Journal of Experimental Psychology:
Learning, Memory, and Cognition
1992, Vol. 18, No. 1, 3–14

0278-7393/92/$3.00

Effects of Exact Repetition and Conceptual Repetition on Free Recall and Primed Word-Fragment Completion

Henry L. Roediger III
Rice University

Bradford H. Challis
University of Toronto,
Toronto, Ontario, Canada

Experiments are reported in which effects of repeating words exactly (e.g., *elephant, elephant*) or repeating some meaningful aspect—a synonym (*pachyderm*), an associate (*tusk*), or a category coordinate (*hippopotamus*)—were examined on free recall and word-fragment completion. In free recall, large effects of both exact repetition and conceptual repetition were found; the magnitude of the latter was about half that of the former. In contrast, in primed word-fragment completion, repetition effects were rather small and there was no evidence of indirect (or conceptual) priming. Also, presentation of synonyms, associates, and coordinates in isolation failed to prime word-fragment completion. The results provide further evidence that the basis of primed word-fragment completion is different from that of free recall; the former seems to have a perceptual (or perhaps lexical) basis, whereas the latter relies more on meaningful processing.

The comparison of explicit and implicit measures of retention has occupied many researchers during the past decade. Although some variables produce parallel effects on the two types of test, researchers have shown most interest in factors producing interactions, or dissociations, between the two kinds of test (see Richardson-Klavehn & Bjork, 1988; Roediger, 1990; Schacter, 1987; Shimamura, 1986, for reviews). Accounting for these dissociations poses a primary theoretical challenge for theorists interested in the interrelation between explicit and implicit memory or, more generally, in interactions between tests as a function of independent and subject variables.

The theory guiding the current research has been referred to as transfer-appropriate processing (Morris, Bransford, & Franks, 1977), and the specific version tested, which originated in work by Jacoby (1983), has been advanced by Roediger and his colleagues (Roediger & Blaxton, 1987b; Roediger, Srinivas, & Weldon, 1989; Roediger & Weldon, 1987; Roediger, Weldon, & Challis, 1989). The basic argument is that one important dimension cutting across the typical manipulation of explicit and implicit memory tests is the type of processing (or type of information) tapped by the test. Most (but not all) of the standard implicit tests provide degraded forms of material (words or pictures) out of context and ask subjects to resolve them, typically without reference to any prior learning episode. We especially include here perceptual identification and fragment completion (in its various forms) of either words or pictures presented out of context. These tests seem perceptual in nature because they are greatly affected by study manipulations such as modality (visual or auditory) and symbolic form (word or picture, or language for bilinguals) and are slightly modified by other surface manipulations such as typography (e.g., Graf & Ryan, 1990; Jacoby & Hayman, 1987; Roediger & Blaxton, 1987a). In addition, these tests are often little affected by manipulations of semantic elaboration (levels of processing, organization of material, and the like; see Jacoby & Dallas, 1981; Rappold & Hashtroudi, 1991; Srinivas & Roediger, 1990). Alternatively, most explicit tests are greatly affected by such elaborative variables and little affected by perceptual (surface) variables, leading to the conclusion that they should be classified as conceptual or conceptually driven tests. The references cited earlier provide the evidence for these assertions.

The distinction between perceptual and conceptual forms of tests does not map directly onto the distinction between implicit and explicit tests because it is perfectly possible to develop conceptual implicit tests and perceptual explicit tests (Blaxton, 1989). In addition, the perceptual–conceptual contrast is best conceived as (at least) two separate dimensions, rather than as a single continuum in which the two types of operations would necessarily trade off against one another, for reasons cited by Weldon (1991; Weldon, Roediger, & Challis, 1989).

The idea that perceptual and conceptual processes account for dissociations between tests has recently come into question, because researchers have found some effects of perceptual variables on conceptual tests (Hunt & Toth, 1990) and conceptual effects on perceptual tests (Bassili, Smith & MacLeod, 1989; Toth & Hunt, 1990; Hirshman, Snodgrass, Mindes, & Feenan, 1990). We consider some of these problems in the General Discussion section. For now we simply note that a great deal of evidence supports the idea of a perceptual component underlying many common implicit memory tests that provide isolated, data-limited displays, whereas conceptual components underlie standard explicit

This research was supported by National Institutes of Health Grant R01 HD15054. Some of these results were presented at the 1987 meeting of the Psychonomic Society, Chicago.

We thank Valerie Ludwick for her help with Experiment 1 and Gregory Riegler for his aid in conducting Experiment 4. This article benefited from the comments of T. A. Blaxton, P. Graf, M. Masson, J. H. Neely, and D. L. Schacter.

Correspondence concerning this article should be addressed to Henry L. Roediger III, Department of Psychology, Rice University, Houston, Texas 77251–1892.

tests such as free recall, semantic cued recall, and unpaced recognition (Roediger, Srinivas, & Weldon, 1989; Roediger, Weldon, & Challis, 1989). Indeed, Schacter (1990) and Tulving and Schacter (1990) found the evidence on these points so persuasive as to propose separate perceptual and conceptual memory systems to underlie the different forms of priming. A perceptual representation system (actually two, one for words and another for objects) underlies perceptual priming, and a conceptual system (presumably semantic memory) is thought to underlie conceptual priming. Evidence from patient populations supports these distinctions (see Schacter, 1990).

The present experiments were designed to gain further evidence on these proposals by comparing the effects of different types of priming events on a perceptual implicit memory test (word-fragment completion). We included a standard conceptual explicit test (free recall) for comparison purposes. The independent variable was the type of priming event: direct or indirect (Cofer, 1967). In direct priming, subjects experience an event (read a word, hear a word, see a picture) and then, in a later phase of the experiment, perform some task that is directly related to prior presentation of the stimulus. A special case of direct priming is repetition priming in which the stimulus (and sometimes the response) is the same between the first and second phases (e.g., naming a word during both phases or making a lexical decision during both phases). In indirect priming, some event with a semantic or associative relation to the target is presented, and its influence on target processing is measured. For example, processing of the word *couch* might be affected by prior presentation of *table* (a category coordinate) or *sofa* (a synonym) among other possible relations. Although classification of some priming events as direct or indirect may be ambiguous (are pictures direct or indirect primes for their verbal counterparts?), the distinction is broadly useful and seems worth preserving.

Researchers interested in word perception and reading have studied the effects of direct and indirect primes intensively for two decades, since publication of Meyer and Schvaneveldt's (1971) seminal paper on semantic priming in the lexical decision task. A huge body of evidence using tasks such as perceptual identification (Tulving & Gold, 1963) and lexical decision (e.g., Neely, 1977) provides evidence for indirect priming if the prime and target stimulus occur either simultaneously or successively with short delays between them. Direct priming is also quite robust in such paradigms (e.g., Scarborough, Cortese, & Scarborough, 1977). Neely (1991) reviewed the literature on semantic priming effects in visual word recognition over short delays.

Although semantic priming has been relentlessly studied in word perception and reading, the issue of indirect priming has rarely been addressed in studies of implicit memory even though the tasks used in the two domains are quite similar (e.g., identifying words from brief displays or completing fragmented words). Researchers studying implicit memory have examined direct priming effects almost exclusively.

Theories of implicit memory offer contrasting predictions on whether indirect priming should affect perceptual implicit tests. Proponents of theories maintaining that perceptual (data-driven) processing underlies performance on those implicit memory tasks that challenge the perceptual system with degraded or rapid presentations of words or pictures would expect little or no effect of indirect or conceptual priming on such tasks (e.g., Roediger, 1990; Schacter, 1990). Alternatively, proponents of theories maintaining that conceptual processing supports performance even on ostensibly perceptual implicit memory tests should predict that indirect primes should be effective (see Hirshman et al., 1990; Masson & Freedman, 1990; Masson & MacLeod, in press; Toth & Hunt, 1990). The present experiments were largely aimed at the issue of whether indirect primes boost performance on the implicit word-fragment completion test, on which priming is believed to rely on perceptual processes (Roediger, 1990).

