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Lexical Decision as an Indirect Test of Memory: Repetition Priming and List-Wide Priming as a Function of Type of Encoding

Marilyn C. Smith and Colin M. MacLeod
University of Toronto, Scarborough Campus, Scarborough, Ontario, Canada

John D. Bain
University of Queensland, Queensland, Australia

Richard B. Hoppe
Kenyon College

Two experiments examined priming in the lexical decision task, an indirect test of memory. Experiment 1 manipulated type of processing during study of unrelated word pairs. Recognition of individual words benefited more from semantic than from nonsemantic processing. Repetition priming in lexical decision depended on the context in which the target appeared. Targets preceded at test by unstudied primes showed greater repetition priming if processed nonsemantically during study; targets preceded at test by studied primes were not affected by type of processing at study. Interestingly, studied targets were facilitated more by studied than by unstudied primes regardless of whether the prime came from the same pair as the target. This list-wide episodic priming occurred under all four processing conditions in Experiment 1 (consonant counting, rote rehearsal, pleasantness rating, and sentence generation) with a 250-ms stimulus onset asynchrony. Experiment 2 showed that this list-wide episodic priming disappeared by 1,000 ms, suggesting that it had resulted from relatively transient activation.

An individual may not consciously recollect having encountered a particular event before, yet may nevertheless behave in ways that clearly indicate prior experience with that event. In recent years, such situations have provoked increasing interest in measures of memory that do not require conscious awareness of the previous occurrence of an event. In contrast to the traditional *direct* measures of memory that do necessitate awareness (e.g., free recall, cued recall, and recognition), *indirect* tests do not require the subject to consciously remember the specific learning episode. Memory inferred via indirect assessment has been called by various other terms: *unconscious memory* (Freud & Breuer, 1895/1966), *unaware memory* or *memory without awareness* (Eriksen, 1960; Jacoby & Witherspoon, 1982), and *implicit memory* (Graf & Schacter, 1985), among others. In this article, we will use the term *indirect* to refer to such tests, consistent with recent reviewers of the literature (cf. Johnson & Hasher, 1987; Richardson-Klavehn & Bjork, 1988).

Although a number of different indirect memory tests have been examined, the predominant methodological tool has been some variant of *repetition priming*. In this procedure, a stimulus is presented twice, once during a study phase and again during a test phase. Subjects are not explicitly tested on whether the stimulus had been studied, but instead are asked to respond to some aspect of the stimulus (e.g., by naming it). If test performance is better for stimuli that had been studied than it is for new, unstudied stimuli, some form of memorial representation of the studied stimuli is assumed. This advantage of studied over unstudied items is repetition priming.

Three different tasks typically have been used to examine repetition priming effects (cf. Schacter, 1987): lexical decision, in which subjects are asked to decide whether a particular letter string is a real word, and response latency is measured; word identification, in which words are presented tachistoscopically very briefly, and some measure of threshold is taken; and word stem or word fragment completion, in which subjects are asked to complete words that have some letters missing, with the dependent variable being percentage of fragments correctly completed. Performance on each of these tasks is generally superior for target items that have been encountered during prior study than it is for new items.

In several instances, a dissociation has been found when memory is tested directly versus indirectly. More specifically, factors that may be important determinants of behavior when memory is tested directly may have little (if any) impact when memory is tested indirectly, or vice versa. Such findings have led some theorists to postulate the existence of two functionally separate memory systems (Johnson, 1983; Squire & Cohen, 1984; Warrington & Weiskrantz, 1982). Alternatively, others have suggested that different types of processing underlie performance on the two types of tests. For example,

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Correspondence concerning this article should be addressed to Marilyn C. Smith or Colin M. MacLeod, Division of Life Sciences, University of Toronto, Scarborough Campus, Scarborough, Ontario, Canada M1C 1A4.

Jacoby (1983) and Roediger and his colleagues (Roediger & Blaxton, 1987; Roediger, Weldon, & Challis, 1989) have suggested that direct memory tests rely primarily on conceptually driven memory processes, whereas most commonly used indirect memory tests rely primarily on data-driven processes. Conceptually driven processes are considered to be subject-initiated, such as organization and elaboration, whereas data-driven processes are largely stimulus determined, such as modality of presentation.

Because direct and indirect tests often behave differently, it is of considerable interest to explore systematically those variables that differentially affect the two types of tests. One such variable appears to be the extent of elaboration carried out during initial study of the stimulus. As Richardson-Klavehn and Bjork (1988) carefully document, when memory is tested directly via recall or recognition, performance is better for stimuli encoded semantically than for those encoded orthographically or phonetically. In contrast, elaboration has little effect when memory is tested indirectly by assessing magnitude of repetition priming.

An early exploration of the effect of initial type of processing on later word identification was that of Winnick and Daniel (1970). During Phase 1 of their study, subjects performed one of three tasks designed to manipulate the form of encoding: They read a visually presented word, they generated the word from a picture of its referent, or they generated the word from its definition. Tachistoscopic word identification was examined during Phase 2. Threshold for identification was significantly reduced only after reading of the word; performance showed little benefit from either of the two generation conditions. This result is in sharp contrast to performance on the direct memory test of free recall, in which recollection in the generate conditions was superior to that found in the reading condition.

