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Separating Consciously Controlled and Automatic Influences in Memory for New Associations

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The process dissociation paradigm was applied to investigate the contributions of automatic and consciously controlled processes to the repetition priming effect for new associations, under elaborative encoding (Experiments 1 and 2) and copy instructions (Experiment 3). Semantically unrelated context–target word pairs were presented during study, and context words and stems were presented during test. Target word stems were paired with the same context words as at study (intact), paired with different context words from study (recombined), or were the stems of unstudied words (control). Participants had to complete stems with the first word that came to mind (indirect), with studied words (inclusion), or with new, unstudied words (exclusion). Results indicated that consciously controlled processes mediated the associative repetition effect under elaborative encoding, whereas automatic processes were implicated under copy instructions.

Over the past decade numerous studies have reported dissociations between direct/explicit and indirect/implicit measures of memory in both amnesic patients and normal participants (for reviews, see Moscovitch, Vriezen, & Goshen-Gottstein, 1993; Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; Schacter, 1987; Shimamura, 1986). For direct measures of memory, such as recognition and recall, participants are instructed to refer back to the study episode, whereas for indirect measures, such as stem completion and perceptual identification, instructions make no reference to the study episode. Despite this absence of reference to the study episode, performance on indirect measures of memory can potentially demonstrate the influence of this episode. For example, the probability that particular words will be generated in a stem-completion task increases if those words were presented in the study phase of the experiment. This facilitation in performance is referred to as *repetition priming.* Dissociations between direct and indirect measures of memory have been typically interpreted as strong evidence that the repetition priming effect reflects, at least in part, unconscious or automatic influences (e.g., Schacter, 1987).

Although most demonstrations of repetition priming have involved single words, there has been some documentation of repetition priming for unrelated word pairs (e.g., Graf & Schacter, 1985, 1987, 1989; Schacter & Graf, 1986a, 1989). Repetition priming for unrelated word pairs (henceforth the *associative repetition effect*) refers to the enhancement of memory for target words on indirect tests as a function of preserving, rather than changing, their paired, unrelated context words from encoding to retrieval. The goal of this study was to determine whether automatic, unconscious processes contribute to the associative repetition effect. To explore this question, we used the process dissociation procedure (Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993) to separate the contributions of consciously controlled processes from those of automatic processes to the associative repetition effect. We first describe the associative stem-completion task (Graf & Schacter, 1985, 1987, 1989; Schacter & Graf, 1986a, 1989). Next, we review evidence for and against the interpretation that the associative repetition effect is mediated by unconscious processes. Finally, we describe the process dissociation procedure and illustrate how this procedure may help determine to what extent automatic processes contribute to the associative repetition effect.

The most reliable demonstration of the associative repetition effect has been achieved using the Graf and Schacter (1985, 1987, 1989; Schacter & Graf, 1986a, 1989) stem-completion procedure, in which participants studied unrelated context–target word pairs (e.g., TABLE–REASON, WINDOW–SHIRT) under elaborative encoding instructions. All target word stems (e.g., REA__) could easily be completed with many different words (e.g., REASON, REACH, REACT, etc.). At test, participants saw a context word beside a target word stem. The pairs were presented either in an intact condition, where target words were presented with the identical context word as at study (e.g., TABLE–REA__, WINDOW–SHI__), or in a recombined condition, where target words were paired with different context words (e.g., WINDOW–REA__, TABLE–SHI__). Graf and Schacter found that target stems of intact pairs were completed more often with studied words than were target stems of recombined pairs. Because target words in both the intact and the recombined conditions had been studied, the advantage

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for the intact over the recombined pairs could be explained only in terms of memory for the associative information.

A number of researchers have interpreted functional dissociations between the indirect associative stem-completion task and the direct cued-recall test as suggesting that unconscious processing may mediate the associative repetition effect. In both the indirect and direct conditions, participants receive the same nominal cues (i.e., context word–stem). However, whereas in the indirect condition participants are asked to complete the stems with the first word that comes to mind, in the direct condition they are asked to complete the stems with words presented during the study phase. Reported dissociations between direct and indirect tests include the following: (a) crossing modality of presentation between study and test attenuated the associative repetition effect (the advantage for intact over recombined pairs), but only on the indirect test (Schacter & Graf, 1989); (b) generating a sentence that related the members of a word pair produced a larger associative repetition effect than reading such a sentence, only on the direct test (Schacter & Graf, 1986a); (c) retroactive and proactive interference manipulations reduced the magnitude of the associative repetition effect only on the direct test (Graf & Schacter, 1987); and (d) mild amnesics showed deficits only on the direct test (Graf & Schacter, 1985).

