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The origins of levels-of-processing effects in a conceptual test: Evidence for automatic influences of memory from the process-dissociation procedure

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In three experiments, we explored automatic influences of memory in a conceptual memory task, as affected by a levels-of-processing (LoP) manipulation. We also explored the origins of the LoP effect by examining whether the effect emerged only when participants in the shallow condition truncated the perceptual processing (the lexical-processing hypothesis) or even when the entire word was encoded in this condition (the conceptual-processing hypothesis). Using the process-dissociation procedure and an implicit association-generation task, we found that the deep encoding condition yielded higher estimates of automatic influences than the shallow condition. In support of the conceptual processing hypothesis, the LoP effect was found even when the shallow task did not lead to truncated processing of the lexical units. We suggest that encoding for meaning is a prerequisite for automatic processing on conceptual tests of memory.

An important distinction in the study of human memory is that between perceptual and conceptual tests (e.g., Roediger, 1990). *Perceptual tests* can be operationally defined as tests in which the studied material is physically reinstated, in whole or in part, and identification of the item is required. In this article, we focus on *conceptual tests*, in which perceptual information regarding the target is not provided during the test phase. Instead, participants are required to produce the target in response to a conceptual cue (e.g., an associated word). Successful performance on conceptual tests likely depends on the recapitulation of conceptual processing, whereas successful performance on perceptual tests probably requires the recapitulation of perceptual processing (e.g., Roediger, Weldon, & Challis, 1989).

Memory research has focused on a further distinction, that between explicit and implicit tests (e.g., Graf & Schacter, 1985). On classical *explicit tests* (e.g., recall and recognition), memory is tapped by asking participants to consciously recollect their prior experiences. On *implicit tests*, in contrast, conscious recollection of an earlier experience is not required. Instead, memory is revealed when previous experience facilitates performance on a task. For example, participants may be exposed to a list of target words (e.g., COOKIES) and subsequently, on a perceptual test such as the stem-completion task (see, e.g., Graf & Schacter, 1985), may be asked to complete word stems with the first word that comes to mind (e.g., COO__). For the instructions to be implicit, participants must not be informed that their memory for the previously studied items is being tested. Likewise, on a conceptual test, such as the *association-generation task* (see, e.g., Weldon & Coyote, 1996), participants may be asked to generate the first association that comes to mind (e.g., COOKIES) in response to a cue word (e.g., MILK). Results show that, relative to stems or associative cues of unstudied words, cues of studied words will more likely be completed with target words. Enhanced performance on conceptual tests is called *conceptual priming*.

Most of the research on perceptual tests has employed implicit instructions. An important theme of this line of research has been that performance on implicit perceptual tests is influenced by automatic processes. In support of this notion, amnesic patients show intact implicit memory on perceptual tests alongside impaired performance on explicit tests (for a review, see Moscovitch, Vriezen, & Goshen-Gottstein, 1993). In addition, many manipulations have been uncovered that dissociate performance on implicit and explicit tasks (for a review, see Roediger & McDermott, 1993). Finally, studies that applied the process-dissociation (PD) procedure to perceptual tests have revealed automatic influences of memory (e.g., Jacoby, 1991; Reingold & Goshen-Gottstein, 1996a, 1996b; Toth, Reingold, & Jacoby, 1994).

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Evidence for the contribution of automatic influences of memory to conceptual tests comes primarily from the behavioral pattern of amnesic patients (e.g., exemplar generation: Graf, Shimamura, & Squire, 1985; Keane, Gabrieli, Monti, Cantor, & Noland, 1993; Keane et al., 1997; but see Blaxton, 1992; association generation: Carlesimo, 1994; Vaidya, Gabrieli, Keane, & Monti, 1995) and from task dissociations in studies that satisfied Schacter, Bowers, and Booker's (1989) retrieval-intentionality criterion (Culp & Rajaram, 1999; Goshen-Gottstein & Kempinsky, 2001; McDermott & Roediger, 1996; Mulligan, 1997; Vaidya & Gabrieli, 2000; Vaidya et al., 1997; Weldon & Coyote, 1996; Zeelenberg, Pecher, Shiffrin, & Raaijmakers, in press; Zeelenberg, Shiffrin, & Raaijmakers, 1999).

In this article, we wished to provide converging evidence for the idea that automatic processes mediate performance on conceptual tests by applying the PD procedure to the association-generation task. The PD procedure (Jacoby, 1991) is a technique that yields estimates of controlled and of automatic influences of memory by comparing two test conditions. In the *inclusion* condition, controlled and automatic influences work in concert to facilitate performance. In the present study, participants were provided with test cues (e.g., MILK) and were asked to generate an associated studied word (e.g., COOKIES) or, failing to do so, to produce the first association that comes to mind. Hence, studied words were produced either because they were consciously recollected or because they came to mind automatically.

In contrast, in the *exclusion* condition, the two influences of memory work in opposition to each other—controlled influences work to minimize particular responses, whereas automatic influences work to promote these same responses. In the present study, participants were asked to provide associated words that were *not* presented earlier. In this condition, automatic influences of memory promoted responding with studied words, whereas controlled influences minimized responding with these words.

Performance in the exclusion condition underestimates the contribution of automatic influences of memory because some of the words that were automatically retrieved may have also been consciously recollected and were, therefore, excluded (Jacoby, 1991). To correct for this underestimation, Jacoby translated performance in the two test conditions into a set of simple equations.

