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Toward a Redefinition of Implicit Memory: Process Dissociations Following Elaborative Processing and Self-Generation

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Does conceptual processing affect unconscious uses of memory? We used a process-dissociation procedure to separate automatic (unconscious) and consciously controlled uses of memory in a stem-completion task. Contrary to results from indirect test conditions, estimates derived from our procedure showed no effect of self-generation and no differential effect of semantic and nonsemantic study conditions on automatic uses of memory. These results provide evidence that (a) indirect tests are often contaminated by conscious uses of memory and (b) stem completion is highly dependent on prior perceptual (and perhaps lexical) processing. The experiments demonstrate the advantages of using process-dissociation procedures over comparisons between direct and indirect tests.

Since the advent of psychoanalysis, researchers have attempted to measure unconscious influences. Much of the contemporary interest in unconscious influences has come from the development of indirect or implicit measures of memory (for reviews see Hintzman, 1990; Richardson-Klavehn & Bjork, 1988; Roediger, 1990; Roediger & McDermott, in press; Schacter, 1987). The defining feature of an indirect test is simply the instructions: Subjects are told to process and respond to stimuli without reference to past experience. The notion is that by telling subjects to respond to stimuli without reference to the past, it is possible to gain an index of unconscious influences of memory; in fact, direct and indirect tests often do respond differently to experimental manipulations. What makes such dissociations interesting is the possibility that indirect tests can be used to reveal unconscious influences. However, although research using indirect tests provides a strong empirical base for inferring the existence of unconscious influences, there is some question as to whether those tests provide a valid estimate of such influences. A number of researchers have voiced concerns that indirect tests may reflect more than implicit memory—that they may be contaminated by explicit or consciously controlled uses of memory (Jacoby, 1991; Reingold & Merikle, 1988, 1990; Richardson-Klavehn & Bjork, 1988; Schacter, Bowers, & Booker, 1989; Toth, Lindsay, & Jacoby, 1992).

In a recent series of studies, Jacoby, Toth, and Yonelinas (1993) presented evidence that measures of conscious recollection gained from direct tests are often overestimated because they fail to take into account automatic (unconscious) influences of memory. In this article, we address the converse issue, the contamination of indirect tests by controlled or intentional uses of memory. We show that conscious contamination of indirect tests not only inflates supposed estimates of unconscious influences but also can lead to mistaken conclusions regarding the effects of experimental manipulations. To this end, we examine recent claims that self-generation or elaborative (semantic) study can influence implicit memory (e.g., Challis & Brodbeck, 1992; Masson & MacLeod, 1992). Analysis of the paradigms on which those claims are based reveals their susceptibility to undetected conscious contamination. To obtain uncontaminated estimates of automatic and consciously controlled uses of memory, we used a process-dissociation procedure (Jacoby, 1991). For comparative purposes, we also collected data from indirect test conditions. Our results provide strong evidence that many supposed demonstrations of conceptual effects on perceptual indirect tests do not reflect implicit memory but rather are the by-product of more consciously controlled uses of memory.

Conceptual Automaticity and the Problem of Conscious Contamination

Much of the theorizing surrounding indirect tests of memory comes from studies showing single dissociations between direct and indirect tests as a function of subject populations and encoding manipulations. Two of the most investigated and cited of the encoding manipulations are level of processing (LoP; Craik & Lockhart, 1972) and self-generation versus reading (Jacoby, 1978; Slamecka & Graf, 1978). Jacoby and Dallas (1981) showed that an LoP manipulation that had a large effect on recognition memory performance had no effect on word (perceptual) identification performance. This finding has been extended to indirect stem- and word-fragment completion performance (e.g., Graf & Mandler, 1984; Roedi-

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ger, Weldon, Stadler, & Riegler, 1992). Similarly, in comparison with reading, generating words at study produces large effects on the direct tests of free recall and recognition (the generation effect) but produces little or no effect on the indirect tests of fragment completion and word identification (Blaxton, 1989; Jacoby, 1983; Srinivas & Roediger, 1990; Weldon, 1991). The lack of conceptual effects on indirect tests such as stem completion, fragment completion, and word identification has been taken as evidence that these tests are predominantly perceptual in nature, either in terms of the processes they evoke (Jacoby, 1983; Roediger, 1990; Roediger, Weldon, & Challis, 1989) or in terms of the representational systems they activate (Schacter, 1990; Tulving & Schacter, 1990).

However, interpretation of indirect test performance is difficult because the majority of these tests constitute "facilitation paradigms" in which both automatic (unconscious) and consciously controlled uses of memory affect performance in qualitatively similar ways. For example, both conscious and unconscious retrieval of a study word would increase performance on an indirect stem-completion test. Because of this arrangement, it is impossible to determine whether performance on an indirect test reflects only one of the two processes or whether an experimental manipulation (e.g., LoP) selectively affects only one of the two processes.

The difficulty associated with interpreting indirect test performance is illustrated by recent reports demonstrating effects of LoP or self-generation on perceptual indirect tests.[1] In a recent review of studies investigating the effects of LoP on perceptual indirect tests, Challis and Brodbeck (1992) found that in 33 of 35 cases (experiments or experimental conditions), facilitation, or "priming" was numerically (and often significantly) greater in the semantic condition than in the nonsemantic condition. This is in addition to more recent reports of significant LoP effects on perceptual indirect tests (Challis & Brodbeck, 1992; Reingold & Merikle, 1991). Similarly, in contrast to initial reports that self-generation produces little or no facilitation on perceptual indirect tests (Jacoby, 1983; Winnick & Daniel, 1970), more recent experiments have found significant effects of self-generation (i.e., generation > new) on both word- and picture-fragment completion tests (Bassili, Smith, & MacLeod, 1989; Gardiner, 1988; Hirshman, Snodgrass, Mindes, & Feenan, 1990; Schwartz, 1989) and on word identification (Masson & MacLeod, 1992; Naito & Komatsu, 1989; Schwartz, 1989; Toth & Hunt, 1990). These findings demonstrate that performance on so-called "perceptual" indirect tests can be influenced by prior conceptual processing. The important theoretical question concerns the nature of that influence. If indirect tests provide a valid (pure) index of implicit memory, then the results of the studies cited earlier provide evidence for "conceptual automaticity"—the automatic or unconscious use of conceptual information. However, this inference is equivocal because those studies used tests in which intentional uses of memory would have produced effects in the same direction as more automatic uses of memory; that is, the indirect tests may have been contaminated by conscious uses of memory.

The dominant approach to the problem of conscious contamination of indirect tests has been to identify dissociations between performance on direct and indirect tests. Formalization of this approach is exemplified by the retrieval intentionality criterion (Schacter et al., 1989) and the method of relative sensitivity (Reingold & Merikle, 1988, 1990). For the retrieval intentionality criterion, the basic idea is to hold all aspects of the task constant and vary only the instructions (direct vs. indirect). Under these conditions, an indirect test is assumed to be process pure (i.e., uncontaminated) when it does not respond, or when it responds differentially, to a variable that affects performance on the direct test. Two problems for this method are (a) potential differences in sensitivity or response criteria across the two tests (Deutsch, 1992; Reingold & Merikle, 1991) and (b) the evidence that unconscious processes contribute to performance on direct tests of memory (Jacoby, Toth, & Yonelinas, 1993). These findings suggest that it may not always be appropriate to use performance on a direct test as a benchmark or ideal against which to compare performance on an indirect test.

