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Capturing conceptual implicit memory: The time it takes to produce an association

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Conceptual implicit memory is demonstrated when, in the absence of explicit retrieval, performance on a task requiring conceptual processing benefits more from prior conceptual encoding than from prior nonconceptual encoding. In the present study, we sought to provide an improved measure of conceptual implicit memory by minimizing contamination from explicit retrieval. On a modified word association test, participants free-associated to the actually studied items, with response time to produce any associate serving as the dependent measure. Experiment 1 varied whether words were read or generated at study and showed that generated words were associated to more quickly than were read words. Experiment 2 varied level of processing at study and showed that words processed semantically were associated to more quickly than were words processed nonsemantically. With modifications to ensure its implicit nature, a conceptual implicit test can be consistently affected by the same encoding manipulations as those that affect conceptual explicit memory tests.

Implicit memory is fascinating, in part, because it shows that we can profit from experience in numerous ways not evident when we consciously try to remember. Implicit memory is defined as a benefit in task performance based on previous experience, but without conscious recollection (Schacter, 1987); that benefit is generally referred to as *priming*. Implicit memory contrasts with explicit memory, for which conscious recollection is the defining attribute. The past quarter century has seen an explosion in research on implicit memory, although, in fact, studies of memory without awareness actually began with the very earliest memory research (Ebbinghaus, 1885/1913).

Categorizing certain measures of memory performance as implicit does not, of course, mean that such tests are, in fact, performed (entirely) implicitly or that they always behave in the same way in response to encoding manipulations. In particular, tests of implicit memory can be differentiated by whether they are affected primarily by perceptual manipulations (such as speaker's voice or type font) or by conceptual manipulations (such as taxonomic category membership) at encoding (see, e.g., Roediger, 1990). To date, the bulk of the research on implicit tests has focused on perceptual implicit tests, which typically show priming in a reliable, predictable way and which quite often dissociate from standard explicit tests. The focus of the present article, however, is on conceptual implicit memory, for which there is much less research and what there is suggests that the priming on these tests is less reliable and predictable.

A major reason for these differences may be that conceptual implicit tests are more vulnerable than are perceptual implicit tests to explicit memory processes that can contaminate the results. In fact, Butler and Berry (2001) have even argued that "there is virtually no evidence that priming on conceptual tasks reflects unintentional and unconscious memory" (p.195). They claimed that, using Schacter's (1987) criteria, a true test of conceptual implicit memory must be completed without participants intending to use explicit memory *and* without their being aware of what is being tested. Despite ample evidence that these criteria can be met with amnesic patients (e.g., Shimamura, 1986), Butler and Berry argued that most studies claiming to demonstrate conceptual implicit memory in normal participants are contaminated by either intentional or unintentional conscious retrieval of information from the prior encoding episode.

Intentional retrieval strategies are obviously a problem for nominally conceptual implicit memory tests because they render the tests clearly no longer implicit. Moreover, unintentional conscious retrieval can occur when a participant produces a response implicitly but then explicitly recognizes the item as having been presented earlier in the experiment. The participant may then become aware of the study–test relation and may even switch to an explicit retrieval strategy for the rest of the test. Even if the participant does not use explicit retrieval, according to Schacter's (1987) strict criteria, simple awareness of the study–test relation is sufficient to render the test no longer implicit.

Why is study–test awareness more problematic in conceptual than in perceptual implicit tests of memory? Perceptual priming requires very little information from the initial exposure to the item in question. That is, a word can be presented very briefly, so that it is recognized explicitly only at chance levels, while still producing significant

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perceptual priming (e.g., Seamon, McKenna, & Binder, 1998). Conceptual priming, on the other hand, relies on semantic analysis of the item during initial exposure: Conceptual priming cannot be shown for items that were not analyzed conceptually. However, as is well known from research on explicit memory, semantic analysis of an item increases its memorability (e.g., levels of processing [LOPs]; Craik & Lockhart, 1972; the generation effect, Slamecka & Graf, 1978). We are thus faced with the task of creating a test in which participants must produce memorable items without consciously remembering them! How can researchers accomplish this when studying normal participants? Butler and Berry (2001) cited only one study as having obtained what they deemed to be valid results on a conceptual implicit memory test, a study by Schmitter-Edgecombe (1999). For this reason, we will examine this study in considerable detail.

Schmitter-Edgecombe (1999) used the process dissociation procedure (PDP; Jacoby, 1991) and a category association task. Participants first studied words under either full or divided attention. They were then presented at test with category names (some corresponding to previously studied items) and were asked to produce one or more exemplars from the category. Conceptual implicit priming would be demonstrated if they produced more studied items than unstudied items in a given category. One group completed the category association test with indirect test instructions (i.e., no reference made to the study episode). Another group completed the test under inclusion/exclusion instructions. For the inclusion instructions, the word *old* was presented with the category name, and the task was to produce two exemplars that had appeared during study. For the exclusion instructions, the word *new* was presented with the category name, and the task was to produce two exemplars that had not appeared during study.