The prior literature is not entirely bereft of studies relevant to the issue of indirect priming on implicit memory tests. The rich literature from the 1960s (see Cofer, 1967) is not as useful as might be expected because often these experiments were conducted under what today would be called explicit test conditions (e.g., Dominowski & Ekstrand, 1967) or the criterial task was conceptual (e.g., free association as in Clifton, 1966). For example, Cramer (1964) showed indirect priming on a free association task that today would likely be classified as reflecting implicit memory. However, the effect occurred for strong forward associates only, the test was given immediately after study of the associates, and the test itself would be classified as a conceptual (rather than perceptual) test in modern parlance. Within the study of word recognition in the lexical decision task, several researchers have compared effects of repetition priming and semantic priming. The most relevant experiment is by Dannenbring and Briand (1982), who directly compared the effects of semantically related words (sea–ocean) with direct repetitions (ocean–ocean) over lags of 0, 1, 5, or 16 intervening items in the lexical decision task. They found strong effects of repetition priming across all lags, but the effect of semantic priming was small and unreliable except at lag 0. Although others found semantic priming with one intervening item in this task (Davelaar & Coltheart, 1975), it seems safe to say that indirect (semantic) priming has short-lived effects on the lexical decision task.

The prior work most relevant to our own is a series of experiments reported by G. Mandler and his associates. Mandler, Graf, and Kraft (1986) examined direct and indirect priming effects in the implicit test of completing word stems (the first three letters of words), in which each stem was capable of several completions. Prior phonological priming through presentation of words rhyming with the target word did produce short-lived (10-min) priming effects, but priming using category associates failed to produce even this level of priming. This outcome accords well with the idea that perceptual priming may be sensitive to lexical but not to semantic aspects of prior experience (e.g., Weldon, 1991). However, the matter is clearly worth a further look because Overson and Mandler (1987) and Mandler, Hamson, and Dorfman (1990) reported some evidence for conceptual priming on word-stem completion, although it was much weaker than either phonological priming or direct priming and not apparent on some measures (i.e., priming occurred on reaction time but not percentage correct in some studies).

The present series of experiments was designed to compare effects of various types of indirect primes (synonyms, associates, or category coordinates) to direct primes in a word-fragment completion task, which is thought to be a perceptual or data-driven test (Roediger & Blaxton, 1987b). Experiment 1 tested these priming conditions from a single presentation of each type, but Experiments 2 and 4 examined the effects of adding an indirect (conceptual) prime to a direct prime. These later experiments also examined the effects of spacing of repetitions on primed word-fragment completion and included free recall for comparison. Experiment 3 was directed solely at repetition and spacing effects in free recall and primed fragment completion, but the rest were aimed at indirect (conceptual) priming. To reiterate, the expectation from prior work is that conceptual primes should have little or no effect on primed word-fragment completion (with its alleged perceptual basis) but should strongly affect free recall (which is thought to be conceptually driven).

Experiment 1

Subjects studied a long list of words that bore various relations to target words presented in fragmented form during the test: synonyms, associates, category coordinates, visually similar words, or the target itself. Following the first fragment-completion test, a second test was given in which context words bearing the various forms of association to new target items were presented simultaneously with the fragments. This second test was given to ensure that the association could provide conceptual priming of fragment completion under immediate priming conditions.

Method

Subjects. One hundred twenty Purdue University undergraduates participated in partial fulfillment of an introductory psychology course requirement.

Materials. The stimuli consisted of 72 target words and a corresponding word fragment as well as words with the following relations to the target word: synonym, category coordinate, associate, a visually similar word, and an unrelated word. For example, one of the target words was *fireplace* whose word fragment was _ire__ac_; synonym was *hearth*; coordinate was *furnace*; associate was *logs*; visually similar word was *foreplay*; and unrelated word was *pumpkin*. The fragment representing the target was constructed to allow only one legitimate solution. Many of the target words and their corresponding word fragments were drawn from the pool of items used by Tulving, Schacter, and Stark (1982). For each target word, the synonym was selected on the basis of meaning; the coordinate, on the basis of belonging to the same category; the associate, on the basis of a normative associative relation; the visually similar word, on the basis of at least some graphemic similarity; and the unrelated word, on its lack of semantic, conceptual, and graphemic similarity. The items were selected from various word norms. Target words ranged in length from 5 to 12 letters; synonyms, coordinates, associates, and visually similar words ranged in length from 3 to 14 letters. Sample materials are presented in Table 1.

The stimulus words were typed in IBM letter gothic print and transferred to 35-mm slides. The word fragments were typed in IBM gothic print on blank white paper and photocopied.

Design. Two separate tests were administered during the experimental session. On Test 1, the delayed priming condition, subjects studied 36 words and then received a word-fragment completion test. The study conditions consisted of items that had the following relations to the target fragment: (a) the target word itself; (b) a synonym of the target, (c) a category coordinate, (d) an associate, (e) a visually similar word, or (f) an unrelated word. The target condition represents a direct (or repetition) priming condition because the word fragment corresponding to the presented word occurred at test; the synonym, coordinate, indirect associate, and visually similar conditions represent indirect priming conditions because the presented word was related to a word fragment that occurred at test. The synonym, coordinate, and associate conditions represent conceptual priming conditions. In the unrelated condition, the presented word was unrelated to any of the test fragments. This served as the control, or baseline, condition against which priming was assessed. The study list of 36 words contained 6 items from each of the 6 study conditions; their order of occurrence in the list was random. The test sheet included the fragments corresponding to each of the 36 study words.

On Test 2, the immediate priming condition, subjects did not study words before the test; rather, words were included on the test sheet adjacent to a fragment. The test conditions were: (a) no context word (fragment only), (b) a synonym, (c) a coordinate, (d) an associate, (e) a visually similar word, and (f) an unrelated word. With one exception, these conditions represent the same conditions as in Test 1; the exception is that the no-context (fragment only) condition replaces the direct (repetition) priming condition because the latter word probably leads to 100% responding (fireplace-_ire__ac_). In the fragment-only condition, just the word fragments were present on the test sheet; in the other five conditions, the priming word from that condition was present adjacent to the corresponding fragment. The test sheet contained 36 fragments; the same test condition was provided for all fragments. For example, a subject assigned to the fragment-only condition received a test sheet containing only fragments, whereas a test sheet for the synonym condition contained a synonym beside each fragment. Thus, unlike the delayed test that preceded it, the priming manipulation was instantiated between subjects in the immediate test.

Table 1
Sample Materials for Experiment 1

Fragment	Target	Synonym	Associate	Coordinate	Visually similar
S__g__n	Surgeon	Doctor	Operation	Nurse	Sturgeon
_arb_c__	Barbecue	Grill	Steak	Hibachi	Barbados
C_nif__	Conifer	Evergreen	Pinecone	Redwood	Confirm
_orn_d_	Tornado	Twister	Basement	Typhoon	Toronto
_rav____d	Graveyard	Cemetery	Tombstone	Park	Graveled
___ble_	Cobbler	Shoemaker	Shoes	Blacksmith	Gobbler
Po__iwo_	Polliwog	Tadpole	Pond	Frog	Polygon
M__ca_a	Mascara	Eyeliner	Lashes	Blush	Margarine

Over 12 experimental conditions (for counterbalancing purposes), the 72 target words and their corresponding synonyms, coordinates, associates, visually similar words, and unrelated words were balanced across study and test conditions. Each item was represented equally often in both immediate and delayed priming conditions.

