JOURNAL OF MEMORY AND LANGUAGE 30, 513–541 (1991)

A Process Dissociation Framework: Separating Automatic from Intentional Uses of Memory

LARRY L. JACOBY

McMaster University

This paper begins by considering problems that have plagued investigations of automatic or unconscious influences of perception and memory. A process dissociation procedure that provides an escape from those problems is introduced. The process dissociation procedure separates the contributions of different types of processes to performance of a task, rather than equating processes with tasks. Using that procedure, I provide new evidence in favor of a two-factor theory of recognition memory; one factor relies on automatic processes and the other relies on intentional processes. Recollection (an intentional use of memory) is hampered when attention is divided, rather than full, at the time of test. In contrast, the use of familiarity as a basis for recognition memory judgments (an automatic use of memory) is shown to be invariant across full versus divided attention, manipulated at test. Process dissociation procedures provide a general framework for separating automatic from intentional forms of processing in a variety of domains; including perception, memory, and thought.

The term "memory" is commonly used to refer to conscious recollection. Conscious recollection of an event in one's past clearly does rely on memory. However, memory also serves other, less obvious, functions. Memory for a prior event can influence later performance even when people do not intend to rely on memory and are unaware of doing so. This is most strikingly shown by experiments examining the memory performance of amnesics. Amnesics perform poorly when directly asked to report on the past, but show a near normal effect of past experience in their performance on a variety of tasks. For example, reading a word makes it more likely that amnesics will later be able to complete a fragment of that word, even though they are unable to recognize the word as one that was earlier read (e.g., Warrington & Weiskrantz, 1974). Such dissociations between performance on direct tests (recognition memory or recall tests) and indirect tests (e.g., a fragment-completion test) of memory also occur in people with normally functioning memories (Hintzman, 1990; Richardson-Klavehn & Bjork, 1988; Schacter, 1987).

I hope to accomplish three goals in the present paper. First, I argue that the distinction between direct and indirect tests of memory is only a *task distinction* and, as such, is best understood as a member of a larger class of task manipulations that have been used to explore the *process distinction* between intentional and automatic processes. Focusing on processes (rather than tasks) reveals useful parallels between memory research and research in attention and perception. Second, I argue that problems interpreting task dissociations have arisen from equating particular processes with particular tasks and then treating those tasks as if they provide pure measures of those processes. I introduce a methodology

This research was supported by a grant from the National Science and Engineering Research Council. I thank Henry L. Roediger, III, Gordon Logan, and Neal Johnson for their comments on earlier versions of this paper, and thank Ann Hollingshead for her assistance collecting and analyzing data. Special thanks are expressed to Steve Lindsay, Ian Begg, and Colleen Kelley for their help on the final revision of this paper. Reprint requests should be directed to Larry Jacoby, Department of Psychology, McMaster University, Hamilton, Ontario, Canada L8S 4K1.

0749-596X/91 $3.00

ical framework, *process dissociation*, for estimating the separate contribution of automatic and intentional processes to performance. The process dissociation framework separates the contributions of different types of processes to performance of a particular task, rather than identifying different processes with different tasks. My third goal is to describe three recognition memory experiments. The first two experiments are used to illustrate problems of interpreting task dissociations and to demonstrate the advantages of interference paradigms (e.g., Stroop, proactive interference) over facilitation paradigms (e.g., transfer effects in word fragment completion) as a means to investigate automaticity. The third experiment illustrates the use of the process dissociation framework, combining data from a facilitation paradigm with those from an interference paradigm so as to separate the contributions of automatic and intentional processing. Using that framework, I provide new evidence in favor of a two-factor theory of recognition memory in which one factor relies on automatic processes and the other relies on intentional processes. These three aims are different aspects of a single central theme, which is that task performance always represents a blend of automatic and intentional processes.

Tasks and Processes

Memory dissociations have caused a great deal of excitement, with the result that investigation of such dissociations is now treated as a distinct, new area for research. The focus of that new research area is "implicit memory," a term used to refer to the form of memory that is revealed by an indirect test (e.g., Schacter, 1987). In contrast, one of my major aims in this paper is to apply a process-oriented approach to gain a better understanding of task dissociations such as those involving different tests of memory. Specifically, the task manipulation that defines the difference between direct and indirect tests in the memory literature is analogous to the task manipulations used in studies comparing automatic and controlled processes in the attention literature (e.g., Hasher & Zacks, 1979; Posner & Snyder, 1975; Schneider & Shiffrin, 1977). Those theories of attention identify consciousness with a central, limited-capacity system that can control mental processing. Controlled processing reflects a person's intentions and is subject to capacity limitations. Automatic processing, in contrast, occurs as a passive consequence of stimulation, is not necessarily accompanied by awareness, and requires neither intention nor processing capacity.

Consider the role of intention in the definitions of automaticity and of indirect memory tests. Hasher and Zacks (1979), for example, argued that if memory for a particular attribute of an event is uninfluenced by instructions to remember, then processing of that attribute can be considered automatic (see Begg, Maxwell, Mitterer, & Harris, 1986, for an alternative view). In other attention paradigms, subjects are instructed to perform an attention-demanding secondary task to ensure that they do not intentionally attend to another source of information. Evidence that unattended information is processed automatically is revealed by performance of the attended task or by performance on an unexpected test of memory for the supposedly ignored information (see Holender, 1986, for a critique of this research). In these cases, performance on tasks defined by a manipulation of instructions or by a manipulation of available processing capacity are used to draw the inference that some forms of processing do not rely on intention. Similarly, performance on indirect memory tests is used to draw the inference that it is not necessary for subjects to intend to retrieve memories at test for those memories to be retrieved and to affect performance. Thus, both for memory dissociations and for automaticity, task manipulations, particularly those of instructions, are used to draw inferences about the role of intent.

There are also parallels between automaticity and unconscious perception. Unconscious perception can be discussed in terms of automaticity, although that literature has emphasized issues of awareness rather than intent. The test conditions used to investigate unconscious perception are designed to rule out intentional processing, just as in studies of automaticity requiring subjects to engage in an attention-demanding distractor task is meant to rule out intentional processing of to-be-ignored information. The finding of effects of an event that is not consciously perceived parallels the finding for amnesics of memory revealed by an indirect test. Of course, claims of unconscious perception have been treated as more controversial than have been claims of automaticity or memory dissociations. Very stringent criteria have been used to ensure that perception was truly unconscious (e.g., Holender, 1986). The problems that arise when one attempts to satisfy those criteria are also relevant to claims of automaticity and to the interpretation of memory dissociations.

Perhaps the most important similarity among investigations of automaticity, unconscious perception, and memory dissociations is that all are riddled with the same problems. Foremost is the problem that the rationale underlying investigations of automaticity, including memory dissociations and unconscious perception, often relies on a one-to-one mapping between processes and tasks. The drawing of conclusions, then, requires that tests be "factor-pure" with regard to the type of processing they measure. The factor-pure problem is most obvious when one considers claims of unconscious perception, but equally applies to the interpretation of memory dissociations and to the interpretation of results typically taken as showing automaticity. The problem is that a result taken as evidence of an unconscious influence might have arisen from a conscious use of memory or perception that was undetected by the experimenter (Holender, 1986; Dunn & Kirsner, 1989; Richardson-Klavehn & Bjork, 1988). This is to say, for example, that one cannot be certain that subjects in an "unconscious-perception" condition were unaware of supposedly subliminal stimuli. Similarly, although instructed to ignore items presented to an unattended ear and required to engage in attention-demanding processing of items presented to the attended ear, people might sometimes switch attention to and intentionally process supposedly ignored items. For memory, amnesics are hardly ever totally amnesic, and it is likely that subjects do sometimes intentionally use memory to aid their performance on indirect tests of memory.

One reaction to the factor-pure problem is to renew efforts toward developing tasks that are truly factor pure. Although this has been a common strategy, particularly in response to criticisms of supposed demonstrations of unconscious perception, one can never fully satisfy critics of a factor-pure assumption (e.g., Holender, 1986). An alternative strategy is to show interactions or task dissociations involving two tasks, one of which is identified with automatic processing and the other with intentional processing. Doing so shows a functional dissociation between conscious and unconscious influences of perception or memory (e.g., Chessman & Merikle, 1986; Jacoby & Dallas, 1981). The most compelling evidence of unconscious influences of perception and of memory comes from findings of task dissociations. Unfortunately, however, when interpreting task dissociations theorists commonly fall into the trap of treating tasks as if they were factor or process pure.

Automatic Processing as a Source of Facilitation

Performance on direct tests of memory typically requires that people intentionally recollect a past episode, whereas facilitation on indirect tests of memory is not necessarily accompanied by either intention to remember or awareness of doing so. This difference between the two types of test can be described in terms of the contrast between consciously controlled and automatic processing. However, there is not a one-to-one mapping between indirect versus direct tests and automatic versus intentional processing. Intentional forms of processing may sometimes "contaminate" performance on indirect tests and be responsible for results taken as evidence of unconscious processes (e.g., Holender, 1986). Conversely, automatic forms of processing contribute to performance on direct, as well as indirect, tests of memory. For example, dual-process theories of memory retrieval (e.g., Atkinson & Juola, 1974; Jacoby & Dallas, 1981; Mandler, 1980) hold that conscious recollection and judgments of familiarity are alternative bases for recognition memory decisions. Compared with conscious recollection, judgments based on familiarity can be viewed as relatively automatic in that they are generally said to be faster, less effortful, and less reliant on intention. From this point on, I use "recollection" to refer to a consciously controlled, intentional use of memory, and "familiarity" to refer to an automatic use of memory for making recognition memory judgments.

In Experiment 1, consciously controlled and automatic influences of memory were defined in terms of their reliance on processing capacity. The notion is that recollection is more reliant on the availability of processing capacity than is the use of familiarity as a basis for judgments. Comparing recognition judgments under conditions of full and divided attention was expected to reveal task dissociations that are similar to those found when performance on direct and indirect tests are compared. On an indirect memory test, intentional use of memory is limited by not instructing subjects to use memory. Dividing attention at test should have a similar effect by making it unlikely that the available processing capacity is sufficient to allow intentional use of memory (recollection). That is, performance on indirect memory tests and performance on recognition memory tests under conditions of divided attention both rely heavily on automatic influences of memory. The procedure used in Experiment 1 is a facilitation paradigm in that automatic influences of memory (familiarity) act as a source of facilitation for task performance. Assessing familiarity and recollection both serve as a means of correctly recognizing old items.