Using the PDP, Schmitter-Edgecombe (1999) calculated the influences of controlled and automatic retrieval processes on completion of the conceptual implicit test. She found that automatic processes did contribute significantly to performance. Most important, she found that, unlike perceptual priming, conceptual priming was reduced by dividing attention at study. This result indicates that conceptual implicit memory may have more in common with conceptual explicit memory than with perceptual implicit memory. Similar effects of divided attention at encoding on category exemplar generation have been found by other researchers as well (e.g., Light, Prull, & Kennison, 2000). Thus, conceptual implicit memory appears to be measurable in normal participants, but it is difficult to isolate from the influences of explicit retrieval (whether intentional or unintentional), and it is difficult to test without participants' awareness.

What clearly is needed is a good measure of conceptual implicit memory only, one that measures conceptual priming without contamination from explicit retrieval processes or study–test awareness. According to Butler and Berry (2001), awareness of what is being tested is a problem because it means that an implicit test of memory might not be implicit at all. That is, conscious processes that intrude make the possibility of explicit retrieval more likely. This is where we began: If there were nothing relevant to retrieve from the study episode, explicit retrieval would not be useful, and awareness would not be problematic.

A relatively pure measure of conceptual implicit memory would be one that measures differential activation of semantic memory (i.e., preexisting knowledge and semantic associations) without any contribution from episodic memory (i.e., explicit retrieval of an earlier study episode). That is, when a word is processed, it is activated above baseline, speeding access to that word in semantic memory. Precisely which aspects of a word are activated depends on how the word is processed. If a single word is read or a surface judgment is made about it (i.e., looking for the letter *e*), only the surface, physical characteristics of that word should be activated, with some activation possibly spreading to its orthographic neighbors (e.g., *cat* might cause activation to spread to *car*). However, if a word is processed semantically, its semantic characteristics should be activated above baseline, and some activation should spread to semantically associated neighbors (e.g., deciding whether *cat* is living may cause activation to spread to *dog*). If the word is presented visually, some activation should also spread to orthographic neighbors by virtue of the physical analysis necessary to complete the semantic analysis. If activation above baseline speeds access to that word in semantic memory, response time (RT) can be a useful dependent measure of conceptual priming, as it frequently is in measuring perceptual priming (e.g., MacDonald & MacLeod, 1998; MacLeod & Masson, 2000). Horton and colleagues (Horton, Wilson, & Evans, 2001; Horton, Wilson, Vonk, Kirby, & Nielsen, 2005) have recently used RT data to demonstrate that explicit retrieval was not used in their tests of conceptual implicit memory. Other researchers (e.g., Light et al., 2000; Zeelenberg, 2005) have also demonstrated that RT is a valuable measure of conceptual implicit memory.

Consider the standard word association test of conceptual implicit memory (e.g., Vaidya et al., 1997). The materials are associatively related stimulus–response pairs (e.g., *broom–closet*). Each study item is the response member (e.g., *closet*) of such a pair. At test, participants are presented with the stimulus member (e.g., *broom*) as a retrieval cue for the response member both for studied and for unstudied pairs. Conceptual priming is taken to occur when the test cues for studied items elicit more of the desired target responses than do the test cues for unstudied items. It is easy to see how study–test awareness can result in the intrusion of explicit retrieval. If participants realize that some of the responses are words that were studied earlier, they may intentionally think back to the earlier study episode to aid retrieval of the appropriate response item. This would, of course, mean that the test was no longer implicit.

A test of conceptual implicit memory in which awareness is not an issue would be one in which there is no relevant information in the study episode that can be retrieved at the time of test to assist that test performance. Even using RT as a dependent measure, the standard word association test is problematic in this respect because, although the participants' goal is to produce the first word that comes to mind, they often produce words that were presented in the earlier study episode, so there is the very real possibility of explicit retrieval.

The procedure that we introduce here involves two modifications to the standard word association test. The major modification is to present at test the studied word itself (i.e., not the unstudied stimulus member of an associated pair to elicit the studied response). In our task, participants can produce any associate that comes to mind. Unlike the traditional word association task, accuracy no longer serves as the dependent measure because there no longer is a "correct" response to a given stimulus. The measure of accessibility of a word's associates, therefore, is RT, constituting our second modification. If conceptual processing during study makes a word and its associates more accessible (e.g., Nelson & Goodmon, 2002), we predict that later producing an associate to that studied word will be faster than either producing an associate to a word that has been studied but not processed conceptually or producing an associate to a word that has not been studied at all.

A key advantage of using RT instead of accuracy as the dependent measure is that explicit retrieval strategies will be much less likely to be a problem (see Bentin, Moscovitch, & Nirhod, 1998; Gabrieli et al., 1999; Light et al., 2000). As in the perceptual implicit memory test of speeded word reading (e.g., MacDonald & MacLeod, 1998; MacLeod & Masson, 2000), participants will likely notice that they have previously seen some of the words for which they are being asked to produce associates. Because the task emphasizes speed, however, awareness of having seen a word earlier will be unlikely to facilitate the conceptual task of producing an associate; indeed, such awareness may actually interfere. Critically, retrieval of information from the study episode cannot be used to help performance on the test, because the study episode will contain the same information as the test episode. And because producing an associate to a word is a conceptual task, this task should show differences between conceptually processed and perceptually processed words, both of which can readily be recognized as having been presented before. Thus, recognition that a test item was a previously studied item should not interfere with the observation of conceptual-priming effects. When episodic memory is not useful in performing a task, the differential activation of words in semantic memory should be sufficient to produce priming on a conceptual implicit test.