Jacoby (1983) reported very similar results: Generated words (e.g., HOT–???, with the rule being to generate an antonym) were recognized better than were read words (HOT–COLD), but word identification was better for COLD if it had been read than if it had been generated. In the absence of overt stimulus presentation (and hence of data-driven processes), generation produces considerably less repetition priming than does reading in word identification. In earlier work, Jacoby and Dallas (1981) examined the case where the stimulus, although always physically present, was encoded under different processing instructions. Whereas recognition memory was found to be better for words that had received semantic analysis than for those that had received orthographic analysis, word identification of a briefly presented masked target word was primed equally by the two prior tasks.

Unlike direct tests of memory, then, priming of presented words often does not benefit from greater stimulus elaboration. Other data reported by Jacoby (1983) converge on this conclusion. Individual words originally presented without context (e.g., XXX–COLD) produced greater priming in word identification than did words originally presented with context (e.g., hot–COLD). Blaxton (1989) reports an analogous result with word fragment completion as the indirect test. If more context leads to greater elaboration, then these results indicate that there is diminished repetition priming with increased conceptual processing.

Indeed, this pattern can be observed even when the direct and indirect test items are identical, with only the test instructions differing. Graf and Mandler (1984) varied the type of processing of a set of words and then presented these words as part of a larger set for which subjects were asked to complete three-letter word stems (e.g., *tab___* for *table*). In all cases, word stem completion was improved by prior presentation of the word *table*. However, the magnitude of repetition priming depended upon whether the task was presented as an indirect or a direct test of memory. In the indirect test, subjects were asked to fill in the blanks with the first word to come to mind, with no mention of any prior presentation. Here, type of initial encoding had little effect. In contrast, the direct test instructions specifically asked subjects to try to remember study list words that began with the specified three letters. Here, stem-cued recall was greater following more elaborative processing.

Similar trends appear in recent experiments in which subjects read texts and then were given indirect tests (Levy & Kirsner, 1989; MacLeod, 1989). As an illustration, MacLeod manipulated processing by varying the context in which words in text were processed. He reported significantly better word fragment completion for test words that had initially been studied in the context of a list of isolated words than for words read in the context of meaningful passages. Intermediate levels of priming were observed for words isolated within the meaningful passages. Assuming that an appropriate context encourages greater conceptual elaboration, this gradient of priming indicates a negative correlation between degree of conceptual processing and magnitude of repetition priming.

These studies and numerous others reveal that extent of elaboration during initial encoding affects indirect and direct memory measures differently. Whereas direct tests typically show a positive correlation between performance and degree of elaboration, two indirect tests—word identification and word completion—have shown either no correlation or a negative one. One aim of the present research was to explore the generality of this dissociation by extending the study of repetition priming to the lexical decision task, in which subjects are asked to decide whether a string of letters is or is not a real word. Would lexical decision show the same dissociation as the other two methods?

To answer this question, magnitude of repetition priming was examined as a function of type of encoding during initial study by means of a typical "depth of processing" manipulation (Craik & Lockhart, 1972; Craik & Tulving, 1975). Subjects were shown an unrelated pair of words such as KEY–FOOTBALL and were asked to make one of four different judgments about the two words in the pair. Two of the judgments encouraged independent processing of the two words in each pair, and two of them encouraged integration of the words in the pair. This independence/integration factor was crossed with an elaboration factor: Two of the judgments promoted semantic processing of the words, and two of them promoted nonsemantic processing. Table 1 illustrates the four conditions.

Table 1

Experiment 1: Instructions for the Four Encoding Conditions With Example Responses for the Pair KEY–FOOTBALL

Instructional condition	Subject's response
Independent	
1. Consonant counting—Count the consonants in each word of the pair and say aloud whether the total is odd or even for the left word followed by the right word.	"Odd . . . odd"
2. Pleasantness judgment—State aloud whether each word in the pair represents something pleasant or unpleasant, judging the left word then the right word.	"Pleasant . . . pleasant"
Integrative	
3. Rote rehearsal—Repeat the two words aloud consecutively while they are on the screen.	"Key, football, key, football"
4. Sentence generation—State aloud a meaningful sentence that uses the left word before the right word.	"The key was found lying behind the football."

A second major question concerned the extent to which repetition priming was influenced by reinstatement of the original study context. In the stem completion task with cue-target word pairs, more priming occurs when a target word is tested in the context of its study list cue than when it is tested alone or with some other cue (Graf & Schacter, 1985, 1987; Schacter & Graf, 1986). Furthermore, the magnitude of this context effect depends on the extent of elaborative processing of the pair during study. Graf and Schacter had subjects study word pairs in a semantic condition, where they generated or read meaningful sentences containing the two words, or in a nonsemantic condition, where they counted the letters in the target word or read anomalous sentences containing the two words. At test, the presence of study list cues benefited word completion only if subjects had engaged in one of the semantic tasks during study.