Specifically, assuming that consciously controlled and automatic influences are independent (for a sample of debates on this issue, see Bodner, Masson, & Caldwell, 2000; Curran & Hintzman, 1997; Hintzman & Curran, 1997; Jacoby, Begg, & Toth, 1997; Jacoby & Shrout, 1997; Jacoby, Yonelinas, & Jennings, 1996; Jones, 1987; Joordens & Merikle, 1993; Reingold & Toth, 1996; Richardson-Klavehn, Gardiner, & Java, 1996), the probability that a studied word will be reported in the inclusion (I) condition can be estimated by the probability of controlled recollection of the item (C) plus the probability of the word automatically (A) coming to mind when controlled recollection fails [$A\ (1 - C)$]; that is, $I = C + A(1 - C)$. For the exclusion condition (E), a studied word will be reported only if it is not consciously recollected yet comes to mind automatically; that is,

$$E = A(1 - C).$$

The probability of controlled recollection can be estimated as the difference in the probability of responding with studied words in the inclusion and exclusion conditions; that is, $C = I - E$. Automatic influences may then be computed as $A = E / (1 - C)$. Jacoby (1991) noted that the estimate of automatic influences (A) reflects a contribution of both automatic influences (M) and the baseline probability (B) of providing a word without having seeing it in the study phase. Jacoby (1991) assumed that M and B are additive ($A = M + B$) and took as evidence for automatic influences an estimate of A being higher than baseline (but see Wainwright & Reingold, 1996).

The PD Procedure and the Locus of Levels-of-Processing (LoP) Effects

Because the PD procedure can separate the contribution of automatic and consciously controlled processes to performance, it provides an opportunity to identify the locus of different experimental effects. In particular, using the PD procedure, one can ask whether an experimental effect is mediated by automatic processes or whether this effect is merely a by-product of consciously controlled contamination. To illustrate, Toth et al. (1994, Experiment 1) asked why directing participants' attention to the meaning of studied words during encoding (i.e., the deep-encoding condition) led to better performance than did directing their attention to the perceptual form of these same words (i.e., the shallow-encoding condition) even on implicit perceptual tests (Challis & Brodbeck, 1992; Thapar & Greene, 1994; for a review, see Brown & Mitchell, 1994). These LoP effects suggest that encoding of the meaning of words can affect automatic influences on implicit tests much as it affects controlled influences on explicit tests (e.g., Craik & Lockhart, 1972).

By applying the PD procedure, Toth et al. (1994) showed that the LoP manipulation affected the estimate of controlled influences but that it did not affect the estimate of automatic influences. Therefore, the effects of LoP on perceptual implicit tests, which could falsely be interpreted as genuine automatic effects, are more likely the by-product of contamination by conscious processes (but see Bodner et al., 2000).

In the present study, we extended the Toth et al. (1994) design to explore conceptual tests. Thus, we asked whether the LoP effects that are often reported in implicit conceptual tests are only a by-product of conscious contamination or whether these effects also reflect a genuine contribution of automatic influences of memory. We hypothesized that, LoP effects on conceptual, in contrast with perceptual, tests of memory reflect, at least in part, a genuine contribution of automatic influences. Hence, we predicted that an LoP effect would be found even on the automatic estimates.

Our prediction was based on at least 3 reasons: First, the hypothesis that LoP effects on conceptual tests of memory represent a genuine automatic influence is in harmony with the finding that dividing attention during encoding resulted in lower estimates of automatic influences relative to a full-attention condition in the category-exemplar generation task. The magnitude of the estimate of automatic influences decreased when attention was divided at encoding (Schmitter-Edgecombe, 1999; Experiment 2), ostensibly because dividing attention at encoding reduced the amount of conceptual processing (Mulligan & Hartman, 1996).

Second, unlike LoP effects on perceptual tests, LoP effects on measures of conceptual priming are quite robust. Such effects were reported on the association-generation task (e.g., Weldon & Coyote, 1996; but see Nelson, Benett, & Xu, 1997, Experiment 3), the category-exemplar generation task (e.g., McDermott & Roediger, 1996; Mulligan, Guyer, & Beland, 1999; Srinivas & Roediger, 1990; Vaidya et al., 1997; Weldon & Coyote, 1996), the general-knowledge question task (e.g., Hamann, 1990; Thapar & Greene, 1994), the sentence-completion task (Goshen-Gottstein & Peres, 1998), and in amnesic patients (Keane et al., 1997).

Finally, according to the transfer-appropriate processing (TAP) framework (e.g., Roediger et al., 1989), recapitulation of conceptual processing enhances performance on conceptual tasks. Because the LoP manipulation is presumed to affect processing of meaning (but see Richardson-Klavehn & Gardiner, 1998) ostensibly leading to differences in conceptual processing, we expected more recapitulation of conceptual processing in the deep-encoding condition than in the shallow condition.

To summarize, the primary goal of this study was to seek evidence for automatic influences of memory on a conceptual task, and, if we found such evidence, we further wished to test whether the LoP manipulation would affect these automatic influences. To this end, we manipulated LoP during encoding and then applied the PD procedure to the conceptual association-generation task (Experiment 2). To anticipate our results, we found an automatic contribution to the LoP effect. For sake of comparison, we also tested the effect of the LoP manipulation on the implicit association-generation task (Experiment 1). Finally, Experiment 3 was designed to better comprehend the nature of the automatic contribution to the LoP effect.

EXPERIMENT 1

The purpose of Experiment 1 was to replicate the LoP effect in the implicit test of association-generation using LoP instructions identical to those used by Weldon and Coyote (1996) in their association-generation experiment.

Method

Participants. Twenty-four introductory psychology students participated in the experiment to fulfill course requirements. All had normal or corrected-to-normal vision.