In the present study, the participants were first presented with a list of words, half of which were processed conceptually and half of which were processed perceptually. For generalization, this differential processing was accomplished using a generate/read manipulation in Experiment 1 and an LOP manipulation in Experiment 2. After study, the participants completed a modified word association task in which they were presented with half of the words previously studied conceptually and half of the words previously studied perceptually, together with unstudied words, and were asked to produce the first word that they thought of when they read each test word.

All the items were presented visually at study and at test, so perceptual priming due to repetition of the studied words on the test would certainly be a component of any RT benefits observed on the word association task. To remove this perceptual priming and, thereby, to calculate a more conservative measure of conceptual priming, the participants also completed a speeded-reading test in which they were presented with a nonoverlapping subset of previously studied words (half conceptually processed and half perceptually processed at study), again along with unstudied words. Any benefit in RT due to perceptual priming could be determined from this speeded-reading test and then subtracted from the RT benefit on the word association test, resulting in a measure of conceptual priming that should be relatively uncontaminated by perceptual priming.

If our predictions are confirmed, this modified word association test will provide an empirical test of an assumption underlying the traditional word association test: that conceptual processing of a word leads to greater availability of it and its associates than does perceptual processing of that word. The predicted RT benefits for producing associates to conceptually processed words will show that differential activation of words in semantic memory can be measured when episodic memory is not useful for task performance. Furthermore, this new association test will be a useful tool for measuring conceptual priming relatively free of contamination from explicit retrieval strategies.

EXPERIMENT 1

The goal of Experiment 1 was to determine whether activation of words in semantic memory, using a conceptual processing task, results in faster subsequent access to those words and their semantic associates. To test this, we examined whether producing associates would be faster for words generated at study than for words read at study. This manipulation has shown that words generated from a meaningful cue (e.g., "the tiny infant commonly put in a cradle–b?" to cue the word *baby*) are explicitly remembered much better than words that are merely read, a finding known as the *generation effect* (Slamecka & Graf, 1978). It has also been argued that tests that show a generation effect are tests that are primarily conceptual in nature (Mulligan, 2002). Consequently, a good test of conceptual implicit memory would be expected to show a greater benefit for generated words than for read words.

Assuming that generating a word activates that word's associates at the time of study more than does reading that same word, generated words should be associated to more quickly than read or new words. Despite not having been physically seen before, generated words still often show priming on perceptual implicit memory tests. Indeed, generated and read words usually show equivalent priming (e.g., Masson & MacLeod, 1992, 2002), so this pattern was anticipated on the speeded-reading test. As a manipulation check, the participants were also asked to recall as many of the generated/read words as they could after the other experimental phases had been completed.

To be consistent with the standard generation effect, the participants should recall more generated than read words, although overall recall was expected not to be high for this surprise free recall test.

Method

Participants. Thirty undergraduate students from the University of Waterloo were paid for participating. All reported normal or corrected-to-normal vision and comfort with the English language.

Materials and Apparatus. The 120 words and their generation cues were 114 items from those used in Masson and MacLeod (1992, Experiment 1) plus 6 similarly constructed items. The experiment was conducted on a Pentium IV computer with a 17-in. CRT monitor. Vocal RTs were collected with a microphone connected to a voice key relay. All the stimuli and instructions were presented in 12-point white font on a black background.

Procedure. The participants were told that they were taking part in an experiment on word reading and associating. In the study phase of the experiment, they were presented with 80 items, 40 consisting of a short definition (e.g., "the piece of furniture used for sitting–c?") and 40 consisting of a single word (e.g., "chair"). They were asked to read the generation cue silently and generate the desired response or to read the single word aloud. Assignment of items to conditions and presentation order was randomized for each participant. Each study trial began with a 500-msec blank screen. The item then appeared in the center of the screen and remained visible until an oral response—a generated word or a read word—was detected by the voice key. The word "Ready?" then appeared in the center of the screen while the experimenter coded whether the response was generated or read correctly. There followed a 250-msec blank screen prior to the next item.

In the test phase, the participants completed a speeded-reading test and a word association test, each consisting of 60 trials. Test order was counterbalanced across participants. For the speeded-reading test, 20 generated words, 20 read words, and 20 new words were presented in random order. Although not explicitly told that they were being timed, the participants were instructed to read each presented word aloud as quickly and accurately as possible. Each word was presented in the center of the screen and remained visible until the participants' response was detected. The word "Ready?" then appeared at the center of the screen. After the experimenter coded the trial as either good or spoiled (microphone misfire, incorrect pronunciation, etc.), a 250-msec blank screen followed; then the next test word appeared.