We wanted to know whether the context of the study list cue would play a similar role in the lexical decision task. McKoon and Ratcliff (1979, 1986) reported more priming in lexical decision when the target word was preceded by its study list cue after subjects had done paired associate learning during study. Specifically, pairs identical to those at study (intact pairs) showed more priming than did pairs created at test by reassigning cues and targets (broken pairs). McKoon and Ratcliff took this to be evidence of episodic priming analogous to the semantic priming observed in lexical decision for highly associated word pairs. Our manipulation of encoding at the time of study would permit an evaluation of the role of elaborative processing in this episodic priming situation. In fact, we modeled the method of our study very closely after theirs.

To summarize our method, subjects initially studied unrelated word pairs (cue plus target) under one of the four encoding conditions shown in Table 1. During the subsequent lexical decision phase, previously studied targets were preceded by one of three different types of prime: the original cue for that target (intact pair), the cue from another target (broken pair), or a previously unpresented cue (new pair). To recapitulate our theoretical concerns, there were two principal issues: (a) the extent to which repetition priming was influenced by initial encoding condition and (b) the extent to which repetition priming was affected by reinstatement of the original presentation context.

Experiment 1

Method

Subjects. Forty undergraduates at the Scarborough Campus of the University of Tornoto participated individually in the experiment, 10 in each of the four encoding conditions. Participants received bonus points toward their introductory psychology course grade for taking part.

Stimuli and apparatus. The words were selected from the Paivio, Yuille, and Madigan (1968) norms to have a concreteness value of 4.00 or greater and a frequency of occurrence of at least 30 per million. Pronounceable nonwords were formed by changing a single consonant of a real word. The total stimulus pool consisted of 250 critical words, 370 filler words, and 108 nonwords. All stimuli were presented at the center of a monitor screen, with stimulus presentation and response recording controlled by an APPLE IIe microcomputer equipped with a Mountain Computer real time clock accurate to one millisecond.

Procedure. The four groups were differentiated by the nature of the instructions that preceded the study phase, as shown in Table 1. Each subject completed 25 blocks of trials, where a block consisted of an initial study phase followed immediately by a lexical decision phase. Pairs of critical unrelated words were created by randomly selecting (without replacement) two words from the pool of 250, and thus were different for all subjects. In the study phase of every block, seven pairs of unrelated words were presented, each pair for 8 s. The first and last of the seven pairs, included to minimize serial position effects, were never tested and were created from the pool of 370 filler words.

Immediately following each study phase, subjects engaged in a series of 10 lexical decision trials. After a 500-ms warning consisting of a row of asterisks, the prime was displayed for 250 ms. The prime was always a word; subjects were instructed to read the word silently. The target—either a word or a nonword—immediately followed offset of the prime and remained on the screen until the subject made a word/nonword judgment by pressing the appropriate key. The screen then blanked for 500 ms before the next trial. All displays were at the center of the monitor screen.

Table 2 shows the composition of a set of 10 lexical decision trials, together with illustrative stimuli. *Old* refers to a word that had appeared in the immediately preceding study phase; *new* refers to a word that had not been encountered previously in the experiment. The number of occurrences of each type of trial in a single block of 10 trials is indicated in the middle column. During each block, subjects responded to six word and four nonword targets. Half of the primes were old words, and half were new words. In addition, half of the word targets were old, and half were new. Over the 25 blocks, primes and targets were selected equally often from the five possible serial positions of the study list (Positions 2–6). No item was ever repeated between blocks. Subjects received two complete practice blocks before beginning the experiment proper.

At the end of the 25 blocks, subjects received an unexpected two-part direct memory test. Both parts were subject-paced. Retention was examined only for words presented during the last four blocks (22–25). The first direct test examined recognition memory for the individual words. Subjects saw a list of 80 words made up of 40 studied words (i.e., 2 words each from the 20 critical pairs presented over the last four blocks) randomly intermixed with 40 new filler words.

The 80 recognition test words appeared as four screen "pages," each containing 10 old words and 10 new words. Runs of more than five old or five new words were not permitted on a page. Subjects had to respond *old* or *new* for each word on the page, with the total numbers of cumulative old responses and new responses shown in the top right corner of the screen. To control for criterion differences, subjects were required to make exactly 10 old and 10 new responses, changing responses on a page as often as required until they were satisfied. This task was expected to display the typical "depth of processing" effect, with superior recognition memory for words that had received more elaborative processing.

The second retention test examined the effect of contextual elaboration on the ability to re-pair the studied words. Subjects were shown two 20-item columns on the screen, the left column consisting of the 20 studied primes from the last four blocks and the right column consisting of the 20 studied targets from the last four blocks. The order of words within each column was randomized, and the subject's task was to recreate the studied pairs by indicating which numbered prime belonged with which numbered target. Once a pair was identified, its prime and target were deleted from the respective columns and displayed in a separate column of pairs. Subjects were permitted to make as many changes as they wished until they were satisfied.

Table 2
An Example Block of Trials for Both Experiments

Study phase word pairs (7)

gold	brain
laughter	shower
barn	twilight
key	football
poet	woods
chain	trumpet
cluster	magazine

Lexical decision phase word pairs (10)

Type of pair	No. of occurrences	Example
old–old (intact)	1	barn–twilight
old–old (broken)	1	poet–football
new–old	2	dress–shower; cousin–woods
old–new	1	key–oxygen
new–new	1	sheriff–cradle
old–nonword	2	laughter–keader; chain–hemon
new–nonword	2	fever–lutter; pony–saster

Note. Each of the 25 experimental blocks used a unique set of words and nonwords.