Design and Materials. Encoding condition (deep, shallow, or unstudied) was manipulated within subjects. In a pilot study, 120 associatively related cue–target word pairs were selected in the following manner. A preliminary list of 360 cue words was presented to 53 participants who were asked to write down, for each cue, the first association that came to mind (Bergerbest & Goshen-Gottstein, 1999b). The 120 word pairs were selected so that the cue word would elicit the target word by approximately 30% of the participants. These 120 pairs were presented in the test list.

The experimental condition of the cues was defined by the status of their respective targets. To this end, the 120 word pairs were randomly divided into three lists of 40 pairs, each to be allocated to one of the encoding conditions. For each session, targets from two of the lists were included in the study list, corresponding to either the deep or the shallow encoding condition, and targets from the third list were not studied. The three lists were counterbalanced so that each participant was presented with an equal number of targets in the three encoding conditions and that, across participants, each target would be allocated an equal number of times to each of the three encoding conditions. Two buffer words were added at the beginning and two at the end of the study list, producing a list of 84 words. Ten additional words, which did not match any of the target words and were not associated with any of the cue words, were used for practicing the two encoding tasks.

Procedure. Individually tested participants were told that they would be shown a list of words and were asked to make one judgment per word by pressing a key on the computer keyboard. For each word in the deep-encoding condition, participants were required to rate the pleasantness of the meaning on a 5-point scale. In the shallow-encoding condition, they were required to count the number of vowels per word.

Participants were informed that the two tasks would be presented in a random order and that task instructions would appear above each of the presented words. No more than four consecutive words appeared with the same instruction.

Each participant received 10 practice trials. Every trial began with a warning signal in the middle of a Macintosh computer screen for 0.5 sec. The warning signal was replaced by the target word and task instructions determining the relevant task ("pleasantness," "vowels"). Task instructions appeared 2 cm above the target word. Target words were presented for 3 sec with the next trial beginning 1 sec later.

The 120 test cues were presented in random order, one cue at a time, and participants were asked to generate for each cue the first association that came to mind. The study and test phases lasted 6 and 30 min, respectively. Both study targets and test cues were presented in Gilboa font (8 mm high, 6 mm wide).

After test, participants were asked whether they had noticed any connection between the first and the second phases of the experiment and whether they had tried to intentionally recall studied words to provide associations on the test phase.

Results and Discussion

For each participant, the proportion of target responses that were generated in each encoding condition was com-

Table 1
Experiment 1: Proportions (*P*s) and Standard Errors of Target Words Generated in the Three Encoding Conditions and Priming Scores, Computed by Subtracting Performance in the Unstudied Conditions From Performance in the Deep and Shallow Encoding Conditions

	Encoding Conditions					
	Deep		Shallow		Unstudied	
	P	*SE*	*P*	*SE*	*P*	*SE*
Proportion of targets	.37	.03	.31	.02	.28	.02
Priming	.09	.02	.03	.02		

puted. Priming scores were calculated, for both the deep and the shallow encoding conditions, by subtracting the proportion of unstudied targets from that of studied targets. Table 1 presents the proportion of target words under each encoding condition and the corresponding priming scores.

Examination of participants' responses revealed that targets were most likely to be generated in the deep-encoding condition, less likely to be generated in the shallow-encoding condition, and least likely to be generated in the unstudied condition. A one-way analysis of variance (ANOVA) revealed that, indeed, the effect of encoding condition was significant [$F(2,22) = 24.92$, $MS_e = .17$, $p < .0001$]. Post-hoc analysis (Levin, Serlin, & Seaman, 1994) revealed that there was significant priming in both the deep-encoding condition [$t(23) = 4.61$, $p = .0001$] and the shallow condition [$t(23) = 1.84$, $p = .039$, one tailed]. Most importantly, the LoP effect was significant [$t(23) = 2.96$, $p = .007$]. The results replicate Weldon and Coyote's (1996) finding of an LoP effect on the implicit association-generation task using the identical set of instructions.

There are two reasons to believe that automatic influences of memory contributed to this LoP effect. First, responses to the posttest questionnaire revealed that not even a single participant reported trying to intentionally recall studied words to provide associations in the test phase. Therefore, all the findings of this experiment represent responses of participants who, according to their subjective reports, did not try to explicitly recollect studied items. Second, and more important, even when analyzing the responses of participants who were unaware during the test phase that they had generated previously presented associations (i.e., Bowers & Schacter, 1990), we still found a significant LoP effect [$t(10) = 2.08$, $p = .032$, one tailed].

Still, because the test phase immediately followed the study phase, and because it included a high percent (66%) of cues that were associated to studied words, the possibility of conscious contamination cannot be ruled out. Therefore, in Experiment 2, we applied the PD procedure to the association-generation task to eliminate the possibility of conscious contamination.

EXPERIMENT 2

The purpose of Experiment 2 was to use the PD procedure to provide converging evidence for the idea that automatic processes mediate performance in the association-generation task and that an LoP effect can be found on these processes. During study, participants studied a list of words under deep- or under shallow-encoding conditions. During test, participants were provided with cues and were asked to produce associations, under either inclusion or exclusion instructions.

Method

Participants. Sixty introductory psychology students, all with normal or corrected-to-normal vision, took part to fulfill course requirements. None had participated in Experiment 1. Because exclusion scores of zero (no target generation) result in an underestimation of the automatic contribution to performance [because $A = E/(1 - C)$] (e.g., Jacoby, 1996), an additional 7 participants were tested to replace participants with exclusion scores of zero, as advocated by Jacoby and colleagues. Replacement of the participants did not affect the pattern of results.

Design and Materials. Encoding condition (deep, shallow, unstudied) and test condition (inclusion, exclusion) were manipulated within subjects. The materials were identical to those used in Experiment 1.