For the association test trials, the participants were instructed to read each presented word silently and then to say aloud the first word that came to mind. They were told not to worry about whether a response made sense or had been previously used, but simply to say the first word that came to mind as quickly as possible. Again, they were not explicitly told that they were being timed. The remaining 20 generated words, 20 read words, and 20 new words were presented in random order at the center of the screen, remaining visible until a response was detected. The word "Ready?" then appeared in the center of the screen while the experimenter coded the trial as good or spoiled (microphone misfire, reading the presented word instead of associating, etc.). A 250-msec blank then preceded the next trial. The participants' responses were tape recorded for later data coding.

As a manipulation check, following the two tests, the participants were given unlimited time to recall as many words as they could from the study phase of the experiment. They were instructed to write down every word that they remembered, regardless of how certain they were that the word had occurred in the first phase.

Results

Spoiled trials, 6.5% of the association trials and 1.5% of the read trials, were removed and not included in the data analysis. All good RTs were submitted to a recursive trimming procedure that removed outliers on the basis of a criterion cutoff set independently for each participant in each condition by reference to the sample size and the standard deviation in that condition (see Van Selst & Jolicœur, 1994). This removed 1.5% of the trials for the speeded-reading test and 3.2% of the trials for the word association test.

Speeded reading. The mean RT data are displayed in the top row of Table 1. A one-way repeated measures ANOVA revealed a significant main effect of encoding condition on RT in the reading test [$F(2,58) = 3.15$, $MS_e = 204$, $p = .05$]. Paired comparisons confirmed the obvious: that generated words and read words did not differ from each other ($p > .10$) but that both were read more quickly than new words ($p < .05$ for read words and $p = .06$ for generated words). Equivalent priming on this perceptual implicit test for read and generated words is the standard finding (MacLeod & Masson, 2000), providing a useful benchmark. This also has the nice feature that the correction for perceptual priming is the same for both the read and the generate conditions.

Word association. The mean RT data appear in the second row of Table 1. A one-way repeated measures ANOVA revealed a significant main effect of encoding condition on time to produce an associate [$F(2,58) = 8.21$, $MS_e = 12346$, $p < .01$]. Planned comparisons revealed that generated words were associated to significantly more quickly than were either read words or new words (both ps $< .01$), which did not differ from each other ($p > .10$). This result suggests that only the generated words showed conceptual priming.

To provide additional confidence in this conclusion, we took one further step. The cues for the generated items at study (e.g., "the piece of furniture used for sitting–c?") often contained one or more words (such as *furniture*) that were associated to the test word (*chair*). We therefore coded the participants' responses as to whether they were or were not words contained in the item's generation cue. Responses from 4 participants were not recorded due to equipment malfunction. For the remaining 26 participants, the proportions of responses that had appeared in the generation cue were .50 in the generate condition, .31 in the read condition, and .35 in the new condition (the standard error was .02 for each of these). A repeated measure ANOVA showed that the main effect of encoding condition was significant [$F(2,50) = 20.34$, $MS_e = 0.012$, $p < .01$]. Paired

Table 1
Experiment 1: Mean Response Times (in Milliseconds, With Standard Errors) for Each Encoding Condition on Each Test

	Encoding Condition					
	Generate		Read		New	
Test	*M*	*SE*	*M*	*SE*	*M*	*SE*
Read	494	9	494	9	502	10
Association	1,315	41	1,416	40	1,416	48
Association − read	821		922		914	

comparisons confirmed that the participants were more likely to produce a response from the generation cue when a word had been generated than when it had been read or not studied at all (both ps $< .01$), which did not differ from each other ($p > .05$). This is simply the generation effect in another guise.

We then sorted the association RTs on the basis of whether the association produced was or was not a word that had appeared in the generation cue. These data are presented in Table 2. Although only the participants in the generate condition actually had seen the generation cue, it could be that words from the generation cues were somehow special; in particular, they may have been words more strongly associated to the target word, which is why they were selected for use in the cue phrase. The resulting analysis was a 3 (encoding condition: generate, read, or new) × 2 (response type: in generate cue or not in generate cue) repeated measures ANOVA. The main effect of encoding condition was significant [$F(2,50) = 4.67$, $MS_e = 27{,}018$, $p < .05$], as was the main effect of response type [$F(1,25) = 18.01$, $MS_e = 28{,}691$, $p < .01$]. The interaction of encoding condition with response type was not significant ($F < 1$), showing that the pattern for responses from the cues was not different from that for responses not from the cues.

Conceptual priming. We next calculated a conservative measure of conceptual priming in word association, the goal being to remove the perceptual-priming element from the RT, given that reading (in this case, rereading) a word is a necessary component of the word association task. Mean reading time was subtracted from mean association time for each encoding condition; these values appear in the bottom row of Table 1. Subtracting the generate condition difference from the new condition difference resulted in a value of 93 msec ($SE = 33$), significantly different from zero [$t(29) = 2.80$, $p < .01$]. The 8-msec ($SE = 30$) difference between the read and the new conditions, however, was in the wrong direction and nonsignificant [$t(29) = 0.25$, $p = .80$]. By this more conservative measure, then, conceptual priming was certainly evident, and only for the generate condition.