Automatic Processes as a Source of Interference

For an interference paradigm, the test is arranged such that automatic and intentional uses of memory act in opposition to one another, with the result that automatic uses of memory are a source of errors. The notion that automatic processing can be a source of errors is a common one—errors are often taken as being particularly revealing. For example, interest in Freudian slips (e.g., Fromkin, 1973; Motley, 1985) is owed to the assumption that those slips arise because automatic forms of processing were not successfully opposed by more intentional processing. The Stroop task (Stroop, 1935) and the "flanker effect" task (e.g., Eriksen & Eriksen, 1974) are examples of interference paradigms used to examine automatic processes. For interference paradigms, intentional processing of to-be-ignored events is unlikely because such processing would be counter to the purpose of performing well on the task. When an interference paradigm is used, an increase in errors produced by a manipulation can sometimes be used as evidence that the manipulation reduced intentional processing, leaving the effects of automatic processes unopposed.

The finding of interference effects was important for demonstrating that some form of memory is preserved by amnesics. In a series of studies by Warrington and Weiskrantz (1968), amnesics were given repeated trials of lists of words, and were asked to recall or recognize words from each list after varying intervals. Not surprisingly, amnesics, as compared to normal subjects, were badly impaired in their recall and recognition memory performance. The surprising finding was that amnesics' memory performance showed large amounts of proactive interference. Half of the words falsely recalled by amnesics were intrusions from earlier lists, many of which had been learned on earlier days. The finding of proactive interference showed that amnesics were capable of storing information for relatively long periods of time. The fragment completion tasks that have become so popular as indirect tests of memory were originally used by Warrington and Weiskrantz to show savings in the performance of amnesics (see Weiskrantz and Warrington, 1975, for a description of this early work showing memory preserved by amnesics). The switch from the presentation of multiple lists to the presentation of fragments as cues for recall is a change from an interference paradigm to a facilitation paradigm for showing automatic influences of memory.

Memory-impaired subjects show larger interference effects in both attention tasks (e.g., Hasher & Zacks, 1988) and in memory tasks (e.g., Winocur, 1982) than do normal subjects. An increase in interference can result from a reduction in intentional forms of processing that, otherwise, would oppose the effects of automatic processing. That is, the greater proactive interference shown by memory-impaired, as compared to normal, subjects might result from automatic processing being largely intact but unopposed by intentional processing. Dividing attention at the time of test may provide another way to limit intentional processing. If so, then dividing attention at test in an interference paradigm will increase the observed amount of interference.

Our fame judgment experiments (e.g., Jacoby, Woloshyn, & Kelley, 1989a, Experiment 2) provided evidence that divided attention at test increases proactive interference. Subjects first read a list of nonfamous names such as "Sebastian Weisdorf." In a second phase, those old names were mixed with new famous and new nonfamous names in a test of fame judgments. Subjects were correctly informed that all of the names they had read in the first list were nonfamous, so if they recollected a name as from the first list they could be certain it was actually nonfamous. In opposition to the effect of recollection, the familiarity of old nonfamous names, produced by earlier reading those names, was a source of false fame. Dividing attention at test made subjects less able to use conscious recollection to oppose false fame than were subjects who devoted full attention to fame judgments. The finding in the divided-attention condition that names that were read earlier were more likely to be mistakenly judged famous than were new nonfamous names (the false fame effect) reflects interference produced by memory for earlier-read nonfamous names, a form of proactive interference. That false fame effect produced by dividing attention at test is evidence that recollection, an intentional use of memory, can be made less likely by reducing the availability of processing capacity. We can be certain that the false fame effect did not arise from subjects intentionally making use of memory for the old nonfamous names when making fame judgments. This is true because conscious recollection of a name as earlier read would produce an effect opposite to that of the false fame effect.

Thus the false fame effect reveals an automatic influence of memory defined in terms of lack of intention and measured by interference. Conscious processes are generally thought of as requiring more active, intentional forms of processing whereas unconscious or automatic processes have been viewed as likely to be revealed when one is relaxed or inattentive (e.g., Dixon, 1971; Ellenberger, 1970). Experiment 2 reported here used a procedure similar to that used in the fame judgment experiments and examined the effects of dividing attention while making recognition memory judgments.

Automaticity Defined in Terms of Process Dissociations

Some special populations may have a deficit in intentional forms of processing, but preserve more automatic or unconscious forms of memory. For example, Dywan and Jacoby (1990) found that the false fame effect is larger for aged than younger subjects. One would like to determine whether automatic influences of memory are the same for the aged as for normal subjects. Early research showing that elderly subjects perform as well on indirect tests of memory as do younger subjects was taken as showing that automatic uses of memory are not influenced by aging; however, more recent research has revealed that elderly subjects suffer some impairment in their performance on indirect tests of memory (for a review see Hultsch & Dixon, in press; Howard, 1988). Despite the intense scrutiny given such effects, the finding of age differences in performance on indirect tests is important only if one assumes that an indirect test is a factor-pure measure of an automatic use of memory. That is, effects of aging on performance of indirect tests might be because performance on those tests is "contaminated" by intentional use of memory. The difficulty for interpreting results is made more obvious when an interference paradigm is used. One cannot be certain that a manipulation or population difference did not influence both types of process rather than just the one. For example, aging or dividing attention at test might influence the use of both familiarity and recollection as bases for recognition memory.

More generally, task dissociations may reveal the existence of different forms of processing, but they cannot be used to reveal invariance in any particular form of processing. In many ways, a finding of invariance is more useful than is a finding of a difference (Stevens, 1951). For example, consider signal detection theory (Swets, Tanner, & Birdsall, 1961). The impressive contribution of that theory was *not* that it showed that both bias and discriminability have an influence on performance. Rather, its power came from showing that discriminability can be constant or invariant across different levels of bias and vice versa. If one cannot separate the contribution of two processes, all that one can do is demonstration experiments to show that the two types of processes exist.

The process dissociation procedure, introduced in Experiment 3, was devised to separate the contributions of automatic and intentional uses of memory. The procedure makes use of both facilitation and interference paradigms to define automaticity. The rationale underlying the process dissociation procedure can be understood in terms of solving simultaneous equations, where the variables in the equations refer to processes that contribute to performance of a task: "A" refers to automatic processing whereas "I" refers to intentional processing. For example, consider the following equations: $A + I = 10$; $A - I = 4$. Those equations are easily solved to yield a solution of $A = 7$ and $I = 3$.

What is needed is a way to arrange tasks so that processes correspond to variables in simultaneous equations that are easily solved. To accomplish that, it is necessary to compare performance on a task for which automatic and intentional uses of memory act in concert, a facilitation paradigm ($A + I = 10$), with performance on a task in which the two types of processes act in opposition ($A - I = 4$), an interference paradigm. Given that arrangement, one can then solve for unknowns and look for process dissociations, rather than look for task dissociations. Process dissociations are defined in terms of differential effects of manipulations on the parameters representing the different processes (A and I), whereas task dissociations are defined in terms of differential effects on overall task performance. Dealing with process dissociations, one can now detect invariance in processing.

The illustration of the process dissociation procedure as involving simultaneous equations is meant to convey the definition of automaticity in terms of intention. In those equations, the contribution of automatic processes is the same whether that contribution acts in concert with or in opposition to the contribution of intentional processes. The process dissociation procedure used in Experiment 3 was devised to separate the contributions of recollection and familiarity to recognition memory judgments. That procedure was validated by showing that estimates of familiarity gained by comparing the performance of conditions tested under conditions of full attention almost perfectly fit performance in a divided-attention condition. That is, I present evidence that familiarity, an automatic influence of memory, remained invariant across levels of recollection, an intentional use of memory.

EXPERIMENT 1

Experiment 1 was done to determine whether the effects of full versus divided attention during a recognition memory test interact with differences in the prior processing of old items. It seems reasonable to assume that the possibility of recollection is limited both by the prior processing of an event and by the availability of processing capacity at the time of test (e.g., Craik, 1982; Jacoby, 1982). The opportunity to engage in consciously controlled processing, provided by full attention at test, may be beneficial only if one earlier engaged in consciously controlled processing of the event that is to be remembered. An interaction of that sort could explain why Baddeley, Lewis, Eldridge, and Thomson (1984) failed to find an effect of divided versus full attention at test. In their experiments, subjects' processing of items during study may have been insufficient to support later recollection. It may be that retrieval from memory is not always automatic, as claimed by Baddeley et al., but that finding an effect of manipulating attention at test depends on the study processing of tested items.

In Experiment 1, the study processing of items was manipulated by presenting words in their normal form to be read or as anagrams to be solved (e.g., dowry vs. yodrw; only letters that were not underlined were to be rearranged), and recognition memory was tested either under full or divided attention. All words were presented in their normal form for the test of recognition memory. In the divided-attention condition, subjects engaged in a listening task while simultaneously judging whether words presented visually were old or new.

In earlier experiments (Allen & Jacoby, 1990; Jacoby & Hollingshead, 1990), the read versus anagram manipulation had opposite effects in performance on direct and indirect tests of memory. Reading a word in its normal form, as compared to producing a word as a solution for an anagram, increased the likelihood of perceptual identification or stem completion, but decreased the likelihood of correct recognition. The recognition memory advantage for words presented as anagrams may be due to an effect on recollection: subjects might later be better able to recollect earlier solving an anagram as compared with earlier reading a word (cf. Gardiner, 1988). If so, and if recollection requires full attention at test, then it should be possible to remove the recognition memory advantage of anagram over read words by dividing attention at the time of test.

Indeed, dividing attention at test might even produce a recognition-memory advantage for words that were read over those presented as anagrams, reversing the effect observed under conditions of full attention. This is because recognition memory decisions made under conditions of divided attention should primarily rely on familiarity, and familiarity has been assumed to reflect the match in the perceptual characteristics of an item between its study and test. For example, Jacoby and Dallas (1981) claimed that the feeling of familiarity rests on the use of a fluency heuristic: words that are relatively easy to perceive are experienced as familiar. Because reading a word does more to enhance its later perceptual identification than does solving an anagram of a word, reliance on a fluency heuristic would produce a corresponding advantage in recognition memory performance for words that were earlier read. The prediction, then, is that comparing performance under conditions of full and divided attention at test should reveal a task dissociation that is similar to that found when comparing performance on direct and indirect tests of memory.

Method

Subjects and design. The subjects were 32 students enrolled in an introductory psychology course; 16 subjects were randomly assigned to each of two (full vs. divided) attention conditions, manipulated at test. Words presented for a test of recognition included words that were earlier presented as anagrams to be solved, words that were earlier read, and words that had not been earlier presented (new words).