The method of relative sensitivity (Merikle & Reingold, 1991; Reingold & Merikle, 1988, 1990) incorporates the notion that tests of memory or perception may not selectively measure only conscious or unconscious processes. For this method, the idea is to compare the relative sensitivity of direct and indirect tests that are matched on all characteristics except instructions: Unconscious influences are inferred only when the indirect test is more sensitive to an experimental manipulation than the direct test. This method is more conservative than the retrieval intentionality criterion; however, it cannot be used to demonstrate unconscious influences in situations in which the direct test is more sensitive than the indirect test (as might be the case with prior conceptual processing). More important, neither method can provide quantitative estimates of the two processes.

Process-Dissociation Procedure

In contrast to relying on process-pure measures or comparing performance between tasks to infer differences in awareness or intentionality, we have placed conscious and unconscious forms of memory in opposition so as to mathematically separate the two components within a task. The advantages of using an opposition paradigm for revealing unconscious influences are exemplified in a series of false-fame experiments carried out by Jacoby, Woloshyn, and Kelley (1989). They had subjects read a list of nonfamous names and later presented those old names, mixed with famous and new nonfamous names, in the context of a fame-judgment task. Subjects were

[1] In accordance with other researchers (Blaxton, 1989; Roediger, Weldon, & Challis, 1989; Tulving & Schacter, 1990), we make a distinction between perceptual and conceptual indirect tests. Perceptual indirect tests involve the presentation of an isolated, degraded test stimulus, as in stem completion, fragment completion, and the identification of briefly presented stimuli. Conceptual indirect tests involve the presentation of, in addition to any perceptual information, associative, semantic, or conceptual information related to the critical (target) item. In this article, we are mainly concerned with perceptual indirect tests, although we address conceptual indirect tests in the General Discussion. Note, however, that ours is an operational distinction rather than a theoretical one.

correctly informed that all of the names they had read in the first list were nonfamous, so if they recognized a name on the fame test as one from the first list, they could be certain that the name was nonfamous. Given this arrangement, any increase in the probability of mistakenly calling an old nonfamous name famous must result from an unconscious influence of memory because conscious recollection would produce an opposite effect. Thus, by placing conscious recollection and automatic familiarity in opposition, these researchers were able to clearly identify unconscious influences of memory.

The present experiments used a similar strategy to gain evidence of unconscious influences of memory on a stem-completion task (see also Jacoby, Toth, & Yonelinas, 1993). Subjects in an exclusion condition were told to complete word stems with words that were not presented on the study list; that is, as in the fame experiments, conscious recollection would serve to exclude items presented earlier. Any increase in the probability of completing stems with old, as compared with new, words would have to reflect an unconscious influence of memory because conscious recollection of a word would have an opposite effect, allowing subjects to reject the old word as a possible completion. Formally, an old word would be mistakenly used as a completion only if it automatically came to mind (A) and subjects failed to consciously recollect (C) that it was presented earlier: A(1 − C).

Placing automatic and controlled uses of memory in opposition can provide evidence for the existence of unconscious influences. However, performance in an exclusion condition does not provide a pure estimate of unconscious influences of memory but rather reflects a combination of automatic (unconscious) and consciously controlled processes: Completing a stem with an old word reflects a sufficiently strong automatic influence of memory combined with a failure of conscious recollection: [A(1 − C)]. Gaining a true index of automatic influences requires that the controlled influence be removed from performance, and this requires a condition in which the two processes are acting in concert.

Thus, in an inclusion condition, subjects are told to complete stems with words presented on the study list or, if they cannot do so, to complete stems with the first appropriate word that comes to mind. In this case, both automatic and controlled uses of memory serve to include words presented earlier. A word stem can be completed with an earlier presented word either because the subject consciously recollects its prior occurrence or because, although recollection fails, the word is automatically produced in response to the stem: C + A(1 − C).

By combining results from an inclusion and exclusion condition, one can estimate the separate effects of automatic and controlled uses of memory. The probability of incorrectly using old words on the exclusion test can be subtracted from the probability of (correctly) using those words on an inclusion test to estimate the probability of conscious control: C = inclusion − exclusion. Given an estimate of control, one can easily compute an estimate of automatic uses of memory, for example, A = (probability of completion on the exclusion test)/(1 − C).

Note that the estimate of A reflects both automatic influences of memory (M; i.e., memory for the specific study experience) and the baseline probability of completing the stems (B). We assume that these two effects are additive (i.e., A = M + B) and thus assess the automatic influences of our particular study experience by subtracting baseline from the estimate of A. The rationale for subtracting baseline from A is the same as that for subtracting baseline from overall performance on old items on an indirect test so as to measure priming. However, because conscious recollection serves as a basis for responding that is separate from automatic influences, we subtract baseline from the estimate of A rather than from overall performance. Empirical support for the notion that M and B are additive was obtained by Jacoby, Toth, and Yonelinas (1993).[2]

In the experiments that follow, we used the process-dissociation procedure to examine automatic and controlled uses of memory on stem completion as a function of LoP (Experiment 1) and self-generation (Experiment 2). We chose these two manipulations because they are extensively used and because recent results suggest they can have significant effects on unconscious uses of memory (as measured by indirect tests). However, our main interests were not in LoP and generation effects per se, but rather in comparing results obtained by using a process-dissociation procedure (Jacoby, 1991) with those obtained by using indirect test instructions. Although we believe that the issue of conceptual automaticity (conceptual priming) is of considerable importance in its own right, the question of whether indirect tests are contaminated by intentional uses of memory has relevance that extends far beyond this issue: We must obtain unbiased measures of implicit memory if we are to address important theoretical concerns, such as the relationship between conscious and unconscious mnemonic processes, the functional and anatomical organization of such processes (i.e., the question of memory systems), and, perhaps most important, the nature of memory deficits.

Experiment 1

We used the process-dissociation procedure in Experiment 1 to derive separate estimates of automatic and controlled uses of memory as a function of LoP. In addition to the inclusion and exclusion test conditions, we included an indirect test condition so as to compare results from the two methods of testing. Subjects in all conditions were treated identically

[2] Note that the distinction between M and B can easily be incorporated into our equations. We have chosen not to separate the two components—opting instead to nest them under A—because we consider the automatic influences of a single prior experience to be of the same sort as those of the multiple experiences that contribute to baseline performance. Nevertheless, the corresponding set of equations that include B (baseline) as a separate component are as follows:

$$\text{I (inclusion)} = C + (M + B)(1 - C);$$

$$\text{E (exclusion)} = (M + B)(1 - C);$$

$$C = I - E;$$

$$M = [E/(1 - C)] - B.$$

except for the instructions used at test. On the basis of recent findings (see Challis & Brodbeck, 1992), we expected the indirect test group to exhibit conscious contamination in the form of an LoP effect. In contrast, even though subjects in the inclusion–exclusion group were directed toward the past, we expected estimates of automatic uses of memory to reveal no difference between the two forms of study processing.

Method

Subjects and design. Sixty-four undergraduate students at the University of Toronto, Ontario, Canada, participated as subjects in return for course credit. The subjects were randomly assigned to one of two groups. One group completed stems under indirect test instructions; the other group completed stems under both inclusion and exclusion test instructions. Word stems presented at test corresponded to (a) words that had been processed semantically, (b) words that had been processed nonsemantically, or (c) words that had not been presented. Subjects were tested individually.