Results

Item recognition. To establish that the four instructional conditions did in fact differentially influence encoding, an analysis of variance (ANOVA) was conducted on the proportions of words correctly recognized. The relevant data appear at the top of Table 3. As with all of the analyses reported in this article (unless stated otherwise), an alpha level of .01 was used for significance tests. Recognition memory for individual words was found to differ significantly as a function of initial encoding condition, $F(3, 36) = 18.70$, $MS_e = 5.92$. In particular, recognition memory was better after the two semantic tasks (sentence generation and pleasantness judgment) than it was after the two nonsemantic tasks (consonant counting and rote rehearsal), $F(1, 36) = 47.34$. Interestingly, the two semantic processing tasks yielded almost identical levels of performance ($F < 1$), whereas the two nonsemantic tasks differed significantly, $F(1, 36) = 8.65$. Rote rehearsal led to somewhat better recognition than did consonant counting. This entire pattern is quite in keeping with usual findings on recognition tests and demonstrates that the manipulation of type of encoding had a reliable effect on a direct test.

Pair matching. Performance on the pair matching test, shown at the bottom of Table 3, likewise was found to depend on study instructions, $F(3, 36) = 100.14$, $MS_e = 5.94$. Pair matching was significantly better when subjects processed a pair of words together in the two integrated conditions than when they processed the words independently, $F(1, 36) = 142.38$. The data suggest that little relational information was stored in the two conditions where the words were processed separately; performance in both the pleasantness judgment and the consonant counting conditions was poor, although performance in the semantic pleasantness judgment condition was reliably better than that in the nonsemantic consonant counting condition, $F(1, 36) = 4.84$, $p < .05$. Most of the benefit of integration was due to the sentence generation condition, which led to dramatically better matching performance than did the rote rehearsal condition, $F(1, 36) = 153.23$. Clearly, the manipulation of contextual elaboration was a success in terms of linking the two words in a pair.

Parenthetically, it is interesting to observe the dissociation between memory for item information and for relational information. This is especially apparent for the two semantic processing tasks of pleasantness judgment and sentence generation. Recognition memory for indivdual words was equally good in these two cases. However, there apparently was little contextual processing when subjects made separate pleasantness judgments for the two words of a study pair compared with the extensive contextual processing when the two words had to be used in a single sentence, as shown by the pair matching data.

These direct memory test data provide evidence that our manipulations did influence encoding during study. Memory for individual words and for interword associations depended upon type of processing at the time of study, evidently in different ways for the two types of information directly tested.

Table 3
Experiment 1: Proportion Correct on the Two Direct Memory Tests

	Encoding condition			
Test	Consonant counting	Pleasantness judgment	Rote rehearsal	Sentence generation
Word recognition	.68	.85	.76	.84
Pair matching	.06	.18	.24	.91

We turn now to our major questions having to do with the way in which these encoding differences affected repetition priming in lexical decision.

Lexical decision. The lexical decision data for all targets are displayed in Table 4 as a function of the four encoding conditions and the seven prime-target relations. Shown for each condition is its mean response latency and the proportion of errors made in that condition.

Two separate 7 × 4 mixed ANOVAS were conducted on the data for the targets, one on mean latencies and one on error proportions. The outcomes of the two analyses were very similar. For latencies, neither the main effect of encoding, $F(3, 36) = 1.04$, $MS_e = 38{,}994$, nor its interaction with prime–target relation, $F(6, 216) = 1.16$, $MS_e = 1{,}824$, was significant. However, the main effect of prime–target relation was highly significant, $F(18, 216) = 98.20$, reflecting the consistent pattern across encoding conditions. This will be explored in detail shortly.

The error analysis also confirmed a nonsignificant main effect of encoding condition, $F(3, 36) = 0.08$, $MS_e = 0.004$, and a nonsignificant interaction, $F(18, 216) = 1.12$, $MS_e = 0.001$. Again, the main effect of prime–target relation was highly significant, $F(6, 216) = 18.88$. The error rate was about .06 for new word targets and for nonword targets but only .01 for old, studied word targets. These overall analyses provide the necessary ingredients for the more detailed analyses below.

Effect of type of encoding on repetition priming. Having shown that semantic processing led to better performance than did nonsemantic processing on two direct tests, we now consider the indirect test, lexical decision. Did type of encoding affect the extent of repetition priming observed? Answering this question requires comparison of performance on old versus new targets. However, when the prime for such a target is old itself, this complicates comparison among targets, which now can be affected by prior context, as well as by prior occurrence. Furthermore, it is not clear how to deal with the two old–old conditions, the intact and the broken pairs. For these reasons, the best conditions in which to examine relatively "pure" repetition priming appear to be those where the target is preceded by new, irrelevant primes—the new–old and new–new conditions (shown in rows 3 and 4 of Table 4). As anticipated, there was reliable repetition priming, with responses averaging about 40 ms faster for targets that were encountered during the study phase than for targets not so encountered, $F(1, 36) = 18.12$.