Materials. A pool of 175 five-letter nouns of varying frequency, as scaled by Thorndike and Lorge (1944), was used as materials. Eighty of those words were divided into two sets of 40 words each and used to construct lists presented in the first phase of the experiment. Words in the one set of 40 were presented as anagrams to be solved and words in the other set were presented in their normal form to be read. To construct anagrams, words were presented with the second and fourth letters in their proper positions and underlined (e.g., yodrw). The remaining letters in a word presented as an anagram were randomly rearranged. Constraining the order of letters made the anagrams easier to solve and, more importantly, gave each anagram only one solution. Two formats were constructed such that words presented as anagrams in the one format were presented to be read in the other format and vice versa. For presentation in Phase 1, five items (three words and two anagrams) were added to the beginning of a list as fillers to produce an 85-item list. Those filler items were constant across formats.

A 175-word list was presented for a test of recognition memory. The first 15 words in that list included 10 new words intermixed with the five old fillers that were at the beginning of the list presented in Phase 1. Those 15 words were presented to subjects in both attention conditions, but the purpose for their presentation was to allow subjects in the divided-attention condition to settle into the listening task before presentation of the main test list. The 160-word main list included 80 old words (40 words that had been read and 40 words that had been presented as anagrams) intermixed with 80 new words. The new words were *not* interchanged with old words across formats. Doing so was not necessary because our interest was in recognition memory performance for words that had been read as compared with those presented as anagrams. The probability of mistakenly calling new words old can serve as a measure of bias regardless of whether those new words were balanced with the old words. The order of items for presentation in Phase 1 and for presentation in the test list was random with the restriction that not more than three items representing the same combination of conditions could be presented in a row.

The listening task used in the divided-attention condition was one previously used by Craik (1982). In this task, subjects monitor a tape-recorded list of random digits to detect target sequences of three odd numbers in a row (e.g. 9, 3, 7). In the list used in Experiment 1, 43 target sequences

of three odd numbers occurred in a randomly ordered list of 224 digits. The restrictions used to construct the list were that a minimum of one and a maximum of five numbers must occur between the end of one and the beginning of the next target sequence. Also, not more than two even numbers could occur in sequence. That list was recorded six times from beginning to end, without pause between repetitions of the list. Digits were recorded at a 1.5 s rate.

Procedure. An Apple IIe computer interfaced with a monochrome green monitor was employed to present the stimuli. The character size of the stimuli was approximately 5.7 × 6.6 mm. Stimuli were presented in lower case letters in the center of the screen.

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 aloud 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 the correct positions within the word. It was emphasized that this meant that only the three letters that were not underlined needed to be rearranged to solve the anagram. If the word said aloud by a subject was the correct solution for a presented anagram, the experimenter pressed a key to initiate presentation of the next item. Otherwise, the subject was informed of the error and was allowed 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, signaled by a beep produced by the computer, the experimenter told the subject the solution word. Under those circumstances, 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 times were being recorded both for reading the words and for solving the anagrams and that the reading times were to be used as a baseline for interpreting the times to solve anagrams. In fact, times were not recorded. No mention was made that a test of memory would be given.

In the final phase of the experiment, a test of recognition memory was given under conditions of either full or divided attention. For both conditions, each test word appeared on the screen with the prompt "Old or New?" printed several lines below. Subjects made recognition judgments by pressing a key on the right to respond old and a key on the left to respond new. Pressing a key to make the recognition judgment cleared the screen. After a 1-s delay, the next test item was presented.

Subjects were instructed to call a word old if they remembered encountering the word in the first part of the experiment, either as a word or as an anagram. Otherwise, a test word was to be called new. The subjects in the full-attention condition made only recognition judgments whereas those in the divided-attention condition simultaneously engaged in the listening task. The subjects in the divided-attention condition were told that it was very important not to miss a target sequence in the listening task and that they should try to do the recognition task "somewhat automatically" so as not to disrupt their performance of the number task. They were also told that the experimenter would be monitoring their performance and would prompt them, by saying "miss," if they missed a target sequence. Subjects were instructed to respond by saying "now" immediately after they detected a target sequence of three odd numbers. The number of repetitions of the list of digits used in the listening task, along with the total number of targets presented, was determined by a subject's rate of responding to the recognition memory task. That is, the tape on which numbers were recorded was played continuously so as to fill the interval during which the test of recognition memory was given.

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

Results and Discussion

In Phase 1, an average of 89% and 87% of the anagrams were solved by subjects in the full- and divided-attention conditions, respectively. Subjects in the divided-attention condition missed an average of 33 out of 92 target sequences (36%) in the listening task.

More importantly, divided attention increased the probability of responding old for read words but had the opposite effect for words that had been presented as anagrams (see Table 1). The probability of a false recognition was higher when attention was divided, rather than full (.18 vs. .06), at the time of test. Correcting for that difference in bias by subtracting the probability of false recognition from that for correct recognition, it can be seen that the manipulation of full versus divided attention did not influence recognition accuracy for words that were earlier read (.32 vs. .34) but did reduce recognition accuracy for words that were earlier presented as anagrams (.66 vs. .49). The interaction between form of prior presentation (read vs. anagram) and full versus divided attention at test was significant, $F(1,30) = 13.17$, $MS_e = .011$.

TABLE 1
PROBABILITY OF CALLING A WORD "OLD" IN EXPERIMENT 1

Test condition	Item type		
	Anagram	Read	New
Full attention	.72	.38	.06
Divided attention	.67	.52	.18

Results of a signal-detection analysis agreed with those from the above analysis of correct recognition. Dividing attention reduced discriminability for words that had been presented as anagrams (1.51 vs. 2.39) more than it did for words that were earlier read (1.05 vs. 1.35). The interaction of presentation condition with full versus divided attention was significant, $F(1,30) = 10.77$, $MS_e = .124$.

In the divided-attention condition, the relation between performance on the listening task and recognition memory performance was informally examined. There was no obvious relation between performance on the two tasks. The detection of such a relationship would be difficult in the present experiment, because of the relatively small number of subjects and rather low variability in performance of the listening task.

The recognition of words earlier presented as anagrams was diminished when the capacity for conscious recollection was reduced by dividing attention at test. In contrast, the small or nonexistent effect of divided versus full attention when words were earlier read is consistent with the claim made by Baddeley et al. (1984) that retrieval can be automatic. However, as shown by the significant interaction of prior processing with full versus divided attention, retrieval from memory is not always automatic. Consciously controlled processing at test was required to fully benefit from the potential advantage in recollection of words presented as anagrams over those that were read. The possibility of recollection is limited by both the prior processing of an event and by the availability of processing capacity at the time of test.

Although the recognition advantage of words presented as anagrams over read words was diminished by dividing attention at test, that advantage was not fully removed. It is possible that dividing attention at test fully eliminated the possibility of recollection and that the remaining advantage of anagrams reflects an advantage in familiarity for anagrams over read words. If so, familiarity is influenced by factors that are different from those usually proposed. Familiarity is usually described as being greatest when the perceptual characteristics of a test item match those of its prior presentation (e.g., Atkinson & Juola, 1974; Jacoby & Dallas, 1981; Mandler, 1980). The match in perceptual characteristics was greater for items that were earlier read than for items presented as anagrams, so the effect was opposite to what would be predicted on the basis of perceptual characteristics. Also, the effect is opposite to that found in investigations of perceptual identification and stem-completion performance (Allen & Jacoby, 1990; Jacoby & Hollingshead, 1990).

Of course, another possible reason for the advantage of anagram over read words is the task used to divide attention may not have fully eliminated the possibility of recollection. Several other experiments in my lab, using different tasks to divide attention, produced results similar to those reported here. None of those experiments was fully completed, because there seemed no reason for doing so. The consistent failure to remove the recognition advantage of anagram over read words by manipulating attention at test led me to seriously consider the possibility that familiarity does not solely rely on perceptual characteristics. Experiment 2 was designed to determine whether words presented as anagrams hold an advantage in familiarity over words that were read.

EXPERIMENT 2

A facilitation paradigm was used in Experiment 1. The outcome was that words presented as anagrams were more likely to be later recognized than words that were read, but were also much more detrimentally affected by divided attention at test. Because of the interaction with dividing attention, it can be concluded that the recognition advantage of words presented as anagrams was at least partially produced by superior recollection of those words. The pattern of results shows that conscious recollection can allow subjects to recognize words that they could not recognize on the basis of familiarity. However, the results of that experiment do not rule out the possibility that words earlier presented as anagrams also had the additional advantage of later being more familiar than were words that were read. In Experiment 2, an interference paradigm was used to further examine the effects of study processing and of dividing attention at test.

Experiment 2 used a procedure similar to that used in the fame judgment experiments (Jacoby et al., 1989a). In the first phase of Experiment 2, words were presented in their normal form to be read or were presented as anagrams to be solved. Subjects then heard a list of words that they were told to remember for a later test of recognition memory. For that test, subjects were instructed to call a test word "old" only if the word was one that they had earlier heard. Subjects were correctly informed that the test list included words that were presented in Phase 1 of the experiment and that none of those words was in the list of words that they had heard. Consequently, they were assured that if they recognized a word as one that they had earlier read or had earlier given as a solution for an anagram, they could be certain that the word was to be called "new." Thus, the recognition memory test was an indirect test of memory for words presented in Phase 1. Memory for those words was revealed by their being falsely recognized as earlier heard, a form of proactive interference.

Parallels were expected between the effects of divided attention at test on normal subjects' memory performance and amnesics' performance on memory tasks (e.g., Craik, 1982). Amnesics can sometimes recognize items, but that ability appears to be based on the familiarity of items, rather than on an ability to recollect a particular prior occurrence. Huppert and Piercy (1978) found that their Korsakoff patients could make recency judgments at an abovechance level, but tended to judge items presented frequently as having been presented recently and vice versa. That is, amnesics based both types of judgments on the familiarity of the item and so were unable to discriminate between frequency and recency. In contrast, subjects with normal memories could use their recollection of particular occurrences of an item to disentangle the effects of recency and frequency of presentation. Similarly, divided attention during a recognition memory test may impair recollection of an event, but not influence the use of familiarity as a basis for judgments. If so, in Experiment 2, the probability of falsely recognizing as earlier heard words that were actually presented in Phase 1 should be higher under conditions of divided, as compared to full, attention. That is, dividing attention at test might impair recollection and thereby leave the effects of familiarity largely unopposed.