Procedure. The study phase was identical to that of Experiment 1. During test, which lasted approximately 40 min, participants were told that their memory would be tested for the words that they had studied. They were informed that they were to see a list of words, one word at a time, accompanied by two types of retrieval instructions. When presented with the instruction "old" (i.e., inclusion), they were to say a studied word that was associated with the cue word. If they could not recollect a studied word, they were to say the first associated word that came to mind. If the instruction "new" appeared (i.e., exclusion), participants were required to say aloud the first associated word that came to mind but to exclude words they recollected as having appeared in the study phase, replacing them with another word that came to mind.

To ensure that participants understood the instructions, they practiced the two tasks. Then, the 120 cue words were presented in a different random order for each participant. Half of the randomly chosen cues, corresponding to target words from each of the three encoding conditions (i.e., 20 cues), appeared in the inclusion condition and the remaining half appeared in the exclusion condition. Across participants, each cue was presented equally often in the two test conditions.

The "old" and "new" instructions appeared in random order with no more than four consecutive cues appearing with the same task instruction. Random presentation of the two test conditions increased the likelihood that controlled recollection was the same for the inclusion and exclusion conditions (see Jacoby, 1998).

Results and Discussion

Table 2 presents the proportions of target words generated under each experimental condition and the estimates derived from the PD procedure equations. In this and the subsequent experiment, only the analysis of the estimates of controlled and automatic influences will be reported because it is statistically redundant to analyze performance in the inclusion and exclusion conditions as well as the pattern of the derived estimates (see Jacoby, 1996).

Examination of participants' performance revealed that in the inclusion condition, participants were more likely to

Table 2
Experiment 2: Proportions (*P*s) and Standard Errors of Target Words Generated as a Function of the Three Encoding Conditions and the Two Test Conditions, and Estimates of Controlled and Automatic Processes

	Encoding Conditions					
	Deep		Shallow		Unstudied	
	P	*SE*	*P*	*SE*	*P*	*SE*
Test Conditions						
Inclusion	.58	.02	.33	.02	.23	.01
Exclusion	.19	.01	.26	.01	.27	.01
Estimates						
Controlled	.38	.03	.07	.02		
Automatic	.32	.02	.28	.01	.25	.01
Automatic-Baseline	.07	.02	.03	.01		

generate targets following deep than following shallow encoding, and that in both encoding conditions more target words were generated than in the unstudied condition. In contrast, in the exclusion condition, participants were more likely to generate unstudied than studied words and were more likely to generate studied words after shallow encoding than after deep encoding.

Analysis of the PD estimates revealed that deep encoding produced more controlled retrieval than did shallow encoding [$t(59) = 7.31, p < .0001$]. More important, the estimate of automatic influences was higher than baseline performance, in both deep- [$t(59) = 3.39, p = .001$] and shallow- [$t(59) = 1.99, p = .025$, one tailed] encoding conditions. Thus, evidence for automatic influences of memory was found with the PD procedure when applied to a conceptual test of memory. Finally, the estimates of automatic influences revealed that deep encoding produced significantly higher automatic influences than did shallow encoding [$t(59) = 1.68, p = .049$, one tailed]. This finding of an LoP effect on the estimates of automatic influences converges with the finding of a LoP effect on the implicit test in Experiment 1.

Next, we compared baseline performance in the inclusion and exclusion conditions to examine whether there was evidence for a change in response strategies across the two tasks. This analysis revealed that the baseline in the inclusion condition was significantly lower than the baseline in the exclusion condition [$t(59) = 2.74, p = .008$]. This difference may have been the result of participants' tendency, during the inclusion condition, to provide a studied word even if it was not related to the cue.[1] Thus, participants may have reported studied words even when responding to a baseline cue. This would have reduced the likelihood of generating the appropriate (unstudied) target for the baseline cues. In contrast, in the exclusion condition, participants may have tried to avoid providing studied words, and so may have been more likely than in the inclusion condition to report the unstudied associates as response to the relevant cues. Indeed, we found that associates that were intended to serve as cues to generate unstudied targets were used to generate studied targets more often in the inclusion condition ($M = 0.068$, $SE = 0.008$) than in the exclusion condition ($M = 0.011$, $SE = 0.002$) [$t(59) = 7.12, p < .001$].

Toth et al. (1994) suggested that higher baselines in the exclusion, relative to the inclusion, condition were a signature for a generate-recognize strategy (but see Bodner et al., 2000, who questioned the validity of this signature by demonstrating that it did not emerge even when test instructions explicitly guided participants to use a generate-recognize strategy). Although our baselines showed an opposite pattern, we still wished to correct for the differences in baselines by estimating the conscious and automatic influences. To do so, we used Wainwright and Reingold's (1996) correction equations.

Wainwright and Reingold's corrections for differences between baselines. Several attempts have been made to derive measures of automatic influences of memory that correct for unequal performance in baseline conditions. Of all the proposals, Wainwright and Reingold's (1996) remains the most comprehensive. These authors presented seven different models for correcting unequal performance in the baseline conditions and were careful to articulate the underlying assumption behind each model. We now describe the estimates that were derived from the three models that assume independence between controlled and automatic processes. In the General Discussion, we argue that if this assumption is incorrect, and participants used a generate-recognize strategy, then our findings of an LoP effect would only be enhanced.

Table 3
Experiment 2: Estimates (*E*s) and Standard Errors of Controlled and Automatic Processes According to the Different Correction Methods Described by Wainwright and Reingold (1996)

	Encoding Conditions			
	Deep		Shallow	
Correction Method	*E*	*SE*	*E*	*SE*
Hits − FA				
Controlled	.43	.04	.11	.03
Automatic	−.16	.15	−.02	.02
Independent guessing				
Controlled	.39	.04	.10	.03
Automatic	.08	.03	.01	.02
Additive				
Controlled	.39	.04	.09	.03
Automatic	.06	.02	.01	.01

Note—All three models assume independence between controlled and automatic influences of memory.

