

Repetition Priming Effects for Newly Formed Associations Are Perceptually Based: Evidence From Shallow Encoding and Format Specificity

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This article is concerned with memory for newly formed associations as displayed on implicit and explicit tests of memory. After studying a list of word pairs, participants were shown the original intact pairs and pairs formed by recombining the original pairs. Pairs were simultaneously presented both at study and at test. In a lexical-decision task in which participants were asked to indicate whether both items were words, responses to intact pairs were faster than to recombined pairs. The size of this association-specific repetition effect was relatively unaffected by a levels-of-processing manipulation, indicating that conceptual processes did not likely contribute to the production of the effect. Furthermore, the effect was not produced when pairs were presented simultaneously at study but sequentially at test, thus highlighting the importance of format of presentation. Finally, in an explicit speeded-recognition task the size of the association-specific effect was largely affected by levels-of-processing manipulation and was revealed even under sequential test presentation suggesting that the associative repetition effects were not contaminated by conscious recollection. Together, the results show that perceptual factors are involved in both storage and retrieval of associative information in data-driven implicit tests of memory.

Our goal in this research was to determine whether there is a perceptual basis to the formation and recovery of newly formed associations on implicit tests of memory. With traditional explicit tests, memory is directly recovered by asking participants to reflect back and recall or recognize target items as having appeared in the study episode. With implicit tests, in contrast, memory is observed indirectly by noting the changes in performance on tasks that require no reference to the study episode. In one subset of implicit tests, a perceptual overlap exists between studied items and test cues (for other subsets, see Moscovitch, Vriezen, & Goshen-Gottstein, 1993). These perceptual or data-driven implicit memory tests include perceptual identification of degraded stimuli (e.g., Jacoby, 1983; Jacoby & Dallas, 1981), word stem completion (Graf & Schacter, 1985), word fragment completion (e.g., Graf, Mandler, & Haden, 1982; Tulving, Schacter, & Stark, 1982; Warrington & Weiskrantz, 1968, 1974), speeded reading (Kollers, 1976; Moscovitch, Winocur, & McLachlan, 1986), or lexical decision (e.g., Glass & Butters, 1985; McKoon & Ratcliff, 1979; Moscovitch, 1985; Scarborough, Cortese, & Scarborough, 1977; Scarborough, Gerard, & Cortese, 1979). Typically, the probability that particular items will be pro-

duced as correct responses to these tasks is enhanced if these items were presented in the study episode. This facilitation in performance toward studied items on implicit tests is the *repetition effect*, known also as *repetition priming*.

In this article, we argue that perceptual factors are involved in the production of the repetition effect for word pairs. This effect, known as the *associative repetition effect* or *associative repetition priming*, is observed when responses to word pairs are faster or more accurate when these pairs are presented in the same combinations as at study (e.g., study: *pause-weird* and *slope-plate*; test: *pause-weird* and *slope-plate*, the intact condition) than when they are rearranged to form new pairs (e.g., study: *pause-plate* and *slope-weird*; test: *pause-weird* and *slope-plate*, the recombined condition). Because all of the words are presented for study, an advantage for the intact over the recombined pairs can only be explained in terms of implicit memory for the associative information.

Converging evidence suggests that item-specific repetition effects have a perceptual basis (for reviews see Kirsner & Dunn, 1985; Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; Schacter, 1987). Evidence for a perceptual basis of association-specific repetition effects is less conclusive. In this article, we present two new findings that suggest that perceptual processes are indeed involved in producing association-specific repetition effects. First, we demonstrate that a levels-of-processing manipulation alters the magnitude of association-specific priming only slightly, suggesting that conceptual processes do not play a critical role in the production of the effect. Second, we show that the effect cannot emerge when format of presentation between study and test is altered. We begin by reviewing the evidence for a perceptual interpretation of item-specific repetition effects, and we describe the less consistent pattern of results that has been observed for association-specific effects.

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Two lines of evidence suggest that perceptual processes are involved in the production of item-specific repetition effects. The first line of evidence is found in demonstrations that unlike performance on explicit tests, in which shallow encoding leads to considerably worse performance than deep encoding (Craik & Lockhart, 1972; Craik & Tulving, 1975), repetition effects are only slightly influenced (Challis & Brodbeck, 1992; but see Toth, Reingold, & Jacoby, 1994) or not at all by levels-of-processing manipulations. Therefore, conceptual processes contribute little, if at all, to the production of item-specific repetition effects.

The second line of evidence for the involvement of perceptual processes in item-specific repetition effects consists of demonstrations that the perceptual nature of retrieval cues critically affects repetition priming performance. The repetition effect is diminished or completely eliminated if the perceptual similarity of retrieval cues to study items is reduced by crossing modality of presentation between study and test (Blaxton, 1989; Graf, Shimamura, & Squire, 1985; Jacoby & Dallas, 1981; Rajaram & Roediger, 1993; Roediger & Blaxton, 1987; for reviews see Donnelly, 1988; Kirsner, Dunn, & Standen, 1989). Even when study and test presentations are within the same modality, presentation of study and test materials in different formats has been shown to diminish repetition priming considerably. For example, presenting the names of people at study and their faces at test (Young, 1994), and changing the language between study and test (Durgunoglu & Roediger, 1987; Kirsner & Dunn, 1985), have all been shown to reduce greatly the repetition effect (for reviews see Kirsner & Dunn, 1985; Roediger & McDermott, 1993). In contrast, the same manipulations affect performance on explicit recall and recognition only marginally (for modality effects on perceptual explicit tests, see Blaxton, 1989; Roediger, Weldon, Sandler, & Riegler, 1992).

The perceptual gestalt of the retrieval cue has also been found to be of critical importance. Changing the fragments that were used as retrieval cues between two successive tests was shown to lead to independent patterns of successes and failures on fragment completion tasks, even when the information provided by one cue was entirely included in the other cue (Tulving, Hayman, & Macdonald cited in Tulving & Schacter, 1990).

Together, the findings reported above implicate perceptual processes for item-specific repetition priming by showing that shallow encoding is sufficient to produce the effect and by demonstrating that whether items will be recovered can be determined by the perceptual similarity of retrieval cues to study materials as well as by their perceptual gestalt. These manipulations have not had as consistent an effect on association-specific repetition effects.