Free recall. The participants' responses on the free recall test were counted as correct only if they had been presented in the study phase. The participants recalled a significantly larger proportion of generated items ($M = .25$, $SD = .09$) than of read items ($M = .06$, $SD = .05$) [$t(29) = 11.85$, $p < .001$], the typical generation effect.

Discussion

In Experiment 1, the generate/read manipulation was used to ascertain whether generated words would be associated to more quickly than read words on a subsequent conceptual implicit test. As the data in Table 1 clearly show, this was, in fact, the outcome. Indeed, only the generated words showed conceptual priming; associating to the read words was no faster than associating to new, unstudied words. A conservative measure of conceptual priming that removed any perceptual priming of the test cue word was also significant. Thus, only conceptual processing at study benefited performance on a later conceptual implicit test, a test developed to minimize any contribution from explicit remembering.

It seems unlikely that the participants were explicitly retrieving information from the study episode when producing associates. Responses to generated items were reliably faster than responses to read items, which did not have any associates present in the study episode to potentially retrieve. The work of Horton et al. (2001; Horton et al., 2005) strongly suggests that retrieving specific information from an earlier incidental study episode should be slower than simply producing the first associate that comes to mind.

Also noteworthy is the fact that the generated items produced as much priming as did the read items on the speeded-reading test, a measure of perceptual implicit memory. The effect of generation on perceptual implicit memory tests is inconsistent in the literature, sometimes resulting in less priming than that for read words (e.g., Jacoby, 1983) but usually resulting in priming equivalent to that of read words (e.g., Masson & MacLeod, 1992, 2002). This inconsistency appears to be related to the generation task used (e.g., from an antonym vs. from a definition). Perceptual priming of generated items can be explained by the orthographic-recoding hypothesis (Masson & MacLeod, 2002): Participants may simply visualize a printed word when they generate it from a cue, and this is sufficient to cause perceptual priming on a test such as the speeded-reading test used here.

Overall, then, Experiment 1 showed that a conceptual manipulation at encoding (generation) can affect priming on a test of conceptual implicit memory. The generation effect observed on the explicit memory test indicates that generating a word at study resulted in more conceptual processing than did simply reading a word; free recall is generally considered to be a test of conceptual explicit

Table 2
Experiment 1: Mean Response Times (in Milliseconds, With Standard Errors) on the Association Test for Each Encoding Condition

	Encoding Condition					
	Generate		Read		New	
Response Status	*M*	*SE*	*M*	*SE*	*M*	*SE*
Response in generation cue	1,259	42	1,379	68	1,359	63
Response not in generation cue	1,407	72	1,452	40	1,483	56

Note—RTs are divided on the basis of whether the response was or was not present in the generation cue.

memory (Roediger, 1990). Explicit retrieval was not likely to have contaminated the word association test, however, because the test was modified to prevent exactly that possibility. Moreover, explicit retrieval would be expected to slow responses to generated words (where relevant information is available in the study episode), relative to read words (where no relevant information is available in the study episode), which we did not observe. Generated words were associated to more quickly than were read or new words, supporting the idea that the test was truly implicit.

The participants were more likely to produce a response contained in the generation cue when they had actually seen that cue (i.e., in the generate condition). Could this indicate that the participants were explicitly retrieving the generation cue from the study episode when responding on the word association test? Interestingly, RTs were shorter for responses from the generation cue in all the conditions, reliably so in the generate and new conditions. It therefore seems unlikely that explicit retrieval underlies the greater proportion of responses from the generation cue in the generate condition. More likely, the response words themselves are special because they are produced more quickly even when the generation cue has not been seen.

The absence of an encoding condition × response type interaction demonstrates that the selective priming in the generation condition was evident for both subsets of responses—those from the generation cue and those not from the generation cue. Thus, the advantage for the generation condition was not restricted to responses that could be recovered, whether implicitly or explicitly, from the cue. We take this as evidence that the associates produced at test were produced implicitly and that our pattern of results did not arise from the intrusion of conscious recollection.

Perhaps the particular associates presented in the generation cue were strengthened preferentially by their exposure at the time of study when the target word was produced. This could have increased the accessibility of those associates more than did semantic-processing alone. If this is true, then exactly what is it about generating a word that results in better memory, whether implicit or explicit? Is it that the word has to be retrieved from memory (i.e., generated)—the prevalent interpretation—or is it that one or more of the word's associates were presented at study? Having the cue present in the read condition as well might help to clarify this question, as might constructing generation cues that do not contain high associates, assuming that is possible.

In sum, generating words at study appears to activate those words and their semantic associates in semantic memory in such a way that later accessing of those words is faster than accessing of read words. That the generation effect was also observed on the word association test supports the claim that the test was truly conceptual. Experiment 1 therefore provides evidence that conceptual implicit memory tests can be affected by one of the same conceptual-encoding manipulations as those that affect explicit memory tests. Conceptual implicit memory can, indeed, be measured in normal participants without interference from explicit memory processes.