The three independence models differ with regard to their assumptions of the relation between a guessing parameter (which is estimated by performance in the baseline conditions) and the controlled and automatic influences (see equations and underlying assumptions of the three models in the Appendix). Reanalysis of the results of Experiment 2 following the three guessing models is presented in Table 3.

The estimates of automatic influences derived from the HITS − FA model yield negative values for the automatic influences. Because the true automatic contribution must be either nil ($A = 0$) or positive, this model obviously underestimates the automatic contribution (probably more in the deep condition than in the shallow condition; see General Discussion). Because the magnitude of this underestimation is unknown, this model turns out to be uninformative. In contrast, the results of the other two models, the independent-guessing model (which "yields corrected estimates that are numerically identical to the Buchner, Erdfelder, & Vaterrodt-Plunnecke [1995] model"; Wainwright & Reingold, 1996, p. 241) and the additive model, yield results that are both reasonable and consistent with each other. Both the independent-guessing model [$t(59) = 2.77, p < .01$] and the additive model [$t(59) = 3.05, p < .01$] provide support for automatic influences of memory under deep, but not under shallow

(ts < 1), encoding, and a significant LoP effect for the automatic influences of memory [$t(59) = 1.78, p = .039$, one tailed, and $t(59) = 1.84, p = .035$, one tailed, respectively].

To summarize, evidence for automatic influences of memory and for an LoP effect on these influences was found both with Jacoby's (1991) original PD equations and when the corrected estimates were derived from Wainwright and Reingold's (1996) models.

EXPERIMENT 3

To increase the probability that controlled and automatic processes are independent, as required by the PD equations, Jacoby and colleagues have recently suggested using a different version of exclusion instructions (see Jacoby, 1998; also see Bodner et al., 2000). One goal of this experiment was to extend our findings to the new version of the instructions.[2] Thus, we asked participants in the exclusion condition to use each test cue as a cue to recall a studied associated word and only then to replace the studied word with another, unstudied, associatively-related word.

An even more important goal of this experiment was to critically examine our interpretation of the LoP effect in Experiment 2. We interpreted this effect as stemming from the reduced encoding-of-meaning of the words in the shallow condition (vowel counting) relative to the deep condition (pleasantness task), which lessened the automatic influences of memory for these words. However, the LoP effect could be interpreted as arising from either of two sources.

First, as we have suggested so far, participants in the shallow condition did not elaborately encode the meaning of the words (henceforth, the "conceptual-processing hypothesis"; Richardson-Klavehn & Gardiner, 1998), and the LoP effect may have resulted from the difference in the amount of encoding-for-meaning that words underwent in the shallow and deep conditions. Second, in the shallow condition, participants may not have even encoded the lexical/perceptual units with which they were presented (the "lexical-processing hypothesis"; Richardson-Klavehn & Gardiner, 1998). That is, participants in the shallow condition may have set themselves to restrict perceptual processing by, for example, only checking for vowels, thereby truncating the perceptual analysis of the stimuli (Richardson-Klavehn & Gardiner, 1998; Thapar & Greene, 1994; for an example of truncated processing in nonverbal stimuli, see Goshen-Gottstein & Ganel, 2000). If this is so, then the Experiment 2 LoP effect may have been mediated by the difference between words for which the lexical units were accessed (deep condition) relative to words for which the lexical units were not accessed (shallow condition), rather than from a difference in the encoding-for-meaning.

According to the conceptual-processing hypothesis, LoP effects are the product of differential encoding for meaning. Hence, if a shallow-encoding task was used in which the lexical units would be processed in their entirety but the encoding-for-meaning would remain minimal, then LoP effects should still be observed. According to the lexical processing hypothesis, however, the source of LoP effects in Experiments 1 and 2 was the truncated lexical processing of words in the shallow condition. Therefore, if a shallow-encoding task were used in which the lexical units would be processed in their entirety, the LoP effect would be eliminated.

Critically, in the posttest interview of Experiment 1, several participants remarked that as they were counting the vowels they did not always notice the actual word with which they were presented. Therefore, our finding of an LoP effect on the automatic estimates might have been the product of truncated lexical processing of words in the shallow condition rather than of reduced processing-for-meaning of these words.

With regard to perceptual implicit tests, several studies have attempted to distinguish between the conceptual-processing and the lexical-processing hypotheses for LoP effects. For example, using the stem-completion task, Richardson-Klavehn and Gardiner (1998; see also Challis, Velichkovsky, & Craik, 1996) found a LoP effect when performance in the semantic condition (i.e., rating pleasantness of meaning) was compared with that of a graphemic condition (i.e., counting enclosed spaces in letters), which ostensibly leads to truncated lexical processing. However, an LoP effect was not found when performance in the semantic condition was compared with that of a phonemic condition (i.e., counting syllables), which ostensibly allows for processing of the entire lexical unit but with minimal processing of the words' meaning.

These results support the lexical processing hypothesis, according to which direct participants' attention to the letter level, as in counting enclosed spaces, can reduce the lexical processing of the studied words and hence produce the observed LoP effect. Although the lexical processing hypothesis seems to account for LoP effects in at least some perceptual tests, it may not account for LoP effects in conceptual tests, where encoding-for-meaning should play a more critical role.

In Experiment 3, we distinguished between the two hypotheses by replacing the vowel-counting task used in Experiment 2 with a syllable-counting task. We chose the syllable-counting task because it seems to demand less processing of the words' meaning than that required in the pleasantness-rating task. Yet, as suggested by the results in the phonemic condition of Richardson-Klavehn and Gardiner (1998), encoding in this task seems to be of the entire lexical unit. Will a LoP effect emerge despite the processing of the entire lexical unit under shallow encoding?