Although several researchers have used functional dissociations as evidence for the involvement of unconscious processing in implicit tests (see Richardson-Klavehn & Bjork, 1988; Schacter, 1987) others have criticized the validity of this technique (Dunn & Kirsner, 1988; Reingold & Merikle, 1988, 1990). Moreover, three important differences between repetition priming for single words and for unrelated word pairs suggest that consciously controlled retrieval processes may underlie the associative repetition effect. First, unlike single-word repetition priming, associative repetition effects have not been reliably demonstrated in densely amnesic patients (Cermak, Blackford, O'Connor, & Bleich, 1988; Cermak, Bleich, & Blackford, 1988; Mayes & Gooding, 1989; Schacter & Graf, 1986b; Shimamura & Squire, 1989). The hallmark of amnesia is a failure to consciously recollect newly acquired information (Moscovitch, 1982). Nevertheless, amnesic patients exhibit normal repetition priming for the same (single) words they cannot remember when tested directly (for a current review see Moscovitch et al., 1993). The inability of densely amnesic patients to show the associative repetition effect suggests that some level of conscious recollection may be necessary for producing that effect.

Second, Bowers and Schacter (1990; Schacter, Bowers, & Booker, 1989) found that normal participants who reported being unaware that words from the study phase were repeated displayed the same amount of single-word repetition priming as did participants who reported being aware that words were being repeated. However, there are conflicting reports regarding whether "unaware" participants display the associative repetition effect. Bowers and Schacter (1990) were not able to obtain the effect in "unaware" participants, indicating that the effect may involve conscious mediation. In contrast, Howard, Fry, and Brune (1991) did obtain the effect in their "unaware" participants.

Third, a prerequisite for obtaining the associative repetition effect appears to be an encoding of the semantic relationship between study word pairs (Graf & Schacter, 1985; but see Micco & Masson, 1991). Encoding words' surface features (e.g., vowel comparison), or even encoding semantic features of individual words (e.g., pleasantness rating), did not produce the effect (Graf & Schacter, 1985; Schacter & Graf, 1986a). In marked contrast, on tests of repetition priming for single words, shallow encoding produced effects only slightly smaller or equivalent to those produced under deep encoding (Challis & Brodbeck, 1992). This relative insensitivity of repetition priming for single words to the levels of processing manipulation (Craik & Lockhart, 1972), coupled with the sensitivity of direct tests to this manipulation, has been interpreted as evidence for unconscious remembering. Thus, it appears that the associative repetition effect is more similar to direct tests of memory than to an indirect repetition priming effect for single words. It can be argued, therefore, that just like direct tests of memory, the associative priming effect may be influenced by conscious recollection.

Together, then, these three differences demonstrate that the extent to which unconscious, automatic processes contribute to the associative repetition effect is unclear. To obtain further evidence regarding the role of unconscious processes in the associative repetition effect, we used the process dissociation procedure (Jacoby, 1991; Jacoby et al., 1993). The process dissociation approach argues that memory retrieval performance on direct and indirect tasks often reflects both consciously controlled and automatic influences. In other words, memory tasks should not be assumed to exclusively reflect either consciously controlled or automatic retrieval, that is, to be process pure. To date, the process dissociation procedure has been applied in an attempt to quantify consciously controlled and automatic influences on memory for single words (e.g., Jacoby et al., 1993; Toth, Reingold, & Jacoby, 1994) and memory for related word pairs (Jacoby, 1994). The present research represents a straightforward application of the inclusion/exclusion manipulation to a stem-completion task such as the one employed by Jacoby et al. (1993). During test we asked participants either to complete target stems of both intact and recombined pairs with studied words (the inclusion condition), or to avoid completing target stems with studied words, and to complete them instead with words they had not seen during the study phase (the exclusion condition).

As we elaborate in the introduction to Experiment 2, the application of algebraic equations to participants' performance in the inclusion and exclusion conditions allows the derivation of quantitative estimates of both consciously controlled and automatic influences. Once such estimates are computed they can be compared across the intact and recombined conditions. Consequently, the process dissociation procedure may help document two different types of memory for new associations. A larger estimate of conscious control for the intact relative to the recombined condition would reflect a consciously controlled associative effect. In contrast, a larger estimate of automatic influences for the intact relative to the recombined condition would reflect an unconscious associative effect. It is important to note that the indirect task used in previous demonstrations of an associative repetition effect often confounds such consciously controlled and automatic influences of memory for associative information. This is the case because both types of influence lead to an increased tendency to complete stems with studied words.

Accordingly, in Experiment 1 we replicated Graf and Schacter's (1985) finding that elaborative, but not shallow, encoding results in an associative repetition effect. However, the application of the process dissociation procedure in Experiment 2 suggested that this effect is largely mediated by consciously controlled processes. In Experiment 3, we replicated Micco and Masson's (1991) finding that copying unrelated word pairs produces an associative repetition effect, and an application of the process dissociation procedure indicated that automatic processes were implicated in that effect.

Experiment 1

Before applying the process dissociation procedure to the associative stem-completion task, we wished to replicate Graf and Schacter's (1985) finding that the repetition effect could be obtained under elaborative, but not shallow, encoding instructions. At study, we presented participants with word pairs (e.g. HORSE–COMET) under either elaborative or shallow encoding instructions. Following Graf and Schacter (1985, 1987, 1989; Schacter & Graf, 1986a, 1989), in the elaborative condition we asked participants to form a sentence that meaningfully related the two words and to say that sentence out loud. However, whereas Graf and Schacter (1985) used a vowel comparison task for the shallow encoding condition, we asked participants to simply read the word pairs out loud. We chose the reading task because some researchers consider it to be the prime example of a shallow encoding task (e.g., Jacoby, 1983; Roediger, Weldon, & Challis, 1989). Also, by asking participants to read the words out loud we ensured that in both the shallow and the elaborative encoding conditions participants articulated the pair members, thus controlling for an articulatory difference across the two conditions.