Procedure. Subjects were tested in groups of 10 to 14; each experimental session proceeded as follows: Subjects were instructed to study a series of presented words on which they would later be tested, although the nature of the memory test was not specified. A list of 36 items was presented individually at the rate of 5 s per item using a Kodak Ektagraphic slide projector.

After the study session, a word-fragment completion test (Test 1) was administered. Subjects were informed that they would see words that had letters missing from them and that they should try to make complete words by filling in the blanks with letters. As an example, the word fragment P_rd_e was displayed and then completed to form *Purdue*. Subjects were informed that they had 20 s to complete a fragment and that at the sound of the tone they should move a cover sheet down the test sheet to expose one new fragment. They were told not to look ahead or to return to any prior fragment. No mention was made of the prior study phase; subjects were told to complete each fragment as quickly as possible.

After Test 1 was completed and collected, copies of Test 2 were distributed to the subjects. Subjects were informed that the procedure for this next part of the experiment was similar to that of the preceding test. A condensed version of the instructions used for Test 1 was read to the subjects. Also, except for those in the fragment-only condition, all subjects were informed that on the test sheet a context word was located beside each fragment and that this word might help them to complete the fragment.

Subjects were debriefed on completion of Test 2. The entire experimental session lasted approximately 45 min.

Results and Discussion

The fragment-completion results are presented in Table 2; the proportion correctly completed is provided for each study condition in both Test 1 and Test 2. Data were combined across the two lists. Each proportion is based on 720 Subject × Item observations. Priming scores relative to the appropriate baseline are given in parentheses.

Test 1. The basic finding is quite straightforward: The direct priming condition produced considerable priming on the delayed test, but none of the indirect priming conditions did. The proportion of word fragments correctly completed in each of the six study conditions was submitted to a one-way analysis of variance (ANOVA), which was significant, $F(5, 595) = 32.01$, $MS_e = .037$. (All effects reported as significant in this article had p values of less than .05.) Newman-Keuls comparisons revealed that the target condition (.51) produced reliably greater fragment completion than did the other five conditions (.28, .26, .29, .29, and .25) and that these five conditions did not differ significantly among themselves.

Table 2
Proportion of Fragments Completed in Experiment 1

Study condition	Test 1 (delayed priming)	Test 2 (immediate priming)
Target (fireplace)	.51 (.26)	—
Synonym (hearth)	.28 (.03)	.72 (.46)
Coordinate (furnace)	.26 (.01)	.56 (.30)
Associate (logs)	.29 (.04)	.57 (.31)
Visually similar (foreplay)	.29 (.04)	.56 (.30)
Unrelated (pumpkin)	.25	.20 (−.06)
Fragment only	—	.26

Note. Numbers in parentheses indicate priming relative to the appropriate baseline condition for the two tests.

Test 2. The failure to find indirect priming in the standard delayed priming conditions is more interesting if it can be shown that these primes exerted an effect under immediate priming conditions as in Test 2. They did. Synonyms produced the most priming, but coordinates, associates, and visually similar words also produced priming relative to either the unrelated or the fragment-only conditions. The proportion of word fragments correctly completed in the six study conditions was submitted to a one-way ANOVA, which was significant, $F(5, 114) = 30.62$, $MS_e = .026$. Newman-Keuls comparisons revealed that (a) the completion rates in the fragment only (.26) and the unrelated (.20) conditions were not reliably different; (b) the synonym (.72), coordinate (.56), associate (.57), and visually similar (.56) conditions all produced reliably greater priming than did the fragment-only and the unrelated conditions; and (c) the synonym condition yielded reliably greater priming than did the other five conditions.

The results of Test 2, which show effects of a relevant bit of context on completing word fragments, help define the sense in which fragment completion (and other perceptually based implicit tests) may be said to be data driven or perceptual. When single fragments are presented without context at some delay from the original presentation, as in Test 1, the test may be considered data driven. There is no other way to complete the fragment than to use the impoverished perceptual clues as the starting point to solve the puzzle posed to the perceptual system. (Of course, higher level processes may come into play during the course of the solution process, especially in word-fragment completion in which the resolution may take seconds rather than milliseconds.) However, it is no surprise that if a fragmented word is modified by a meaningful context, then conceptual processes can affect word-fragment completion or performance on other perceptual tests as has been known for years (e.g., Tulving & Gold, 1963). That a conceptually related context can affect word-fragment completion, as in Test 2 here, is fully in accord with the notions originally put forward by Roediger and Blaxton (1987b), although some claimed such findings are inconsistent with transfer-appropriate processing theory (e.g., Lewandowsky, Kirsner, & Bainbridge, 1989).

Finally, we note that visually similar primes had no effect on the delayed test. This agrees with Weldon's (1991) conclusion that a prime must lead subjects to the lexical identity of the target to have an effect. She found that presentation of a nonword like *geldon* did not prime a fragmented form of *golden* unless, during study, subjects were instructed to think of the word that would result if the vowels of the nonword were interchanged. Under this instruction, presentation of the nonwords did produce priming.

Experiment 2

The results of Experiment 1 showed no effect of indirect priming on a delayed word-fragment completion test. Even synonyms, which served as excellent clues in the immediate priming test, produced a paltry 3% effect on delayed priming. Experiment 2 was designed to extend this finding in several ways. First, we wanted to examine the effects of a conceptually related word after direct priming by the target. Even though presenting *hearth* in a list did not prime the fragment of *fireplace* given in a later test, perhaps if both items were given in the list priming would be greater than if only the target item were presented. The assumption is that an indirect (conceptually related) prime may add to the effect of a prior direct prime even if it has no effect when presented by itself. This provides a further test of the assumption that indirect primes should have little effect on a perceptually based test.

A second issue addressed by Experiment 2 is whether conceptually related words would influence target word recall on an explicit, conceptually driven test (free recall). A finding that indirect primes have no effect on the presumably data-driven word-fragment completion test (as in Experiment 1) is of interest only if this manipulation can be shown to have an effect on a conceptually driven test. Otherwise, our manipulation or materials may simply have been inappropriate. Therefore, we compared performance on word-fragment completion with that on free recall as a function of repetition in Experiment 2.

The third issue examined in this experiment is the effect of exact repetition of items on primed word-fragment completion. When we began this study, the most relevant prior experiment had produced mixed results about the effects of repetition and spacing of repetitions on perceptually based implicit tests. Jacoby and Dallas (1981) performed two experiments that produced slight effects of repetition and spacing of repetitions (significant in one but not the other). Others also found weak and variable spacing effects in implicit tests (e.g., Perruchet, 1989), although Greene (1990) recently placed these findings on firmer ground by reporting repetition and spacing effects on three implicit tests (including word-fragment completion) with more powerful designs. In our experiment, we were mostly interested in effects of exact repetitions and their spacing in comparison to conceptual repetitions.

In Experiment 2, all subjects studied 108 words and then received a test a few minutes later. Within the study list, target words were presented: (a) once; (b) once followed by a synonym, coordinate, or associate; or (c) twice. In the latter two conditions, the paired presentations were shown with a lag of zero or nine. Subjects received either a free recall or a word-fragment completion test. We expected that conceptual repetition should increase recall of the target in free recall but have little or no effect on primed word-fragment completion.

Method

Subjects. The subjects were 72 Purdue undergraduates who participated in the experiment in partial fulfillment of an introductory psychology course requirement.