A number of tasks have been used to study the associative repetition effect. These include stem completion (Graf & Schacter, 1985, 1987, 1989; Micco & Masson, 1991; Schacter & Graf, 1986a, 1989), lexical decision (Carroll & Kirsner, 1982; Dagenbach, Horst, & Carr, 1990; Durgunoglu & Neely, 1987; McKoon & Ratcliff, 1979, 1986; Neely & Durgunoglu, 1985; Smith, MacLeod, Bain, & Hoppe, 1989), speeded reading of degraded stimuli (Moscovitch et al., 1986; Musen & Squire, 1992), and perceptual identifications (Light & LaVoie, 1992;

Musen & Squire, 1992; Paller, unpublished data cited in Mayes, 1992). Only studies using the associative stem completion task (Graf & Schacter, 1985) have yielded consistent positive results and have also addressed the question of whether association-specific repetition effects are perceptual or conceptual in nature.

In the associative stem completion task, participants were initially presented with word pairs for study. At test, one member of the pair was presented alongside the stem (i.e., the first letters of a word) of the other member. Participants were asked to complete the stem with the first word that came to mind. Schacter and Graf (1989) found that crossing modality of presentation between study and test attenuated the associative repetition effect (i.e., reduced the advantage that intact pairs displayed over recombined pairs). This finding, in line with that observed for single items, supports a perceptual interpretation for the associative repetition effect. A different finding, however, calls this interpretation into question. Unlike item-specific repetition effects, association-specific effects were only observed under elaborative encoding conditions. Shallow encoding (e.g., vowel comparison, Graf & Schacter, 1985) was ineffective as was semantic encoding when it only involved the semantic features of the individual items (e.g., pleasantness ratings, Schacter & Graf, 1986a).

To account for these seemingly discrepant findings, Schacter and Graf (1989; see also Schacter & McGlynn, 1989) suggested that the processes mediating the *retrieval* of the association are perceptually based but that *encoding* and *storage* of the association demand deeper relational processing, which is needed for unitizing the previously unrelated pair members into a new representation in memory.

Although Schacter and Graf's (1989) account can accommodate the data, there are reasons to doubt that associative repetition priming, as tested by stem completion, is primarily a perceptual, implicit test of memory. Association-specific priming could not be obtained in amnesic patients (Cermak, Bleich, & Blackford, 1988; Mayes & Gooding, 1989; Schacter & Graf, 1986b; Shimamura & Squire, 1989) or in normal people who were unaware that memory was being tested (Bowers & Schacter, 1990; but see Howard, Fry, & Brune, 1991), though both groups showed normal item-specific repetition priming (Moscovitch et al., 1993; Schacter, 1987; Shimamura, 1986). Using the process-dissociation procedure (Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993), Reingold and Goshen-Gottstein (in press) have recently shown that in those normal people who do show association-specific repetition priming, the effect was dependent almost entirely on conscious recollective (control) processes rather than on automatic, implicit ones.

Together, these findings suggest that conceptual processes at encoding, as well as conscious recollection at retrieval, may contaminate association-specific priming as tested by stem completion. The possibility remains that other tests would not have these drawbacks and would better satisfy the conditions of implicit tests of memory. One such test that appears promising is the simultaneous lexical-decision test, which yielded positive association-specific repetition priming effects in a previous study (Goshen-Gottstein & Moscovitch, 1995b). In this procedure, two simultaneously presented words were presented at study. At test, participants were asked to indicate

whether two simultaneously presented letter strings were both legal English words (for the same task used for a different purpose, see Meyer & Schvaneveldt, 1971). Unlike the stem completion task, this task is speeded, thereby diminishing the likelihood of recruiting recollective processes at retrieval. Word pairs were contiguously presented at study to enable the creation of a unitized memory representation. Test presentation was likewise contiguous to enable the recovery of this unitized representation.

The simultaneous lexical-decision procedure was designed to accommodate predictions derived from the *perceptual contiguity hypothesis* (Goshen-Gottstein & Moscovitch, 1995b). According to this hypothesis, perceptual contiguity is necessary and sufficient for binding items together and retrieving them in data-driven implicit tests of memory. Although semantic relatedness may at times also contribute to the conjoining of items, the perceptual contiguity hypothesis claims that semantic relatedness is not necessary. In Experiment 1, we showed that the association-specific repetition effect, like the item-specific repetition effect, is relatively insensitive to a levels-of-processing manipulation when the simultaneous lexical-decision task was used. Performance on an explicit version of the test, however, was affected by this manipulation.

We further established the importance of perceptual contiguity in Experiment 2, in which the association-specific repetition effect was not produced when pair presentation was changed from simultaneous at study to sequential at test. Sequential test presentation did not allow the recovery of the perceptual information as encoded at study. In contrast, performance on an explicit version of the test was unaffected by changes in format. Thus, perceptual contiguity seems to be a necessary component for recovering associative information implicitly. Together, the relative ineffectiveness of the levels-of-processing manipulation on the size of the association-specific repetition effect and the format specificity of the effect provide converging evidence for the perceptual contiguity hypothesis.

Experiment 1

Recently, Goshen-Gottstein and Moscovitch (1995b) used the simultaneous lexical-decision task and found faster responses to intact than to recombined pairs. Furthermore, the effect was eliminated when modality of presentation was crossed between study and test (see also Schacter & Graf, 1989). This suggested that perceptual processes were involved in obtaining association-specific priming, providing partial support for the perceptual contiguity hypothesis. In this experiment, we sought further evidence for the perceptual nature of associative repetition priming by testing whether, like the item-specific repetition priming effect, it is not sensitive to a levels-of-processing manipulation. Participants, therefore, performed the simultaneous lexical-decision task after studying word pairs either elaborately or under shallow encoding instructions.

To argue that conscious recollection did not contribute to lexical-decision performance, we compared participants' performance on the lexical-decision task with performance on an explicit version of this task under shallow structural and elaborative semantic encoding conditions. In the explicit

version of the task, participants were asked to indicate as quickly as possible whether they remembered having studied both members of the pair either together or separately. Thus, participants were to respond "old" to both intact and recombined pairs. A "new" response was to be made on the explicit recognition test only to pairs in which one or both of the items had not previously been studied (see also Clark & Shiffrin, 1987). This speeded-recognition task simulated the explicit processing that participants would perform if they relied on consciously recollected information to support lexical-decision performance, and this task could therefore serve as a benchmark against which to compare implicit test performance.