At test, we presented participants with a context word (e.g., HORSE) and the target word stem (e.g., COM__). We asked participants to complete the stem with the first word that came to mind. The pairs were presented either in an intact or in a recombined condition. Also, new pairs were introduced for control. In these control pairs, the context word was always a studied word, whereas the target stem was that of an unstudied word. Thus, across the intact, recombined, and control conditions, the context words were always studied words. Hence, participants could not plan a strategy for completion based on the study status of the context words. We found an associative repetition effect only under the elaborative encoding condition.

Method

Participants. Forty-eight undergraduate students at the University of Toronto participated in return for course credit. All had normal or corrected-to-normal vision.

Design and materials. The experimental design consisted of one between-subjects factor and one within-subjects factor. The between-subjects factor was the type of encoding instructions (shallow or elaborative). The within-subjects factor was the type of word pair (intact, recombined, or control).

During the study phase, participants saw 126 context–target word pairs. Of these, 42 were presented at test in the same pairings, 42 were recombined at test into new pairings, and the context words of the remaining 42 pairs were used as context words in the control test condition. Study pairs were presented under shallow encoding or elaborative encoding instructions.

At test, participants saw 42 intact study pairs and 42 recombined pairs. An additional 42 pairs were presented to provide an estimate of baseline performance by assigning an unstudied target word to a studied context word.

The 126 to-be-remembered word pairs comprised 42 triads of 3 pairs each, and these triads formed a pool from which all words would be drawn. For example, the pairs DOLL–QUART, HORSE–COMET, and SPIDER–SCALP formed such a triad. We refer to these triad pairs as *A–B*, *C–D*, and *E–F* pairs. An extra word (henceforth *X*), for example LAUGH, was assigned to each triad. This extra word was used as the target word in the study phase but was replaced at test with the stem of an unstudied target word for control. The *A*, *C*, and *E* words served as context words and appeared to the left of the *B*, *D*, *F* and *X* words that served as targets.

Two constraints were observed in forming the triads. First, within each triad all combinations of the context and target words created semantically unrelated word pairs. Thus, no obvious semantic relation existed between any of these pairs (for any two words some obscure relation can always be made up). Second, all target words were five-letter words whose three-letter stems had more than one possible completion. The context words were names commonly given to Snodgrass and Vanderwart's (1980) line drawings. Thus, each pair consisted of at least one noun. We ensured that the three-letter stems of each target were unique and that no context word had a stem that was identical to that of a target stem. Mean word frequency (Kučera & Francis, 1967) was 42 ($SD = 53$) and 45 ($SD = 71$) for context and target words, respectively.

As shown in Table 1, for each triad at test, all participants received the identical pairings of context words and target word stems, namely, *A–B*, *C–D*, and *E–F* (e.g., DOLL–QUA __, HORSE–COM __ , SPIDER–SCA __). The pairing of the context and target words at study determined the test condition to which each pair belonged for each participant.

For each triad, six permutations were formed so that each target word would be in the intact, recombined, and control conditions an equivalent number of times. These permutations are presented in Table 1. The 42 triads were subdivided into six groups of 7 triads each. For each participant an assignment of the six groups of triads to the six permutation conditions shown in Table 1 was made in accordance with a Latin square design such that, across participants, each group of triads was equally likely to be assigned to each of the permutation conditions. Thus, the complete counterbalancing of the study and test materials ensured that all participants were tested with exactly the same items, but that across participants each item was equally likely to belong to the intact, recombined, or control condition. In addition, each participant was tested with an equal number (42) of intact, recombined, and control test items. For each participant the order of trials during study and test was randomly determined.

Table 1
Six Study Permutations of Triads and the Corresponding Test Lists in Experiments 1 and 2

P1	P2	P3	P4	P5	P6
		Permutations used to create study pairs[a]			
A–B	*A–D*	*A–B*	*A–E*	*A–X*	*A–X*
C–D	*C–B*	*C–X*	*C–X*	*C–D*	*C–F*
E–X	*E–X*	*E–F*	*E–B*	*E–F*	*E–D*
		Experiment 1 test list			
A–B (I)	*A–B* (R)	*A–B* (I)	*A–B* (R)	*A–B* (C)	*A–B* (C)
C–D (I)	*C–D* (R)	*C–D* (C)	*C–D* (C)	*C–D* (I)	*C–D* (R)
E–F (C)	*E–F* (C)	*E–F* (I)	*E–F* (R)	*E–F* (I)	*E–F* (R)
		Experiment 2: Test List 1			
A–B (I), OLD	*A–B* (R), NEW	*A–B* (I), NEW	*A–B* (R), OLD	*A–B* (C), OLD	*A–B* (C), NEW
C–D (I), OLD	*C–D* (R), NEW	*C–D* (C), OLD	*C–D* (C), NEW	*C–D* (I), NEW	*C–D* (R), OLD
E–F (C), NEW	*E–F* (C), OLD	*E–F* (I), OLD	*E–F* (R), NEW	*E–F* (I), NEW	*E–F* (R), OLD
		Experiment 2: Test List 2			
A–B (I), NEW	*A–B* (R), OLD	*A–B* (I), OLD	*A–B* (R), NEW	*A–B* (C), NEW	*A–B* (C), OLD
C–D (I), NEW	*C–D* (R), OLD	*C–D* (C), NEW	*C–D* (C), OLD	*C–D* (I), OLD	*C–D* (R), NEW
E–F (C), OLD	*E–F* (C), NEW	*E–F* (I), NEW	*E–F* (R), OLD	*E–F* (I), OLD	*E–F* (R), NEW