Materials. The stimuli consisted of 72 target words and a corresponding word fragment, synonym, coordinate, and associate selected from the materials used in Experiment 1. The stimulus words were typed in IBM letter gothic print and transferred to 35-mm slides. The word fragments were typed in IBM gothic print on blank white paper and photocopied.

Design. At study, a target word was presented in one of three conditions: (a) once presented; (b) exact repetition in which the target was presented twice; or (c) conceptual repetition in which the target was followed by a synonym, category coordinate, or associate. In the repetition conditions,the second item of the pair was presented with a lag of zero (massed) or nine (spaced). Thirty-six subjects received either a free recall or a word-fragment completion test.

A base list of 108 stimulus items was constructed containing 6 different blocks of 18 items. A block was comprised of 2 single presentations, 2 exact repetition presentations (lag zero and nine), and six conceptual repetition presentations (synonym, coordinate, or associate × two lags). Ten target items occurred in each block. The position of these conditions within each block was randomized within the limitations imposed by the spaced condition requiring 9 intervening items between the presentation of items. The 6 blocks of items were randomly ordered to form the base list. The base list contained 60 of the 72 target items; the remaining 12 target items were assigned to the nonstudied condition. Across 12 presentation lists created for counterbalancing purposes, each target item occurred once in all repetition conditions and twice in the single and nonstudied presentation conditions.

Of the subjects who studied a particular list, half were randomly selected to complete a free-recall test and the other half were administered a word-fragment completion test.

Procedure. Subjects were tested in groups of 3 or 4; each experimental session proceeded as follows: Subjects were instructed to study a series of words on which they would later be tested, although the nature of the test was not specified. They were also informed that the study session would take about 10 min, with a brief interruption in the middle to change slide trays. A list of 108 items was presented sequentially at the rate of 5 s per item using a Kodak Ektagraphic slide projector. After presentation of the 54th item, the slide tray was changed, resulting in an interruption of less than 30 s.

Tests were administered after the study session. Subjects in the free-recall group were given a sheet of lined paper and told to write down as many of the presented words as possible in any order; and if subjects were unsure about a word they were told to write it down. Subjects were informed that the recall period was 10 min and that after each minute, when hearing the word "line" on the tape recorder, they should draw a line under the last word written down. Subjects in the word-fragment group received the same instructions administered with the first test in Experiment 1. The entire experimental session lasted approximately 45 min. All subjects were debriefed at completion of the session.

Results and Discussion

Free recall. The results of the free-recall test are presented in Table 3; the proportion of correctly recalled target words is provided for each study condition. Subjects were scored for recalling target words (e.g., fireplace) and not for recall of conceptually related words. Each proportion is based on 216 Subject × Item observations except the single presentation condition, which is based on 432 observations.

A primary question is whether repetition and spacing effects occurred in free recall in the exact repetition condition. A one-way ANOVA that included single presentation, massed

Table 3
Proportion of Target Words Free Recalled Following Various Study Conditions in Experiment 2

Study condition	Repetition lag 0 (massed)	Repetition lag 9 (spaced)	*M*
Target	—	—	.09
Target–target	.31	.36	.34
Target–synonym	.22	.25	.23
Target–coordinate	.25	.22	.24
Target–associate	.26	.21	.24

repetition, and spaced repetition conditions was significant, $F(2, 70) = 29.70$, $MS_e = .025$. Newman-Keuls comparisons revealed that repeated presentation of a word, whether in the massed (.31) or spaced (.36) condition, led to significantly greater recall of that word relative to the recall of a singly presented word (.09). The improvement in recall for spaced repetitions over massed repetitions was not reliable. Recall performance, therefore, reflected a strong repetition effect but only a weak tendency toward a spacing effect.

The second important finding is that presentation of an item conceptually related to an earlier presented target item enhanced recall of the target relative to the single presentation condition but not as much as in the exact repetition condition. The proportion of target words correctly recalled in each of the five study conditions (collapsed over the spacing variable, which had no effect) was submitted to a one-way ANOVA, which was significant, $F(4, 175) = 12.55$, $MS_e = .022$. The Newman-Keuls method of multiple comparisons revealed that the repeated presentation condition (.34) was reliably greater than the other four presentation conditions and that the three paired presentations (.24, .24, and .23) were not different among themselves but were all reliably greater than the single-presentation condition (.09). Thus, as expected, target recall was influenced by additional conceptual information present at study; relative to the single presentation of an item, recall improved for items followed by a synonym, coordinate, or associate.

A subsidiary 3 (conceptual repetition condition) × 2 (spacing condition) ANOVA revealed nonsignificant main effects of presentation, $F(2, 70) = 1.84$, $MS_e = .038$, and of spacing, $F(1, 35) < 1$, and a nonsignificant interaction between presentation and spacing, $F(2, 70) = 1.09$, $MS_e = .037$. This confirms that the presentation of a synonym, coordinate, or associate in a massed or spaced condition had similar effects on the later recall of the related target item.

These results replicate Kolers and Gonzalez's (1980) finding that recall of a target item followed by a synonym was intermediate between the recall of target items presented once and those presented twice. We also replicated Neely and Balota's (1981) finding that recall of a target followed by a semantically related item was similar whether the related item was presented in a massed or spaced condition, and in both cases recall was greater than recall of target items presented once.

Fragment completion. The fragment-completion results are presented in Table 4; the proportion correctly completed is provided for each study condition. The number of Subject × Item observations was 216 for the exact and conceptual repetition conditions but 432 for the nonstudied and single presentation conditions. Reliable priming effects were found in all study conditions, with superior completion rates for studied items than for nonstudied items. A preliminary ANOVA on the total proportion of fragments completed in each of the six study conditions was significant, $F(5, 210) = 18.86$, $MS_e = .030$. The Dunnett method of comparing all means with a control (Winer, 1971, p. 201) revealed that all studied conditions were reliably greater than the nonstudied condition.

Although all conditions produced reliable priming, none differed significantly among themselves. We conducted several analyses on the results but report only the most straightforward. Because a preliminary ANOVA indicated no effect of lag, we conducted an ANOVA on the mean performance in the five conditions in which targets had been studied, which was not significant, $F(4, 175) = 1.00$, $MS_e = .034$. A Newman-Keuls procedure indicated that no two means were significantly different.

The main purpose of Experiment 2 was to confirm the finding from Experiment 1 that indirect priming does not affect word-fragment completion. We found that adding an indirect prime to a direct prime did not affect the amount of priming, as expected. However, this outcome is undercut by the unexpected finding that presentation of two direct primes also had no significant effect on priming relative to one prime. If a second direct prime does not add to the impact of a first prime, then it is hardly surprising that an indirect prime fails to do so. Because of the large number of conditions included in Experiment 2, the number of observations per condition was not great; hence, experimental power was rather low. In Experiment 3, we repeated some conditions of Experiment 2 with a more powerful design.

Despite the inconclusiveness of these word-fragment completion results with respect to the issue of indirect priming, the contrast with free-recall results is interesting for two reasons. First, under the current presentation conditions, the effects of repetition were quite powerful in free recall (25% greater recall from two than from one presentation and 15% greater recall from a conceptual repetition), but these factors had no statistically detectable effect on primed fragment completion. This contrast points up yet more differences between a data-driven implicit test and a conceptually driven

Table 4
Proportion of Fragments Completed in Each Study Condition in Experiment 2

Study condition	Repetition lag 0 (massed)	Repetition lag 9 (spaced)	*M*	Priming
Target	—	—	.53	.31
Target–target	.55	.56	.56	.34
Target–synonym	.45	.50	.48	.26
Target–coordinate	.50	.53	.51	.29
Target–associate	.56	.52	.54	.32
Nonstudied	—	—	.22	—

explicit test (see Roediger, Weldon, & Challis, 1989, for others).