A secondary goal of the experiment was to determine whether a different pattern of repetition priming would be found for pairs in which both members of the pair are low-frequency words as compared with pairs in which both members of the pair are high-frequency words. To date, the only consistent demonstration of association-specific repetition priming has been with stem completion as the implicit test. Because stem completion has not produced a reliable frequency effect for single items (Hintzman & Hartly, 1990; Roediger et al., 1992), it could not be used to investigate the effects of frequency on associative repetition. Lexical decision, however, has produced large frequency effects for single items, with a larger repetition effect for low- than for high-frequency words (Duchek & Neely, 1989; Forster & Davis, 1984; Rajaram & Neely, 1992; Scarborough et al., 1977). This task could therefore be used to measure the effect that word frequency has on implicit and explicit tests of memory for new associations.

Method

Participants

Seventy-two University of Toronto undergraduates participated in the experiment. Participants either received course credit for participation or were paid \$5.

Design and Materials

Test type (implicit and explicit) and levels-of-processing instructions (shallow and deep) were manipulated between subjects. Pair type (intact, recombined, and control) and word frequency (low and high) were manipulated within subject and were completely crossed.

The critical test items were 120 word pairs organized into 60 double-pair arrays. For the sake of brevity, we refer to the pairs that made up the double-pair arrays as A-B and C-D pairs (e.g., *pause-weird* and *slope-plate*) and label the A and C items as context words and the B and D items as target words. During all stages of this experiment, the context words were presented to the left of the target words.

Thirty of the double-pair arrays consisted of high-frequency words, with Francis and Kučera (1982) frequencies ranging between 50 and 397 occurrences per million ($M = 116.77$, $SD = 73.48$). The remaining 30 arrays consisted of low-frequency word pairs, with frequencies ranging between 10 and 23 occurrences per million ($M = 14.09$, $SD = 3.62$).

Three constraints were observed in the construction of the double-pair arrays. First, within each array, the word frequency of the target words was equated. For the high-frequency arrays, the B items had a mean Francis and Kučera (1982) word frequency of 100.77 occur-

rences per million ($SD = 52.70$), compared with 101.40 occurrences per million ($SD = 54.08$) for the D items (Pearson $R^2 = .99, p < .001$). A paired t test did not find this difference to be significant, $t(29) = 1.46, p > .15$. For the low-frequency arrays, the B items had a mean frequency of 13.83 occurrences per million ($SD = 3.83$), compared with 13.73 occurrences per million ($SD = 3.85$) for the D items (Pearson $R^2 = .98, p < .001$). This difference, too, did not achieve significance, $t(29) = 0.77, p > .44$. Because the context words were identical for the intact and recombined pairs, no constraints were imposed on them (except for the fact that within an array, all words were either high or low frequency).

The second constraint was that within an array, all members were randomly related. This meant that no obvious semantic relation existed between any of the pairs (for any two words, however, some obscure relation can always be created). The third constraint was that all target words were monosyllabic five-letter words. The context words were also five-letter words. However, some of the context words were monosyllabic, and some were bisyllabic. Within an array, however, the context words were always equated in syllable length.

Test conditions were established by varying study pairs within subject and keeping test pairs uniform across conditions and across subjects (e.g., for a particular array, uniform test presentation may have been A-B and C-D). If pairs were presented in their intact form during study (i.e., A-B and C-D), then the uniform presentation at test constituted the intact condition for that participant. If pairs were presented in their recombined form during study (i.e., A-D and C-B), then the uniform presentation at test constituted the recombined condition and provided a baseline measurement for the association-specific effects. Finally, if the pairs forming the array were not presented at study, then the uniform presentation at test provided a baseline measurement for the item-specific effects.

For counterbalancing purposes, the 60 double-pair arrays were divided into three equally sized blocks, each containing 10 high- and 10 low-frequency arrays (20 high- and 20 low-frequency pairs). Three study lists were then constructed by assigning two of the three blocks (for a sum of 40 high-frequency and 40 low-frequency pairs) to each of the study lists. One block was assigned in its intact form, and one block was assigned in its recombined form. This ensured that each participant would be tested in the three pair type conditions and in the two-word frequency conditions an equal number of times. Assignment of the blocks to the lists and conditions was made in accordance to a Latin square design so that across subjects, each target word would appear in the three pair type conditions an equal number of times.

Implicit condition. In addition to the 80 experimental pairs presented at study, 40 extra pairs, identical for each of the study lists, were added to the study lists. The 80 five-letter words that formed these pairs were to be included in the test list in foil trials that contained nonwords and studied words.

The single test list contained 120 experimental pairs intermixed with 120 foil trials. The foil trials consisted of 40 trials that contained two nonwords and 80 trials that contained a nonword and a studied word, with the nonword serving as context on half the trials and as target on the other half. Inclusion of studied words in the foil trials ensured that study status of the context word would not be completely confounded with the decision on lexicality. It should be noted, however, that because nonwords were not presented at study, a partial confound between study status and lexicality still remained. Still, this partial confound is only problematic to the extent that it would make the lexical decision data look like the explicit recognition data, which to anticipate our findings, it did not (Neely, 1989, pp. 239–242).

All nonwords were derived from legal English words by changing one letter and substituting it with a letter of equal bigram frequency. The parent English words were all five-letter words, with either one or two syllables.

Explicit condition. The test list for the explicit test condition was changed so that half of the trials would be old trials (40 intact and 40 recombined) and half of the trials would be new foil trials (40 control, new–new; 20 new–old; and 20 old–new). To this end, new words replaced the nonwords in 40 of the pairs that contained a nonword, with the new word serving as context on half the trials and as target on the other half. The 40 test trials that contained two nonwords, as well as the remaining 40 pairs that contained only one nonword, were eliminated. Otherwise, the explicit test list was identical to the implicit test list.

Procedure

Participants were randomly divided into one of four equally sized groups ($n = 18$) corresponding to the 2×2 between-subjects conditions. Each participant was individually tested. Participants were told that they would be shown word pairs and after a distractor task, they would then be asked to remember them. In the elaborative encoding condition, participants were asked to create a sentence that contained the two words, was meaningful, and retained the order of the words as they appeared on the screen. In the shallow encoding condition, participants were asked to indicate, by pressing one of two keys, whether the words contained the same number of vowels.

After 10 practice trials, in which feedback was given, the 120 study pairs were presented on the screen of a MacIntosh Plus computer in random order for each participant. Each pair was presented for 5 s, after which it disappeared. Participants were required to generate a sentence or complete the vowel comparison task, even if the pair was no longer visible. After encoding the study pairs, participants activated the next trial by pressing the space bar.