Finally, the results of Experiment 2 allow one to determine whether solving anagrams produces an advantage in both familiarity and in recollection as compared to earlier reading a word. Greater recollection of items earlier presented as anagrams than of items earlier presented as words would be expected only in the full-attention condition. Greater recollection of anagrams would be revealed by subjects' being less likely to falsely recognize those items than items earlier presented as words. When attention is divided at test, recognition judgments should primarily reflect the familiarity of test items. Greater familiarity of words presented earlier as anagrams would be reflected by subjects in the divided-attention condition being more likely to falsely recognize those words than words that were earlier read. A finding of greater familiarity of anagram than of read words would be opposite to the finding of greater transfer for read than for anagram words on indirect tests of memory such as word identification and would conflict with the claim that perceptual fluency is the sole basis for familiarity.

Method

Subjects. The subjects were 42 students enrolled in a psychology course who served in the experiment for course credit; 21 students were randomly assigned to each of two (full vs. divided) attention conditions.

Materials. A set of 135 words was selected from the pool of words used in Experiment 1. Sixty of those words were broken into three sets of 20 words each to serve as critical items presented as anagrams, to be read in Phase 1 of the experiment, or to be presented as new words on the recognition memory test given in Phase 3 of the experiment. Anagrams were constructed in the same manner as in Experiment 1. In the 40-item list presented in Phase 1, items presented in the first six and last four positions in the list (five anagrams and five read words) were buffers for primacy and recency effects. Those buffer words were not tested later. Three formats were constructed by rotating the three sets of 20 words through presentation conditions (anagram, read, and new) so that, across formats, each set of words represented each presentation condition. A different set of 60 words, not among those presented in Phase 1, was selected to construct the list of words that was presented aurally in Phase 2 of the experiment.

The test list in Phase 3 was comprised of 120 words: 60 words that were heard in Phase 2; 15 words read in Phase 1; 15 words presented as anagrams in Phase 1; 15 critical new words that were balanced with the read and anagram words; and 15 new words that served as fillers in that performance on those words was not scored. The fillers were included so as to make the total number of anagram, read, and new words equal to the number of words that were heard. Other details of materials and list construction were the same as in Experiment 1.

Procedure. The procedure for Phase 1 of the experiment was the same as in Experiment 1. In Phase 2, words were presented by means of a tape recorder at a 2-s rate. Subjects were instructed to repeat each word aloud and to remember the words for a later test of recognition memory.

In the final phase of the experiment, a test of recognition memory was given under conditions of either full or divided attention. For that test, subjects were instructed to call a word old only if the word was one that they had heard in Phase 2 of the experiment. Subjects were warned that the test list included words that were earlier read and words earlier presented as anagrams and were told that those words should be called new. The number of target sequences presented in the listening task was smaller in Experiment 2 than in Experiment 1 because the length of the recognition memory test list and, consequently, the amount of time required for the test, was shorter in Experiment 2. Other details of the procedure used for the recognition test were the same as in Experiment 1.

Results and Discussion

In Phase 1, an average of 93% and 90% of the anagrams were solved by subjects in the full- and divided-attention conditions, respectively. Subjects in the divided-attention test condition missed an average of 15 out of 61 target sequences (24%) in the listening task used to divide attention.

Most important, an analysis of the probabilities of false recognition (see Table 2) revealed a significant interaction between the manipulation of attention and that of prior presentation, $F(1,40) = 7.72$, $MS_e = .018$. That interaction shows that, as compared with words that were earlier read, words earlier presented as anagrams were more likely to be falsely recognized when attention was divided (.54 vs. .43), $t(40) = 2.66$, whereas when attention was full at the time of test the direction of the difference was the opposite (.30 vs. .35), although not reliably so, $t(40) = 1.21$.

TABLE 2
PROBABILITY OF CALLING A WORD "OLD" IN EXPERIMENT 2

Test condition	Item type			
	Anagram	Read	New	Heard
Full attention	.30	.35	.17	.66
Divided attention	.54	.43	.21	.54

Of less interest, another analysis included data only from words that were earlier heard and from words that were truly new on the recognition test. The results of that analysis revealed a significant interaction between prior presentation and full versus divided attention, $F(1,40) = 8.86$, $MS_e = .016$. The significant interaction arose because divided, as compared with full, attention at test reduced the accuracy of discrimination between words that were earlier heard and those that were new (see Table 2). The finding of a reduction in the accuracy of recognition memory performance is consistent with the claim that dividing attention hampered conscious recollection.

Consistent with the results of Experiment 1, the effect of dividing attention at test was larger for words earlier presented as anagrams than for words earlier read. That interaction provides evidence that subjects were better able to recollect earlier solving an anagram as compared with earlier reading a word. Dividing attention at test hampered recollection and, thereby, allowed differences in familiarity to be revealed. Words presented as anagrams were more likely to be falsely identified as heard than were read words under conditions of divided attention, but not under conditions of full attention. One can be certain that when attention was divided the higher probability of falsely recognizing words earlier presented as anagrams was produced by their greater familiarity (an automatic influence of memory), because a difference in recollection (an intentional use of memory) would produce the opposite effect. The results show that words presented as anagrams held an advantage over read words in familiarity as well as in recollection.

The finding that words presented as anagrams were later more familiar than words that were read is important for the way that one thinks about familiarity. Familiarity has been described as relying most heavily on the perceptual characteristics of a test item matching those of its prior presentation (e.g., Atkinson & Juola, 1974; Jacoby & Dallas, 1981; Mandler, 1980). From that standpoint, words that were read should have been more familiar than words that were presented as anagrams, because the test items were words not anagrams. In perceptual tasks, the read versus anagram manipulation has an effect that is opposite to its effect on recognition memory (Allen & Jacoby, 1990; Jacoby & Hollingshead, 1990). In combination with the results from those earlier experiments, the results of the present experiment show that familiarity relies not only on the perceptual characteristics of a tested item, but, rather, also reflects processing of the item.

The finding of better recognition memory performance for words presented as anagrams corresponds to a "generation effect" (e.g., Slamecka & Graf, 1978). Gardiner (1988) required subjects to indicate when recognizing a word whether they could recollect its prior occurrence in the study list. A generation effect was not found for items that were recognized but whose prior occurrence was not recollected: items that were recognized on the basis of their familiarity. The implication of Gardiner's results would seem to be that the generation effect totally reflects an influence on recollection. However, the results of the present experiment clearly show that generation influences familiarity as well as recollection. Again, words presented as anagrams held an advantage in both familiarity and recollection over words that were read.

Experiment 3

A facilitation paradigm was used in Experiment 1, whereas an interference paradigm was used in Experiment 2. In Experiment 3, data from a facilitation paradigm were combined with those from an interference paradigm to estimate the separate contributions of familiarity and of recollection. The rationale underlying the process dissociation procedure used in Experiment 3 was that if responding is under conscious control, people should be able to respond differentially to items of a given class depending on the demands of the task. In Experiment 1, for example, conscious recollection allowed subjects to select *for* earlier presented items and increased the probability of correctly calling words old. In Experiment 2, conscious recollection allowed subjects to select *against* words that were earlier read or earlier presented as anagrams and decreased the probability of those words being falsely recognized as earlier heard. In contrast, automatic influences of memory do not support such selective responding. Familiarity increased the probability of calling anagram and read words old, regardless of whether those words were to be called old (Experiment 1) or new (Experiment 2).

Typically, recognition memory tests tap a mixture of consciously controlled recollection and automatic familiarity. However, given that only recollection can allow subjects to both select for and select against items, it should be possible to estimate the separate contributions of recollection and familiarity to recognition memory judgments. To do so, a process dissociation procedure was developed. The rationale underlying that procedure is that recollection can be measured as the difference between the likelihood of responding to an item of a given class when people are attempting to select *for* items of that class as compared to when they are attempting to select *against* items of that class.

The process dissociation procedure developed in Experiment 3 used the procedure and materials used in Experiment 2, with the addition of a testing factor: In the inclusion test condition, subjects were instructed to call a word old if it had been read in Phase 1, if it had been a solution to an anagram in Phase 1, or if it had been heard in Phase 2. In the exclusion test condition, as in Experiment 2, subjects were instructed to call a word old only if it had been heard in Phase 2, and were told that if they could recollect encountering a test word in Phase 1, either as a word that was read or as a word that was a solution for an anagram, they could be certain that the word was not earlier heard, and consequently should not be called old. Thus, in the exclusion condition, subjects used conscious recollection to exclude items from Phase 1.

The notion is that conscious control can be measured as the difference between performance when a person is trying *to* as compared with trying *not to* use information from some particular source. To illustrate, consider a case in which conscious control of responding is complete, so that the probability of recollections is 1.0. In that case, a word earlier presented as an anagram, for example, would always be called old in the inclusion test condition and never be called old in the exclusion test condition. The difference between the probabilities of calling an item of the particular type old would then be 1.0, the probability of recollection. In contrast, consider a case in which the probability of recollection is 0 and words are called old solely on the basis of their familiarity. In that case, the probability of calling an item old would not be controlled by instructions and would be the same in the inclusion and the exclusion test conditions. More generally, the difference between the probabilities of calling an item old in the inclusion and the exclusion conditions can be used to estimate the probability of recollection.

Following others (e.g., Mandler, 1980), it is assumed that recollection (R) and familiarity (F) serve as two independent bases for calling an item old on a test of recognition memory. In the inclusion condition, the probability of saying old to a word earlier presented as an anagram (O_{IA}) is

$$O_{IA} = R_A + F_A - R_A F_A. \quad (1)$$

In the exclusion condition, an item earlier presented as an anagram would be called old (O_{EA}), indicating its false recognition as earlier heard, only if the item was familiar and its presentation as an anagram was not recollected:

$$O_{EA} = F_A(1 - R_A) = F_A - R_A F_A. \quad (2)$$

The probability of recollection can then be estimated as

$$R_A = O_{IA} - O_{EA}. \quad (3)$$

Of course, the same equations hold for words that were read as words presented as anagrams. As can be seen by comparing Eq. (1) and (2), when recollection equals 0, the probability of calling an item old is the same in the inclusion and exclusion test conditions and totally reflects familiarity.

The goal of Experiment 3 was to separate the effects of recollection from those of familiarity. The process dissociation procedure, described above, was used to estimate both the probability of an item being called old on the basis of recollection and the probability of an item being called old on the basis of its familiarity. By simple algebra, F can be estimated given an estimate of R and the observed probability of calling items old (e.g., O_{IA}).

The validity of the estimation procedure was checked by comparing estimated probabilities with probabilities observed in the divided-attention test condition in Experiment 2. To the extent that dividing attention at test fully eliminated the possibility of recollection, such that familiarity fully determined the probability of a word being called old, the estimates of familiarity-based responding gained from Experiment 3 should fit the observed probabilities from the divided-attention test condition in Experiment 2.