Materials. The critical stimulus set consisted of 160 five-letter words, mostly nouns, ranging in frequency from 1 to 200 (Kucera & Francis, 1967). For the indirect test group, the words were divided into four sets of 40 (mean frequency range = 22.3 to 25.3). For any one subject, one set was used for each of the two study conditions, and the other two sets were used in the new condition (thus equating the number of stems at test corresponding to old and new items). Sets were rotated through conditions so that each word served equally often in each condition (i.e., studied and nonstudied, semantically and nonsemantically processed). For the inclusion–exclusion test group, the four sets were further divided to create eight sets of 20 (mean frequency range = 21.6 to 25.4) so that, in addition to conditions described earlier, each word served equally often as a word to be included and a word to be excluded. In addition to the 160 critical words, each study block (see *Procedure*) began and ended with 2 five-letter buffer words.

Word stems for the test list were created by replacing the last two letters in each word with two dashes. This resulted in 160 unique word stems, each of which had at least two completions.

Procedure. The experiment was conducted in two phases, study and test. The study phase was identical for all subjects and was incidental with respect to memory. Subjects were told they would be presented with four blocks of words and that they would be making different judgments about the words in each block. For the semantic blocks, subjects judged the pleasantness of each word on a 7-point scale; for the nonsemantic blocks, subjects judged whether the current word shared any vowels with the previously presented word (Graf, Mandler, & Haden, 1982). Half of the subjects in each test group made semantic (pleasantness) judgments to words presented in Blocks 1 and 3 and nonsemantic (vowel) judgments to words presented in Blocks 2 and 4. For the other subjects in each group, the order of judgments was switched (i.e., nonsemantic judgments in Blocks 1 and 3 and semantic judgments in Blocks 2 and 4). Presentation order of words within a block was random for each subject. Immediately following the fourth block, subjects were given the stem completion test.

For all subjects, the test phase consisted of the presentation of 160 word stems, 80 that corresponded to words presented in the study phase and 80 that corresponded to words not presented earlier. Word stems were presented in lowercase letters in the middle of the computer screen, and the presentation order was random for each subject. The test was self-paced, and subjects typed their (two-letter) responses.

Subjects in the indirect test group were told to complete each stem using the first five-letter word that came to mind. They were informed that some of the stems could be completed with words presented in the preceding phase but, irrespective of this, their job was to complete each stem with the first legal completion that came to mind.[3]

Table 1
Proportion of Stems Completed With Critical Items and Estimates of Controlled and Automatic Influences of Memory in Experiment 1

Performance measure	Study processing: Semantic	Nonsemantic	New
Test			
Indirect	.51	.45	.30
Inclusion	.60	.47	.29
Exclusion	.33	.43	.26
Estimate			
Controlled	.27	.03	—
Automatic	.42 (.45)	.45 (.44)	—

Note. Numbers in parentheses are estimates computed from mean proportions. Dashes indicate that estimates were not computed for nonstudied (new) items.

Subjects in the inclusion–exclusion test group were told that their memory was to be tested for the words presented in the first part (Phase 1) of the experiment. To introduce the exclusion test condition, we also told subjects that the test of memory would be intermixed with a test of creativity. To signal the different test conditions, the computer displayed one of two messages, "Old" or "New," above and to the left of the word stem; the two stimuli (message and word stem) were displayed simultaneously. Subjects were told that if the message was Old (inclusion condition), they were to use the stem as a cue to recall one of the words presented in the first part of the experiment and to complete the stem using that word. If they could not recall an old word, they were to complete the stem with the first completion that came to mind. Alternatively, if the message was New (exclusion condition), they were to complete the stem with a word that was not presented earlier. Subjects were told to complete as many of the stems as possible; however, they were also told that if on exclusion (New) trials they could produce only one completion that they knew was presented earlier, they were to pass that stem. This pass option was used in the exclusion condition to avoid the possibility that studied words would be used when a novel completion could not be produced. The exact test instructions given to the subjects are provided in the Appendix.

Results and Discussion

Table 1 presents the proportion of stems completed with critical words under each experimental condition. On the indirect test, stem completion performance was higher for words processed semantically than for those processed nonsemantically; a one-way analysis of variance (ANOVA) was reliable, $F(2, 62) = 51.93$, $MS_e = .007$, and post hoc analyses (Tukey's honestly significant difference) showed that all means were significantly different (all $ps < .01$). This result has now been obtained in a number of laboratories (see Challis & Brodbeck, 1992; Chiarello & Hoyer, 1988; Reingold & Mer-

[3] Some might argue that by informing subjects that some of the stems corresponded to study words, we have increased the potential for conscious contamination. Although this is a possibility, we note that similar instructions have been used by a number of authors to study "priming" and "implicit memory" (e.g., Gardiner, 1988; Tulving, Schacter, & Stark, 1982). Moreover, in a pilot study using indirect test instructions that did not refer to the earlier study experience, the LoP effect was even larger than that obtained in the present experiment.

ikle, 1991) and therefore appears to be a reliable phenomenon: Under a variety of experimental conditions, the performance of normal subjects on stem completion following indirect test instructions is affected by prior semantic processing. As discussed by Light and Singh (1987), failures to show the effect may often reflect a lack of statistical power.

A one-way ANOVA of performance following inclusion test instructions was reliable, $F(2, 62) = 78.46$, $MS_e = .010$, and again, post hoc analyses showed that all means were significantly different (all $ps < .01$). In an ANOVA treating indirect and inclusion instructions as a between-subjects variable, the main effect of study experience (semantic, nonsemantic, or new) was significant, $F(2, 124) = 129.83$, $MS_e = .009$, as was the interaction between study experience and test instructions, $F(2, 124) = 4.96$, $MS_e = .009$. The interaction was due to the higher probability of completing stems with semantically processed words in the inclusion, as compared with the indirect, test condition, $t(62) = 2.64$, $p = .01$, and suggests that intentional retrieval played a larger role on the inclusion test. The probabilities of completing stems with new words or with words processed nonsemantically did not differ between the two test conditions (both $ts < 1$).

Exclusion test performance revealed that subjects were better able to exclude words processed semantically than those processed nonsemantically. Analysis of the inclusion–exclusion data revealed a main effect of test instructions, $F(1, 31) = 36.99$, $MS_e = .016$, and study experience, $F(2, 62) = 48.77$, $MS_e = .015$. More important, the two factors interacted, $F(2, 62) = 23.06$, $MS_e = .014$. The probability of completing stems with old words in the inclusion condition was higher for the semantically, as compared with nonsemantically, processed words (.60 vs. .47), but this pattern of performance was reversed in the exclusion condition (.33 vs. .43). Baseline performance did not differ between the two conditions, $t(31) = 1.34, p > .15$.

Estimates of controlled and automatic influences were calculated by using the formulas described earlier and are presented in Table 1. These values show that semantic processing produced a larger controlled component than nonsemantic processing (.27 vs. .03), $t(31) = 5.37, p < .001$. In contrast, estimates of automatic influence showed no significant difference between words processed semantically (.42) and those processed nonsemantically (.45), $t(31) = .81, p > .40$. The slight disadvantage for words processed semantically is most likely due to a few subjects whose performance was near zero in the exclusion condition for semantically processed words; extremely low levels of performance in the exclusion condition can result in an underestimation of the automatic contribution to performance. Calculating the automatic contribution from the mean proportions in which no floor effect is apparent produces estimates of .45 and .44 for semantic and nonsemantic items, respectively (see Table 1). On the basis of these estimates, we conclude that semantic study produces no more automatic influence than nonsemantic study on recall cued with isolated word stems.