After presentation of the study list, participants in the implicit test condition were told that they would perform a distractor task (in truth, the implicit simultaneous lexical-decision task), and after this distractor task, their memory of the original items would be tested. Participants were asked to press as quickly and with as few errors as possible the *M* key with the right-hand index finger if both letter strings were legal English words and the *Z* key with the left-hand index finger if one or both letter strings were non-English words (instructions were reversed for left-handed participants, for this and for subsequent procedures). We explicitly mentioned to participants that some of the letter-string pairs they would see had appeared at study. They were to disregard this coincidence as it was purely due to convenience of setting up the experiment.

In the explicit test condition, participants were told that their memory for studied items would be tested. If both members of the pairs had previously been presented, either together or in separate pairs, participants were required to press *M* as quickly and with as few errors as possible. If one or both words had not been shown during study, participants were required to press *Z*. After 10 practice trials, in which feedback was given, the test list was presented in a different random order for each participant.

Results and Discussion

Means were calculated from the reaction time (RT) distributions of correct responses, in which the skewness was reduced by eliminating values that were more than two standard deviations above the mean for that condition, for each participant in each of the six within-subject conditions (3 [pair types] \times 2 [frequencies]). These means were then averaged across subjects and are presented, along with the proportion of correct responses, in Table 1.

For all tests, the significance level was set at $\alpha = .05$. We now

describe how levels of processing and test type affected item-specific and association-specific memory. We then describe how frequency interacted with these variables.

Effects of Levels of Processing on Memory for New Associations

Figure 1 describes the association-specific priming effect under the simultaneous lexical-decision task and the explicit recognition test as a function of levels of processing. Examination of Figure 1 and the RT data in Table 1 revealed that for the lexical-decision task, RTs to intact pairs were faster than to recombined pairs under both shallow encoding and elaborative encoding instructions. For the speeded-recognition task, however, RTs to intact pairs were faster than to recombined pairs under elaborative but not under shallow encoding.

To assess the degree to which item-specific information was recollected, we compared responses to recombined and control pairs in the implicit test condition. This analysis was only conducted for the implicit test condition because for the recognition task, responses to intact and recombined pairs were positive and may have therefore involved different cognitive operations to the negative responses made for the control pairs. Furthermore, responses to control pairs were confounded with responses by the nondominant hand.

Responses to recombined pairs (962 ms) were faster than to control pairs (1,035 ms), $F(1, 34) = 41.41, MSE = 4,773, p < .001$. That responses to recombined pairs were also more

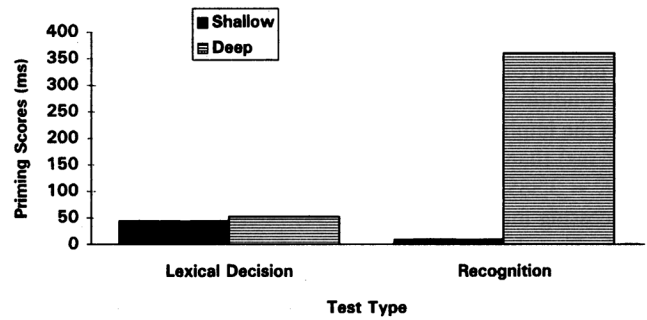


Figure 1. Association-specific priming scores, computed by subtracting the reaction time for the intact pairs from that for the recombined pairs, under the simultaneous lexical-decision task and the explicit recognition test as a function of levels of processing.

accurate (recombined 98% and control 94%) indicated that there was no speed-accuracy trade-off. In addition, we found that recombined and control pairs did not interact significantly with levels of processing, $F(1, 34) = 2.25, MSE = 4,773, p > .1$. This finding replicates previous results that item-specific repetition effects are influenced only slightly (Challis & Brodbeck, 1992), if at all, by levels-of-processing manipulations (but see Ducheck & Neely, 1989).

The association-specific information was analyzed by using a four-way analysis of variance (ANOVA), with pair type (intact and recombined) and frequency (low and high) as within-subject variables and levels of processing (shallow and deep) and test type (implicit and explicit) as between-subjects variables. Pairs used as controls were excluded from this and subsequent association-specific analyses because in the recognition task, responses to control pairs were negative and were confounded with responses by the nondominant hand. Only effects achieving significance are reported.

RTs to intact pairs (1,084 ms) were faster than to recombined pairs (1,200 ms), and RTs on the lexical-decision task (939 ms) were faster than on the speeded-recognition task (1,345 ms): for pair type, $F(1, 68) = 26.70, MSE = 35,998, p < .001$; and for test type, $F(1, 68) = 31.64, MSE = 376,485, p < .001$. Participants also responded more accurately to intact (86%) than to recombined pairs (82%), were more accurate on the lexical-decision task (98%) than on the speeded-recognition task (70%), and were more accurate under elaborative encoding (89%) than under shallow encoding (78%): for pair type, $F(1, 68) = 20.03, MSE = 0.006, p < .001$; for test type, $F(1, 68) = 177.15, MSE = 0.032, p < .001$; and for levels of processing, $F(1, 68) = 27.32, MSE = 0.032, p < .001$.

RTs for pair type interacted significantly with both levels of processing, $F(1, 68) = 16.26, MSE = 35,998, p < .001$, and with the test type, $F(1, 68) = 9.79, MSE = 35,998, p = .003$. Similarly, the accuracy data for pair type interacted significantly with both levels of processing, $F(1, 68) = 9.97, MSE = 0.006, p = .002$, and with the test type, $F(1, 68) = 28.27, MSE = 0.006, p < .001$. Moreover, the interaction between levels of processing and test type achieved significance, $F(1, 68) = 25.48, MSE = 0.032, p < .001$.

Most important, however, was the significant three-way interaction between pair type, levels of processing, and test

Table 1
Experiment 1: Lexical-Decision and Speeded-Recognition Mean Reaction Times (RTs; in Milliseconds) and Proportion Correct by Pair Type and Frequency Under Shallow and Encoding Elaborative Instructions

Encoding	Pair type					
	Intact		Recombined		Control	
	RT	P	RT	P	RT	P
Lexical decision						
Shallow						
High ^a	885	.997	874	1.000	912	.991
Low ^b	974	.945	1,028	.971	1,103	.928
Mean	913	.971	951	.985	1,007	.960
Deep						
High	868	.997	909	.994	953	.976
Low	968	.966	1,035	.972	1,174	.875
Mean	918	.981	972	.983	1,063	.925
Speeded recognition						
Shallow						
High	1,295	.633	1,335	.593	1,409	.552
Low	1,277	.582	1,264	.544	1,355	.654
Mean	1,286	.608	1,300	.569	1,382	.603
Deep						
High	1,226	.854	1,729	.692	1,569	.874
Low	1,211	.904	1,423	.777	1,468	.924
Mean	1,218	.879	1,576	.734	1,519	.899

Note. Speeded-recognition responses to control pairs were with the nondominant hand. P = proportion correct.