The top row of Table 5 presents amount of priming as the difference between the new–old and new–new conditions separately for each type of processing. Inspection suggests that there was greater priming under the nonsemantic conditions of consonant counting and rote rehearsal than there was under the semantic conditions of pleasantness judgment and sentence generation. Analysis confirmed this to be a reliable pattern. A one-way ANOVA on the individual subject difference scores for the four encoding conditions showed an overall significant effect, $F(3, 36) = 2.77$, $MS_e = 2{,}467$, $p = .05$. The contrast between the two semantic and the two nonsemantic conditions was significant, $F(1, 36) = 6.13$, but the residual was not, $F(2, 36) = 1.77$. These results are in the opposite direction from those found in the direct recognition test: Conditions that produced the best recognition resulted in the least repetition priming.

Although more difficult to interpret, we also examined repetition priming for targets preceded by old primes. These data appear in the bottom two rows of Table 5. Amount of priming again is expressed in the form of difference scores, in this case the difference between the intact or broken condition and the old–new condition. A 4 × 2 ANOVA (Encoding Condition × Type of Pair) produced no significant effects (all *F*s < 1). Thus, unlike the pattern of repetition priming found when the prime was novel, here the magnitude of repetition priming was independent of encoding condition.

Table 4
Experiment 1: Mean Response Latencies (RT, in Milliseconds) and Proportions of Errors (PE) for Targets as a Function of the Four Encoding Conditions and the Prime–Target Relation in Lexical Decision

	Encoding condition									
	Consonant counting		Pleasantness judgment		Rote rehearsal		Sentence generation		*M*	
Prime–target relation	*RT*	*PE*	*RT*	*PE*	*RT*	*PE*	*RT*	*PE*	*RT*	*PE*
Old–old (intact)	542	.016	519	.000	535	.016	580	.016	544	.012
Old–old (broken)	553	.008	522	.024	545	.016	572	.016	548	.016
New–old	572	.006	547	.014	569	.018	611	.022	575	.015
New–new	623	.048	582	.040	638	.068	618	.056	615	.053
Old–new	609	.068	579	.064	609	.064	638	.062	608	.064
New–nonword	746	.064	654	.056	703	.030	712	.072	704	.055
Old–nonword	713	.064	659	.062	715	.074	725	.048	703	.062

Table 5
Experiment 1: Mean Repetition Priming (in Milliseconds) as a Function of Prime–Target Relation and Type of Encoding

	Encoding condition			
Test condition	Consonant counting	Rote rehearsal	Pleasantness judgment	Sentence generation
New–old	51	69	35	7
Old–old (intact)	67	74	60	59
Old–old (broken)	56	64	58	67

Note. Repetition priming was calculated as a difference score between the condition identified and the appropriate baseline, specifically new–new for the new–old condition and old–new for both of the old–old conditions.

Apparently, whether type of encoding at study influences repetition priming on a lexical decision test depends on the context in which the target word occurs at test. In the context of a novel prime, repetition priming is greater following nonsemantic encoding at study. In the context of previously studied primes, repetition priming is not sensitive to type of encoding. The contextual advantage with studied primes appears to override the differential effect of type of encoding on priming.

Effect of contextual processing on priming. Our second concern was the extent to which contextual elaboration influenced priming in lexical decision. Here, we focused on the three conditions where the targets were old words (the top three rows of Table 4); results were combined over encoding condition because that variable produced no main effect or interaction in the overall analysis. Given the very low and identical error proportions in these three conditions, there will be no further discussion of these error rates.

In the latency analysis of these three conditions, prime–target relation did significantly influence latency. Two contrasts clearly demonstrate this. First, contrasting the two old prime conditions against the single new prime condition resulted in a significant effect, $F(1, 216) = 12.05$. Second, contrasting the intact pairs against the broken pairs produced a nonsignificant result ($F < 1$). Thus, when an old prime preceded an old target—regardless of whether the pair was intact or broken—subjects responded about 30 ms faster than when a new prime preceded an old target. There was no further advantage when a prime came from the same studied pair (intact) versus from a different pair (broken). The nonsignificant interaction of type of encoding and prime–target relation indicated that this pattern was consistent across encoding conditions.

One might argue that old primes share some general characteristic that causes them to produce this sort of priming whenever they occur. For instance, they might somehow be more arousing. As a partial response to such an argument, we examined the impact of old versus new primes on new targets (rows 4 and 5 of Table 4), again combining results over encoding condition. There were no significant effects in the relevant latency analysis ($F < 1$) or in the relevant error analysis ($F < 1$). The old–new condition did not differ from the new–new condition. Similarly, there were no significant effects in a corresponding analysis for nonwords preceded by old versus new primes ($F < 1$ for the latency analysis and $F < 1$ for the error analysis). Thus, facilitation caused by old primes was not general; it was limited to the case where the target words also had appeared during the study phase.

Discussion

This experiment provided clear evidence that type of processing during encoding can affect a direct and an indirect test differently. When memory was tested directly by word recognition, performance was positively correlated with the degree of semantic elaboration at study. Also, when memory was tested directly by pair matching, performance benefited to the degree that processing instructions encouraged integration. In contrast, the indirect measure of memory, lexical decision, revealed a negative correlation between extent of semantic elaboration and repetition priming, although only for unstudied primes. With unstudied primes, more facilitation was observed after nonsemantic processing than after semantic processing. These results increase the generality of the dissociation observed between direct and indirect tests as a function of type of encoding in tests of word completion (e.g., Roediger & Blaxton, 1987) and perceptual identification (e.g., Jacoby, 1983), where a similar pattern has been reported.