Method

Forty-eight introductory psychology students, none of whom had participated in the previous experiments, participated in the experiment to fulfill course requirements. Five additional participants were run to replace participants with exclusion scores of zero. As in Experiment 2, this did not affect the pattern of results.

The method was identical to that of Experiment 2 except that, in the shallow-encoding condition, participants were asked to count the number of syllables per word. Also, during the exclusion trials, par-

Table 4
Experiment 3: Proportions (*P*s) and Standard Errors of Target Words Generated as a Function of the Three Encoding Conditions and the Two Test Conditions, and Estimates of Controlled and Automatic Processes

	Encoding Conditions					
	Deep		Shallow		Unstudied	
	P	*SE*	*P*	*SE*	*P*	*SE*
Test Conditions						
Inclusion	.63	.02	.35	.02	.24	.02
Exclusion	.18	.02	.25	.01	.27	.02
Estimates						
Controlled	.45	.03	.09	.02		
Automatic	.32	.02	.27	.01	.25	.01
Automatic-Baseline	.07	.02	.02	.01		

ticipants were asked to use each test cue as a cue to recall a studied associated word and only then to replace the studied word with an unstudied associatively related word. Participants were told to provide the first association that came to mind if they could not recollect a related studied word.

Results and Discussion

The results were scored as in Experiment 2 and are presented in Table 4. The general pattern of results was similar to that in Experiment 2. However, in contrast to Experiment 2, the difference between baselines was not significant [$t(47) = 1.60, p > .1$].

As in Experiment 2, deep encoding resulted in higher consciously controlled estimates than did shallow encoding [$t(47) = 12.15, p < .0001$]. More importantly, the estimate of automatic influences were higher than baseline performance following deep encoding [$t(47) = 2.61, p = .012$]. Thus, Experiment 3 provides a replication of the Experiment 2 finding of automatic influences of memory following the deep-encoding condition on the association-generation task. The estimate of automatic influences following shallow encoding did not differ significantly from baseline [$t(47) < 1$]. The interpretation of this null effect is discussed in the General Discussion. For now, suffice it to say that the absence of automatic influences of memory following shallow encoding was consistent with the absence found using Wainwright and Reingold's (1996) equations, which corrected for unequal baselines (Experiment 2).

Most importantly, an examination of the LoP effect revealed a significantly larger estimate of automatic influences in the deep-encoding condition than in the shallow-encoding condition [$t(47) = 1.93, p = .03$, one tailed]. This LoP effect replicates that of Experiment 2 where the pleasantness-rating task was contrasted with the vowel-counting task. Because the syllable-counting task used in our experiment presumably does not induce truncated lexical processing, the ensuing LoP effect supports the notion that this effect was based on reduced processing-of-meaning in the shallow condition rather than on the absence of lexical processing.

Correcting for differences between baselines. The baselines in Experiment 3 did not differ significantly. Still, as in Experiment 2, we reanalyzed the results according to the three guessing-correction models that were suggested by Wainwright and Reingold (1996); the results are presented in Table 5.

As in Experiment 2, the HITS − FA model yielded negative values for the estimates of automatic influences and was therefore rejected. In contrast, the two other models, the independent-guessing model and the additive model, yielded results that are both reasonable and consistent with each other. Both the independent-guessing model [$t(47) = 1.67, p = .05$, one tailed] and the additive model [$t(47) = 2.11, p = .04$] provided support for automatic influences of memory in the deep-encoding condition but not the shallow condition (ts < 1). Moreover, in both models, the LoP effect for automatic influences was significant [independent-guessing model, $t(47) = 1.80, p = .039$, one tailed; additive model, $t(47) = 1.89, p = .033$, one tailed].

Thus, as in Experiment 2, evidence for automatic influences of memory and for an LoP effect on these influences was found both with Jacoby's original PD equations and when the corrected estimates were derived from Wainwright and Reingold's (1996) models.

GENERAL DISCUSSION

In the present study, we addressed three questions. First, do automatic influences of memory affect performance on the association-generation task? Second, if they do, can such processes be affected by an LoP manipulation? Third, are the LoP effects, if found, due to differences in lexical processing between the shallow and deep conditions or due to differences in the relative amount of processing-of-meaning?

In Experiment 1, we found a conceptual priming effect, which was sensitive to LoP. This effect was found even when one considers only the performance of test-unaware participants. Using the Experiment 1 stimuli, we applied the PD procedure to the association-generation task in Experiment 2 and, in reply to the first question, found evidence for automatic influences of memory.

Table 5
Experiment 3: Estimates (*E*s) and Standard Errors of Controlled and Automatic Processes According to the Different Correction Methods Described by Wainwright and Reingold (1996)

	Encoding Conditions			
	Deep		Shallow	
Correction Method	*E*	*SE*	*E*	*SE*
Hits − FA				
Controlled	.48	.04	.13	.03
Automatic	−.30	.23	−.10	.04
Independent guessing				
Controlled	.45	.03	.11	.03
Automatic	.05	.03	−.01	.02
Additive				
Controlled	.45	.03	.10	.03
Automatic	.05	.02	.01	.02

Note—All three models assume independence between controlled and automatic influences of memory.

In response to the second question, we found that the automatic influences were greater following deep than following shallow encoding. Thus, results of the PD procedure converged with those of conceptual priming. In the domain of perceptual tests, Toth et al.'s (1994) suggested that LoP effects were a by-product of contamination by consciously controlled processes. In contrast, in our study, when a conceptual test was used, the LoP effects showed up both on the measure of conceptual priming and on the estimates of automatic influences of memory as derived from the PD procedure. Therefore, the LoP effect that was found in conceptual priming seems to be not merely a by-product of conscious contamination.