Note. P1–P6 refer to the six permutations; each triad is composed of three pairs of words (*A–B*, *C–D*, and *E–F*), where *A*, *C*, and *E* are context words; *B*, *D*, and *F* are target words; and *X* is an additional target word that is used only during study. I, R, and C refer to the intact, recombined, and control test conditions, respectively. OLD refers to the inclusion test condition, and NEW refers to the exclusion test condition. Each target word (*B*, *D*, or *F*) and each test pair (*A–B* , *C–D*, or *E–F*) appeared in the intact, recombined, and control test conditions an equal number of times. Moreover, across Test Lists 1 and 2 in Experiment 2, each target word and test pair was equally likely to be in an inclusion condition or an exclusion condition.
[a]Each permutation was applied to seven triads to create a total of 126 study pairs.

Procedure. Of the 48 participants, 24 were randomly assigned to the elaborative encoding condition, and 24 to shallow encoding condition. All participants were tested individually. At study, all participants were told that they would be shown some word pairs. Those in the elaborative condition were asked to generate, out loud, a meaningful sentence that contained both words, and maintained the order of the words as they appeared on the screen. Participants in the shallow encoding condition were asked to read the words out loud. All were given 10 practice pairs as an illustration of the nature of the study task.

The 126 study pairs were then presented on the screen of an IBM compatible computer. Each pair was presented for 5 s and then disappeared. Participants had to generate sentences even if the words had disappeared. Presentation was self paced; after the 5-s presentation of a word pair, participants initiated the presentation of the next pair by pressing the space bar. The next pair appeared 250 ms after the space bar had been pressed.

After the study list had been presented, participants performed the indirect associative stem-completion test. They were told that a word would appear to the left of a three-letter stem, and that they should complete the stem with the first word that came to mind. No explanation was given regarding the function of the context word. Following a practice session of 10 pairs, the test list was presented in a different random order for each participant. An experimenter typed the participants' answers directly into the computer.

Results and Discussion

Table 2 presents the proportion of stems completed with target words, and the standard error of the mean for each experimental condition. Examination of the data revealed that under elaborative encoding, more stems were completed with studied words in the intact than in the recombined condition. Under shallow encoding no such difference was found.

Because the control condition served only to estimate repetition priming for single-word information, we initially analyzed the data from only the intact and recombined conditions. A two-way analysis of variance (ANOVA), with pair type as a within-subjects variable and encoding as a between-subjects variable, showed that the main effect of encoding was not significant ($F < 1$). A significant effect was found, however, for pair type, $F(1, 46) = 16.03$, $MSE = 0.007$, $p < .001$. Most important, the interaction was significant, $F(1, 46) = 4.89$, $MSE = 0.07$, $p < .05$. This interaction reflects that stems of intact pairs were completed more often with studied words than were stems of recombined pairs under elaborative encoding, $t(23) = 4.16$, $p < .001$, but not under shallow encoding, $t(23) = 1.35$, $p = .19$.

Next, we analyzed the word level repetition effect by

Table 2
Proportions of Stems Completed With Target Words Under Elaborative and Shallow Encoding Instructions by Pair Type in Experiment 1

Encoding task	Pair type: Intact *M*	Intact *SE*	Recombined *M*	Recombined *SE*	Control *M*	Control *SE*
Elaborative	0.46	0.02	0.36	0.02	0.25	0.03
Shallow	0.42	0.02	0.39	0.02	0.24	0.02

comparing recombined with control items. A two-way ANOVA revealed a significant pair-type effect, $F(1, 46) = 40.77$, $MSE = 0.01$, $p < .001$. However, neither the encoding condition nor the interaction achieved significance ($Fs < 1$).

These findings replicated those of Graf and Schacter (1985) by showing that the advantage of intact over recombined pairs was displayed under elaborative, but not shallow, encoding. In Experiment 2 we applied the process dissociation procedure to better assess the nature of the associative repetition effect.

Experiment 2

In Experiment 1 we obtained the associative repetition effect under elaborative encoding instructions. In this experiment we employed the process dissociation procedure to separate the contributions of consciously controlled processes from those of automatic processes to the effect. At study, participants were presented with the same stimuli used in Experiment 1. At test, participants were instructed either to complete stems with studied words (inclusion condition) or to avoid completing stems with studied words and to complete them with new words (exclusion condition).