^aPairs containing high-frequency words. ^bPairs containing low-frequency words.

type, $F(1, 68) = 13.44$, $MSE = 35,998$, $p < .001$. The nature of this three-way interaction can best be understood by observing the pattern of two-way interactions in the implicit and explicit test conditions.

In the implicit test condition, responses were faster to intact (916 ms) than to recombined pairs (962 ms), $F(1, 34) = 22.08$, $MSE = 3,385$, $p < .001$, and were unaffected by the levels of processing manipulation, $F(1, 34) = 0.71$, $MSE = 3,385$, $p = .405$. Post hoc analysis (Levin, Serlin, & Seaman, 1994) confirmed that intact pairs were processed faster than recombined pairs in the shallow encoding condition, $t(17) = 2.44$, $p = .025$. Examination of the accuracy data revealed, however, more accurate responses to recombined pairs than to intact pairs in the shallow encoding condition. Still, the RT data were probably not the result of a speed-accuracy trade-off because the effect of accuracy was not significant, $t(17) = 1.44$, $p > .15$.

In contrast to the implicit test, speeded-recognition responses to intact pairs were faster than those to recombined pairs under elaborative, but not under shallow, encoding, $F(1, 34) = 15.55$, $MSE = 68,613$, $p < .001$. In fact, RTs to intact pairs in the shallow encoding condition were 14 ms faster than RTs to recombined pairs, $t(17) = 0.41$, $p > .65$, as compared with 358 ms in the elaborative encoding condition, $t(17) = 4.41$, $p < .001$. It must be noted, however, that participants' responses to recombined pairs were more accurate in the elaborative encoding condition than in the shallow encoding condition, suggesting a possible speed-accuracy trade-off. Still, intact pairs were remembered more accurately than recombined pairs under elaborative encoding but not under shallow encoding, $F(1, 34) = 8.97$, $MSE = 0.011$, $p < .005$. Therefore, the pattern of the accuracy data remained consistent with that found for the latency data, with superior association-specific recollection in the elaborative encoding condition (15% effect), $t(17) = 5.51$, $p < .001$, than in the shallow encoding condition (4% effect), $t(17) = 1.65$, $p = .118$.

Finally, because the false-alarm rates differed across the shallow and deep conditions, we calculated d' scores (and standard deviations) to adjust the accuracy scores. We found that under shallow encoding, d' did not differ significantly for intact and recombined pairs: intact, $d' = 0.575$ ($SD = 0.58$); recombined, $d' = 0.478$ ($SD = 0.48$); and $t(17) = 1.54$, $p > .1$. Under elaborative encoding, however, d' for intact pairs was significantly higher than for recombined pairs: intact, $d' = 2.16$ ($SD = 0.65$); recombined, $d' = 1.58$ ($SD = 0.62$); and $t(17) = 6.58$, $p < .001$. A within-subject ANOVA confirmed the significant Levels of Processing \times Pair Type interaction, $F(1, 34) = 19.83$, $MSE = 0.053$, $p < .001$.

In summary, under elaborative encoding, memory for new associations was demonstrated on both implicit and explicit tests. Under shallow encoding conditions, however, performance on the explicit test dropped substantially but was affected little, if at all, on the implicit test.

The results of this experiment replicate the association-specific repetition effect found by using the simultaneous lexical-decision task (Goshen-Gottstein & Moscovitch, 1995b) and extend them by showing that the size of the effect was not altered significantly by a levels-of-processing manipulation. The fact that shallow encoding produces an effect that is not much diminished from that observed under elaborative encod-

ing is consistent with the perceptual contiguity hypothesis. According to this hypothesis, perceptual contiguity is sufficient for the formation of newly formed associations in memory, such that they can be later recovered on perceptual data-driven implicit tests. Therefore, contrary to the suggestion of others (Graf & Schacter, 1985; Schacter & Graf, 1986a), the creation and storage of a new association does not require deep, elaborate encoding.

Because no task is process pure, it is possible that some conceptual information was nevertheless available at study, even though the shallow vowel comparison task was used in our experiment. Our point, however, is that for unitization to occur and be evident on an implicit test, elaborative encoding is not necessary; perceptual contiguity, accompanied by shallow encoding of pair members, is sufficient.

By contrast, in the recognition task, memory for the associations was poor when encoding was shallow. This dissociation reveals that whatever the nature of the conceptual processes that items undergo with the vowel comparison task in the implicit test, these processes are too insubstantial to support memory on an explicit version of the test. This being the case, it is unlikely that the lexical-decision task was supported by explicit recognition. It should be acknowledged, however, that even in the explicit test condition, the effect was in the expected direction, although small and insignificant.

Examination of the magnitude of the latency data casts further doubts on the possibility that the simultaneous lexical-decision task benefited from explicit recognition. RTs to recognize items were on average 1,345 ms. By contrast, latencies for lexical-decision responses were over 400 ms shorter. If consciously decided-about episodic information were being used in the lexical-decision task, then participants' RTs in this simultaneous lexical-decision task should have been much slower. That they were not makes the "explicit" interpretation less plausible.

Frequency

Examination of the frequency data revealed that on the lexical-decision task, RTs were faster to high-frequency pairs (900 ms) than to low-frequency pairs (1,047 ms). In the speeded-recognition task, however, RTs to the low-frequency pairs (1,333 ms) were faster than those to the high-frequency pairs (1,427 ms). Likewise, the proportion of correct responses was higher to high-frequency pairs (99%) than to low-frequency pairs (94%) in the lexical-decision task, and the reverse was true for the speeded-recognition task, with more accurate responses to low-frequency (73%) than to high-frequency (70%) pairs. A four-way ANOVA, with pair type (intact and recombined) and frequency (low and high) as within-subject variables and levels of processing (shallow and deep) and test type (implicit and explicit) as between-subjects variables, found this Frequency \times Test Type interaction to be significant: for latency, $F(1, 68) = 24.17$, $MSE = 38,703$, $p < .001$; and for accuracy, $F(1, 68) = 4.12$, $MSE = 38,703$, $p < .05$.

