, G. (1984). Activation makes words more accessible, but not necessarily more retrievable. *Journal of Verbal Learning and Verbal Behavior*, 23, 553–568.
- Graf, P., Shimamura, A. P., & Squire, L. R. (1985). Priming across modalities and priming across category levels: Extending the domain of preserved function in amnesia. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 2, 386–396.
- Graf, P., Squire, L. R., & Mandler, G. (1984). The information that amnesic patients do not forget. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 10, 164–178.
- Grand, S., & Segal, S. J. (1966). Recovery in the absence of recall: An investigation of color-word interference. *Journal of Experimental Psychology*, 72, 138–144.
- Hintzman, D. L. (1990). Human learning and memory: Connections and dissociations. *Annual Review of Psychology*, 41, 109–139.
- Hirshman, E., Snodgrass, J. G., Mindes, J., & Feenan, K. (1990). Conceptual priming in fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 4, 634–647.
- Holender, D. (1986). Semantic activation without conscious identification in dichotic listening, parafoveal vision, and visual masking: A survey and appraisal. *Behavioral and Brain Sciences*, 9, 1–23.
- Jacoby, L. L. (1978). On interpreting the effects of repetition: Solving a problem versus remembering a solution. *Journal of Verbal Learning and Verbal Behavior*, 17, 649–667.
- Jacoby, L. L. (1983). Remembering the data: Analyzing interactive processes in reading. *Journal of Verbal Learning and Verbal Behavior*, 22, 485–508.
- Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, 30, 513–541.
- Jacoby, L. L. (in press). Measuring recollection: Strategic vs. automatic influences of associative context. In C. Umiltà & M. Moscovitch (Eds.), *Attention and performance XV*. Cambridge, MA: Bradford.
- Jacoby, L. L., & Brooks, L. R. (1984). Nonanalytic cognition: Memory, perception and concept learning. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 18, pp. 1–47). San Diego, CA: Academic Press.
- Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General*, 3, 306–340.
- Jacoby, L. L., & Hollingshead, A. (1990). Toward a generate/recognize model of performance on direct and indirect tests of memory. *Journal of Memory and Language*, 29, 433–454.
- Jacoby, L. L., & Kelley, C. M. (1991). Unconscious influences of memory: Dissociations and automaticity. In D. Milner & M. Rugg (Eds.), *The neuropsychology of consciousness* (pp. 201–233). San Diego, CA: Academic Press.
- Jacoby, L. L., Ste-Marie, D., & Toth, J. P. (1993). Redefining automaticity: Unconscious influences, awareness and control. In A. D. Baddeley & L. Weiskrantz (Eds.), *Attention, selection, awareness and control: A tribute to Donald Broadbent* (pp. 261–282). Oxford, England: Oxford University Press.
- Jacoby, L. L., Woloshyn, V., & Kelley, C. M. (1989). Becoming famous without being recognized: Unconscious influences of memory produced by dividing attention. *Journal of Experimental Psychology: General*, 118, 115–125.
- Jones, G. V. (1987). Independence and exclusivity among psychological processes: Implications for the structure of recall. *Psychological Review*, 94, 229–235.
- Kintsch, W. (1970). *Learning, memory, and conceptual processes*. New York: Wiley.
- Kirsner, K., & Dunn, J. (1985). The perceptual record: A common factor in repetition priming and attribute retention? In M. I. Posner & O. S. M. Marin (Eds.), *Mechanisms of attention: Attention and performance XI* (pp. 547–565). Hillsdale, NJ: Erlbaum.
- Kirsner, K., Milech, D., & Standen, P. (1983). Common and modality-specific processes in the mental lexicon. *Memory & Cognition*, 6, 621–630.
- Koriat, A., & Feuerstein, N. (1976). The recovery of incidentally acquired information. *Acta Psychologica*, 40, 463–474.
- Light, L. L., & Singh, A. (1987). Implicit and explicit memory in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 13, 531–541.
- Logan, G. D. (1991). Automaticity and memory. In W. E. Hockley & S. Lewandowsky (Eds.), *Relating theory and data: Essays on human memory in honor of Bennet B. Murdock* (pp. 347–366). Hillsdale, NJ: Erlbaum.
- Masson, M. E. J., & MacLeod, C. M. (1992). Re-enacting the route to interpretation: Enhanced perceptual identification without prior perception. *Journal of Experimental Psychology: General*, 121, 145–176.
- Moscovitch, M. (1991). *Cognitive resources and retrieval interference effects in normal people: The role of the frontal lobes and hippocampus*. Paper presented at the meetings of the Psychonomic Society, San Francisco, CA.
- Moscovitch, M., & Winocur, G. (1992). The neuropsychology of memory and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 315–372). Hillsdale, NJ: Erlbaum.
- Nelson, D. L., Schreiber, T. A., & McEvoy, C. L. (1992). Processing implicit and explicit representations. *Psychological Review*, 99, 322–348.
- Neumann, O. (1984). Automatic processing: A review of recent findings and a plea for an old theory. In W. Prinz & A. F. Sanders

- (Eds.), *Cognition and motor processes* (pp. 255–293). Berlin: Springer-Verlag.
- Parkin, A. J., Reid, T. K., & Russo, R. (1990). On the differential nature of implicit and explicit memory. *Memory & Cognition*, 18, 507–514.
- Reingold, E. M., & Merikle, P. M. (1990). On the inter-relatedness of theory and measurement in the study of unconscious processes. *Mind and Language*, 5, 9–28.
- Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology*, 39, 475–543.
- Roediger, H. L. (1990). Implicit memory: Retention without remembering. *American Psychologist*, 45, 1043–1056.
- Roediger, H. L., Weldon, M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 3–41). Hillsdale, NJ: Erlbaum.
- Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 13, 501–518.
- Shimamura, A. P. (1986). Priming effects in amnesia: Evidence for a dissociable memory function. *Quarterly Journal of Experimental Psychology*, 38A, 619–644.
- Slamecka, N. J., & Graf, P. (1978). The generation effect: Delimitation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, 4, 592–604.
- Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General*, 117, 34–50.
- Squire, L. R., & Zola-Morgan, S. (1988). Memory: Brain systems and behavior. *Trends in Neurosciences*, 11, 170–175.
- Swets, J. A., Tanner, W. P., & Birdsall, T. G. (1961). Decision processes in perception. *Psychological Review*, 68, 301–340.
- Thorndike, E. L., & Lorge, I. (1944). *The teachers' handbook of 30,000 words*. New York: Columbia University.
- Toth, J. P., & Hunt, R. R. (1990). Effect of generation on a word-identification task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16, 993–1003.
- Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science*, 247, 301–305.
- Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 8, 336–342.
- Warrington, E. K., & Weiskrantz, L. (1974). The effect of prior learning on subsequent retention in amnesic patients. *Neuropsychologia*, 12, 419–428.
- Wegner, D. M., & Schneider, D. J. (1989). Mental control: The war of the ghosts in the machine. In J. Uleman & J. Bargh (Eds.), *Unintended thought* (pp. 287–305). New York: Guilford Press.
- Weldon, M. S., Roediger, H. L., & Challis, B. H. (1989). The properties of retrieval cues constrain the picture superiority effect. *Memory & Cognition*, 17, 95–105.

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