The finding of converging evidence of conceptual priming with the PD estimates leads to the conclusion that, at least for the association-generation task, the measures of conceptual priming may not have been subject to much contamination by controlled processes (also see McBride & Shoudel, in press; Nelson et al., 1997; Schmitter-Edgecombe, 1999). The suggestion that conscious contamination was not responsible for the LoP effects in Experiment 1 conforms with the finding that LoP effects were found with both test-aware and test-unaware participants (see Bowers & Schacter, 1990). This seems most reasonable for tests such as association generation, which neither place any constraints on the answers generated by participants nor require any "correct answers." Participants are least likely to be motivated to try to recollect words from an earlier study phase to assist their performance in this task as opposed to other conceptual tasks. Providing the first association that automatically comes to mind seems to demand very little—and may indeed be performed without—conscious control.

The Lexical- Versus the Conceptual-Processing Hypothesis

Our third question, whether the LoP effect resulted from differences in lexical processing or from differences in conceptual processing, was addressed in Experiment 3. To this end, we replaced the vowel-counting (shallow) task, which ostensibly leads to truncated lexical processing, with the syllable-counting task, which allows the processing of entire lexical units. As predicted by the conceptual-processing hypothesis, LoP effects were still found on the estimates of automatic influences of memory derived from the PD procedure (Experiment 3). Thus, although words in both the shallow- and the deep-encoding tasks were encoded in their entirety, the additional processing-of-meaning that words underwent in the deep-encoding condition produced higher levels of automatic influences of memory.

Our results establish that adding conceptual information above and beyond the activation of the lexical unit enhances automatic influences. This contrasts with the finding of Richardson-Klavehn and Gardiner (1998), who found that once the entire lexical unit was accessed, priming did not benefit from additional processing-of-meaning.

The different results are easily explained by considering the different requirements that are made by the memory tests in the two studies. In Richardson-Klavehn and Gardiner's (1998) stem-completion study, a perceptual test was used, in which successful performance presumably depends on the recapitulation of perceptual processing (Roediger et al., 1989; Masson & MacLeod, 2002). Therefore, because materials presumably underwent similar perceptual processing under the pleasantness-rating (semantic) task and under the syllable-counting (phonemic) task, it should not be surprising that the magnitude of perceptual priming in these tasks was similar.

In the present study, in contrast, a conceptual test was used, one in which successful performance presumably depends on the recapitulation of conceptual processing that studied material undergoes during encoding (e.g., Roediger et al., 1989). Because materials undergo more conceptual processing under the pleasantness-rating task than under the syllable-counting task, it makes sense that the automatic influences were larger in the deep-encoding condition than in the shallow-encoding condition.

Furthermore, the absence of conceptual processing in the shallow condition did not enable a contribution of automatic influences (see estimates of these influences in the independent-guessing model and additive model shown in Table 3). Even in the syllable-counting task (Experiment 3, Table 5), when participants perceptually encoded the entire words (as demonstrated by Richardson-Klavehn & Gardiner, 1998), no evidence for an automatic contribution was found. This establishes that a minimal amount of encoding-for-meaning is required if conceptual priming is to be found. If this amount is not available (i.e., shallow encoding), priming cannot emerge.

The only other published report of the PD procedure applied to the association-generation task is that of Nelson et al. (1997). Although these authors found support for automatic influences of memory, they did not find evidence that the LoP manipulation affected either performance in the implicit test or the estimates of automatic influences as derived from the PD procedure. It is unclear what accounts for the different results. A comparison of association-generation studies that have shown an LoP effect (Vaidya et al., 1997, Experiment 3; Weldon & Coyote, 1996, Experiment 5; our study) or failed to show one (Nelson et al., 1997, Experiment 3; Vaidya et al., 1997, Experiment 2) suggests that certain variables, which seem to play a role in finding LoP effects in other studies (e.g., whether LoP was manipulated between blocks or in random order: Thapar & Greene, 1994; but see Mulligan et al., 1999; and the strength of cue-to-target associations: Vaidya et al., 1997) cannot account for the discrepant findings between our study and that of Nelson et al. For example, the strength of cue-to-target associations was very similar in our study and in Nelson et al.'s study, yet LoP affected performance only in our study. It also seems that the discrepant findings cannot be resolved by attributing them to different encoding tasks in the two studies because the encoding tasks of Experiments 1 and 2 are very similar to Nelson et al.'s encoding tasks.

We argue that our data are more reliable because the application of the PD procedure depends on obtaining intra-experimental baselines under both inclusion and exclusion conditions (e.g., Jacoby, 1998; Toth et al., 1994). Nelson et al. (1997), however, acquired baselines from extra-experimental participants. This does not allow for a comparison of the automatic estimates with an intra-experimental baseline measure, does not allow for a comparison of baseline performance in the inclusion and exclusion conditions to assess the validity of the independence assumption, and provides no means to correct for baseline differences. Moreover, the results of Nelson et al. describe an impossible-to-prove null effect and might be the result of insufficient statistical power.

Does the Conclusion That LoP Affects Automatic Influences of Memory Depend on the Validity of the Independence Assumption?

The estimation of automatic influences in our study depends on the independence assumption. Does the conclusion that LoP affects automatic influences also depend on this assumption? We suggest that even if participants in our study used a generate-recognize strategy instead of a direct-retrieval strategy,[3] the conclusion derived from our findings is still valid.