More novel is our finding concerning the role of context in priming. Context appears to have influenced repetition priming in two ways. First, it modulated the impact of initial type of encoding. When a target was preceded by an unstudied prime, repetition priming was affected by type of encoding at study, with nonsemantic being better than semantic. However, in the context of a studied prime, type of prior encoding did not differentially affect repetition priming. This appears to be due to the fact that semantically processed targets improved more when tested in the context of a studied prime. Perhaps, when the initial amount of repetition priming is relatively small, performance can benefit more from the presence of an old context, with the result that this episodic priming eliminates differential effects of type of processing at study.

Context also affected the overall magnitude of repetition priming so that studied words were processed faster when primed by previously studied words than when primed by new words. However, the size of this priming effect was not affected by whether the prime word had been paired with the particular target word at the time of study. Intact and broken pairs showed an equivalent amount of priming, about 30 ms more than old words preceded by new words.

These context results are intriguing. McKoon and Ratcliff (1979) reported a reliable priming advantage for intact pairs over broken pairs following study of "easily learned" but nominally unrelated word pairs (e.g., CITY–GRASS, PLAINLY–SEE, WIDOW–CHILD). They called this "episodic priming," drawing an analogy to the familiar semantic priming between related pairs such as TABLE–CHAIR. Why, then, did the relation between prime and target for studied words not produce any differential effect on the amount of priming in our experiment?

Because we wished to establish that there was nothing peculiar about our experimental procedure that would inadvertently have precluded pair-specific priming, an additional 10 subjects were tested only in the lexical decision phase of the experiment. For these subjects, the stimuli were the standard high associates typically used for studies of semantic priming (e.g., BREAD–BUTTER). With all other procedural details of the testing phase identical to those of Experiment 1, the usual 30 ms. semantic priming effect emerged. Subjects responded more rapidly to targets preceded by semantically associated primes than they did to targets preceded by unrelated primes. Thus, our general procedure, closely modeled after that of McKoon and Ratcliff (1979) in the first place, seems to be suitable.

Initially, we thought that McKoon and Ratcliff's use of "easily learned" pairs might have been the reason for the difference. Perhaps even a weak relation is adequate to establish pair-specific priming following a single study episode. Because our words were randomly paired, they were completely unrelated, and a single study episode might not have been adequate to promote pair-specific priming. Carroll and Kirsner (1982) had also failed to obtain episodic priming with unrelated word pairs. However, Durgunoglu and Neely (1986) obtained pair-specific episodic priming with the McKoon and Ratcliff materials despite arbitrarily re-pairing the words. Consequently, the matter of when to expect pair-specific versus list-wide episodic priming remains to be explained. Experiment 2 was carried out to explore this question further.

Experiment 2

The difference in pattern between the McKoon and Ratcliff (1979) result and our own was especially puzzling because we had set out to follow their procedure as closely as possible. In combing the two methods for a potential explanation, the most obvious candidate was the encoding instructions. Because we had wanted to manipulate encoding, we used four different instructional sets in Experiment 1. None of these was identical to those used by McKoon and Ratcliff. They had simply instructed their subjects to study the word pairs as paired associates so that, given the first word, they would be able to generate the second word. We decided to use this encoding instruction in Experiment 2.

To try to maximize the possibility of obtaining pair-specific episodic priming, it seemed that sufficient time should be left between the prime and the target for strategic processes to operate (cf. Neely, 1977; Posner & Snyder, 1975). In Experiment 1, we used a 250-ms stimulus onset asynchrony (SOA), the same value employed by McKoon and Ratcliff (1979). Although they did obtain pair-specific episodic priming, short SOAs would seem to work against such effects to the extent that these effects are strategic. A longer SOA would allow more strategic processing of the prime prior to the appearance of the target so that subjects could take advantage of the elaborative processing during the study phase. With this in mind, we manipulated SOA in Experiment 2: To the 250-ms SOA of Experiment 1, we added a 1,000-ms SOA. We expected to see more priming in the 1,000-ms condition, particularly in the intact pairs, if this episodic priming is strategic in origin.

Method

Subjects. Fifty students at the Scarborough Campus of the University of Tornoto participated in this study to gain bonus points in their introductory psychology course.

Apparatus and stimuli. The method of presentation and the stimulus lists were identical to those used in the first experiment.

Procedure. During acquisition (Phase 1), all subjects studied the word pairs under paired associate learning instructions so that they could later generate the target word (response) when shown the prime word (stimulus). In lexical decision (Phase 2), SOA was a between-groups variable: Half of the subjects did lexical decision with a 250-ms SOA, and the other half did it with a 1,000-ms SOA. All other elements of the procedure were identical to those in Experiment 1.