In the exclusion condition, consciously controlled and automatic processes are placed in opposition, because consciously controlled influences will lead participants to successfully exclude studied words, whereas automatic or unconscious influences will bias participants towards a completion with studied words. Formally, in the exclusion condition a studied word is incorrectly produced as a completion only if it comes to mind automatically (A) and participants fail to consciously recollect it ($1 - C$). If these two processes are assumed to be independent, then the probability of completing with a studied word equals $P(\text{exclusion}) = A(1 - C)$.

To gain an index of automatic processes, we must employ an inclusion condition, wherein consciously controlled and automatic processes act in concert to produce studied words. In this condition participants were told to complete stems with studied words or, if they could not do so, to complete stems with the first appropriate word that came to mind. A stem would therefore be correctly completed as a studied word if the participant consciously recollected it (C), or if the participant did not recollect the word ($1 - C$) but it came to mind automatically (A): $P(\text{inclusion}) = C + A(1 - C)$.

We can use the exclusion and inclusion conditions to estimate the magnitude of the consciously controlled and automatic influences. If the probability of completing an old word incorrectly in the exclusion condition is subtracted from the probability of completing an old word correctly in the inclusion condition, then we get an estimate of consciously controlled influence: $P(\text{inclusion}) - P(\text{exclusion}) = [C + A(1 - C)] - [A(1 - C)] = C$. Thus, the estimate of intentional control is computed by measuring the difference in performance when one is "trying to" (inclusion condition) compared with "trying not to" (exclusion condition) rely on past information. If one is as likely to produce studied words when trying not to as when trying to, then clearly one has no conscious control.

Once an estimate of consciously controlled remembering is obtained, an estimate of automatic influences can be simply computed as $A = P(\text{exclusion})/(1 - C)$.

For a more detailed analysis of the process dissociation procedure and its underlying assumptions, see Jacoby (1991), Jacoby et al. (1993), and Reingold and Toth (1996). Following the above rationale, we found evidence in this experiment that the associative repetition effect under elaborative encoding is mediated largely by consciously controlled rather than automatic remembering.

Method

Participants. Thirty-six undergraduate students at the University of Toronto participated in return for course credit. All had normal or corrected-to-normal vision, and none had participated in Experiment 1.

Design and materials. The experimental design consisted of two within-subjects factors. These were pair type (intact, recombined, or control) and test type (inclusion or exclusion).

The study phase was identical to that of Experiment 1. For the test phase two test lists were constructed so that each item would be equally likely to be in the intact, recombined, or control condition, and to appear with inclusion or exclusion instructions. The first test list was created by adding the word OLD above half the pairs, signaling the participant to complete the stems with studied words (i.e., inclusion), and the word NEW above the remaining half of the pairs, signaling the participant to complete the stems with new, unstudied words (i.e., exclusion). The second test list was created by exchanging the OLD and NEW instructions for the pairs used in the first list. Table 1 presents the detailed modifications to the test pairs that corresponded to each of the six possible study permutations. Half of the participants received the first test list and the other half received the second test list. Consequently, during test, each pair of words was equally likely to represent one of the six experimental conditions (Pair Type × Test Type). Otherwise, all aspects of the design and materials were identical to those of Experiment 1.

Procedure. Each participant was tested individually. At study, all participants received the elaborative encoding instructions that were used in Experiment 1. After the study list had been presented, participants received inclusion and exclusion instructions. They were told that a word would appear on the left of the screen beside a three-letter stem and that the instruction for completing the stem would be written above the pair. If the word OLD appeared above the pair, participants were to complete the stem with an old, studied word. If they could not remember the studied word, they were to complete the stem with the first word that came to mind. If the word NEW appeared above the pair, participants were to complete the stem with an unstudied word. For both the inclusion and the exclusion tasks, participants were given the option of not completing the stem, but were told to avoid arbitrary use of this option, and to try to comply with the OLD/NEW instructions. They were to use this option only if they felt they could not comply with the instructions, or could not come up with a valid completion for the stem. Following a practice session of 10 pairs, the test list was presented in a different random order for each participant. The experimenter typed the participants' answers directly into the computer.

Results and Discussion

Table 3 presents the proportion of stems completed with studied words under each experimental condition. In the inclusion task, significantly more intact pairs were completed with studied words than were recombined pairs, $t(35) = 6.13$,

Table 3
Proportions of Stems Completed With Target Words by Inclusion–Exclusion and Pair Type, and Estimates of Controlled and Automatic Processes for the Intact and Recombined Conditions in Experiment 2

	Pair type					
	Intact		Recombined		Control	
Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*
	Performance					
Inclusion	0.55	.03	0.37	.02	0.22	.02
Exclusion	0.25	.03	0.26	.02	0.20	.02
	Estimates					
Control	0.30	.05	0.10	.03		
Automatic	0.32	.03	0.29	.02		

$p < .001$, whereas in the exclusion task, there was no significant difference between the intact and recombined conditions ($t < 1$). A two-way ANOVA confirmed these findings, showing a significant interaction between pair type and test type, $F(1, 35) = 20.57, MSE = 0.017, p < .0001$.