Method

Subjects. The subjects were 42 students from the same subject pool as used for Experiment 2, with 21 subjects randomly assigned to each of two test conditions (inclusion vs. exclusion).

Materials and procedure. The materials and procedure were the same as for Experiment 2, aside from the manipulation of test instructions. Subjects in the inclusion test condition were instructed to call an item old if the item was earlier presented as an anagram, earlier read, or earlier heard. Subjects in the exclusion test condition were instructed to call an item old only if it was earlier heard. They were warned that the test list would include words that were earlier presented as anagrams and words that were earlier read and were told that those words should be called new. For both test conditions, subjects were allowed to give full attention to the test of recognition memory.

Results and Discussion

An average of 94% and 92% of the anagrams presented in Phase 1 were solved in the inclusion and the exclusion test conditions, respectively.

Effects on the probability of calling an item old. The interaction between read versus anagram and test condition (see Table 3) was significant, $F(1,40) = 40.18$, $MS_e = .021$. The difference between the inclusion and exclusion condition in the probability of responding old was much larger for anagram (.80 vs. .29) than for read (.48 vs. .37) words. In the inclusion test condition, anagram words were more likely to be called old than were read words (.80 vs. .48), $t(40) = 7.16$, whereas in the exclusion condition anagram words were slightly less likely to be called old than were read words (.29 vs.

TABLE 3
PROBABILITY OF CALLING A WORD "OLD" IN EXPERIMENT 3

Test condition	Item type: Anagram	Read	New	Heard
Inclusion	.80	.48	.18	.69
Exclusion	.29	.37	.22	.67

.37), $t(40) = 1.79$, $p < .08$. That interaction shows that subjects were much more likely to recollect earlier solving an anagram than they were to recollect earlier reading a word.

Another analysis was done to examine the effect of the test condition on subjects' ability to discriminate between heard and new words. The only significant effect revealed by that analysis was that heard words were more likely to be called old than were new words (.68 vs. .20), $F(1,40) = 278.07$, $MS_e = .017$. The lack of an effect of test condition is not surprising, because subjects in both test conditions were instructed to respond old to heard words and new to new words.

Separating recollection and familiarity. As argued earlier, the probability of recollection for anagram and read words can be estimated by subtracting the probability of calling a word old in the exclusion condition from that in the inclusion condition. Doing so, the probability of recollection was estimated to be .51 and .11 for anagram and read words, respectively. By simple algebra, those probabilities of recollection along with the probabilities of calling a word old in either the inclusion or the exclusion condition can be used to estimate the familiarity of anagram and read words. The estimated probability of calling a word old on the basis of its familiarity was .59 for anagram and .42 for read words.

Those estimated probabilities were compared with the observed probabilities of calling anagram and read words old in the divided-attention test condition of Experiment 2. The comparison of estimated probabilities with those observed probabilities provides a way of validating the estimation procedure. To the extent that dividing attention at test prevented recollection, the probability of calling a word old would be determined by its familiarity. Consequently, the estimates of familiarity gained in Experiment 3 would fit the probabilities of calling an item old in the divided-attention condition in Experiment 2. The estimated probability was very close to the observed probability for both anagram (.59 vs. .54) and for read (.42 vs. .43) words.

The fit of the predicted to the observed probabilities is impressive. Indeed, the lack of exact fit might only reflect error variance in the observed probabilities. However, I suspect that the lack of an exact fit was because dividing attention at test did not fully eliminate recollection. Jacoby et al. (1989a, Experiment 3) used recognition memory performance to estimate the probability of subjects' recollecting that they had earlier read an old nonfamous name. That estimate was used to compute the probability of an old nonfamous name being sufficiently familiar to be mistakenly called famous if familiarity were unopposed by recollection. The data used in the estimation procedure came from subjects who made fame judgments under conditions of full attention. The estimate of familiarity was compared to an observed probability gained from subjects who made fame judgments under conditions of divided attention. The rationale underlying that comparison was the same as the comparison made here: If dividing attention at test fully eliminated recollection, then the familiarity estimate gained from a full-attention condition should fit performance in a divided-attention condition. The fit of predicted and observed probabilities in that experiment, as in the present experiment, was close but not exact. The difference between the probabilities of mistakenly responding "famous" to old and new nonrecognized names in the full-attention condition (.35 vs. .18) was approximately the same as that in the divided-attention condition (.28 vs. .14).

Jacoby et al. (1989a) concluded that dividing attention at test reduced the probability of recollection, but had no effect on the use of familiarity as a basis for judgments, other than that of leaving familiarity largely unopposed by recollection. The same conclusion can be drawn from the results of the present experiment. In Experiment 2 reported by Jacoby et al., attention was divided during study rather than at the time of test, and, again, predicted and observed probabilities of false fame judgments were compared. The difference between the probabilities of mistakenly responding "famous" to old and new nonrecognized names in the full-attention condition (.51 vs. .31) was identical to that in the divided-attention condition (.39 vs. .19). The estimation procedure used in the fame experiments differed from the process dissociation procedure used here, but results from the two procedures converge on the same conclusion: Divided, as compared with full, attention greatly reduces the probability of recollection while leaving the use of familiarity as a basis for judgments totally invariant.

Biases in the estimation procedure. The estimation procedure rests on the assumption that the probability of responding old to an item because of its familiarity would be the same in the inclusion and the exclusion test conditions had it not been for recollection. That is, the criterion used for familiarity-based judgments in the inclusion test condition was assumed to be the same as that in the exclusion test condition. Some evidence to show that the assumption of equal criteria was not violated comes from the false alarm rate to new words. The false alarm rate was roughly equivalent across the inclusion (.18) and the exclusion (.22) conditions in Experiment 3 and the divided-attention condition (.21) in Experiment 2.

A second assumption upon which use of the estimation procedure rests is that the probability of recollection in the inclusion test condition was the same as in the exclusion test. That assumption might be problematic. Subjects might be more likely to engage in recollection when it is necessary to discriminate words presented in Phase 1 from those presented in Phase 2 (exclusion test) than when a discrimination between the two sources is not required (inclusion test). A bias of that sort would result in the estimated probability of recollection being someplace between the true probabilities of recollection for the two test conditions. The near perfect fit of predicted and obtained probabilities makes it safe to conclude that any problems produced by bias in the estimates of the probability of recollection were not serious ones.

A third assumption upon which use of the estimation procedure rests is that of complete independence of bases for judgments (0 covariance). That is, values of familiarity and values of recollection are assumed to be totally uncorrelated. The assumption is a strong one, but it is the same as made for discrimination and response bias when using signal detection theory. Snodgrass and Corwin (1988) compared four theoretical models of recognition memory performance with regard to their associated measures of discrimination and response bias. The four models did differ in the degree to which correlation between discrimination and response bias parameters were observed. However, application of the different models generally led to the same conclusions being drawn. For present purposes, the important point is that a minor violation of the assumption of independence need not seriously distort results. The near perfect fit of predicted and observed probabilities provides some confidence that any violation of the independence assumption was only a minor one. Confidence that the assumptions underlying the process dissociation procedure are justified would be strengthened by further findings of invariance in one factor across large changes in the other factor. As will be described in the General Discussion, several further findings of that sort have now been obtained.

General Discussion

The experiments were done to separate intentional from automatic influences of memory. Converging evidence that the two uses of memory differ in their reliance on attention was gained by manipulating full versus divided attention at test. Dividing attention at test was expected to hamper intentional processing, but to have little if any influence on automatic processing. From the results of the experiments, I draw the following conclusions:

1. There are two qualitatively different bases for recognition memory judgments.
2. Recollection, as a basis for recognition memory judgments, requires prior processing of a sort that will support later recollection and is also subject to limits on attention at test. Dividing attention at test can make recollection nearly impossible, as can superficial processing of the event that is to later be recollected.
3. Familiarity, as a basis for recognition memory judgments, is not totally reliant on the perceptual characteristics of the tested material, but, rather, can also reflect other aspects of its earlier processing.
4. Familiarity-based judgments require relatively little processing capacity. Dividing attention at test has very little, if any, influence on familiarity-based judgments, aside from leaving those judgments unopposed by conscious recollection.
5. Recollection and the assessment of familiarity are independent processes.

The results of Experiment 1 provided evidence of qualitatively different bases for recognition memory judgments by showing an interaction between prior processing and full versus divided attention at test. However, from the results of that experiment, one cannot tell whether the manipulation of prior processing influenced only recollection-based judgments, or both recollection- and familiarity-based judgments. By placing the two bases for judgment in opposition, as in Experiment 2, one can see that the manipulation influenced both bases for judgments. When effects are placed in opposition, results taken as evidence of automatic influences could not have been produced by an intentional use of memory that was undetected by the experimenter. This is true because an intentional use of memory would produce an opposite effect.

Compared to facilitation paradigms, interference paradigms can provide much clearer evidence concerning the influence of intentional processing. Nonetheless, facilitation paradigms can provide important insights that would not be obtained from interference paradigms. For example, if one looked only at the results of Experiment 2, one might conclude that recollection always follows the assessment of familiarity and is only important to avoid being deceived by familiarity gained from an inappropriate source. However, the results of Experiment 1 show that recollection can serve to allow recognition of items that were not recognized on the basis of their familiarity. This is shown by the interaction between prior processing and divided versus full attention at test. Dividing attention at test had an effect both when bases for judgment acted in concert (Experiment 1) and when they were in opposition (Experiment 2). In both cases, that effect was because dividing attention at test hampered recollection.

Even more interpretive power can be gained by comparing performance in the in-concert case, an inclusion test condition, with that in the opposition case, an exclusion test condition, so as to estimate the probability of recollection (i.e., the process dissociation procedure used in Experiment 3). The rationale underlying the process dissociation procedure is that intentional processing can be measured as the difference between the likelihood of responding to an item of a given class when people are attempting to select *for* items of that class as compared to when they are attempting to select *against* items of that class. Put simply, the notion is that if responding is under conscious control, subjects should be able to select either for or against items of a given class, whichever they are instructed to do.

The process dissociation procedure contrasts with other procedures that have been used to separate different bases for responding. In what follows, I first compare the process dissociation procedure with other procedures. I argue that the process dissociation procedure provides an escape from the problems in interpretation that have plagued those other procedures. Next, harkening back to the Introduction, I relate the notion of familiarity to theorizing about automaticity. Finally, I describe directions for future research. Reference to a process dissociation *framework* is justified by illustrating the applicability of process dissociation procedures across a wide variety of domains.