Several signatures for the use of a generate-recognize strategy have been proposed. These include reduced baseline performance in the exclusion condition as compared to the inclusion condition (e.g., Jacoby, 1998; Jacoby, Toth, & Yonelinas, 1993; Toth et al., 1994), as well as paradoxical results on the automatic estimates, such as reduced estimates of automatic influences following deep than shallow encoding or automatic estimates that are significantly below baseline (e.g., Bodner et al., 2000; Curran & Hintzman, 1995; Jacoby, 1998; Russo, Cullis, & Parkin, 1998; Toth et al., 1994).

In our study, none of the proposed signatures for a generate-recognize strategy were found. However, Bodner et al. (2000) demonstrated that the generate-recognize signature of lower exclusion baseline may be absent even when a "generate-recognize" strategy is used. Thus, the absence of a "traditional" signature for a generate-recognize strategy in our study cannot rule out the possibility that participants did, nevertheless, use such a strategy. Moreover, in Experiment 2, participants were biased in the inclusion condition to report studied words even when responding to a baseline cue, thereby reducing baseline inclusion performance. This bias may have concealed elevated inclusion baseline performance—the signature of a generate-recognize strategy—which may, conceivably, have emerged if the bias were eliminated.

Nevertheless, Bodner et al. (2000) have suggested that if a generate-recognize strategy is used by participants, in which target words come to mind automatically and are then submitted to a recognition check, then items that were encoded for meaning (e.g., deep-encoding condition) would be recognized most easily and would, therefore, most likely be withheld on exclusion trials. Such encoding conditions would lead to artificially low exclusion performance and to an underestimation of automatic influences (for similar ideas, see Curran & Hintzman, 1995; Jacoby, 1998; Russo et al., 1998). We argue, therefore, that even if a generate-recognize strategy had been used in our study, it would have resulted in an underestimation of the true automatic influences, particularly following deep encoding. According to this logic, the real LoP effects on automatic influences are, most probably, even larger than the reported results.

Bodner et al.'s (2000) proposal was supported by comparing stem-completion performance following a study condition in which participants read a word (the "read" condition) with performance following a study condition in which participants read a word and then generated an associate (the "associate" condition). Because the perceptual information was equated in the two conditions (i.e., participants in both conditions read the word), the associate condition should lead to estimates of automatic influences that were at least as large as those in the read condition. Yet, not only were the estimates of automatic influences in the associate condition lower than those found in the read condition, they were even lower than baseline (for similar results, see Curran & Hintzman, 1995; Jacoby, 1998; Richardson-Klavehn & Gardiner, 1998; also see Russo & Andrade, 1995; Russo et al., 1998).

Pursuing this logic, even if participants in our study did use a generate-recognize strategy, it could be argued following Bodner et al. (2000) that the PD equations would lead to a more pronounced underestimation of automatic influences in the deep-encoding condition than in the shallow-encoding condition. Therefore, the LoP effects reported in our study on the automatic influences might underestimate the true LoP effects. In sum, our study has established that automatic influences of memory on the conceptual association-generation task are dependent on the earlier encoding of items, with attention directed to the meaning of words during study increasing the likelihood that these words will later come to mind automatically.

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NOTES

1. We thank Michael Masson for suggesting this possibility to us.

2. In the exclusion condition of Experiment 2, participants were asked to write down for each cue word the first association that came to mind, but to replace associations they recollected as words that appeared in the study phase with another association. It could be argued that these instructions directed participants to use a generate-recognize strategy, thereby violating the independence assumption. Note, however, that lower performance in the inclusion relative to the exclusion baseline condition in Experiment 2 was in the opposite direction to that taken as a signature (e.g., Toth et al., 1994) for a generate-recognize strategy in the exclusion condition (but see Bodner et al., 2000).

3. The relation between controlled and automatic influences of memory may actually be one of exclusivity, in which items either can be consciously recollected or can come to mind automatically, but not both (for support of the exclusivity assumption, see Richardson-Klavehn et al., 1996). If so, performance in the exclusion condition would be the estimate of automatic influences (e.g., Reingold & Toth, 1996). This would lead to the difficult-to-embrace conclusion that, in our study, automatic influences following deep encoding were lower than those following shallow encoding.

APPENDIX A

Model Equations for the PD Procedure, Assuming Independence Between Controlled and Automatic Influences of Memory, by Correction Method

Correction Method	Model Equations
Hits − FA	$I = C + U - C * U + G^i$
(Conscious and guessing–exclusivity	$E = U - C * U + G^e$
Automatic and guessing–exclusivity)	$C = I - E - d$
	$U = (E - B^e)/(1 - C)$
Independent guessing	$I = C + U - U * C + (1 - C) * (1 - U) * G^i$
(Conscious and guessing–independence	$E = U - U * C + (1 - C) * (1 - U) * G^e$
Automatic and guessing–independence)	$C = [(I - r * E) + (r - 1)]/r$
	$U = [1/(1 - B^e)] * \{[E/(1 - C)] - B^e\}$
Additive	$I = C + (U + G^i) - C * (U + G^i)$
(Conscious and guessing–independence	$E = (U + G^e) - C * (U + G^e)$
Automatic and guessing–exclusivity)	$C = (I - E - d)/(1 - d)$
	$U = [E/(1 - C)] - B^e$

Note—I, proportion of "old" responses in inclusion; C, estimate of conscious influences; E, proportion of "old" responses in exclusion; U, estimate of unconscious influences; G^i, probability of guessing in inclusion; B^i, base rate from inclusion; G^e, probability of guessing in exclusion; B^e, base rate from exclusion; $r = (1 - B^i)/(1 - B^e)$; $d = B^i - B^e$. Adapted from Wainwright and Reingold (1996).

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