It is important to emphasize that the interaction between study processing (semantic–nonsemantic) and test condition (indirect–inclusion) suggests that the indirect instructions reduced the contribution of consciously controlled uses of memory to test performance. By following the retrieval intentionality criterion (Schacter et al., 1989), researchers have used this sort of interaction to argue that indirect tests are not contaminated by intentional retrieval processes (e.g., Rappold & Hashtroudi, 1991; Schacter & Church, 1992). If our indirect test is taken as an uncontaminated index of implicit memory, then we have evidence that unconscious influences of prior conceptual processing affect performance on stem completion. This conclusion would suggest major limitations to current process (Roediger, 1990; Roediger et al., 1989) and systems (Schacter, 1990; Tulving & Schacter, 1990) approaches to memory. In contrast, although both the inclusion and exclusion test conditions are direct tests of memory and showed the largest effects of the study manipulation, estimates derived from these conditions revealed no unconscious influence of prior conceptual processing. We believe that the latter results are more theoretically sound and thus conclude that LoP effects obtained with perceptual indirect tests are the by-product of conscious uses of memory. Given that LoP effects on stem and fragment completion have been found in a number of studies (see Challis & Brodbeck, 1992), our results suggest widespread contamination of indirect measures.

Experiment 2

Experiment 1 investigated the effects of LoP on automatic and intentional uses of memory in stem completion. Experiment 2 was designed to investigate a related manipulation that has also played a large role in the indirect test literature—the effects of self-generation (Jacoby, 1978; Slamecka & Graf, 1978).

In a number of experiments using direct tests, self-generated information has been shown to support better memory performance than externally provided (read) information (e.g., Begg, Snider, Foley, & Goddard, 1989; Rabinowitz & Craik, 1986). However, this pattern of results is reversed on perceptual indirect tests such as word identification (Jacoby, 1983; Winnick & Daniel, 1970). One of the most straightforward explanations of this reversal concerns the overlap in processing requirements at study and test. Read words, but not generated words, require visual analysis at study. Similarly, perceptual indirect tests (e.g., word identification and stem completion) are thought to involve predominantly visual, or data-driven, analysis. Thus, because of their prior visual processing, read words show a larger benefit than generated words in subsequent reprocessing. This explanation, a specification of transfer-appropriate processing (Kolers & Roediger, 1984; Morris, Bransford, & Franks, 1977), has been particularly influential in accounting for dissociations between direct and indirect tests. In fact, Roediger et al. (1989) have suggested that the read–generate manipulation be used as part of an operational definition of perceptual (data-driven) and conceptual tests of memory. The notion is that a test can be identified as measuring predominantly conceptually driven processes if self-generation produces better memory performance than reading; the reverse pattern (i.e., read > generate) is taken as an indication that the test taps primarily perceptual or data-driven processes.

However, the strategy of using the read–generate manipulation as a criterion for identifying conceptual and perceptual tests has been called into question by findings that generation can have significant effects on putative perceptual indirect tests (Bassili et al., 1989; Gardiner, 1988; Hirshman et al., 1990; Schwartz, 1989; Toth & Hunt, 1990; Weldon, 1991). For example, Masson and MacLeod (1992) found that generation can produce facilitation in word identification that is often as large as that obtained following reading. They argued, in contrast to Jacoby (1983), that the extent of facilitation was not related to prior visual processing but rather depended on the degree to which the target item (i.e., the read or generated word) was integrated with its encoding context. Jacoby used antonyms as generation cues and found little or no facilitation, whereas Masson and MacLeod found significant effects when they used synonyms and sentence frames. According to the operational definition proposed by Roediger et al. (1989), Masson and MacLeod's findings would indicate that conceptual processes play a significant role in word identification, thereby questioning its perceptual status. More important, their findings suggest a large conceptual influence on automatic (unconscious) uses of memory in a task that provides few (if any) semantic cues.

It is possible, however, that the indirect tests used in many of the generation studies cited in the previous paragraph were contaminated by intentional uses of memory. This may seem to be an unusual possibility for word identification given its extreme data limitations. However, as pointed out by Nairne (1988), the word-identification process is essentially generative: As in stem or fragment completion tasks, subjects are required to produce a word in response to degraded information, often without any restriction on response time or strategy. Moreover, as with most indirect tests, word identification is generally implemented as a facilitation paradigm in which both automatic and intentional uses of memory would result in the production of a study word.

In Experiment 2, we investigated the effects of self-generation and reading on automatic and intentional uses of memory in stem completion. We used stem completion rather than word identification so as to maintain continuity with the previous experiment. Although word identification and stem completion draw on different processes (Weldon, 1991; Witherspoon & Moscovitch, 1989), both have been classified as perceptual indirect tests. Furthermore, both tests have been used to show significant effects of generation (Bassili et al., 1989; Masson & MacLeod, 1992).

The logic underlying Experiment 2 was the same as that motivating Experiment 1: to contrast results obtained using indirect test instructions with those obtained using the process-dissociation procedure. Unlike the first experiment, however, we did not expect generation and reading to produce equivalent automatic influences of memory. Rather, because of the mismatch in perceptual information provided by study and test cues, generation, like solving anagrams (Jacoby, Toth, & Yonelinas, 1993), should produce little if any automatic influence on stem completion. We expected our results to parallel those found by Jacoby (1983): Estimates of conscious control should show a pattern similar to that found with recognition memory (generation > read); conversely, estimates of automatic processing should parallel the pattern of performance found with perceptual identification (read > generate = new).

Method

Subjects and design. Thirty-two undergraduate students at McMaster University, Hamilton, Ontario, Canada, participated as subjects in return for course credit. The subjects were randomly assigned to one of two groups. One group completed stems under indirect test instructions; the other group completed stems under both inclusion and exclusion test instructions. Word stems presented at test corresponded to (a) words that were earlier read in isolation, (b) words that had been generated in the context of a sentence (first letter provided), or (c) words that had not been previously presented. Subjects were tested individually.

Materials and procedure. With the exception of 8 words, the critical set of target words was the same as that used in Experiment 1; 8 words were replaced to accommodate the creation of sentence frames. Aside from this change, the division of critical words into sets and the rotation of sets through conditions were the same as in Experiment 1. A sentence frame, similar to the frames used by Masson and MacLeod (1992, Experiment 7), was created for each of the target words. Sentence frames contained from 4 to 15 words and were designed to elicit the target with relative ease. The to-be-generated word appeared most often as the last word in the sentence, and its first letter was provided followed by four underscores. Two examples of the sentence frames are "The pizza had a very thin c _ _ _ _" (crust) and "When the door on the spaceship slid open, everyone saw the a _ _ _ _" (alien). In addition to the critical target words and sentence frames, the study phase began and ended with the presentation of four buffer trials: two isolated words and two sentence frames requiring the generation of a missing word.

Words stems for the test list were created by replacing the last two letters in each word with two dashes. This resulted in 160 unique word stems, each of which had at least two completions.

Procedure. The experiment was conducted in two phases, study and test. Procedurally, the study phase was identical for all subjects and was incidental with respect to memory. Subjects were told that the experiment concerned verbal and general-knowledge skills and that they would be presented with a series of trials involving the presentation of either a single word or a sentence that was missing a word. They were told that, for trials involving the presentation of a single word, their task was to say that word aloud; for trials involving the presentation of a sentence, they were to read the sentence silently and say aloud the five-letter word that was missing from the sentence. They were also told that, although they should not rush, their performance would be timed and there would be a maximum of 15 s allowed on each trial; in fact, no response times were recorded.