Tasks and Processes

The strategy of using the process dissociation procedure to separate automatic and intentional processes by estimating their effects contrasts with the strategy of searching for task dissociations. As noted in the Introduction, most past investigations of automatic (unconscious) influences of memory or perception assumed a one-to-one mapping between processes and tests. The drawing of conclusions, then, requires that tests be factor- or process-pure with regard to the type of processing they measure. A difficulty for identifying processes with tasks is that tasks are probably never process pure (e.g., Dunn & Kirsner, 1989; Reingold & Merikle, 1990). That problem is not fully solved by finding task dissociations between manipulations of prior processing or between subject populations and type of test. Given that a dissociation has been found, one is still unable to answer questions such as, "Was automatic processing at a normal level?," without making the process-pure assumption.

The process dissociation procedure provides an escape from problems of identifying processes with tasks which have plagued attempts to define automaticity. The manipulation of indirect versus direct tests is best treated as an attempt to influence reliance on automatic processes. In addition to the parallels described here, Logan (1990) has pointed out parallels between performance on indirect tests of memory and effects of extensive training of the sort that are generally taken as evidence of automaticity. However, equating performance on indirect tests with automaticity is made less attractive by problems encountered when attempting to define automaticity. Bargh (1989) criticized the standard definition of automaticity by arguing that the criteria of being capacity-free, outside of awareness, and unintentional are seldom simultaneously met. Each of those criteria has been used to design tasks with which automaticity has been equated. In contrast, I define automaticity solely in terms of the relation between performance in a facilitation paradigm and that in an interference paradigm. Automatic influences of memory are unintentional in that they remain the same regardless of whether those influences facilitate or interfere with performance of a task. Defining automaticity in this way allows use of the process dissociation procedure to separate the contribution of intentional and automatic processes. Doing so avoids problems that arise when automaticity is identified with a particular combination of training or test conditions or is identified with some characteristic of a response, such as its rapidity.

Lack of awareness has sometimes been used as a criterion for automaticity or unconscious processing. Awareness has generally been assessed by asking subjects to report on (or to make judgments that rely on) their memory for details of the event in question (e.g., Bowers & Schacter, 1990; Gardiner, 1988). A difficulty for assessing awareness in this way is that reports of, and judgments about, details of an event can have multiple bases, just as do recognition memory judgments (e.g., Huppert & Piercy, 1978; Kelley, Jacoby, & Hollingshead, 1989). Interest in awareness is usually fueled by its implications for intention: If one is aware of an event, then processing can be intentionally changed in a way that takes that event into account. However, rather than awareness being a prerequisite for intentional processing, awareness sometimes follows behavior and reflects an inference or attribution process (e.g. Jacoby, Kelley, & Dywan, 1989b; Kelley & Jacoby, 1990). Similarly, Johnson and her colleagues (e.g., Johnson & Raye, 1981) have investigated memory for source by asking subjects to make overt judgments about the sources of their memories and have noted that source judgments might have multiple bases. The process dissociation procedure provides a means of separating different bases for judgment.

Another approach to separating different bases for judgment is to assume that bases differ in terms of the amount of time that they require, and to then relate effects on decision time or effects of the amount of time allowed for a decision to the different bases for judgment (e.g., Atkinson & Juola, 1974; Gillund & Shiffrin, 1984; Gronlund & Ratcliff, 1989). Logan (1988) accounted for the speeding of decisions that comes from extended practice by assuming that, as a result of practice, people change over from computing responses algorithmically to relying on memory—a more rapid basis for responding. Although assumptions about response time seem to hold in some situations, it is unlikely that automatic and intentional processes differ reliably across situations in terms of the time that they require. For example, recollection may not always be slower than is familiarity. The clarity of recollection might sometimes lead to a faster response than does a vague feeling of familiarity.

Decision times are unlikely to provide a factor-pure measure of the basis of responding. With the process dissociation procedure, it need not be assumed that use of a short deadline produces responding that is purely automatic. Rather, effects of response deadline on automatic and intentional bases for responding can be separately observed just as were the effects of full versus divided attention at test. Also, rather than treating extended practice as a prerequisite for automaticity (e.g., Shiffrin & Schneider, 1977), the effects of practice on automatic and intentional processing can be assessed using process dissociation procedures. As described in the next section, automatic influences can rely on memory for a particular prior episode rather than extended practice. In the experiments reported here, a single prior presentation of a word gave rise to an automatic influence of memory.

The goal of the process dissociation procedure is the same as that motivating Mandler's (e.g., 1980) attempt to estimate separately the influence of different bases for recognition memory decisions. However, unlike Mandler's procedure, the process dissociation procedure does not rely on an assumption that a particular type of test yields a process-pure measure of recollection. Mandler gave subjects a free- or cued-recall test and then used their probability of recall as an estimate of the probability of recollection. That estimated probability of recollection was combined with recognition memory performance to compute an estimate of the probability of an item being called old on the basis of its familiarity. Two important assumptions underlie Mandler's procedure. First, it is necessary to assume that free- and cued-recall tests are process-pure as measures of the probability of recollection. Second, it must be assumed that the process of recollection measured by a test of recall is the same as the process of recollection in the context of a recognition memory test. There is reason to doubt that either assumption is often satisfied. Recall performance reflects a mix of recollection and automatic influences of memory just as does recognition memory performance. Correct "guesses" on a test of cued-recall may reflect the same automatic process as does performance on an indirect test of memory (Jacoby & Hollingshead, 1990). This means that a test of recall does not provide a process-pure measure of recollection. Also, the recollection required for recall is likely to differ from the recollection required for a recognition memory test. At the least, there is a difference in what must be recollected. To be credited with recollection when given a cued-recall test, one must recall the word with which the target word was earlier paired. For a recognition memory test, it is enough to recollect that the target word was earlier paired with another word, without having to recollect that word.

Hastie and Park (1986) used a method for separating "memory-based" from "on-line" judgments that is, in many ways, similar to the method used by Mandler (1980) to separate different bases for recognition memory. Their procedure is open to criticisms that are similar to those given for Mandler's procedure (Jacoby, Marriott, & Collins, 1990). The use of a perceptual identification test to measure the perceptual fluency said to underlie the feeling of familiarity (Johnston, Dark, & Jacoby, 1985) also rests on a process-pure assumption. Although there is good evidence that the feeling of familiarity reflects the use of a fluency heuristic (Jacoby & Whitehouse, 1989; Whittlesea, Jacoby, & Girard, 1990), the fluency measured by a test of perceptual identification may sometimes differ in important ways from the fluency that is responsible for the feeling of familiarity that serves as a basis for recognition memory judgments. The experiments reported here showed that the effects of the read versus anagram manipulation on familiarity are opposite to the effect of that manipulation on perceptual identification and stem completion performance. The basis for the feeling of familiarity is further discussed in the next section.

The major advantage offered by the process dissociation procedure is that one need not treat tasks as if they were process pure. Similar to signal detection theory, the process dissociation procedure separates the contributions of different types of processes to performance of a task, rather than equating processes with tasks. Doing so allows one to examine process dissociations rather than task dissociations. This is important because otherwise one is unable to examine invariance in processes. Use of the process dissociation procedure in the experiments reported here showed that the influence of automatic processes was invariant across a manipulation of attention at test that had a large effect on recollection (an intentional use of memory). That invariance could not be shown by equating processes with tasks and then examining task dissociations, because tasks are almost never process pure. Automatic and intentional processes combine to determine performance of nearly all tasks and so tasks cannot legitimately be treated as process pure.

Familiarity and Automaticity

It is common to assume that familiarity primarily reflects memory for the perceptual characteristics of an item (e.g., Jacoby & Dallas, 1981; Mandler, 1980) and, consequently, is relatively context free (e.g., Atkinson & Juola, 1974; Mandler, 1980). Results of the experiments reported here show both those assumptions to be wrong. Familiarity was greater for words that had earlier been presented as anagrams to be solved than for words that had been read in their normal form. To explain that effect of prior processing, one might claim that familiarity is produced by the activation of relationships among items as well as by the activation of a representation of the perceptual characteristics of an item (e.g., Mandler, 1980). A model of that sort would hold that familiarity is relatively context free, because it depends on an abstract representation of the perceptual characteristics of an item, such as a logogen (Morton, 1979), along with an abstract representation of relationships among items, such as an associative network (e.g., Anderson & Bower, 1972). However, the advantage of anagram over read words cannot be explained as produced by the activation of some abstract representation of solving an anagram, because subjects had never before solved those anagrams. The result also cannot be explained as produced by the activation of an abstract perceptual representation. This is because reading a word does more to enhance its later perceptual identification than does producing the word as a solution for an anagram (Allen & Jacoby, 1990).

Tulving and Schacter (1990) used the term "priming" to refer to facilitative effects of prior experience on indirect tests of memory. In contrast, effects described as produced by priming can as well be treated as reflecting automatic influences of memory and explained in terms that are very old, such as "habit" (James, 1890). The major difference between priming and habit is that the term priming refers to effects of a single prior presentation of an item, whereas habit usually refers to the effects of extensive training. However, there are probably trade-offs among factors such as amount of training, retention interval, and the retrieval conditions provided by an indirect test of memory. Given good cues for retrieval and a relatively short retention interval, memory for a single prior presentation of an item can act like a habit in serving as a basis for an automatic influence of memory. An indirect test is, perhaps, best viewed as a test of "incidental or unintentional retrieval," with incidental retrieval being treated in the same way as has been incidental learning (Jacoby, 1984). Just as most everyday learning is incidental rather than intentional, most effects of the past are incidental and unintentional. The use of memory for a prior episode as a source of automatic influences, of course, does not imply that one can or does recollect that prior episode. As shown in the present experiments, automatic influences of memory can originate from memory for a single prior presentation of an item and rely on processes that are different from the intentional processes that are responsible for recollection.

In line with the above arguments, Logan (1988) has described automaticity as relying on memory for instances, rather than on the

development of an abstract representation (cf. Schneider & Shiffrin, 1977). Logan (1990) has pointed out parallels between performance on indirect tests of memory and automaticity by showing that effects of a small number of prior presentations of an item that are typically taken as showing priming fall on the early portion of the curve that describes the development of automaticity as a function of extensive training. The motivation for adopting an episodic theory of automaticity is the same as that for adopting an instances or episodic view of categorization performance (Brooks, 1978, 1987; Hintzman, 1986; Medin & Schaffer, 1978). The longevity and the specificity of the effects of a prior presentation are understandable if those effects rely on the retrieval of memory for a prior experience rather than on the priming of some abstract representation (e.g., Jacoby & Brooks, 1984; Jacoby, Baker, & Brooks, 1989).