An ANOVA that treated the inclusion condition and results from the indirect task in Experiment 1 (elaborative encoding) as a between-subjects variable showed a significant main effect of pair type, $F(1, 58) = 46.78, MSE = 0.013, p < .001$, and a significant interaction between pair type and test type, $F(1, 58) = 4.01, p < .05$. This interaction was due to the higher probability of completing stems of intact pairs with studied words in the inclusion condition compared with the indirect task condition, $t(58) = 2.197, p < .05$. This suggests that intentional retrieval played a larger role in the inclusion task relative to the indirect task. The probability of completing recombined pairs and control pairs with target words did not differ across the two test conditions ($ts < 1$).

Before computing the estimates of controlled and automatic influences, we ensured that response strategies did not change across the inclusion and exclusion tasks (see also Jacoby et al., 1993) by comparing performance for the inclusion versus exclusion baselines. No significant difference was found in the proportion of completions with target words across these two baseline conditions ($t < 1$). Estimates of controlled and automatic influences were calculated for each subject using the formulas described earlier and the means are presented in Table 3. These values showed that intact pairs were consciously recollected more often than were recombined pairs, $t(35) = 4.54, p < .001$. In contrast, estimates of automatic influences showed no significant difference between intact and recombined pairs, $t(35) = 1.31, p = .2$. It is of course possible that with a large enough sample size the difference between the automaticity estimates for the intact and recombined conditions would become statistically significant. The power of the present experiment to detect a true effect of the observed size was only .26 for a two-tailed test with $\alpha = .05$. However, it is important to note that such a small effect, even if real, would pale in comparison with the large difference in conscious recollection estimates across the intact and recombined conditions. Thus, the most important finding to emerge from this experiment is that the associative repetition effect under elaborative encoding (Graf & Schacter, 1985, 1987, 1989; Schacter & Graf, 1986a, 1989) is largely attributable to consciously controlled processing rather than to automatic, unconscious influences. In the next experiment we show that under different encoding instructions, automatic processes can indeed influence the associative repetition effect.

Experiment 3

In Experiment 2 we showed that the associative repetition effect under elaborative encoding conditions mainly reflected a differential increase in consciously controlled processing for the intact versus recombined conditions. This is consistent with the findings of Toth et al. (1994), which demonstrated that a level-of-processing manipulation (c.f., Craik & Lockhart, 1972; Craik & Tulving, 1975) affects consciously controlled processes but not automatic processes in the retrieval of single words. Given that the associative repetition effect under elaborative encoding appeared to be largely attributable to consciously controlled retrieval, we next attempted to investigate an associative repetition effect that was demonstrated under shallow encoding instructions. It seemed reasonable to expect that an associative repetition effect under shallow encoding may represent automatic retrieval of associative information.

The only positive report of associative stem-completion priming that did not rely on elaborative encoding was documented by Micco and Masson (1991), who found an associative repetition effect when participants encoded word pairs by copying them side by side. These researchers argued that their copy task encourages participants to encode members of a word pair in relation to each other, and that this is sufficient to form an association that can be indirectly recovered. It is important to note that the effect was not observed on the direct cued-recall version of this task, where participants were asked to recall studied words that completed the stem cues. That the associative information was not retrieved on the direct task suggests that consciously controlled processes did not contribute to the effect.

In this experiment we replicated Micco and Masson's (1991) finding. We expanded their findings by applying the process dissociation procedure and found that the effect was largely driven by automatic processes.

Method

Participants. Sixty undergraduate students at the University of Toronto participated in return for course credit. Twenty-four participated in the indirect condition and 36 participated in the process dissociation condition. All participants had normal or corrected-to-normal vision, and none had participated in the previous experiments.

Design and materials. For the indirect condition, the experimental design consisted of one within-subjects variable, which was pair type (intact, recombined, or control). For the process dissociation condition, the experimental design consisted of two within-subjects variables, which were pair type (intact, recombined, or control) and test type (inclusion or exclusion).

For the indirect condition, the materials from Experiment 1 were used. For the process dissociation condition, the materials from Experiment 2 were used.

Procedure. At study, participants copied the pair members side by side onto an index card, turned over the card, and then received a new card. In this way, each pair was copied onto a different index card. Participants did not have to generate sentences or read words aloud. On the indirect task, participants had to complete stems with the first word that came to mind. On the inclusion task, participants were instructed to complete stems with studied words or, if they could not do so, to complete stems with the first appropriate word that came to mind. On the exclusion task, participants were instructed to complete stems with unstudied words. All other aspects of the procedure were identical to those of Experiments 1 and 2 for the indirect and process dissociation conditions, respectively.

Results and Discussion

Table 4 presents the proportion of stems completed with studied words for each experimental condition and the estimates of controlled and automatic influences. Examination of the data for the indirect task revealed that stems were more often completed with studied words in the intact than in the recombined condition, with the fewest completions in the control condition.

A one-way ANOVA showed the three conditions to be significantly different, $F(2, 46) = 27.46$, $MSE = 0.004$, $p < .001$. Further analysis revealed a significant difference between the intact and recombined conditions, $t(23) = 2.345$, $p < .05$, as well as between the recombined and control conditions, $t(23) = 4.93$, $p < .001$. Thus, both the associative level and the word level repetition effects were found to be significant. These findings replicated those of Micco and Masson (1991) by showing that the advantage of intact over recombined pairs was displayed under study instructions to copy the pairs.