The presentation of isolated words and sentence frames was intermixed in a pseudorandom fashion; individual words and sentence frames were randomized for each subject but were presented in such a way that no more than two trials of the same type could occur in succession. Both isolated words and sentence frames were presented in the center of the screen and remained on the screen until the subject responded. When the subject responded, the experimenter pressed a key on the keyboard to record the subject's response and another key to initiate the next trial. If a subject could not produce the correct response within 15 s, the computer sounded a beep and the experimenter told the subject the correct response.

Immediately following the study phase, the subjects were given the stem completion test. For all subjects, the test phase consisted of the presentation of 160 word stems, 80 that corresponded to words presented (or generated) in the study phase and 80 that corresponded

Table 2
Proportion of Stems Completed With Critical Items and Estimates of Controlled and Automatic Influences of Memory in Experiment 2

Performance measure	Study processing		
	Generate	Read	New
Test			
Indirect	.44	.54	.30
Inclusion	.56	.61	.32
Exclusion	.21	.40	.31
Estimate			
Controlled	.34	.21	—
Automatic	.28 (.32)	.48 (.51)	—

Note. Numbers in parentheses are estimates computed from mean proportions. Dashes indicate that estimates were not computed for nonstudied (new) items.

to words not presented earlier. All stems appeared in the middle of the computer screen, and the presentation order was random for each subject. All other procedural details were identical to those used in Experiment 1. Test instructions are provided in the Appendix.

Results and Discussion

The proportion of generation errors at study was .16 for the indirect test group and .18 for the inclusion–exclusion test group. Table 2 presents the proportion of stems completed under each experimental condition, conditionalized on correct generation at study. On the indirect test, stem completion performance was higher for read words than for words that had been generated; a one-way ANOVA was reliable, $F(2, 30) = 38.53$, $MS_e = .006$, and post hoc analyses showed that all means were significantly different (all $ps < .01$). This pattern is consistent with other findings in the literature (e.g., Weldon, 1991) but does not replicate Masson and MacLeod's (1992) finding of equivalent performance for the two study orientations. Nevertheless, completing stems with words previously generated was well above baseline, producing a facilitation (priming) score of .14. Using a generation task similar to the one used here, Masson and MacLeod (1992, Experiment 7) found a comparable level of facilitation in word identification (.19).

A one-way ANOVA of performance following inclusion test instructions was reliable, $F(2, 30) = 32.915$, $MS_e = .012$. Post hoc analyses revealed no difference between performance in the reading and generating conditions. In an ANOVA treating the indirect and inclusion tests as a between-subjects variable, only the main effects were reliable: test, $F(1, 30) = 6.37$, $MS_e = .017$, and study experience, $F(2, 60) = 67.14$, $MS_e = .009$. The interaction between these two factors failed to reach significance, $F(2, 60) = 2.42$, $MS_e = .009$, $p = .098$.

Exclusion performance revealed that previously read words were used to complete stems more often than previously generated words; this result is consistent with the notion that conscious recollection (explicit memory) is higher for generated than for read words. Analysis of the inclusion and exclusion data revealed a main effect of test instructions, $F(1, 15) = 18.20$, $MS_e = .045$, and study experience, $F(2, 30) = 20.13$, $MS_e = .014$. More important, the two factors interacted, $F(2, 30) = 16.90$, $MS_e = .014$; in the exclusion condition, the probability of completing stems with read words was much higher than that of generated words (.40 vs. .21). This difference was greatly reduced in the inclusion condition (.61 vs. .56).

Estimates of controlled and automatic influences were calculated by using the formulas described earlier and, as predicted, paralleled the pattern of performance found by Jacoby (1983). Generation produced a larger controlled component than reading (.34 vs. .21), $F(1, 15) = 4.58$, $MS_e = .031$, but estimates of automatic influence showed the reverse pattern, with reading producing a much larger automatic influence than generation (.48 vs. 28), $F(1, 15) = 23.93$, $MS_e = .013$. Two subjects produced no intrusions of generated items on the exclusion test, thus artificially lowering the estimate of automatic influences. As in Experiment 1, we recalculated the automatic contribution from the mean proportions in which no floor effect is apparent (see Table 2). This resulted in automatic estimates of .51 following reading and .32 following generation. Subtracting baseline performance from these estimates provided an index of the automatic influence produced by our specific study experience. By comparing the two adjusted estimates, we found that reading a word produced a sizable automatic influence on later stem completion (.19); generation, however, produced no detectable influence (.00).

The present results show that generation produced no effect on automatic uses of memory in stem completion. Furthermore, as with LoP effects (Experiment 1), the findings suggest that influences of generation on perceptual indirect tests (i.e., generation > new) were the result of intentional uses of memory. These findings call into question recent claims that generation affects automatic or unconscious uses of memory (Bassili et al., 1989; Gardiner, 1988; Hirshman et al., 1990; Masson & MacLeod, 1992; Toth & Hunt, 1990; Weldon, 1991).

Unlike the first experiment, there was no significant interaction between the direct (inclusion) and indirect test conditions as a function of study processing; thus, on the basis of the retrieval intentionality criterion (Schacter et al., 1989), we would have correctly identified the indirect test as contaminated by conscious uses of memory. However, without a method for separating the two influences, we may have considered the experiment a failure. Use of the process-dissociation procedure allowed us to show that the apparent parallel effects actually concealed a very interesting crossover interaction.

The estimates derived from the process-dissociation procedure would appear to support Roediger et al.'s (1989) classification of stem completion as a perceptual or data-driven measure. However, its perceptual status is only in terms of the automatic or unconscious processes evoked by the test stimulus; if consciously controlled uses of memory are not removed from performance, stem completion may respond predominantly to prior conceptual processing. Stated differently, stem completion as a test of memory reflects both perceptual and conceptual (or semantic) processes; however, under the conditions studied here, the conceptual influence on that test appears to be a by-product of explicit (consciously controlled) uses of memory.

General Discussion

The experiments presented here investigated the effects of LoP and self-generation on automatic (implicit) and intentional (explicit) uses of memory in a stem completion task. The experiments also allowed us to compare performance following indirect test instructions with estimates of automatic influences of memory derived from a process-dissociation procedure (Jacoby, 1991). Experiment 1 confirmed the presence of an LoP effect in stem completion with indirect test instructions (Challis & Brodbeck, 1992; Reingold & Merikle, 1991). However, estimates gained from the process-dissociation procedure showed no effect of the LoP manipulation on automatic influences. In Experiment 2, indirect test instructions resulted in a significant amount of priming for previously generated words; estimates gained from the process-dissociation procedure showed no effect of prior generation on automatic influences. We take these findings as evidence that indirect tests are often contaminated by explicit memory (cf. Jacoby, Toth, & Yonelinas, 1993). In support of this, both semantic encoding and self-generation produced significantly higher estimates of intentional uses of memory than nonsemantic encoding and reading.

At a general level, the results reported here highlight the danger of using an indirect test as an index of implicit or automatic uses of memory. Apparent significant differences on an indirect test as a function of an experimental manipulation (e.g., LoP) may often hide equivalent automatic influences (Experiment 1). Conversely, apparent null effects of an experimental manipulation (e.g., reading vs. solving anagrams) may be produced by differential contributions of automatic and controlled processes that offset one another in overall (indirect) performance (Jacoby, Toth, & Yonelinas, 1993). Finally, use of indirect tests may produce a pattern of results suggesting a significant influence on implicit memory (e.g., of self-generation) that in fact constitutes no influence at all (Experiment 2).