The facilitated processing of the high-frequency word pairs on the lexical-decision task illustrates the word frequency effect for item-specific information (Duchek & Neely, 1989; Scarborough et al., 1977). Because single low-frequency words

are processed more slowly and less accurately than single high-frequency words, pairs consisting of low-frequency words were also processed more slowly and less accurately than pairs consisting of high-frequency words. Similarly, the reverse effect that was observed for speeded recognition is consistent with the better recognition that is found for low-frequency words than for high-frequency words (Balota & Neely, 1980; Glanzer & Bowles, 1976; Jacoby & Dallas, 1981; Shepard, 1967; see Gillund & Shiffrin, 1984, for a review).

Next, to examine the extent to which the item-specific repetition effect was influenced by word frequency, we compared lexical-decision performance for the recombined and control pairs. For both accuracy and latency data, we found a significantly larger effect for pairs consisting of low-frequency (107 ms, 7%) words than for pairs consisting of high-frequency (41 ms, 1%) words: for latency, $F(1, 34) = 4.47$, $MSE = 8,640$, $p < .05$; and for accuracy, $F(1, 34) = 9.04$, $MSE = 0.003$, $p = .005$. This item-specific frequency attenuation effect replicates many previous findings (Jacoby & Dallas, 1981; Jacoby & Hayman, 1987; Kirsner, Milech, & Stumpf, 1986), including those that used lexical decision (Duchek & Neely, 1989; Forster & Davis, 1984; Rajaram & Neely, 1992; Scarborough et al., 1977).

Finally, we examined whether the association-specific effect interacted with frequency. In the speeded-recognition task, a significantly larger association-specific effect (i.e., intact was faster than recombined) was found for high-frequency pairs (271 ms) than for low-frequency pairs (99.5 ms), $F(1, 34) = 4.64$, $MSE = 58,044$, $p = 0.038$. However, in the lexical-decision task, this effect was not observed, $F(1, 34) = 1.14$, $MSE = 6,843$, $p > .25$. This three-way interaction of frequency with pair type and test type achieved significance, $F(1, 68) = 5.68$, $MSE = 32,444$, $p = .02$. This dissociative pattern of results provides further support that the implicit and explicit tests were mediated by different underlying processes.

A possible explanation for the finding that the association-specific effect did not interact with word frequency in the lexical-decision task is that even though the individual members of the pairs were high- or low-frequency words, the associations themselves were all newly formed. Because frequency of previous encounter with the pairs as a whole was not manipulated, but only frequency of encounter with their component members was manipulated, it makes sense that frequency did not interact with the association-specific effect but did with the item-specific effect. According to this explanation, if frequency of the pair itself were high, then the repetition effect for the association would be diminished. Consistent with this predication, Goshen-Gottstein and Moscovitch (1995b) showed that if the associations themselves were high-frequency, that is pair members were highly related (e.g., *lamb-wool*), association-specific repetition effects in a lexical-decision task were not significant. Thus, when frequency of encounter with the individual pair members is high, but frequency of encounter with the pair itself is low, repetition serves to facilitate performance. However, when frequency of encounter with the pair as a whole is very high, repetition does not facilitate processing, at least as measured in a lexical-decision task.

In contrast, on speeded recognition, an attenuated associa-

tion-specific frequency effect was found, with pairs consisting of high-frequency words producing a larger effect than pairs consisting of two low-frequency words. This finding replicates that of Clark (1992) and suggests that conscious recollection of associations is easier when individual words are high, rather than low, frequency (but see Hockley, 1991).

Experiment 2

In Experiment 1, the associative repetition effect was observed under shallow encoding instructions, suggesting that perceptual contiguity is sufficient for producing the association-specific repetition effect. In this experiment, we wished to determine whether perceptual contiguity is also necessary for producing the effect. To do so, we examined whether association-specific repetition effects occurred when the perceptual gestalt of word pairs was not preserved across study and test.

In this study, we broke up the perceptual gestalt of word pairs between study and test by presenting word pairs in different formats at study and at test and asking participants to make speeded decisions regarding the lexicality of both items. Almost all previous lexical-decision studies also broke the perceptual gestalt of word pairs in this way (albeit for different reasons, see Neely, 1991). This "standard" procedure failed to produce the effect unless a circumscribed set of conditions was met, such that nonwords and semantically related words that were presented during test were not displayed during study (see Durgunoglu & Neely, 1987). Even when items were encoded elaborately (Smith et al., 1989) and on many trials over many days (Dagenbach et al., 1990), the effect was still not obtained. One factor that was not investigated in these studies was format of presentation.

According to the perceptual contiguity hypothesis (Goshen-Gottstein & Moscovitch, 1995b), the difficulty in obtaining association-specific effects in the standard lexical-decision task is likely due to the change in perceptual display: from simultaneous at study to sequential at test (for a possible alternate explanation, see Doshier & Rosedale, 1991). Accordingly, a prediction derived from this hypothesis is that when the perceptual display is maintained across study and test, an association-specific effect should emerge. Only a single study (Carroll & Kirsner, 1982) has provided occasion to test this prediction (albeit for a different reason) by presenting word pairs simultaneously at both study and test. Surprisingly, an association-specific effect was not obtained. Certain aspects of their procedure may likely account for their negative findings (see the General Discussion section for further details).

It should also be noted that in the standard procedure, participants were required to make decisions regarding only the target items, whereas participants in Experiment 2 were required to make decisions regarding both context and target items. This deviation from the standard procedure was used because in Experiment 1, both words had to be considered in making decisions. Thus, by asking participants to make decision regarding both items, we ensured that making decisions regarding two items, as opposed to one, was not a confounding variable between the two experiments. Furthermore, asking participants to respond to both items rather than to one should

only increase the probability of obtaining an association-specific repetition effect, which we predicted would not emerge.

Because explicit tests are less sensitive than implicit tests to perceptual manipulations (for a review see Roediger and McDermott, 1993), we also predicted that changing format of presentation across study and test should have little effect on explicit recognition. To test this, other participants in this experiment were asked to indicate whether both items had previously been presented for study or whether one or both of them were unstudied items. If maintaining the perceptual gestalt is critical only for implicit tests, then sequential test presentation should have little effect on this explicit test. As predicted, when memory was explicitly tested, the advantage of intact over recombined pairs was maintained, despite changes in format between study and test. This outcome provides an additional dissociation between implicit and explicit test performance, suggesting that conscious recollective processes did not likely contaminate implicit test performance.