In the inclusion task, the difference between completion in the intact and recombined conditions did not achieve significance, $t(35) < 1$. Thus, as originally shown by Micco and Masson (1991), copy encoding did not produce a difference between intact and recombined pairs in a cued-recall condition.

As in Experiment 2, before computing the estimates of controlled and automatic influences, we ensured that response strategies did not change across the inclusion and exclusion tasks (see also Jacoby et al., 1993), by comparing performance for the inclusion versus exclusion baselines. No significant difference was found in the proportion of completions with target words across these two baseline conditions ($t < 1$). Estimates of controlled and automatic influences were calculated for each participant and the means are presented in Table 4. Estimates of controlled influences showed no difference between intact and recombined pairs ($t < 1$). Thus, there was no evidence for differential involvement of consciously controlled processes. Equally important, estimates of the automatic influences were significantly higher for intact pairs than for recombined pairs, $t(35) = 2.08$, $p < .05$. Because the magnitude of this effect (.04) was only slightly larger than the insignificant effect (.03) observed under elaborative encoding (Experiment 2), we reanalyzed the data using the more conservative Wilcoxon test. Again, under elaborative encoding (Experiment 2) the automatic effect was not significant ($z = 0.79$, $p > .4$), whereas under copy encoding the effect was significant ($z = 2.09$, $p < .05$).

Table 4
Proportions of Stems Completed With Target Words by Retrieval Instructions and Pair Type, and Estimates of Controlled and Automatic Processes for the Intact and Recombined Conditions in Experiment 3

	Pair type					
	Intact		Recombined		Control	
Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*
			Performance			
Indirect	0.38	.02	0.34	.02	0.24	.02
Inclusion	0.41	.03	0.39	.02	0.22	.02
Exclusion	0.32	.02	0.28	.02	0.22	.02
			Estimates			
Control	0.10	.04	0.10	.03		
Automatic	0.35	.02	0.31	.02		

The important finding to emerge from this experiment is that the associative repetition effect under copy instructions was almost exclusively attributable to automatic rather than to consciously controlled processes. This stands in marked contrast to the finding in Experiment 2 that the associative repetition effect under elaborative encoding was largely attributable to consciously controlled processes.

General Discussion

In this study we applied the process dissociation procedure (Jacoby, 1991; Jacoby et al., 1993) to the associative stem-completion task (Graf & Schacter, 1985, 1987, 1989; Schacter & Graf, 1986a, 1989). When we used elaborative encoding, we did not find evidence for automatic influences on the associative repetition effect (Experiment 2). When we used copy encoding, however, we found that automatic processes were implicated (Experiment 3).

The finding that elaborative encoding is necessary to obtain an associative repetition effect (Experiment 1; Graf & Schacter, 1985) has been difficult to reconcile with the single-word repetition priming literature. Under shallow encoding of single words, repetition priming effects are obtained that are equivalent to or only slightly smaller (Challis & Brodbeck, 1992) than those obtained under deep encoding. This inconsistency with single-word repetition effects can be understood in light of the present findings. The results of Experiment 2 provided evidence that the associative repetition effect under elaborative encoding is largely attributable to consciously controlled processes. Our results are consistent with those reported by Toth et al. (1994). These authors demonstrated that whereas relative to shallow encoding, elaborative encoding may sometimes result in an increase in indirect repetition priming for single words, this difference likely reflects the increase in consciously controlled influences (also referred to as conscious contamination). By applying the process dissociation procedure, these authors found that for the retrieval of single words, automatic processes were unaffected by levels-of-processing manipulations, whereas consciously controlled processes were affected. An argument can therefore be made that if elaborative encoding does not affect automatic processes, and the most commonly demonstrated associative repetition effect is demonstrated only under elaborative encoding (and not shallow encoding), then this effect likely reflects consciously controlled processes. Interestingly, the results of Experiment 3 demonstrate that the only associative repetition effect under shallow encoding reported to date, namely that found under copy instructions (Micco & Masson, 1991), was shown to be attributable to automatic processes. Thus, the present results point to a potential resolution of some discrepancies between the literature on single-word repetition priming and the literature on associative repetition priming. More specifically, in contrast to single-word repetition priming, the associative repetition effect was not produced in normal participants who were "unaware" of the test manipulation (Bowers & Schacter, 1990; but see Howard et al., 1991), in normal participants under shallow encoding (Graf & Schacter, 1985; but see Micco & Masson, 1991), or in densely amnesic patients (Cermak, Blackford, et al., 1988; Cermak, Bleich, et al., 1988; Mayes & Gooding, 1989; Schacter & Graf, 1986b; Shimamura & Squire, 1989). If, indeed, the associative repetition effect under elaborative encoding is largely mediated by consciously controlled retrieval processes, then these differences are no longer surprising. One important implication for future research is that the finding of an indirect associative repetition effect under shallow encoding may prove an important marker for automatic retrieval processing, and the application of the process dissociation paradigm may provide important convergent evidence. In the case of a demonstrated associative repetition effect, such as the one found under copy instructions, there is a straightforward prediction that such an effect will also be obtained in densely amnesic patients, as well as "unaware" normal participants. One problem with the associative repetition effect under copy instructions is that its magnitude is relatively small, and it may be advantageous in future research to try to identify a more sizable associative repetition effect under shallow encoding (see Reingold & Goshen-Gottstein, in press, for such an effect).