In the discussion that follows, we address four issues: (a) the conscious contamination of indirect tests, (b) the assumptions underlying the process-dissociation procedure, (c) the possibility of conceptual influences on automatic uses of memory, and (d) the implications of our findings for other measures of implicit memory.

Conscious Contamination of Indirect Tests

It is generally acknowledged that indirect tests of memory are not process-pure measures of implicit memory (Dunn & Kirsner, 1989; Jacoby, 1991; Reingold & Merikle, 1988, 1990). The question facing memory researchers is how to obtain such process-pure measures. It is only with uncontaminated estimates that researchers can truly address issues such as whether an experimental manipulation selectively affects a particular process or whether neurological insult affects only one form of memory while leaving other uses of memory intact. We believe process-dissociation procedures have the potential for providing such uncontaminated estimates. Of course, any procedure designed to achieve this goal carries with it certain theoretical assumptions. We address some of these assumptions for the process-dissociation procedure later. First, however, we point out some of the problems associated with other approaches to the measurement of implicit memory.

The pattern of data most often used to argue for unconscious influences is the single dissociation in which a variable has an effect on one test and no effect on another. As noted by a number of authors (e.g., Dunn & Kirsner, 1989), this pattern of task performance is theoretically compatible with a number of different assumptions concerning underlying processes. The pattern may reflect something as simple as differences in sensitivity between the two tests, or it may reflect something as complex as the expression of independent memory systems. Without explicit specification of the relationship between the processes of interest and their relation to performance, a variety of theories are equally unfalsifiable. Even with explicit specification, however, empirical validation will require a method for gaining uncontaminated estimates of the underlying processes because test performance is multiply determined.

The present experiments clearly show the inadequacy of assuming that indirect tests are process-pure measures of implicit memory. In Experiment 1, indirect test performance suggested that unconscious influences were affected by prior conceptual processing. Given the significant interaction between the direct (inclusion) and indirect tests, that conclusion would appear to be confirmed by the retrieval intentionality criterion (Schacter et al., 1989), yet it is inconsistent with much of the theorizing surrounding implicit memory (Roediger, 1990; Tulving & Schacter, 1990). Using a process-dissociation procedure to separate the different bases for performance, however, we showed that the conceptual influence was an artifact of conscious contamination. Experiment 2 illustrates how theoretically important results may be overlooked by reliance on indirect tests. Performance following reading and generating was quite similar in the direct (inclusion) and indirect tests. In the absence of additional information, such parallel effects might be interpreted as relatively uninteresting—as showing no qualitative difference between conscious and unconscious processes or, worse, showing that one or both of the tests were contaminated. However, use of the process dissociation procedure allowed us to uncover a significant crossover interaction.

Some researchers might argue that our inclusion test does not correspond to a direct test of memory—that by encouraging subjects to guess, performance on the inclusion test reflects a mixture of implicit (unconscious) and explicit (conscious) memory. However, that argument assumes that by telling subjects not to guess, one can eliminate unconscious influences of memory. That assumption is similar to the one underlying much implicit memory research: that subjects will not intentionally recollect the past unless instructed to do so. In light of the present results and those of Jacoby, Toth, and Yonelinas (1993), these assumptions seem questionable. The process-dissociation procedure is based on the notion that performance on all tests of memory and perception reflects a mixture of conscious and unconscious influences. The strategy of encouraging subjects to guess is designed to equate response criteria across test conditions, thereby enabling us to better estimate the contribution of conscious and unconscious processes to performance.

Different response criteria across conditions or populations are a problem for many approaches to the measurement of memory, including the process-dissociation procedure. However, the problem may be particularly serious for approaches based on direct–indirect test comparisons, such as the retrieval intentionality criterion (Schacter et al., 1989). For example, a number of researchers (e.g., Roediger et al., 1992) have used the differential effects of LoP or generation as a litmus test for the process purity of indirect measures. Such a strategy may not be reliable if the pattern of results found on direct and indirect tests is due to differences in response criteria rather than the influence of qualitatively different processes. Consider the results from Experiment 2: If subjects had not been encouraged to guess on the inclusion test, the most likely effect would have been a decrease in performance on read items, thereby producing a generation effect (Slamecka & Graf, 1978). The lack of this effect on the indirect test could lead to the mistaken conclusion that the indirect test was process pure and that unconscious influences were affected by generation, when in fact the interaction mainly reflected differences in response criterion. Similar arguments apply to the LoP manipulation in Experiment 1. Indeed, Reingold and Merikle (1991) have shown that the magnitude of the interaction between LoP and test (direct and indirect) can be closely related to the response criterion that subjects adopt on the direct test. Of course, this line of argument extends to manipulations other than generation or LoP. The general point is that the strategy advocated in the retrieval intentionality criterion—equating cues and varying only instructions across tests—may not produce only differences in retrieval orientation (implicit or explicit) but instead produce only differences in response criterion (Deutsch, 1992; Reingold & Merikle, 1991).

Assumptions Underlying the Process-Dissociation Procedure

We believe the process-dissociation procedure offers a number of advantages over the use of direct and indirect tests for measuring implicit and explicit memory. One of the main advantages for recommending the approach is that it requires one to provide specific, testable proposals concerning the relationships between processes of interest (Dunn & Kirsner, 1989). For example, here and elsewhere (e.g., Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993), we have made the explicit assumption that conscious and unconscious forms of memory make independent contributions to performance. This is a strong assumption, subject to empirical test. To provide support for this assumption, we have adopted the same strategy used by proponents of signal detection theory to justify the assumed independence of discrimination and bias (e.g., Snodgrass & Corwin, 1988). For our approach, if automatic (implicit) and consciously controlled (explicit) memory are truly independent, it should be possible to vary one component while leaving the other component unchanged. In fact, a variety of experiments have now been completed showing that manipulations of attention (Jacoby, Toth, & Yonelinas, 1993), list length (Yonelinas & Jacoby, 1993), response time at test (Toth, 1992), aging (Jennings & Jacoby, 1993), and study processing (Experiment 1) may have large effects on consciously controlled uses of memory but leave automatic uses of memory unchanged. Experiments now in progress show that the converse relationship can also be obtained: invariance in controlled uses of memory across variations in automatic uses.

One of the main assumptions underlying the process-dissociation procedure is that the criterion for responding on the basis of automatic influences is the same in the inclusion and exclusion test conditions. As noted earlier, we instructed subjects to respond to all test items—even if they felt they were only guessing—in an attempt to equate response criteria in the two test conditions. The most plausible check of this assumption is performance on new items. In the present experiments, completion of new stems with critical items (i.e., baseline) was not statistically different in either experiment (differences of .023 and .005 in Experiments 1 and 2, respectively), suggesting that the assumption of equivalent response criteria was not violated. However, it should be noted that if response criteria (baseline performance) are not equated across the two test conditions, then the equations as presented here will not yield valid estimates. A more general form of the equations would include an additional parameter to represent the criterion strength that is required for responding. We are presently working on a set of equations that would adjust for different response criteria. However, for the present set of equations, the assumption of equivalent response criteria can be met by obtaining equivalent performance on baseline items and by avoiding ceiling or floor performance in the two conditions.