In settings of the sort investigated by social psychologists as well as in more standard memory experiments, indirect tests of memory reveal effects that are too specific to the details of prior experience to be easily explained as produced by priming (Smith, 1990). Indeed, the difference between an episodic view and the psychoanalytic view of automatic or unconscious influences of memory is one of the specificity of predicted effects (Jacoby & Kelley, 1990). Recent research has shown that even Freudian slips are much more reliant on the specific details of a situation than would have been predicted by the psychoanalytic tradition (e.g., Fromkin, 1973; Motley, 1985).

What is the nature of the familiarity that can serve as a basis for recognition memory decisions? Perhaps it is best to think of the contrast between recollection and familiarity as being of the same kind as the contrast between nonanalytic and analytic bases for categorization (Jacoby & Brooks, 1984). For categorization, analytic judgments are made on the basis of some defining characteristic, whereas nonanalytic judgments reflect the global similarity between a test item and memory for earlier-presented items. Applying a distinction of that sort to describe recognition memory performance, recollection serves as an analytic basis for judging, for example, whether an item was presented in a particular list, whereas familiarity is a nonanalytic judgment of the global amount learned from the prior presentation of an item. This description of familiarity is generally consistent with global memory models of familiarity (e.g., Gillund & Shiffrin, 1984; Hintzman, 1988) and of plausibility (Reder, 1987).

Treating familiarity as a nonanalytic judgment means that familiarity cannot be differentiated from recollection in terms of a distinction between item and relational information (cf. Humphreys & Bain, 1983), because both types of information influence both of the bases for recognition memory judgments. Although the perceptual characteristics of an item might objectively remain constant across situations, what is stored in memory are the operations used to deal with an item in the context of a particular task (e.g., Kolers, 1979). This makes it necessary to define familiarity in terms of the task in which a person was currently engaged, rather than treating familiarity as reflecting the status of some context-free, abstract representation. Familiarity is not simply a correlate of some characteristic of a memory trace such as strength. For example, the estimated familiarity of words read in Phase 1 of Experiment 3 would probably have been different if the list of words presented to be remembered in Phase 2 had been read rather than heard. That is, I believe familiarity is better described as arising from relationships among items, in the same way that similarity is traditionally described, rather than as an absolute characteristic of memory for an item. Familiarity is context dependent in a way that results in its changing across tasks and situations and may be as subject to context effects as is similarity.

The claim that familiarity is context specific is consistent with recent changes in the way automaticity is viewed. Neumann (1984) criticized the notion that automaticity reflects "stimulus-driven" processing by arguing that behavior, including even simple reflexes, is never totally stimulus-driven. Specifically, he points out that automatic processes are not independent of a person's current intentions and direction of attention. Neumann noted that the criteria that are typically proposed for defining a process as automatic are almost never satisfied, and he went on to describe automaticity in terms of a view of different levels of control that he attributes to Wundt. Similarly, Bargh (1989) talked in terms of conditional automaticity and Logan (1989) argued that automatic responding is tightly controlled, rather than uncontrolled as is implied when automatic processing is contrasted with controlled processing.

Problems for the contrast between data-driven and conceptually-driven processing as an account for memory dissociations (e.g., Jacoby, 1983; Roediger, 1990) are the same as those for the contrast between stimulus-driven and intention-driven processing. Data-driven processing is synonymous with stimulus-driven processing. Data-driven processing is not separable from the task for which the data are being processed (e.g., Levy & Kirsner, 1989; Whittlesea & Jacoby, 1990). Attempts to order tasks with regard to a quantitative difference in data-driven processing ignore qualitative differences in processing and so are of limited utility. More generally, little can be gained by using task dissociations to classify tasks unless one has a good theory of processes within a task. Gaining a theory of that sort requires that one be able to separate the contributions of different processes to performance of a task. Consistent with the notion of levels of control (Neumann, 1984), the process dissociation procedure examines the contribution of automatic processes within a task, rather than treating automaticity as being task- or context-free.

Clearly, the effects of devoting divided versus full attention to a test of recognition memory are relevant to theories of automaticity. In the experiments reported here, attention was divided by requiring subjects to engage in a listening task while making recognition memory judgments. Had a different task been used or had the listening task been made easier or more difficult, the effects of dividing attention on recognition memory judgments would likely be different from those that were observed. Issues of this sort led to the development of multiple-resource models of attention (e.g., Wickens, 1984). Such models of attention are similar to accounts of task dissociations in terms of separate memory systems (e.g., Tulving & Schacter, 1990) but rest on a body of research that is, in some ways, more sophisticated than that used to infer the existence of multiple memory systems. The conclusion that there are multiple resources rests on results from interference paradigms, whereas the conclusion that there are multiple memory systems has typically been supported with results from facilitation paradigms.

In an excellent paper, Allport (1989) reviewed evidence used to support multiple-resource models of attention and argued that effects of dividing attention are better described in terms of conflicts in the scheduling and execution of processing, rather than in terms of a collection of limited-capacity processors. In that vein, the distinction between memory as a tool and memory as an object, proposed by Jacoby and Kelley (1987), was an attempt to describe conflicts between different uses of memory. The argument is that conscious recollection of a prior experience (memory as an object) can require a retrieval orientation along with types of retrieval activities that conflict with automatic influences of memory (memory as a tool).

Future Directions

The strategy that I have followed here differs from that used by other investigators

of memory dissociations. I have introduced a new procedure for separating different uses of memory and related that new procedure to the old contrast between automatic and intentional processing. More commonly, the introduction of new tasks is accompanied by new names for the processes thought to underlie performance of those tasks. For example, implicit memory tasks were introduced as measuring implicit memory (Graf & Schacter, 1985). Such close identification of processes with the tasks used to measure them is reminiscent of the days of radical operationalism (see Leahey, 1987, for an excellent discussion of reasons for the downfall of radical operationalism and logical positivism). In contrast, I draw a strong distinction between processes and the way that effects of processes are measured. The process dissociation procedure separates the contributions of automatic and intentional processing to performance of a task, rather than identifying different types of processing with different tasks as is done when interpreting task dissociations.

Why identify the process dissociation procedure with the contrast between automatic and intentional processing? The process dissociation procedures introduced here are atheoretical in the sense that they could be used as easily by those seeking evidence of the existence of separate memory systems as by those interested in differences in processing. For example, process dissociation procedures might be seen as a way of "correcting" for the influence of episodic memory on an indirect test of memory. I have not described the procedure as being a correction procedure because I am equally interested in the two bases for judgments revealed by the use of that procedure. I have two reasons for identifying the procedure with the contrast between automatic and intentional processing: First, the procedure nicely captures the difference between facilitation and interference paradigms, along with the notion that the contribution of automatic processes remains constant over conditions that reverse the direction of the contribution of intentional processes. Second, by relating the procedure to the contrast between automatic and intentional processing, I gain the advantages offered by a long history of research investigating automaticity.

Use of the older terms is meant to facilitate contact with history so as to gain the benefits of earlier research, and it is also meant to highlight the similarity of problems across research areas that have been differentiated by identifying possesses with tasks. Indeed, the distinction between automatic and intentional processing might hold across a number of such supposedly different areas. The supposedly different areas that I have in mind are: perception, attention, memory, thinking, categorization, social interaction, etc. The complaint is that textbooks are organized around tasks with the implication that tasks are process-pure, rather than being organized around processes so as to emphasize the similarity among supposedly different areas of psychology. More locally, the equation of processes with tasks has obscured the relation between interference and facilitation paradigms. For example, proactive interference is not generally treated as reflecting implicit memory but provides as much, or more, evidence of automaticity as do effects in facilitation paradigms. The automaticity observed in studies of memory and the automaticity observed in studies of attention can be described in a common framework.

Experiment 3 reported here was the first of a large number of experiments that have now been done using process dissociation procedures. Use of the process dissociation procedures to investigate the effects of dividing attention during study shows that automatic influences of memory remain invariant across the manipulation of attention, whereas the probability of recollection is much lower following divided, as compared with full attention to study (a brief description of one experiment from that series is reported in a paper by Jacoby & Kelley, in press). Other experiments that my colleagues and I have done generalize the use of process dissociation procedures to separate automatic from intentional processes in the following tasks: recall cued by presentation of word stems, unconscious perception, Stroop performance, thinking, and categorization. Experiments are underway to test the possibility that aging and some forms of amnesia leave automatic influences of memory invariant while producing a deficit in intentional uses of memory. The success of later experiments provides support for the assumptions underlying the process dissociation procedure introduced in Experiment 3.

Experiments that my colleagues and I have done to generalize the use of process dissociation procedures have met with a good deal of success, but have also encountered problems. Even those problems have proved extremely useful. An advantage of working in the framework of process dissociation procedures is that the requirements of those procedures are sufficiently constraining to allow one to know when one is wrong and to provide a direction for changes.

At the broadest level, the contrast between automatic and intentional processes is the same as that between habit and reason (e.g., James, 1890). What I find exciting is that process dissociation procedures give us a way to make that very general distinction experimentally tractable. Neither habit nor reason is often, if ever, found in a pure form. Habit condemns us to carry on as we have in the past, whereas reason provides hope for change. There is good reason for abandoning the practice of equating processes with tasks. Doing so provides hope for progress.

References

Allen, S. W., & Jacoby, L. L. (1990). Reinstating study context produces unconscious influences of memory. *Memory and Cognition*, 18, 270–278.

Allport, A. (1989). Visual attention. In M. I. Posner (Ed.), *Foundations of Cognitive Science* (pp. 631–682). Cambridge, MA: MIT Press.

Anderson, J. R., & Bower, G. H. (1972). Recognition and retrieval processes in free recall. *Psychological Review*, 79, 97–123.

Atkinson, R. C., & Juola, J. F. (1974). Search and decision processes in recognition memory. In D. H. Krantz, R. C. Atkinson, R. D. Luce, & P. Suppes (Eds.), *Contemporary developments in mathematical psychology, Vol. 1, Learning, memory and thinking*, (pp. 243–293). San Francisco, CA: Freeman.

Baddeley, A., Lewis, V., Eldridge, M., & Thomson, N. (1984). Attention and retrieval from long-term memory. *Journal of Experimental Psychology: General*, 113, 518–540.

Bargh, J. A. (1989). Conditional automaticity: Varieties of automatic influence in social perception and cognition. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 3–51). New York: Guilford Press.