It remains for future research to reconcile the current conclusion, that the associative repetition effect under elaborative encoding is largely attributable to consciously controlled retrieval, with the functional dissociations reported by Graf and Schacter (1985, 1987, 1989; Schacter & Graf, 1986a, 1989), which have been taken as evidence of unconscious, automatic retrieval. These researchers have documented a variety of manipulations that produced single dissociations between the indirect associative stem-completion task and the direct associative cued-recall task. The present research suggests that the application of the process dissociation procedure will help clarify the separate contributions of consciously controlled and automatic processes. Consequently it may be beneficial to apply the process dissociation procedure to experimental manipulations that have produced dissociations between direct and indirect associative tasks. Until these manipulations have been more intensively explored it will be impossible to determine the generality of the present demonstration of conscious contamination in associative repetition priming under elaborative encoding, and it remains possible that under some conditions elaborative encoding will indeed result in automatic influences on associative priming.

Though we ought to keep in mind the necessity for caution, the results of the present experiments raise an interesting suggestion that there may be two distinct types of associative repetition effects: one mediated by conscious control, and the other influenced by an automatic, unconscious process. Obviously, we need to try to specify the crucial differences between the elaborative encoding condition used in Experiment 2 and the copy instructions used in Experiment 3. One theoretical framework that may be useful in accounting for these differences is the transfer appropriate processing paradigm (e.g., Roediger, Weldon, & Challis, 1989). Specifically, the unitization that occurs in the copy condition may be largely perceptual-motor, and consequently, the retrieval cues may automatically reinstate the encoded unit. In contrast, the elaboration condition may integrate the word pair on a semantic, conceptual level. Although the elaborative encoding episode may be reinstated at the time of retrieval, this reinstatement is consciously controlled, and therefore does not contribute to the estimate of automaticity. The hypothesis that perceptual integration and unitization are crucial for obtaining an automatic, associative effect needs to be evaluated further (see also Bowers & Schacter, 1993; Toth & Reingold, 1996; Toth et al., 1994, Experiment 2).

Finally, given that our conclusions are based, crucially, on the validity of the process dissociation procedure, it is important to acknowledge that this procedure has generated a considerable amount of controversy (e.g., Gardiner & Java, 1993; Graf & Komatsu, 1994; Jacoby, Toth, Yonelinas, & Debner, 1994; Jacoby, Yonelinas, & Jennings, in press; Joordens & Merikle, 1993; Reingold & Toth, 1996, in press; Richardson-Klavehn, Gardiner, & Java, 1994; Roediger & McDermott, 1993; Toth, Reingold, & Jacoby, 1995). Although the details of this controversy are beyond the scope of the present article, one specific issue needs to be addressed. On the basis of an a priori analysis, Graf and Komatsu (1994) concluded "that the PDP [process dissociation procedure] is not suitable for learning about implicit versus explicit memory test performance" (p. 116). This claim is, of course, in direct conflict with the rationale of the present series of experiments, as well as that of other studies (e.g., Jacoby et al., 1993; Toth et al., 1994) that compared performance across indirect/implicit tests with the estimates derived from the process dissociation procedure. Although Graf and Komatsu's (1994) critique has been evaluated and replied to elsewhere (Reingold & Toth, 1996; Toth et al., 1995), we would like to argue that the present experiments provide an interesting case study in which the implicit–explicit and process dissociation procedure methodologies converge to form a unified explanation. Graf and Komatsu (1994) argue that indirect/implicit tests should not be compared with the automatic and consciously controlled estimates derived from the process dissociation procedure. However, we argue that such a comparison has the potential of providing important convergent evidence. More specifically, one important empirical prediction of the process dissociation procedure is that when conscious control is minimal, automaticity estimates should approximate performance in an indirect condition. This is the case because under such conditions the indirect measure could be expected to reflect a relatively uncontaminated measure of automatic, unconscious influence.

Such a pattern of findings was indeed obtained in Experiment 3. As shown in Table 4, under shallow copy instructions, conscious control was minimal for both the intact and the recombined conditions, making it possible to compare the automaticity estimate with indirect performance. Indirect performance was .38 and .33 for the intact and recombined conditions, respectively, and the corresponding automatic estimates were .35 and .31. A similar finding was obtained by Toth et al. (1994) in their Experiment 1, where a levels-of-processing manipulation was used in both indirect and process dissociation procedure conditions. In the shallow encoding condition, the estimate of conscious control approximated zero (.03), and the estimates of automaticity and indirect performance were in close agreement (.44 versus .45, respectively). Thus, both of these examples demonstrate the usefulness of an empirical comparison between process dissociation procedure estimates and implicit performance. The importance of an a priori analysis notwithstanding, we argue that comparisons such as those conducted in the present experiments are vital if real progress is to be made in evaluating the validity of paradigms and in converging on a satisfactory theoretical explanation of the relationship between consciousness and memory.

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