Results and Discussion

Recognition and pair matching. Accuracy on the tests of individual word recognition and pair matching were not expected to differ for the two SOA groups. In fact, the difference was nonsignificant in the pair matching data ($F < 1$), with the 250-ms SOA group correctly matching .52 of the pairs and the 1,000-ms SOA group correctly matching .43 of the pairs. The marginally significant difference in the recognition data also favored the 250-ms group ($M = .80$) over the 1,000-ms group ($M = .75$), $F(1, 48) = 2.96$, $MS_e = 0.011$, $.05 < p < .10$. These small discrepancies probably were both due to sampling differences. Combining results over the two SOA groups, the average word recognition performance was .78, in the same general range as the recognition scores in Experiment 1. However, at .48, pair matching performance in Experiment 2 was twice that of the superficially most similar condition in Experiment 1, the rote repetition condition, where only .24 of the pairs were correctly matched. There is some suggestion, then, that paired associate learning instructions produced more extensive processing than did rote rehearsal instructions.

Lexical decision. Table 6 presents the mean response latencies and proportions of errors for each of the seven prime–target relations as a function of separate SOA group. A 2 × 7 ANOVA on latencies indicated that the 250-ms SOA group (mean of 587 ms, collapsing over prime–target relation) was marginally faster overall in responding than was the 1,000-ms SOA group (mean of 634 ms), $F(1, 48) = 2.90$,

Table 6
Experiment 2: Mean Response Latencies (RT) With Proportions of Errors (PE) for Targets as a Function of Stimulus Onset Asynchrony and the Prime–Target Relation in Lexical Decision

	Stimulus onset asynchrony			
	250 ms		1,000 ms	
Test condition	*RT*	*PE*	*RT*	*PE*
Old–old (intact)	525	.014	561	.010
Old–old (broken)	522	.026	569	.018
New–old	547	.018	563	.012
New–new	581	.066	629	.029
Old–new	589	.070	647	.051
New–nonword	622	.090	741	.057
Old–nonword	680	.095	729	.057

$MS_e = 67{,}665$, $.05 < p < .10$. Probably, this again reflected sample differences on this between-subjects variable. In addition, there was a highly reliable main effect of prime–target relation, $F(6, 288) = 110.56$, $MS_e = 2{,}201$, and a marginally significant interaction, $F(6, 288) = 2.06$, $.05 < p < .10$, both of which will be examined in more detail shortly.

The error analysis demonstrated a nonsignificant trend toward more errors in the 250-ms group (.054) than in the 1,000-ms group (.033), $F(1, 48) = 2.33$, $MS_e = 0.016$, $p = .13$, but no interaction of SOA group with prime–target relation, $F(6, 288) = 1.16$, $MS_e = 0.002$. Only the main effect of prime–target relation was significant, $F(6, 288) = 15.52$. Once again, there were more errors for the new words (.054) and for the nonwords (.075) than for the word targets (.016).

As in Experiment 1, we examined whether prime type (new vs. old) affected new targets or nonword targets, this time combining results over SOA. The same result obtained as in Experiment 1: Prime type had no effect on either latency ($F < 1$) or error rate ($F = 1.25$) for new targets. Nor did prime status affect either latency ($F < 1$) or error rate ($F < 1$) for nonword targets. Only when the targets were previously studied old words did the type of prime matter, as in Experiment 1.

The crucial data, then, are in the top three rows of Table 6. As this table clearly shows, there were no differences in error rate over the three old target conditions. For the 250-ms SOA, the same latency pattern was evident as in Experiment 1, which also used a 250-ms SOA. The two old–old conditions (intact and broken) differed from the new–old condition by about 25 ms, $F(1, 288) = 4.11$, $p < .05$. Surprisingly, however, when SOA was lengthened to 1,000 ms, this list-wide priming disappeared altogether ($F < 1$); there was only repetition priming for the old targets relative to the new targets.

The results for the 250-ms SOA condition confirm again the pattern observed over four different encoding conditions in Experiment 1. We now have five independent replications of list-wide episodic priming without pair-specific episodic priming. Clearly, the choice of paired associate learning instructions was not the critical difference between the McKoon and Ratcliff (1979) study and ours. Experiment 2 also adds a new finding to the others reported earlier: List-wide priming disappears if the prime–target SOA is lengthened to 1,000 ms. Apparently, then, the list-wide priming observed at a 250-ms SOA is a very short-lived phenomenon.

General Discussion

Several earlier studies have observed a dissociation between type of encoding and later memory performance, depending upon whether memory was tested by a direct or an indirect test. A large literature exists to show that direct measures such as recall and recognition consistently produce superior performance for more elaboratively encoded stimuli (e.g., Craik & Tulving, 1975). In contrast, as Richardson-Klavehn and Bjork (1988) document, indirect measures such as word completion and perceptual identification have demonstrated either no relation or a pattern opposite to that seen on direct tests. One of our goals was to test the generality of this dissociation by using the most frequently studied measure of priming over the past 20 years, the lexical decision task.

The results of Experiment 1 point to a negative correlation between encoding elaboration and degree of priming in lexical decision. Contrary to the recognition results where greater semantic processing led to better memory performance, there was more repetition priming in lexical decision for words that had been processed nonsemantically, at least when tested in the presence of a novel context. When tested in the context of a studied prime, this effect of type of encoding disappeared. However, the contextually based episodic priming caused by studied primes clouds interpretation of repetition priming for targets with studied primes. Thus, the dissociation observed in other indirect tests may extend to lexical decision as well, but the picture is not a simple one.