Method

Participants

Thirty-six University of Toronto undergraduates participated in the experiment. Participants either received course credit for participation or were paid \$5.

Design, Materials, and Procedure

Test type (implicit and explicit) was manipulated between subjects. Pair type (intact, recombined, and control) was manipulated within subject. To increase the probability of obtaining an association-specific repetition effect, we used elaborative encoding instructions.

The materials and study procedure were identical to those of the elaborative encoding condition of Experiment 1. At test, the context word was displayed for 350 ms. The target word immediately replaced it and remained on the screen until the participant made a decision by pressing the appropriate key. The screen then blanked for 500 ms before the next trial began. Participants were informed of the sequential-nature test presentation and were asked to make decisions (either lexical decisions or speeded recognition) with regard to both items. In all other respects, the procedure in this experiment was identical to that of Experiment 1.

Results and Discussion

Table 2 presents the mean RTs and proportion correct calculated as in Experiment 1. We begin with a description of the effects of sequential and simultaneous test presentation on association-specific and item-specific memory. We then describe the frequency data.

The Effects of Sequential Tests Presentation

Figure 2 describes the association-specific priming effect under the sequential lexical-decision task and the explicit recognition test that uses elaborative encoding. Examination of Figure 2 and the RT data in Table 2 revealed that for the lexical-decision task, RTs to intact pairs were not faster than to recombined pairs. For the speeded-recognition task, however, RTs to intact pairs were faster than to recombined pairs.

Likewise, an association-specific effect was revealed in the accuracy data only for the speeded-recognition task.

To assess the degree to which item-specific information was implicitly recovered, we compared responses to recombined and control pairs in the lexical-decision task. Responses to recombined pairs were found to be faster than to control pairs, $F(1, 17) = 9.58$, $MSE = 954$, $p = .007$. That responses to recombined pairs were also more accurate indicates that there was no speed-accuracy trade-off.

With only a few exceptions, the vast majority of previous attempts to find association-specific repetition effects have been unsuccessful, yet they showed robust item-specific repetition effects (Carroll & Kirsner, 1982; Dagenbach et al., 1990; Durgunoglu & Neely, 1987; Neely & Durgunoglu, 1985; Smith et al., 1989). It is interesting to note that although the item-specific effect achieved significance, it was smaller than the 100–120 ms effect reported by others (e.g., Dagenbach et al., 1990; Smith et al., 1989). It is unclear what accounts for this difference. Neely (1991) has shown that small parametric differences in procedure (e.g., length of prime exposure, word-nonword ratio, and positive-negative trials ratio) may account for similar differences.

The association-specific information was analyzed by using a three-way ANOVA, with pair type (intact and recombined) and frequency (low and high) as within-subject variables and test type (implicit and explicit) as a between-subjects variable. Only effects achieving significance are reported.

RTs to intact pairs (774 ms) were faster than to recombined pairs (917 ms) and faster for the lexical-decision task (556 ms) than for the speeded-recognition task (1,135 ms): for pair type, $F(1, 34) = 22.56$, $MSE = 32,901$, $p < .001$; and for test type, $F(1, 34) = 33.73$, $MSE = 357,433$, $p < .001$. Participants also responded more accurately to intact (96%) than to recombined pairs (88%) and were more accurate on the lexical-decision task (98%) than on the speeded-recognition task (85%): for pair type, $F(1, 34) = 83.50$, $MSE = 0.003$, $p < .001$; and for test type, $F(1, 34) = 78.75$, $MSE = 0.008$, $p < .001$.

Of most interest to us, however, was the significant Pair Type \times Test Type interaction observed for both latency and

Table 2

Experiment 2: Lexical-Decision and Speeded-Recognition Mean Reaction Times (RTs; in Milliseconds) and Proportion Correct by Pair Type and Frequency Under Sequential Test Presentation

Frequency	Pair type					
	Intact		Recombined		Control	
	RT	P	RT	P	RT	P
Lexical decision						
High	537	.994	533	.988	539	.977
Low	567	.977	587	.965	626	.939
Mean	552	.986	560	.976	582	.958
Speeded recognition						
High	1,071	.904	1,441	.724	1,325	.862
Low	918	.944	1,108	.830	1,145	.919
Mean	995	.924	1,274	.777	1,235	.891

Note. Speeded-recognition responses to control pairs were with the nondominant hand. P = proportion correct.

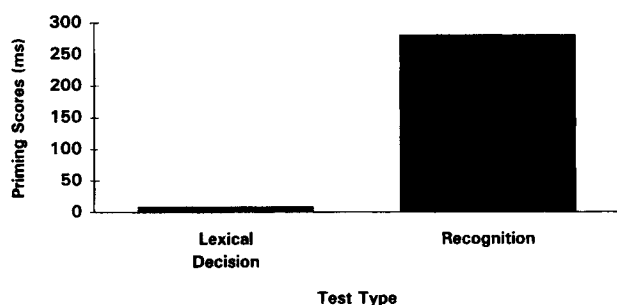


Figure 2. Association-specific priming scores, computed by subtracting the reaction time for the intact pairs from that for the recombined pairs, under the sequential lexical-decision task and the explicit recognition test by using elaborative encoding.

accuracy measures: for latency, $F(1, 34) = 20.23$, $MSE = 32,902$, $p < .001$; and for accuracy, $F(1, 34) = 65.24$, $MSE = 0.003$, $p < .001$. Thus, although responses were significantly faster and more accurate to intact than to recombined pairs in the speeded-recognition task, no such benefit was demonstrated on the lexical-decision task. In fact, RTs to intact pairs in the lexical-decision task were less than 7 ms faster than to recombined pairs, $t(17) = 0.85$, $p > .4$, as compared with 279 ms in the speeded-recognition task, $t(17) = 4.68$, $p < .001$. Similarly, responses were only 1% more accurate for intact than for recombined pairs in the lexical-decision task, $t(17) = 1.14$, $p = .27$. In the speeded-recognition task, however, responses to intact pairs were 15% more accurate than responses to recombined pairs, $t(17) = 9.73$, $p < .001$. This benefit was also displayed in the d' scores: intact, $d' = 2.48$ ($SD = 0.54$); and recombined, $d' = 1.78$ ($SD = 0.59$); $t(17) = 9.44$, $p < .001$.