Experiment 3

The purpose of Experiment 3 was to determine if repetition and spacing effects could be obtained in primed word-fragment completion.[1] We included only single-presentation and exact-repetition conditions (with spacing manipulated as in Experiment 2). Half the subjects were tested on free recall and half on word-fragment completion.

Method

Subjects. One hundred sixty-eight Purdue undergraduates participated to complete an introductory course requirement.

Materials and design. The stimulus materials were the same 72 target words and their corresponding word fragments used in Experiments 1 and 2. The study conditions were: (a) once presented, (b) massed repetition (lag of zero), and (c) spaced repetition (lag of nine). A base list was constructed that included 18 once-presented, 18 massed-repetition, and 18 spaced-repetition items. In the base list, instances of each of the three study conditions occurred with equal frequency in each third of the list. An additional 10 unrelated items were included at the end of the list to serve as filler items between the first and second presentations of a spaced repetition. The base list contained 100 items. Eighteen items were assigned to a nonstudied condition. Over 12 lists, each of the 72 target items occurred three times in each study condition, once in each third of the list, and three times in a nonstudied condition.

Eighty-four subjects were randomly assigned to a free-recall or a word-fragment completion test condition.

Procedure. Subjects were tested in groups of 7 to 9. The procedure was the same as that in Experiment 2.

Results and Discussion

Free recall. The proportions of items recalled in the single-presentation, massed-repetition, and spaced-repetition conditions were .19, .24, and .31, respectively. Each proportion was based on 1,512 Subject × Item observations. A one-way ANOVA indicated a reliable effect, $F(2, 166) = 17.53$, $MS_e = .017$. Newman-Keuls comparisons verified that massed repetition of a target word led to significantly greater recall of that word relative to the recall of a singly presented word. As well, the spacing of repetitions significantly improved recall over massed repetition.

Unlike the results in Experiment 2, the spacing manipulation had a significant impact on performance here. The power of Experiment 3 was greater as a result of more numerous observations per condition, but details of list construction differed somewhat too. Regardless of the reason for a significant spacing effect here, we can proceed with more confidence to seek repetition and spacing effects in primed word-fragment completion under these experimental conditions.

Fragment completion. The fragment-completion results are presented in Table 5; the proportion correctly completed and priming scores are provided for each study condition. Each proportion was based on 1,512 Subject × Item observations. Word fragments were more likely to be correctly completed for words presented once during study relative to nonstudied items, $F(1, 83) = 320.05$, $MS_e = .032$.

Table 5
Proportion of Fragments Completed and Priming in Experiment 3

Study condition	Proportion correct	Priming
Once presented	.54	.33
Massed repetition	.55	.34
Spaced repetition	.61	.40
Nonstudied	.21	—

A one-way ANOVA that included once-presented, massed-repetition, and spaced-repetition conditions was significant, $F(2, 166) = 5.91$, $MS_e = .023$. The Newman-Keuls comparison revealed that, relative to words presented only once (.54), the massed repetition of words (.55) did not reliably improve fragment-completion performance. However, the spaced repetition of words (.61) did reliably improve performance relative to massed repetitions and single presentations. These results show that repetition and spacing effects can be obtained in primed word-fragment completion confirming Greene's (1990) finding. However, these effects apparently occur only under conditions of spaced repetitions; massed repetition is roughly equivalent to a single presentation in our results and in most others (e.g., Challis & Brodbeck, in press; Greene, 1990; Jacoby & Dallas, 1981). This outcome contrasts with free recall in which even massed repetitions generally produce reliably greater recall than do single presentations.

Experiment 4

Fortified by the knowledge that repetition and spacing effects could be obtained in primed word-fragment completion, we doggedly returned to our original question concerning the effects of indirect primes (or conceptual repetitions) on free recall and primed word-fragment completion. To enhance our chances of finding repetition effects if they were to be found, we manipulated spacing over a wide range (lags up to 31) and used only one type of conceptual repetition instead of three to provide more observations per condition. We chose the associate condition because it had produced the largest (albeit still nonsignificant) tendency toward indirect priming in Experiments 1 and 2.

Method

Subjects. One hundred forty-four Purdue undergraduates participated as part of an introductory course requirement.

Materials and design. The stimulus materials were the same 72 target words and their corresponding associates and word fragments used in the previous experiments. At study, a target word was presented in one of three conditions: (a) once presented, (b) exact repetition, or (c) conceptual repetition in which the target was preceded by an associate. In the repetition conditions, the second item of the pair (the target) was presented with a lag of 0, 10, 21, or 31

[1] Greene's (1990) report of positive spacing effects in several implicit tests had not appeared at the time our experiment was conducted.

after its associate. Subjects received either a free-recall or a word-fragment completion test.

A base list of 108 stimulus items was constructed containing 3 different blocks of 36 items. Each block consisted of 2 conceptual repetitions and 2 exact repetitions in each of the 4 lag conditions and 4 single presentations. The position of the 20 target items and 16 associates in each block was randomized within the limitations imposed by the spacing requirements. The 3 blocks were combined to form the base list. Then 12 lists were constructed such that each target word occurred once in each of the Repetition × Lag conditions and twice in both the single and nonstudied conditions. Each list contained 60 of the 72 target items; 12 target items served as nonstudied items. Nine buffer items were included at the beginning and at the end of each list, resulting in a study list of 126 items (60 targets plus repetitions, associates, and buffers).

Of the subjects who studied a particular list, one half received a free-recall test, and the other half were administered a word-fragment completion test. Across all lists, 72 subjects received each type of test.

Procedure. Subjects were tested in groups of 6 to 8. The procedure was the same as that used in Experiments 2 and 3.

Results and Discussion

Free recall. The results of the free-recall test are presented in the top panel of Figure 1; the proportion of correctly recalled targets is provided for each study condition. The number of Subject × Item observations was 420 in each repetition condition and 1,680 in the once-presented condition. It is apparent that repetition and lag effects were obtained in the exact repetition condition, but an inverse lag effect was obtained in the conceptual repetition condition: A target following an associate at zero lag was recalled better than one following at a long lag.

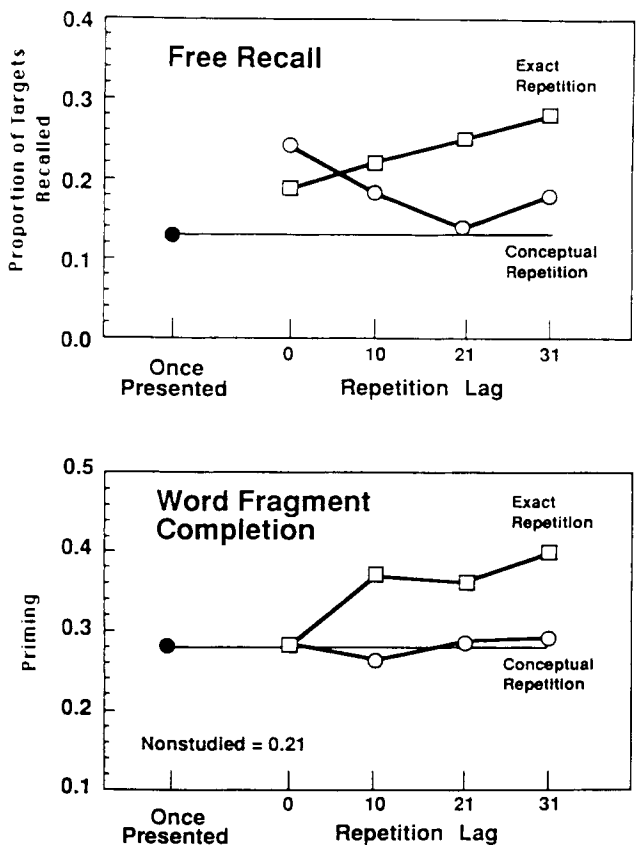

Figure 1. Free recall (top panel) and primed word-fragment completion (bottom panel) as a function of study condition in Experiment 4. (Priming scores in the lower panel represent performance above the nonstudied baseline. The line in each panel indicates the performance level from a single presentation.)