EXPERIMENT 2

Experiment 2 was designed to conceptually replicate the findings of Experiment 1, generalizing the effect to a different encoding manipulation known to affect conceptual explicit memory. An LOP manipulation (Craik & Lockhart, 1972) was used to determine whether conceptually processed words would be associated to more quickly than would perceptually processed words. In the traditional word association test, the aim is to prime a particular response so that it becomes more likely to be elicited by an associated test word. In the present experiment, the studied word was re-presented, and the time to produce an associate to it was recorded. In this way, the actual response given was of little importance. This experiment therefore examined whether, like generation, depth of processing affects the spread of activation from a word to its associates and the subsequent retrieval of one of these associates, given the previously studied word as a cue. Replication of the pattern of findings in Experiment 1 would confirm that differential activation of words in semantic memory later results in differential access to those words and their associates—that is, conceptual implicit memory in the absence of contamination from explicit memory processes.

The LOP manipulation in Experiment 2 has one key advantage over the generate/read manipulation used in Experiment 1: There is almost no difference between conditions in the amount or type of information presented in the study episode. In Experiment 1, each word in the generate condition was produced from a unique definition that included strong associates to the target word, whereas each word in the read condition was simply presented in isolation to be read. Clearly, the amount and type of information present in the study episode was different between the two conditions. Because words from the generation cue did tend to be used as responses on the implicit association task, we wanted to eliminate this avenue of responding. In Experiment 2, therefore, study words were presented along with one of two questions intended to encourage either semantic or nonsemantic processing. Thus, the only difference between the two encoding conditions was the exact phrasing of the repeated question ("Is it living?" [semantic] or "Is there an 'e'?" [nonsemantic]) and the type of processing required (semantic or nonsemantic) to answer the question. There no longer was more associative information in the study stimulus for the conceptual condition.

Assuming that semantic processing of a word activates its associates at the time of study more than does nonsemantic processing, semantically processed words should be associated to more quickly than nonsemantically processed words or new words on a conceptual implicit test. Therefore, as in Experiment 1, we should see the effects of differential activation of semantic memory as shorter association times for semantically processed words than for nonsemantically processed words. This would confirm that conceptual implicit memory can be measured in normal participants without the influence of explicit retrieval. As would be expected on a test of perceptual implicit memory, previously seen words (both semantic and nonsemantic) should be read more quickly than new words on the speeded-reading test.

Method

Participants. Forty-two undergraduate students from the University of Waterloo, none of whom had participated in Experiment 1, took part. All reported normal or corrected-to-normal vision and comfort with the English language. They received pay or credit for their introductory psychology course. An additional 13 participants took part in a manipulation check version of the experiment in which they completed a free recall test immediately following the study phase.

Materials and Apparatus. The equipment setup was identical to that in Experiment 1. The 128 words were selected from various categories in the Battig and Montague (1969) norms so that 25% would be responded to positively in both the semantic and the nonsemantic conditions, 25% would be responded to positively in the semantic condition but negatively in the nonsemantic condition, 25% would be responded to negatively in the semantic condition but positively in the nonsemantic condition, and 25% would be responded to negatively in both the semantic and the nonsemantic conditions. The semantic processing question was "Is it living?"; the nonsemantic processing question was "Is there an 'e'?"

Words were randomly assigned into conditions for each participant. Sixty-four words were assigned to the study list, with 32 words each assigned to the semantic and nonsemantic conditions. Sixteen each of the semantic and nonsemantic words were then presented on the speeded-reading test, along with 32 new words. Each of the remaining 16 semantic and nonsemantic words was presented on the association test, along with 32 new words.

Procedure. The participants were told that the experiment concerned word reading and associating. In the first phase, the participants were presented with 64 words, half paired with the semantic question and half with the nonsemantic question. Assignment of words to conditions and order of presentation were randomized for each participant. Each trial began with the processing question's appearing centered at the top of the screen for 2 sec. The word then appeared in the center of the screen for 2 sec with the question remaining visible. The participants responded aloud by saying either "yes" or "no" into the microphone. There was then a 250-msec blank screen prior to the next study word.

In the second phase, the participants completed four blocks of test trials, alternating between blocks of 32 speeded-reading trials and blocks of 32 association trials, for a total of 128 trials. Block order was counterbalanced across participants. In the speeded-reading blocks, the participants were to read each presented word as quickly and accurately as possible. In the association blocks, they were to read the presented word silently and then to say the first word that came to mind. They were told not to worry about whether their responses made sense or whether they had previously used a response.

For both types of trials, following a 250-msec blank screen, the test word was shown at the center of the screen and remained visible until the participants responded aloud. The word "Ready?" then appeared in the center of the screen while the experimenter coded the trial as either good or spoiled (microphone misfire, incorrect pronunciation, etc.). The 16 old words (8 semantic and 8 nonsemantic) and 16 new words were presented in random order. The participants' responses were tape-recorded for later data coding.

Results

Spoiled trials, which accounted for 7.9% of the association trials and 4.1% of the read trials, were removed prior to data analysis. All RTs were submitted to a recursive trimming procedure that removed outliers on the basis of a criterion cutoff set independently for each participant in each condition by reference to the sample size and the standard deviation in that condition (see Van Selst & Jolicœur, 1994). This removed 2.2% of the trials for the speeded-reading test and 2.7% of the trials for the word association test.