Begg, I., Maxwell, D., Mitterer, J. O., & Harris, G. (1986). Estimates of frequency: Attribute or attribution? *Journal of Experimental Psychology: Learning, Memory and Cognition*, 12, 496–508.

Bowers, J. S., & Schacter, D. L. (1990). Implicit memory and test awareness. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 16, 404–416.

Brooks, L. R. (1978). Non-analytic concept formation and memory for instances. In E. Rosch & B. Lloyd (Eds.), *Cognition and categorization*, (pp. 169–211). Hillsdale, NJ: Erlbaum.

Brooks, L. R. (1987). Decentralized control of categorization: The role of prior processing episodes. In U. Neisser (Ed.), *Categories reconsidered: The ecological and intellectual bases of categories* (pp. 141–174). Cambridge, England: Cambridge University Press.

Chessman, J., & Merikle, P. M. (1986). Distinguishing conscious from unconscious perceptual processes. *Canadian Journal of Psychology*, 40, 343–367.

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: Deutscher Verlag der Wissenschaffen.

Dixon, N. F. (1971). *Subliminal perception: The nature of a controversy*. London: McGraw-Hill.

Dunn, J. C., & Kirsner, K. (1989). Implicit memory: Task or process? In S. Lewandowsky, J. C. Dunn, and K. Kirsner (Eds.), *Implicit memory: Theoretical issues*, (pp. 17–31). Hillsdale, NJ: Erlbaum.

Dywan, J. & Jacoby, L. L. (1990). Effects of aging on source monitoring: Differences in susceptibility to false fame. *Psychology and Aging*, 5, 379–387.

Ellenberger, M. F. (1970). *The discovery of the unconscious: The history and evolution of dynamic psychiatry*. New York: Basic Books.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception and Psychophysics*, 16, 143–149.

Fromkin, V. A. (1973). Slips of the tongue. *Scientific American*, 229, 110–117.

Gardiner, J. M. (1988). Functional aspects of recollective experience. *Memory and Cognition*, 16, 309–313.

Gillund, G., & Shiffrin, R. M. (1984). A retrieval model for both recognition and recall. *Psychological Review*. 91, 1–67.

Graf, P. & Schacter, D. L. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 11, 501–518.

Gronlund, S. D., & Ratcliff, R. (1989). Time course of item and associative information: Implications for global memory models. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 15, 846–858.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General*, 108, 356–388.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review of a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation, Vol. 22*. New York: Academic Press.

Hastie, R., & Park, B. (1986). The relationship between memory and judgment depends on whether the judgment task is memory-based or on-line. *Psychological Review*, 3, 258–268.

Hintzman, D. L. (1986). "Schema abstraction" in a multiple-trace memory model. *Psychological Review*, 93, 411–428.

Hintzman, D. L. (1988). Judgments of frequency and recognition memory in a multiple-trace memory model. *Psychological Review*, 95, 528–551.

Hintzman, D. L. (1990). Human learning and memory: Connections and dissociations. *Annual Review of Psychology*, 41, 109–139.

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.

Howard, D. V. (1988). Implicit and explicit assessment of cognitive aging. In M. L. & C. J. Brainerd (Eds.), *Cognitive development in adulthood: Progress in cognitive development research* (pp. 3–37). New York: Springer-Verlag.

Hultsch, D. F., & Dixon, R. A. (in press). Learning and memory and aging. In J. E. Birren and K. W. Schaie (Eds.), *Handbook of the psychology of aging* (3rd ed.). San Diego: Academic Press.

Humphreys, M. S., & Bain, J. D. (1983). Recognition memory: A cue and information analysis. *Memory and Cognition*, 11, 583–600.

Huppert, F. A., & Piercy, M. (1978). The role of trace strength in recency and frequency judgments by amnesic and control subjects. *Quarterly Journal of Experimental Psychology*, 30, 346–354.

Jacoby, L. L. (1982). Knowing and remembering: Some parallels in the behavior of Korsakoff patients and normals. In L. S. Cermak (Ed.), *Human memory and amnesia*, (pp. 97–122). Hillsdale, NJ: Erlbaum.

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. (1984). Incidental versus intentional retrieval: Remembering and awareness as separate issues. In L. R. Squire & N. Butters (Eds.), *Neuropsychology of memory*, (pp. 145–156). New York: Guilford Press.

Jacoby, L. L., Baker, J. G., & Brooks, L. R. (1989). Episodic effects on picture identification: Implications for theories of concept learning and theories of memory. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 15, 275–281.

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). New York: 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. (1987). Unconscious influences of memory for a prior event. *Personality and Social Psychology Bulletin*, 13, 314–336.

Jacoby, L. L., & Kelley, C. M. (1990). An episodic view of motivation: Unconscious influences of memory. In E. T. Higgins, & R. M. Sorrentino (Eds.), *Handbook of motivation and cognition: Foundations of social behavior* (Vol. 2, pp. 451–481). New York: Guilford Press.

Jacoby, L. L., & Kelley, C. M. (in press). Unconscious influences of memory: Dissociations and automaticity. In D. Milner & M. Rugg (Eds.), *The neuropsychology of consciousness, St. Andrews, Scotland, Sept. 4–5, 1990.*

Jacoby, L. L., Kelley, C. M., & Dywan, J. (1989b). Memory attributions. In H. L. Roediger & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving*, (pp. 391–422). Hillsdale, NJ: Erlbaum.

Jacoby, L. L., Marriott, M., & Collins, J. (1990). The specifics of memory and cognition. In T. K. Srull & R. S. Wyer (Eds.), *Advances in social cognition, Volume III. Content and process specificity in the effects of prior experiences* (pp. 111–121). Hillsdale, NJ: Erlbaum.

Jacoby, L. L., & Whitehouse, K. (1989). An illusion of memory: False recognition influenced by unconscious perception. *Journal of Experimental Psychology: General*, 118, 126–135.

Jacoby, L. L., Woloshyn, V., & Kelley, C. M. (1989a). Becoming famous without being recognized: Unconscious influences of memory produced by dividing attention. *Journal of Experimental Psychology: General*, 118, 115–125.

James, W. (1890). *Principles of psychology*. New York: Henry Holt.

Johnson, M. K., & Raye, C. L. (1981). Reality monitoring. *Psychological Review* 88, 67–85.

Johnston, W. A., Dark, V. J., & Jacoby, L. L. (1985). Perceptual fluency and recognition judgments. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 11, 3–11.

Kelley, C. M. & Jacoby, L. L. (1990). The construction of subjective experience: Memory attributions. *Mind and Language*, 5, 49–68.

Kelley, C. M., Jacoby, L. L., & Hollingshead, A. (1989). Direct versus indirect tests of memory for source: Judgments of modality. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 15, 1101–1108.

Kolers, P. A. (1979). A pattern-analyzing basis of recognition. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory* (pp. 363–384). Hillsdale, NJ: Erlbaum.

Leahey, T. H. (1987). *A history of psychology: Main currents in psychological thought*. Englewood Cliffs, NJ: Prentice-Hall.

Levy, B. A., & Kirsner, K. (1989). Reprocessing text: Indirect measures of word and message level processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 407–417.

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review*, 95, 492–527.

Logan, G. D. (1989). Automaticity and cognitive control. In J. E. Uleman & J. A. Bargh (Eds.), *Unintended thought*, (pp. 52–74). New York: Guilford Press.

Logan, G. D. (1990). Repetition priming and automaticity: Common underlying mechanisms? *Cognitive Psychology*, 22, 1–35.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review*, 87, 252–271.

Medin, D. L., & Schaffer, M. M. (1978). Context theory of classification learning. *Psychological Review*, 85, 207–238.

Morton, J. (1979). Facilitation in word recognition: Experiments causing change in the logogen model. In P. A. Kolers, M. E. Wrolstal, & H. Bonma (Eds.), *Processing of visible language. Vol. 1*, (pp. 259–268). New York: Plenum.

Motley, M. T. (1985). Slips of the tongue. *Scientific American*, 253, 116–127.

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.

Posner, M. I., & Snyder, C. R. R. (1975). Attention and cognitive control. In R. L. Solso (Ed.), *Information processing in cognition: The Loyola Symposium* (pp. 55–85). Hillsdale, NJ: Erlbaum.

Reder, L. M. (1987). Strategy selection in question answering. *Cognitive Psychology*, 19, 90–138.

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.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 13, 501–518.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human information processing. I. Detection, search and attention. *Psychological Review*, 84, 1–66.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing. II. Perceptual learning, automatic attending, and a general theory. *Psychological Review*, 84, 127–190.

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, 4, 592–604.

Smith, E. R. (1990). Content and process specificity in the effect of prior experiences. In T. K. Srull & R. S. Wyer (Eds.), *Advances in social cognition* (Vol. 3). Hillsdale, NJ: Erlbaum.

Snodgrass, J. G., & Corwin, J. (1988). Pragmatics

of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General*, 117, 34–50.

Stevens, S. S. (1951). Mathematics, measurement, and psychophysics. In S. S. Stevens (Ed.), *Handbook of experimental psychology*. New York: John Wiley & Sons.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experiment Psychology*, 18, 643–662.

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.

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science*, 247, 301–305.

Warrington, E. K., & Weiskrantz, L. (1968). A study of learning and retention in amnesic patients. *Neuropsychologia*, 6, 283–291.

Warrington, E. K., & Weiskrantz, L. (1974). The effect of prior learning on subsequent retention in amnesic patients. *Neuropsychologia*, 12, 419–428.

Weiskrantz, L., & Warrington, E. K. (1975). The problem of the amnesic syndrome in man and animals. In R. L. Isaacson & K. H. Pribram (Eds.), *The hippocampus* (Vol 2.) New York: Plenum.

Whittlesea, B. W. A., & Jacoby, L. L. (1990). Interaction of prime repetition with visual degradation: Is priming a retrieval phenomenon? *Journal of Memory and Language*, 29, 546–565.

Whittlesea, B. W. A., Jacoby, L. L., & Girard, K. A. (1990). Illusions of immediate memory: Evidence of an attributional basis for feelings of familiarity and perceptual quality. *Journal of Memory and Language*, 29, 716–732.

Wickens, C. D. (1984). Processing resources in attention. In R. Parasuraman & D. R. Davies (Eds.), *Varieties of attention*. New York: Academic Press.

Winocur, G. (1982). Learning and memory deficits in institutionalized and noninstitutionalized old people: An analysis of interference effects. In F. I. M. Craik and S. Trehub (Eds.), *Aging and cognitive processes* (pp. 155–181). New York: Plenum Press

(Received July 16, 1990)

(Revision received January 28, 1991)