The proportion of target words correctly recalled in each of the three study conditions (collapsed over the spacing variable) was submitted to a one-way ANOVA, which was significant, $F(2, 213) = 13.54$, $MS_e = .015$. Newman-Keuls comparisons revealed that exact repetitions (.23) were recalled reliably better than conceptual repetitions (.18) and that both repetition conditions produced reliably greater recall than did single presentations (.13).

A subsidiary 2 (repetition condition) × 4 (lag) ANOVA revealed a nonsignificant main effect of spacing, $F(3, 213) = 1.24$, $MS_e = .025$, a significant main effect of type of repetition, $F(1, 71) = 12.00$, $MS_e = .028$, and a significant interaction between spacing and repetition, $F(3, 213) = 8.06$, $MS_e = .024$.

To assess further the effects of spacing within each repetition condition, the proportion of target words correctly recalled in each of the four lag conditions, along with the single-presentation condition, was submitted to a one-way ANOVA. This analysis was significant for the exact repetition condition, $F(4, 355) = 7.40$, $MS_e = .033$, and for the conceptual repetition condition, $F(4, 355) = 4.93$, $MS_e = .026$. Finally, we tested the advantage in recall for conceptual relative to exact repetitions at the zero lag condition (.24 vs. .19) and found it to be significant, $t(71) = 2.07$, $p = .04$, two-tailed.

Fragment completion. The fragment-completion results are presented in the lower panel of Figure 1; the priming is provided for each study condition (relative to a .21 nonstudied baseline). A planned comparison verified that word fragments were more likely to be correctly completed for words presented once during study (.49) compared with nonstudied items (.21), $F(1, 71) = 193.21$, $MS_e = .058$.

The proportion of fragments correctly completed in each of the three study conditions (collapsed over the spacing variable) was submitted to a one-way ANOVA, which was significant, $F(2, 213) = 5.03$, $MS_e = .025$. Newman-Keuls comparisons revealed that priming in the once-presented condition (.49) did not differ reliably from the conceptual repetition condition (.50) and that the exact repetition condition (.57) produced significantly greater priming than did the once-presented and conceptual repetition conditions.

A subsidiary 2 (repetition condition) × 4 (spacing condition) ANOVA revealed a significant effect of spacing, $F(3, 213) = 2.67$, $MS_e = .041$, a significant main effect of repetition, $F(1, 71) = 12.91$, $MS_e = .056$, and a significant interaction between spacing and repetition, $F(3, 213) = 3.33$, $MS_e = .033$.

A one-way ANOVA of the four conceptual repetition lag conditions and the once-presented condition was not significant, $F(4, 355) < 1$, whereas a similar analysis involving the exact repetition condition and once-presented condition was significant, $F(4, 355) = 5.63$, $MS_e = .042$.

The results of Experiment 4, taken with those of earlier experiments, show that in free recall (averaged over lags) exact repetition has a greater benefit than does conceptual repetition, but the latter condition adds significantly to the effect of a single presentation on target recall (albeit at short lags). Alternatively, effects of exact repetition seem much smaller (although significant) in primed word-fragment completion, but the effect of conceptual repetition is nil. Even at lag zero in which conceptual repetition had its greatest effect in free recall, the effect on primed word-fragment completion was no greater than a single presentation of the target. This conclusion agrees with that drawn from Experiments 1 and 2: Indirect (or conceptual) priming has no effect on primed word-fragment completion.

General Discussion

The main findings of the four experiments reported here are relatively straightforward. The primary goal was to study direct and indirect priming on word-fragment completion, believed to be an implicit memory test that is largely perceptual (or data driven) in nature. Although direct priming had large effects on primed word-fragment completion, we failed to find any reliable effect of indirect primes. This held true when indirect primes appeared by themselves during the study phase (Experiment 1) or when indirect primes and direct primes were both included (Experiments 2 and 4). In the latter case, indirect primes failed to add to the effect of direct primes on word-fragment completion. Our manipulation of conceptual priming was not too weak to exert an effect, because the conceptual repetition manipulation in Experiments 2 and 4 had sizable effects on free recall of target words. (In addition, the conceptual primes had a large effect on fragment completion when the primes and fragments were presented simultaneously in Experiment 1.) We conclude that the basis of primed word-fragment completion does not depend on conceptual elaboration as does free recall.

The other findings of interest in these experiments have to do with exact repetition and the spacing of repetitions. In general, the results of Experiments 2, 3, and 4 show that repetition effects occurred in both primed word-fragment completion and free recall but that these effects seem much smaller and more fragile in word-fragment completion. We hasten to qualify this assertion by noting the difficulties in comparing performance on these two tasks based on different measurement scales with different inherent variability. Nonetheless, with this proviso, a measure of relative treatment magnitude, omega squared, revealed that exact repetition effects were consistently greater in free recall than primed word-fragment completion in Experiments 1, 2, and 3. As well, repetition and spacing effects in perceptually based implicit tests are small and notoriously variable (e.g., Challis & Brodbeck, in press; Jacoby & Dallas, 1981; Musen & Treisman, 1990; Perruchet, 1989; Schacter, Cooper, Delaney, Peterson, & Tharen, 1991), although Greene (1990) also reported significant effects like those we find in Experiments 3 and 4. Given that the effects operate in the same direction in both primed word-fragment completion and free recall, there seems little theoretical import to hang on the possibly slighter effect of these variables on perceptual implicit memory tests than on free recall.

We now know of many variables that affect free recall and primed word-fragment completion differently. These include: (a) modality of presentation (greater priming from visual than auditory presentation in word-fragment completion but no difference in free recall; Blaxton, 1989; Donnelly, 1988; Roediger & Blaxton, 1987a); (b) presentation of pictures versus words (picture superiority in free recall, the reverse in word-fragment completion; e.g., Roediger & Weldon, 1987); (c) language of presentation for bilinguals (see Durgunoğlu & Roediger, 1987); (d) levels of processing (positive effects in free recall and little or no effect in primed word-fragment completion; e.g., Srinivas & Roediger, 1990, Experiment 3); (e) reading words out of context relative to generating them from a conceptual clue (reading produces greater primed word-fragment completion and generating produces greater recall; Blaxton, 1989; Smith & Branscombe, 1988); (f) instructions to form mental images of words at study (positive effect on free recall and no effect on primed fragment completion when typography at test matches that at study; Blaxton, 1989). To these we may now add; (g) effects of indirect (conceptual) primes, which have no effect on primed word-fragment completion but boost recall of targets in free recall.

All seven of these differences can be accounted for by the transfer-appropriate processing approach emphasizing a distinction between perceptually based processes critical in primed word-fragment completion and conceptual processes believed to be more important in free recall (see Roediger, Weldon, & Challis, 1989; also Blaxton, 1989; Roediger, Srinivas, & Weldon, 1989; for further explanation). In brief, the manipulations that involve conceptual elaboration generally affect free recall but not primed word-fragment completion, whereas manipulation of surface features without accompanying effects on conceptual processing (such as modality manipulations) have effects on primed word-fragment completion but not on free recall. Other theorists emphasizing transfer-appropriate processing, such as Graf and Ryan (1990), can also account for these results although they make slightly different assumptions. Indeed, the findings reported in the foregoing experiments are not uniquely supportive of the transfer-appropriate processing approach but can be readily accommodated by any view that distinguishes between perceptual and conceptual components of tasks, such as Schacter's (1990) and Tulving and Schacter's (1990) proposal that various perceptual representation systems exist for words and objects (that would presumably be unaffected by indirect priming) and other systems (episodic and semantic memory) that represent conceptual information and, hence, would be so affected.