Speeded reading. The RT data were analyzed in a 2 (block: 1 or 2) × 3 (LOP: semantic, nonsemantic, or new) repeated measures ANOVA. There was a significant main effect of block [$F(1,41) = 4.83$, $MS_e = 3{,}202$, $p < .05$], with responses faster in Block 2 ($M = 564$ msec) than in Block 1 ($M = 580$ msec), presumably an effect of practice. Block did not interact with LOP [$F(2,82) = 0.40$, $MS_e = 692$, $p > .10$], so the data were collapsed over block. The resulting means are displayed in the top row of Table 3. Critically, the main effect of LOP on RT was significant [$F(2,82) = 6.45$, $MS_e = 396$, $p < .05$]. Paired comparisons revealed that whereas semantically and nonsemantically processed words did not differ from each other ($p > .10$), both were read more quickly than were new words (both ps $< .01$). Thus, perceptual priming was equivalent for all the studied words, regardless of LOP.

Word association. These RT data were also analyzed in a 2 (block: 1 or 2) × 3 (LOP: semantic, nonsemantic, or new) repeated measures ANOVA. There was no significant main effect of block [$F(1,41) = 2.19$, $MS_e = 76{,}127$, $p > .10$], nor did block interact with LOP [$F(2,82) = 2.08$, $MS_e = 32{,}969$, $p > .10$], so the data were again collapsed across blocks. The resulting means are shown in the second row of Table 3. Critically, there was a significant main effect of LOP on RT [$F(2,82) = 3.69$, $MS_e = 20{,}861$, $p < .05$]. Paired comparisons revealed that semantically processed words were associated to significantly more quickly than were both nonsemantically processed words and new

Table 3
Experiment 2: Mean Response Times (in Milliseconds, With Standard Errors) for Each Encoding Condition on Each Test

	Encoding Condition					
	Semantic ("Is it living?")		Nonsemantic ("Is there an 'e'?")		New	
Test	*M*	*SE*	*M*	*SE*	*M*	*SE*
Read	570	11	566	11	581	13
Association	1,348	44	1,426	54	1,416	42
Association − read	778		860		835	

words (both *p*s $< .05$), which did not differ from each other in association times ($p > .10$). This pattern contrasted with the reading speed measure of perceptual implicit memory, where all the studied words were primed regardless of type of encoding: In the conceptual implicit memory test, only the semantically processed words were primed.

The recorded responses given by the participants were coded as to whether they were categorical (e.g., the response *flower* to the stimulus *rose*), associative (e.g., the response *love* to the stimulus *rose*), descriptive (including properties of the stimulus; e.g., the response *red* or *thorn* to the stimulus *rose*), or other (i.e., not clearly in one of the first three groups; e.g., the response *aunt* to the stimulus *rose*). Two experimenters coded the responses, with interrater agreement of .94. Disagreements were resolved by a third experimenter. As is evident from Table 4, there were no differences as a function of LOP in terms of the types of responses given, indicating that LOP affected only the time to associate to a word, and not the type of associate produced.

Conceptual priming. A conservative measure of conceptual priming in word association would remove perceptual priming from the associative response time, given that rereading a word is a component of the word association task. Mean reading time was therefore subtracted from mean association time for each LOP condition. These values are shown in the bottom row of Table 3. Subtracting the semantic condition difference from the new condition difference resulted in a value of 57 msec, significantly different from zero [$t(41) = 2.08$, $p < .05$]. Subtracting the nonsemantic condition difference from the new condition difference resulted in a value of −25 msec, in the wrong direction and not significantly different from zero [$t(41) = -0.83$, $p = .40$]. By this more conservative measure, then, conceptual priming was again evident, and again only for the items that had been processed conceptually at study.

Free recall. Counting only correct responses, the participants recalled significantly more semantically processed items ($M = .33$, $SD = .09$) than nonsemantically processed items ($M = .14$, $SD = .05$) [$t(12) = 6.97$, $p < .001$]. This indicates that the LOP manipulation used in the present experiment produced the expected effect on the explicit memory test.

Discussion

The results of Experiment 2 entirely paralleled those of Experiment 1. Semantically processed words were associated to more quickly than were nonsemantically processed words or new words. Most important, semantically and nonsemantically processed words behaved differently on the association test than they did on the speeded-reading test. Speeded reading, a measure of perceptual implicit memory, showed an RT benefit (relative to new words) for both semantically and nonsemantically processed words. That is, it mattered only that the words had been seen earlier in the experiment, not how they had been processed. In sharp contrast, on the word association test, nonsemantically processed words did not show any RT benefit, relative to new words: Only semantically processed words showed priming on the word association test. This difference confirms that the RT benefit seen for the semantically processed words on the word association test is, indeed, the result of conceptual priming. Moreover, conceptual priming benefits only the time it takes to produce an associate to a word; it does not affect the type of associate produced (see Table 4).