This dissociation is readily interpreted in terms of the processing account of Roediger and his colleagues (Roediger & Blaxton, 1987; Roediger et al., 1989). Their suggestion is that most indirect tests rely primarily on data-driven processes, whereas most direct tests rely primarily on conceptually driven processes. Semantic tasks such as pleasantness judgment and sentence generation should encourage extensive conceptual processing at study, thereby matching the type of processing invoked by a conceptually driven direct test. On the other hand, nonsemantic tasks such as counting consonants or rote rehearsal should encourage data-level processing at study, thereby matching the type of processing invoked by a data-driven indirect test. This is the pattern we observed.

Our second major goal was to examine contextual effects of primes on the processing of targets in lexical decision. We found that lexical decisions about previously studied targets were made more rapidly when the target was preceded by a prime from the study list. Moreover, the magnitude of facilitation was the same—approximately 25–30 ms—for five different study conditions (all using a 250-ms SOA between prime and target). Thus, the effect is a very reliable one. Furthermore, it is not simply a result of some sort of general arousal engendered by old primes, because there was no corresponding effect on new word or on nonword targets. Clearly, this is a type of episodic priming.

At least one other study has previously found no effect of elaboration on priming. Schacter and McGlynn (in press) instructed subjects to study common idioms such as SOUR–GRAPES under one of two study conditions designed to encourage or to discourage elaborative encoding. They then administered two tests, a direct test where SOUR was presented as a cue to recall its paired word GRAPES, and an indirect test where subjects were simply to write down the first word that came to mind when given a cue such as SOUR. The direct test was influenced by type of encoding at study; the indirect test showed no effect.

Although our results conflict with the pair-specific priming observed by McKoon and Ratcliff (1979, 1986), there are other studies in the literature that did not obtain pair-specific priming. Carroll and Kirsner (1982) had subjects perform a lexical decision task on pairs of words in a study phase. The test phase was either lexical decision again or recognition. In lexical decision, pairs of words that had appeared together in the first phase (intact pairs) were no faster than were reassigned pairs (broken pairs). In contrast, in recognition, words from intact pairs were better recognized than those from broken pairs.

Similar results were reported by Neely and Durgunoglu (1985) in an experiment in which subjects initially studied semantically unrelated pairs of words and then made either recognition judgments or lexical decisions. Whereas recognition of studied words was facilitated by prior occurrence in these episodically related pairs, lexical decision showed no corresponding effect of prior context. Durgunoglu and Neely (1986) went on to show that the occurrence of pair-specific priming is highly sensitive to subtle procedural features, which they carefully mapped out. Unfortunately, their criteria would not have predicted the priming we observed; thus we are at rather a loss to explain it. Yet this priming certainly is a reliable phenomenon, having occurred in five out of five independent groups of subjects.

There is one published report of similar list-wide priming. Neely, Schmidt, and Roediger (1983) found that recognition of a previously studied word was faster in the context of another studied word even when the two words had not been adjacent in the study list. Although this result occurred for a direct test of recognition, it provides an interesting parallel. Because we did not examine context effects on speed of recognition, it would be worthwhile to determine whether recognition and lexical decision would respond to context in the same way within the confines of a single experiment.

Another clear finding is that our list-wide episodic priming has an exceedingly short time course. It appears with an SOA of 250 ms, but not with an SOA of 1,000 ms, a pattern more in keeping with an automatic process than with a strategic one. It is as if the entire list episode is momentarily activated or reinstated, an idea that has been discussed previously (e.g., Anderson & Bower, 1972; Neely et al., 1983). Such a hypothesis would not necessitate pair-specific priming; indeed, it would suggest that any list item could prime any other list item. We have shown that any prime can facilitate any target in a brief list. It remains to be seen whether two targets (or primes) can facilitate each other and just what the boundary conditions are on this list-wide priming. For example, could words from different lists in the same experiment prime each other? Over what length of interval between study and test is it possible to obtain the effect? And, perhaps most intriguing, what conditions are required to produce pair-specific episodic priming in addition to list-wide episodic priming?

In conclusion, we have reported three main new findings. First, unlike recognition, where semantic processing leads to better performance than does nonsemantic processing, lexical decision is either unaffected by type of processing or benefits more from prior nonsemantic processing of word pairs.[1] Second, when primed with a previously studied word, a target in lexical decision is facilitated, but there is no additional benefit when the prime word was originally paired with that target. Apparently, the entire list is temporarily activated. Third, this list-wide episodic priming is fleeting, dissipating somewhere between 250 and 1,000 ms after the occurrence of the prime. This initially broad activation followed by rapid narrowing in episodic priming is reminiscent of the pattern found in semantic priming with homonyms (e.g., Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982). Perhaps this quick narrowing from a broad initial set is a more general phenomenon than realized until now.

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[1] It is interesting to note that whereas some indirect tests of memory have shown greater priming following nonsemantic processing (Blaxton, 1989; Jacoby, 1983; Winnick & Daniel, 1970), others have shown no effect of prior type of processing (Graf & Mandler, 1984; Jacoby & Dallas, 1981). It is unclear what underlies this difference, whether across experiments or within a single study.

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