Possibly the most controversial assumption underlying the process-dissociation procedure is that automatic and controlled uses of memory make independent contributions to performance. We believe that results from the process-dissociation experiments cited earlier provide strong evidence for this assumption (for additional evidence, see Jacoby, Yonelinas, & Jennings, 1993). Nevertheless, other assumptions concerning the relationship between controlled and automatic processes are possible. One of the most intuitively appealing models of performance in cued tasks such as stem completion is that of the generate-recognize model (for a description and assessment of other models, see Jacoby, Toth, & Yonelinas, 1993; Jacoby, Yonelinas, & Jennings, 1993; Jones, 1987). The basic notion here is that a subject automatically generates an item and then attempts to consciously recognize whether the item was studied earlier. If recognition is successful, the item is either included or excluded depending on test instructions; if recognition fails, then the subject simply outputs the generated item. Note that this model is quite distinct from the independence model we have advocated. For the independence model, automatic and controlled retrieval occur as separate, parallel processes. In contrast, for a generate-recognize model, the relationship between the automatic (generation) and controlled (recognition) processes is one of sequential dependence because an item cannot be recognized unless it is first generated.

How can we decide between these two models of memory? One method would be to cast the two models in equations and then look for process dissociations that distinguish the two. In fact, Jacoby, Toth, and Yonelinas (1993) reported process dissociations produced by manipulations of attention that could not have been predicted by a generate-recognize model but were predicted by the independence equations used here. These results would seem to provide strong grounds for rejecting a generate-recognize model. However, Richardson-Klavehn, Gardiner, and Java (in press) recently argued that a generate-recognize strategy may only apply to the exclusion condition. Such a mixed model is more difficult to distinguish from our proposed independence model. For one reason, because the mixed model has at least one additional parameter (recognition), the equations cannot be solved by using only the inclusion and exclusion conditions as presented here. Nevertheless, even with additional parameters, it is unclear how a model that includes a dependent, generate-recognize process could account for the findings of invariance cited here.

Although the two models may be difficult to distinguish empirically (but see Jacoby, Yonelinas, & Jennings, 1993), the consequences of assuming independence when a mixed model is correct are relatively straightforward: The independence equations would overcorrect for the probability of conscious recollection and thus underestimate the probability of automatic influence. One prediction that follows from such underestimation is that our estimates of A should often be below baseline, which is a pattern that we have not observed. Nevertheless, even with some small underestimation, our estimates of the magnitude of unconscious influences would be conservative and, in our opinion, are to be preferred over more liberal indexes such as those gained from indirect tests.

It should also be noted that the phenomenology of using a generate-recognize strategy is not necessarily inconsistent with an underlying independence processing model, especially given the plausible assumption that automatic processes are often faster than consciously controlled processes (e.g., Shiffrin & Schneider, 1977). That is, if controlled retrieval finished subsequent to automatic retrieval, the subjective experience may be that of (automatic) generation followed by (intentional) recognition: The target response would automatically come to mind, followed some time later by conscious recollection of the same response. If such recollection occurred before the behavioral response, the subject could reject that item and go on to produce an alternative completion. Nevertheless, the underlying processing dynamics would still be that of two parallel, independent processes rather than the serial processing relationship assumed by the generate-recognize model.

In summary, although the independence assumption is certainly open to question, it is both well supported by the available data and not necessarily contradicted by the intuitive feel associated with the exclusion test. Thus, at this point, we concur with the consensus noted by Jones (1987) that "on a criterion of parsimony, processes should be assumed to be unaffected by each other's presence until a demonstration to the contrary occurs" (p. 230).

Conceptual Effects on Automatic Uses of Memory

The present results argue strongly against the claim that semantic or conceptual study processing affects subsequent automatic uses of memory on tests using isolated and degraded word (or picture) information as retrieval cues (cf. Bassili et al., 1989; Challis & Brodbeck, 1992; Hirshman et al., 1990; Masson & MacLeod, 1992). The evidence supporting that claim was based on findings of significant LoP or generation effects on indirect tests. However, all of the studies showing those effects used experimental designs (facilitation paradigms) that do not rule out the possibility of conscious contamination. When consciously controlled responding is mathematically removed from performance, automatic uses of memory are completely accounted for by prior perceptual processing.

As noted earlier, Roediger et al. (1989) have suggested that the read–generate manipulation be used as part of an operational definition of data-driven and conceptually driven tests of memory. Difficulties for such a classification scheme may have stemmed from the assumption that direct and indirect tests selectively measure conscious and unconscious processes. This process-pure assumption appears to be invalid. However, if the general goal of Roediger et al.'s (1989) approach is viewed as a useful one, adopting the process-dissociation procedure as a method for estimating conscious and unconscious influences may yield a more precise classification of memory tests. For example, Experiment 2 showed that self-generation produces no effect on unconscious uses of memory in stem completion. A similar finding with regard to changes in surface structure from study to test was shown by Jacoby, Toth, and Yonelinas (1993). Taken together, these results meet Roediger et al.'s operational definition that unconscious influences in stem completion are completely perceptual or data driven.

It is important to note, however, that our results do not rule out the possibility that automatic or unconscious uses of memory can reflect prior conceptual processing. We believe that such conceptual automaticity can occur in at least three ways. First as Weldon (1991) has argued, prior lexical processing is probably required to obtain automatic influences in tasks requiring lexical output or analysis (e.g., perceptual identification, stem and fragment completion, and lexical decision). In fact, Hayman and Jacoby (1989) presented strong evidence that presentation of a letter string produces no (lexical) priming unless the string is processed as a lexical unit. Note that lexical processing may often contribute equally to semantic and nonsemantic study conditions; nevertheless, it reflects processing beyond the sensory and perceptual level and is therefore properly viewed as conceptual.

Higher level semantic or elaborative processing effects most likely depend on test environments that reinstate aspects of the original encoding context. Such contextual reinstatement could be in the form of either perceptual cues or semantic–conceptual cues. In terms of perceptual cuing, it has been shown that the use of an identical fragment at study and test can produce significant generation effects in fragment completion (Gardiner, 1988) and word identification (Toth & Hunt, 1990). Thus, on tests involving the presentation of perceptually impoverished stimuli, a second form of conceptual automaticity may arise from the reinstatement of specific perceptual features that act to recruit prior conceptual processes.

Finally, in terms of conceptual cuing, Jacoby (in press) used a process-dissociation procedure to provide evidence for unconscious influences of conceptual information in a paired-associate task. Conceptual effects have also been found on indirect tests that provide conceptual or semantic cues related to the target response (conceptual indirect tests). Thus, indirect measures such as exemplar generation (Graf, Shimamura, & Squire, 1985; Hamann, 1990; Srinivas & Roediger, 1990) and general knowledge questions (Blaxton, 1989), or tests that provide the cue words from paired-associate lists (Graf & Schacter, 1985; Toth & Hunt, 1990), provide some evidence for the notion of conceptual automaticity. However, all of the experiments using indirect tests are open to the charge of conscious contamination; whether conceptual automaticity is exhibited in all of these domains must await further research. Nevertheless, all three forms of conceptual automaticity outlined here are consistent with the notion that highly specific retrieval cues can act to recruit both perceptual and conceptual aspects of a prior processing episode (Jacoby, Levy, & Steinbach, 1992; Kolers & Roediger, 1984; Levy & Kirsner, 1989; Masson & Freedman, 1990; Toth & Hunt, 1990).