Experiment 2 clearly confirmed that a conceptual manipulation at encoding can affect priming on a test of conceptual implicit memory. Because of the nature of the responses required (i.e., speeded oral responses), there was little opportunity for explicit retrieval to contaminate the test. More critically, explicitly retrieving information from the study episode would not have been useful in this modified word association task. All that was potentially available for retrieval was information about whether the word was a living thing (semantically processed words) or whether it contained the letter *e* (nonsemantically processed words), and neither piece of information was useful for producing an associate to a word. Indeed, the responses *living* or *nonliving* were never produced in response to a semantically processed word. Moreover, one might expect association responses to be *slower*, relative to unstudied words, if explicit retrieval were used in responding (see Horton et al., 2001; Horton et al., 2005). In fact, semantically processed words were associated to *more quickly* than were unstudied or nonsemantically processed words, indicating that the test was truly implicit. This was true even when perceptual priming was taken into account, indicating that the modified test is truly conceptual. Again, we conclude that a conceptual-encoding manipulation can affect priming on a conceptual implicit memory test.

Table 4
Experiment 2: Proportions of Types of Association Responses Produced in Each Encoding Condition

	Encoding Condition		
Type of Response	Semantic (“Is it living?”)	Nonsemantic (“Is there an ‘e’?”)	New
Categorical	.28	.26	.25
Associative	.57	.57	.59
Descriptive	.14	.15	.15
Other	.01	.01	.01

GENERAL DISCUSSION

In the present study, we investigated a new way to measure conceptual implicit memory in which awareness of what is being tested is not a problem and in which explicit retrieval of information from the study episode is not useful and is unlikely to occur. These enhancements optimize the implicit nature of this new test. Both experiments showed that encoding manipulations that produce robust effects on an explicit test of memory also affect an implicit test of memory that requires conceptual processing. In Experiment 1, we used a generate/read (Slamecka & Graf, 1978) manipulation to show that generating a word leads to enhanced accessibility of that word’s associates, relative to either reading a word or not studying a word at all. In Experiment 2, we used an LOP (Craik & Lockhart, 1972) manipulation to show that semantic processing of a word leads to enhanced accessibility of that word's associates, relative to either nonsemantic processing or not studying the word at all.

These results are consistent with a transfer-appropriate-processing (e.g., Roediger, 1990) account of implicit memory. That is, the amount of priming observed on a given test is related to the overlap between the processes carried out at study and those carried out at test. In both experiments, processing a word on a conceptual level resulted in facilitation on a conceptual task and on a perceptual task. Perceptual processing of an item resulted in facilitation only on a perceptual task. This fits well with the transfer-appropriate-processing account: Perceptual analysis facilitated performance on a perceptual test, whereas conceptual analysis facilitated performance on a conceptual test. Because all the words were presented visually at both study and test, perceptual analysis of a studied word was necessary to perform the conceptual analysis of that word; consequently, this perceptual analysis led to facilitation on the perceptual test, as well as on the conceptual test.

In the present study, we used a modified form of the word association task intended to solve the problems of awareness and explicit retrieval. This modified test also removes potential contributions of individual differences in preexisting associations among words. Nelson, McEvoy, and Dennis (2000) pointed out that, "for a given individual, [association] strength can vary from moment to moment, and, for different participants, the same response can be represented at different strengths depending on their experience" (p. 896). Given this intuitive comment on how words are associated to one another, it seems that using norms to select stimulus–response pairs to somehow be equivalent for all participants is unlikely to be successful, which could play a part in the inconsistency of the effects seen on word association tests in the literature. By not relying on specific associative pairs, the present modified test circumvents this problem.

This modified word association test is promising as a tool for measuring conceptual implicit memory without the twin concerns of study–test awareness and explicit retrieval. Our findings confirm the reality of conceptual implicit memory as an aspect of memory that can be measured in normal participants. Our findings also clearly establish that a conceptual implicit memory test can show effects of conceptual-encoding manipulations without explicit contamination. Claims that all demonstrations of conceptual implicit memory are flawed because of the intrusion of conscious recollection are undermined by our new task and its associated findings. The nature of the response used in an implicit memory test is important: Speeded responding provides less opportunity for the troublesome invasion of explicit retrieval strategies to occur. Explicit retrieval should slow responding on an implicit task and should, therefore, be unlikely as a strategy—or, at least, apparent in lengthened response latencies. Conceptual processing of a word selectively speeds later responding to that word on a conceptual task, much as perceptual processing of a word selectively speeds later responding to that word on a perceptual task.

Complaints about the validity of most conceptual implicit memory tests (Butler & Berry, 2001) suggest that contamination from explicit retrieval processes is the most troublesome issue with regard to measuring conceptual implicit memory in normal participants. We suggest that a pure test of conceptual implicit memory therefore measures differential activation of concepts in semantic memory, with no opportunity for episodic memory to contribute to test performance. Our study indicates that encoding manipulations known to affect conceptual explicit memory do produce differential activation in semantic memory. This differential activation is observable as facilitation of later access to conceptually processed words, as compared with perceptually processed words. Priming in conceptual implicit memory relies both on recent experimental manipulations (such as differential encoding tasks) and on preexisting associations. Both of these contributors must be considered to successfully capture conceptual implicit memory.

AUTHOR NOTE

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