Several recent reports provided evidence against the separation of perceptual and conceptual components operating differently in various memory tests (e.g., Hirshman et al., 1990; Hunt & Toth, 1990). The general form of the evidence is to show either that some manipulation that seems perceptual in nature can affect performance on a test like free recall (believed to be conceptually driven) or to show effects of some conceptual manipulation on tests that seem perceptually based. Of course, as Roediger and Blaxton (1987b) pointed

out, the tests for assessing perceptual and conceptual processing are not factor pure because primed word-fragment completion reveals cross-modal (auditory to visual) and cross-form (picture to word) priming effects even if these are generally much smaller than same-form priming effects. On the basis of some recent results, Weldon (1991) argued that lexical processing is critical in establishing priming in word fragment completion and other perceptual implicit tests that are verbal. Kirsner, Dunn, and Standen (1989) argued for both modality-specific and modality-independent components in perceptual tests; the modality-independent component may be some abstract lexical representation similar to Weldon's (1991) proposed idea.

On the basis of these findings, several researchers suggested that conceptual factors play a significant role in perceptual priming tests, such as completing word fragments (e.g., Bassili, Smith, & MacLeod, 1989; Hirshman et al., 1990; Masson & Freedman, 1990; Masson & MacLeod, in press; Toth & Hunt, 1990). The present results, consistently showing no effect of indirect or conceptual primes on word-fragment completion, seem problematic for these proposals. If presentation of *elephant* enhances the later probability of completing _lep_an_ by about .30, and if a good part of this priming is due to conceptual factors, then why should prior presentation of *pachyderm* produce no detectable priming? In attempting to solve this problem, we hope that proponents of the idea that conceptual processes pervade seemingly perceptual implicit tests will attend to the other six differences between free recall and primed fragment completion noted previously and provide an account capable of explaining them too.

We hasten to add that we see the separation of cognitive processes on memory tests into the two broad classes of perceptual and conceptual components as quite preliminary and as greatly needing further specification. Clearly, many tasks, such as rereading inverted text, involve both conceptual and perceptual components in producing a benefit from repetition (Kolers, 1975; see also Jacoby, Levy, & Steinbach, 1992). Roediger and Blaxton (1987b) argued that tests could be arranged along a dimension or continuum reflecting differential amounts of perceptual or conceptual processing. Now we argue for at least two dimensions or continua: one reflecting perceptual processing and the other, conceptual processing (Tulving & Schacter, 1990; Weldon, 1991). This change emphasizes that the two dimensions are separate and do not necessarily trade off against one another as would be implied by a single continuum. Also, encoding or test manipulations could then emphasize either or both types of processing. Clearly, even with this change, the proposal is too simple and must be fleshed out. Perceptual priming involves modality-dependent and modality-independent components (Donnelly, 1988; Kirsner et al., 1989), and the latter likely involves lexical processing (Weldon, 1991). There is no doubt that conceptual priming will turn out to be complex too, but we avoid further speculation on this matter for the moment because it is unwarranted by the present results.

The results of Experiment 1 clarify what we mean by a test being perceptual in nature, or data driven. We use these terms when test items are single words or pictures that have been degraded either by omitting information or presenting items at fast rates so that context provides no top-down operations to help resolve the perceptual puzzle. Of course, if context is added to the test cue, as in priming of new associations (Graf & Schacter, 1985) or numerous other manipulations, then it is no surprise to see the task reflect both a perceptual and conceptual component (see Weldon et al., 1989).

Still, recent work indicates that even tasks considered relatively factor pure in terms of data-driven or conceptually driven processing—such as free recall or perceptual identification, respectively—can sometimes be affected by factors reflecting the other type of processing. For example, Hunt and Toth (1990) showed that orthographic distinctiveness of words has a significant effect both on primed fragment completion and free recall: Words with unusual orthographies produced more priming in word-fragment completion (hence implicating the variable as data driven) but also were better recalled than orthographically common words. Similarly, others reported greater priming on a picture-fragment identification task from generating a word from a sentence context than from reading it out of context, which argues that perceptual identification of pictures may involve conceptually driven processes (Hirshman et al., 1990). It is unclear at present how these and other puzzles can be reconciled with the seven findings reviewed earlier that provide support for the notion that tasks such as free recall and primed word-fragment completion are differentially sensitive to perceptual and conceptual components of experience. A simple but rather unsatisfying solution is simply to argue that no tests are factor pure—perceptual and conceptual operations can affect all memory tests under the right circumstances—but that free recall (and other explicit and implicit tests that are largely conceptually driven) will be more affected by conceptual operations, whereas perceptual tests (primed word-fragment completion and so on) will be more affected by manipulations that affect perceptual processes such as modality. We must await future research to determine if this rather simple assumption will account for the puzzles that have appeared in the literature or whether some more fundamental changes in theory must be made. Ultimately, of course, the latter position must be correct, but for the moment we see many advantages in continuing to consider dissociations among memory tests as reflecting differential transfer from various aspects of prior experience in line with the ideas originally propounded by Morris et al. (1977).

Finally, another limitation of the present experiments should be noted. We compared two tests—free recall and primed word-fragment completion—that differ in several characteristics besides the ones of interest. For example, free recall is explicit and no retrieval cues are provided, whereas word-fragment completion is implicit and provides a lexical cue for the target. Our interest in these experiments was on comparing performance on a relatively pure conceptual and perceptual test and not on comparing performance per se on explicit and implicit tests. Still, it should be of interest to determine if the present findings extend to other tests. The transfer-appropriate processing principle predicts that conceptual priming and conceptual repetition should affect conceptually driven tests, even over delays, but should have little effect on perceptual tests (whether explicit or implicit) except

under short-delay conditions. Some evidence from the prior literature mentioned at the beginning of this article is germane to these predictions (e.g., the work by Dannenbring & Briand, 1982, on semantic and repetition priming in the lexical decision task). Also Clifton (1966) showed priming of associates on a free association test under conditions that would probably lead the test to be classified as an implicit conceptual test today (but see Cramer, 1964). In addition, presenting conceptually related words before a recognition test (an explicit and largely conceptual test) produces false alarms to their semantically related lures (Underwood, 1965). Conceptual repetition affects recognition too (Neely & Balota, 1981). We must await further work to determine if the findings reported here about indirect priming and conceptual repetition will generalize to other perceptual and conceptual tests (both implicit and explicit), but the findings from prior work make such generalizations seem likely.

References

Bassili, J. N., Smith, M. C., & MacLeod, C. M. (1989). Auditory and visual word-stem completion: Separating data-driven and conceptually-driven processes. *Quarterly Journal of Experimental Psychology, 41A*, 439–453.

Blaxton, T. A. (1989). Investigating dissociations among memory measures: Support for a transfer-appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 657–668.

Challis, B. H., & Brodbeck, D. R. (in press). Level of processing affects priming in word fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition.*

Clifton, C. (1966). Some determinants of the effectiveness of priming word associates. *Journal of Verbal Learning and Verbal Behavior, 5*, 167–171.