Implications for Other Measures of Implicit Memory

In the foregoing discussion, we have implied that a variety of conclusions that were based on results from indirect tests may be invalid. However, it should be obvious that our results directly apply only to the stem-completion task. Nevertheless, given that the majority of perceptual indirect tests are facilitation paradigms, we believe that the problem of conscious contamination is rather general in the implicit memory literature. For example, although indirect tests of memory usually show more perceptual specificity than direct tests, a number of studies show significant transfer across surface characteristics (e.g., modality: Bassili et al., 1989; Hunt & Toth, 1990; Roediger & Blaxton, 1987). Because of their contamination by intentional uses of memory, indirect tests as measures of automatic influences may often underestimate the specificity of the effects of prior experience (but see Rajaram & Roediger, 1993). Jacoby, Toth, and Yonelinas (1993) presented evidence that significant transfer across changes in surface characteristics on indirect tests may be due to contamination by intentional uses of memory. In the present study also (Experiment 2), generated items, for which only a single letter was visually presented at study, showed a substantial priming effect on the indirect test; however, estimates gained from the process dissociation procedure showed no automatic influence. This pattern of results suggests that indirect measures may often overestimate the contribution of automatic or unconscious influences to the processing of stimuli that are physically different at study and test.

Of course, even if indirect tests are often contaminated by conscious uses of memory, the reason why some experimental conditions result in more conscious contamination than others remains an open question. Nevertheless, as shown by the results of Experiment 2, differential contamination as a function of experimental manipulations may not be unusual. For example, in a replication of Jacoby's (1983) study, Masson and MacLeod (1992) showed that identification of words generated from antonym cues did not differ from baseline performance; however, under nearly identical experimental procedures, words generated from synonym cues showed substantial facilitation (priming). This would seem to suggest that the two types of cues result in different levels of unconscious influence; alternatively, it may simply be that conscious recollection is better for words generated from synonym cues than those generated from antonym cues and thus results in different levels of conscious contamination. Indeed, Masson and MacLeod's claim that antonym generation produces a more integrated cue–target pairing than synonym generation is consistent with this hypothesis.

Research within the text-processing domain also seems consistent with this position. Carr and colleagues (Carr, Brown, & Charalambous, 1989) have reported general, nonspecific transfer in their investigations of reading and have argued that savings in rereading reflect the priming of very abstract representations of earlier read words. As a striking example of general transfer, Alejano and Carr (1991) reported that reading a rebus (picture) text resulted in as much transfer to later reading a standard (word) version aloud as did earlier reading of the same standard (word) text. It seems likely that such complete transfer reflects the intentional use of memory. That is, their rereading effects probably have the same mixed origins as revealed in stem-completion performance. Reading a rebus version of a text, like self-generation or solving an anagram, might produce good explicit memory but do little to enhance word identification or stem completion. This is important for investigations of the acquisition of reading skills because it would seem to be automatic word recognition, rather than explicit memory, that is of greatest interest.

Perhaps the most important implication of the experiments presented here concerns the measurement of memory following neurological insult. On the basis of comparisons of performance on direct and indirect tests (for reviews see Richardson-Klavehn & Bjork, 1988; Shimamura, 1989), many researchers have claimed that amnesics show normal levels of implicit memory in the face of impaired explicit memory. However, Ostergaard (in press) reviewed a number of studies showing below-normal priming in amnesic patients; similar to the arguments made concerning LoP effects on indirect tests, Ostergaard suggested that the majority of priming studies using amnesics do not have sufficient statistical power to detect the small differences that are often reported. One obvious inference from this observation is that, contrary to popular opinion, amnesic patients may often have deficits in implicit memory (Jernigan & Ostergaard, 1993). Conversely, given the findings presented here, the disadvantage for amnesic patients on indirect tests may simply reflect the use of consciously controlled strategies by normal controls. This possibility is in line with earlier findings (Jacoby, Toth, & Yonelinas, 1993) showing that experimental conditions producing identical levels of performance on an indirect test may actually reflect very different levels of automatic and intentional uses of memory that offset one another in overall performance. Indirect tests provide no basis for deciding between these two possibilities, although either would have a substantial impact on theories of memory function, neural localization, and approaches to rehabilitation.

Conclusion: Toward a Redefinition of Implicit Memory

Claims of unconscious influences have traditionally relied on findings of dissociations between direct and indirect tests.

The major problem for that approach is the identification of processes with tests. Rather than treating tests as process pure, we have used a process-dissociation procedure to estimate the separate effects of automatic and conscious-controlled processes within a single task. The results of our experiments show that there is good reason for adopting such a strategy: Indirect tests of memory are sometimes badly contaminated by intentional uses of memory.

In previous articles, we have cast our results in terms of automaticity, rather than implicit memory, to emphasize the similarity between the theoretical issues recently encountered in the study of memory and those that have perpetually surrounded the study of attention (see Jacoby, Ste-Marie, & Toth, 1993; Jacoby, Toth, Lindsay, & Debner, 1992). In the attention literature, automatic processes have been described as fast, stimulus-driven processes that occur without awareness (e.g., Hasher & Zacks, 1979; Posner & Snyder, 1975; Shiffrin & Schneider, 1977); very similar characteristics have been used to describe implicit memory or priming (Klatzky, 1984; Logan, 1990). However, possibly the most consequential similarity between the two concepts is that both automaticity and implicit memory have been defined in terms of a set of experimental conditions. Automaticity has been equated with performance under conditions of divided attention or fast responding. Similarly, implicit memory has been equated with performance following indirect test instructions. All of these procedures may act to limit conscious control, but they cannot be relied on to do so completely or consistently. Redefining implicit memory in terms of the process-dissociation procedure changes the status of those conditions from definitions to variables whose importance for limiting conscious control can be investigated empirically.

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Appendix

Test Instructions for Experiments 1 and 2

Note: The instructions are presented here verbatim. In recent experiments we have replaced the "creativity" explanation of the exclusion test condition with a more straight-forward description such as the following: "If the message is 'New' your job is to use the stem as a cue to recall one of the words from the first part of the experiment; however, you should complete the stem with a different word—that is, a word that was NOT presented in the first part of the experiment. If you can't remember a word from the first part that fits into the stem provided, then just complete the stem with the first five-letter word that comes to mind."

Indirect

In the next part of the experiment you will be presented with a series of word-stems; that is, the first three letters of a five-letter word followed by two dashes. Your job is simply to complete each word stem with the first five-letter word that comes to mind by typing in the two appropriate letters. Some of the stems will correspond to words presented in the first part of the experiment and some will correspond to words not presented in this experiment, but irrespective of this, your job is to try to come up with a completion for each stem. Also, do not use proper nouns. Ok, now what are you supposed to do?

Inclusion–Exclusion

In the next part of the experiment you will be given a memory test for all of the words from the first part of the experiment. The test of memory will also be interleaved with a test of creativity. On each trial the computer will present you with a word-stem; that is, the first three letters of a five-letter word followed by two dashes. The computer will also display one of two messages: "Old" or "New." If the message is "Old" your job is to use the stem as a cue to recall one of the words from the first part of the experiment; that is, you should complete the stem with an old word by typing in the two appropriate letters. If you can't remember a word from the first part that fits into the stem provided then just complete the stem with the first five-letter word that comes to mind. If the message is "New" then the test is one of creativity. In this case, I want you to complete the word-stem with a word that was NOT presented to you in the first part of the experiment; that is, try to come up with a novel completion. If all you can think of is a completion that was presented in the first part, then it's ok to pass that stem by pressing the return key; however, each of the stems can be completed with more than one word, so you should try to complete each one within the constraints I have just explained. Also, do not use proper nouns. Ok, now what are you supposed to do?

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