Cofer, C. N. (1967). Conditions for the use of verbal associations. *Psychological Bulletin, 68*, 1–12.

Cramer, P. (1964). Successful mediated priming via associative bonds. *Psychological Reports, 15*, 235–238.

Dannenbring, G. L., & Briand, K. (1982). Semantic priming and the word repetition effect in a lexical decision task. *Canadian Journal of Psychology, 36*, 435–444.

Davelaar, E., & Coltheart, M. (1975). Effects of interpolated items on the association effect in lexical decision task. *Bulletin of the Psychonomic Society, 6*, 269–272.

Dominowski, R. L., & Ekstrand, B. R. (1967). Direct and associative priming in anagram solving. *Journal of Experimental Psychology, 74*, 84–86.

Donnelly, R. E. (1988). *Priming across modality in implicit memory: Facilitation from auditory presentation to visual test of word-fragment completion.* Unpublished doctoral dissertation, University of Toronto, Toronto, Ontario, Canada.

Durgunoğlu, A. Y., & Roediger, H. L. (1987). Test differences in accessing bilingual memory. *Journal of Memory and Language, 26*, 377–391.

Graf, P., & Ryan, L. (1990). Transfer-appropriate processing for implicit and explicit memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 978–992.

Graf, P., & Schacter, D. L. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11*, 501–518.

Greene, R. L. (1990). Spacing effects on implicit memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 1004–1011.

Hirshman, E., Snodgrass, J. G., Mindes, J., & Feenan, K. (1990). Conceptual priming in fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 634–647.

Hunt, R. R., & Toth, J. P. (1990). Perceptual identification, fragment completion, and free recall: Concepts and data. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 282–290.

Jacoby, L. L. (1983). Remembering the data: Analyzing the interactive processes in reading. *Journal of Verbal Learning and Verbal Behavior, 22*, 485–508.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 110*, 306–340.

Jacoby, L. L., & Hayman, C. A. G. (1987). Specific visual transfer in word identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*, 456–463.

Jacoby, L. L., Levy, B. A., & Steinbach, K. (1992). Episodic transfer and automaticity: Integration of data-driven and conceptually driven processing in rereading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 15–24.

Kirsner, K., Dunn, J. C., & Standen, P. (1989). Domain-specific resources in word recognition. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical issues* (pp. 99–122). Hillsdale, NJ: Erlbaum.

Kolers, P. A. (1975). Specificity of operations in sentence recognition. *Cognitive Psychology, 7*, 289–306.

Kolers, P. A., & Gonzalez, E. (1980). Memory for words, synonyms, and translations. *Journal of Experimental Psychology: Human Learning and Memory, 6*, 53–65.

Lewandowsky, S., Kirsner, K., & Bainbridge, V. (1989). Context effects in implicit memory: A sense-specific account. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical issues* (pp. 185–198). Hillsdale, NJ: Erlbaum.

Mandler, G., Graf, P., & Kraft, D. (1986). Activation and elaboration effects in recognition and word priming. *Quarterly Journal of Experimental Psychology. Section A: Human Experimental Psychology, 38A*, 645–662.

Mandler, G., Hamson, C. O., & Dorfman, J. (1990). Tests of dual process theory: Word priming and recognition. *Quarterly Journal of Experimental Psychology. Section A: Human Experimental Psychology, 42A*, 713–739.

Masson, M. E. J., & Freedman, L. (1990). Fluent identification of repeated words. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 355–373.

Masson, M. E. J., & MacLeod, C. M. (in press). Re-enacting the route to interpretation: Context dependency in encoding and retrieval. *Journal of Experimental Psychology: General.*

Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90*, 227–234.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior, 16*, 519–533.

Musen, G., & Treisman, A. (1990). Implicit and explicit memory for visual patterns. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 127–137.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General, 106*, 226–254.

Neely, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In D.

Besner & G. W. Humphreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264–336). Hillsdale, NJ: Erlbaum.

Neely, J. H., & Balota, D. A. (1981). Test-expectancy and semantic-organization effects in recall and recognition. *Memory & Cognition, 9,* 283–300.

Overson, C., & Mandler, G. (1987). Indirect word priming in connected and phonological contexts. *Bulletin of the Psychonomic Society, 25,* 229–232.

Perruchet, P. (1989). The effect of spaced-practice on explicit and implicit memory. *British Journal of Psychology, 41,* 320–331.

Rappold, V. A., & Hashtroudi, S. (1991). Does organization improve priming? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 103–114.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology, 39,* 475–543.

Roediger, H. L. (1990). Implicit memory: Retention without remembering. *American Psychologist, 45,* 1043–1056.

Roediger, H. L., & Blaxton, T. A. (1987a). Effects of varying modality, surface features, and retention interval on priming in word fragment completion. *Memory & Cognition, 15,* 379–388.

Roediger, H. L., & Blaxton, T. A. (1987b). Retrieval modes produce dissociations in memory for surface information. In D. Gorfein & R. R. Hoffman (Eds.), *Memory and cognitive processes: The Ebbinghaus centennial conference* (pp. 349–379). Hillsdale, NJ: Erlbaum.

Roediger, H. L., Srinivas, K., & Weldon, M. S. (1989). Dissociations between implicit measures of retention. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical issues* (pp. 67–84). Hillsdale, NJ: Erlbaum.

Roediger, H. L., & Weldon, M. S. (1987). Reversing the picture superiority effect. In M. A. McDaniel & M. Pressley (Eds.), *Imagery and related mnemonic processes: Theories, individual differences, and applications* (pp. 151–174). New York: Springer-Verlag.

Roediger, H. L., Weldon, M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 3–14). Hillsdale, NJ: Erlbaum.

Scarborough, D. L., Cortese, C., & Scarborough, H. S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance, 3,* 1–17.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 501–518.

Schacter, D. L. (1990). Perceptual representation systems and implicit memory: Toward a resolution of the multiple memory systems debate. In A. Diamond (Ed.), Development and neural bases of higher cognitive functions. *Annals of the New York Academy of Sciences, 608,* 543–578.

Schacter, D. L., Cooper, L. A., Delaney, S. M., Peterson, M. A., & Tharen, M. (1991). Implicit memory for possible and impossible objects: Constraints on the construction of structural descriptions. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 3–19.

Shimamura, A. P. (1986). Priming effects in amnesia: Evidence for a dissociable memory function. *Quarterly Journal of Experimental Psychology, 38A,* 619–644.

Smith, E. S., & Branscombe, N. (1988). Category accessibility as implicit memory. *Journal of Experimental Social Psychology, 24,* 490–504.

Srinivas, K., & Roediger, H. L. (1990). Testing the nature of two implicit tests: Category association and anagram solution. *Journal of Memory and Language, 29,* 389–412.

Toth, J. P., & Hunt, R. R. (1990). Effect of generation on a word-identification task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 993–1003.

Tulving, E., & Gold, C. (1963). Stimulus information and contextual information as determinants of tachistoscopic recognition of words. *Journal of Experimental Psychology, 66,* 319–327.

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science, 247,* 301–305.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 336–342.

Underwood, B. J. (1965). False recognition produced by implicit verbal response. *Journal of Experimental Psychology, 70,* 122–129.

Weldon, M. S. (1991). Mechanisms underlying priming on perceptual tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 526–541.

Weldon, M. S., Roediger, H. L., & Challis, B. H. (1989). The properties of retrieval cues constrain the picture superiority effect. *Memory & Cognition, 17,* 95–105.

Winer, B. J. (1971). *Statistical principles in experimental design.* (2nd ed.). New York: McGraw-Hill.

Received February 17, 1991
Revision received June 6, 1991
Accepted June 7, 1991 ■