Comparing the Effects of Sequential and Simultaneous Test Presentation

To demonstrate that format of presentation was critical for lexical-decision performance, we compared responses in the sequential version of the task used in Experiment 2 with the simultaneous version used in Experiment 1. We found that responses to intact pairs (735 ms) were faster than to recombined pairs (766 ms), $F(1, 34) = 17.02$, $MSE = 1,991$, $p < .001$. More important, the Pair Type \times Test Format interaction achieved significance, with faster RTs to intact than to recombined pairs under simultaneous, but not under sequential, test presentation, $F(1, 34) = 9.62$, $MSE = 1,991$, $p < .005$. Thus, only under simultaneous test presentation was the association-specific repetition effect produced. Under sequential test presentation, this effect was not produced.

To demonstrate that format of presentation was not critical for speeded-recognition performance, we compared responses in the sequential version of the task used in Experiment 2 with the simultaneous version (elaborative encoding condition) used in Experiment 1. Both latency and accuracy produced a significant pair type effect: for latency, $F(1, 34) = 39.99$, $MSE = 91,398$, $p < .001$; and for accuracy, $F(1, 34) = 92.81$, $MSE = 0.008$, $p < .001$. The Pair Type \times Test Format

interaction, however, was not significant, for both accuracy and latency, $F(1, 34) < 1$.

In addition, because the false-alarm rates differed across the two experiments, we calculated d' scores (and standard deviations) to adjust the accuracy scores. We found an advantage for intact over recombined pairs under both simultaneous and sequential test presentation: For simultaneous, intact presentations, $d' = 2.16$ ($SD = 0.65$), and for simultaneous, recombined presentations, $d' = 1.58$ ($SD = 0.62$), $t(17) = 6.58$, $p < .001$. For sequential, intact presentations, $d' = 2.48$ ($SD = 0.54$), and for sequential, recombined presentations, $d' = 1.78$ ($SD = 0.59$), $t(17) = 9.44$, $p < .001$. Consistent with our interpretation, a within-subject ANOVA did not yield a significant Test Format \times Pair Type interaction, $F(1, 34) = 1.06$, $MSE = 0.060$, $p > .3$. Therefore, when testing was explicit, an association-specific repetition effect was produced under both simultaneous and sequential test presentation formats.

The findings of this experiment demonstrate that the associative repetition effect is format specific, with an advantage for intact over recombined pairs exhibited under the simultaneous, but not under the sequential, format of presentation. This provides additional support for the hypothesis that perceptual processes underlie the associative repetition effect.

Because participants made decisions regarding two items, as opposed to one item, in both this experiment and in Experiment 1, it is not possible that a decision component was a critical factor in producing the associative repetition effect. Rather, the results confirm the prediction derived from the perceptual contiguity hypothesis that presentation of study and test must be in the same format to obtain association-specific repetition priming. However, if presentation of the test is sequential, as it was in this study, the association-specific repetition effect does not emerge. Perceptual contiguity seems therefore to be a necessary condition for producing association-specific repetition effects.

The findings of this experiment also demonstrate that sequential test presentation does not affect performance on explicit tasks. This dissociation with the implicit test results argues against the hypothesis that the advantage of intact over recombined pairs in the implicit lexical-decision task was influenced by a conscious recollective process.

The absence of an association-specific repetition effect in Experiment 2 provides an operational replication (Lykken, 1968) of the standard lexical-decision procedure (Dagenbach et al., 1990; Durgunoglu & Neely, 1987; Neely & Durgunoglu, 1985; Smith et al., 1989; but see Durgunoglu & Neely, 1987, Experiment 3; McKoon & Ratcliff, 1979, 1986). However, decisions were made regarding both items in our procedure and regarding only target items in the standard procedure (but see Carroll & Kirsner, 1982). Therefore, using the identical materials of Experiment 2, we conducted a literal replication (Lykken, 1968) of the standard lexical-decision procedure. To this end, we asked 18 participants to make lexical decisions regarding only target items.

To ensure that half the trials would be foils trials, we modified the foils in the test lists of Experiment 2 by switching the order of pair members in the nonword-word trials so that the target items would always be nonwords. In addition, in foil

trials that included two nonwords, the context nonword was replaced with a legal word.

The corrected means were calculated as in Experiment 1 and are presented in Table 3. As predicted, the association-specific effect was not significant: for latency, $t(17) < 1$; and for accuracy, $t(17) = 1.19, p = .25$. This finding provides a literal replication of the standard lexical-decision procedure and demonstrates that a critical aspect for obtaining the associative repetition effect is whether the perceptual gestalt of the word pairs is retained between study and test. Whether participants respond to one or both items is inconsequential.

Frequency

The frequency data were analyzed to investigate whether they produced dissociative performance on the implicit lexical-decision task and the explicit recognition task. Examination of the frequency data revealed an identical pattern to that found in Experiment 1, with faster lexical-decision RTs to high-frequency pairs (536 ms) than to low-frequency pairs (593 ms) and faster speeded-recognition RTs to the low-frequency pairs (1,057 ms) than to high-frequency pairs (1,279 ms). Likewise, the proportion of correct responses was higher to high-frequency pairs (99%) than to low-frequency pairs (96%) in the lexical-decision task, and the reverse was true for the speeded-recognition task, with more accurate responses to low-frequency (90%) than to high-frequency (83%) pairs. A three-way ANOVA, with pair type (intact and recombined) and frequency (low and high) as within-subject variables and test type (implicit and explicit) as between-subjects variables, found this Frequency \times Test Type interaction to be significant: for latency, $F(1, 34) = 22.48, MSE = 32,407, p < .001$; and for accuracy, $F(1, 34) = 18.66, MSE = 0.004, p < .001$.

Next, we examined the extent to which item-specific performance was influenced by word frequency by comparing lexical-decision performance for the recombined and control pairs. Despite the greater item-specific repetition effect observed for pairs consisting of low-frequency words (20 ms) than consisting of high-frequency (-4 ms) words, neither the latency data nor the accuracy data produced significant results: for latency, $F(1, 17) = 2.54, MSE = 1,857, p = .129$; and for accuracy, $F(1, 17) < 1$. This failure to find a frequency attenuation effect was unexpected (Experiment 1; see also Duchek & Neely, 1989; Forster & Davis, 1984; Rajaram & Neely, 1992; Scarborough et al., 1977) and is probably the result of a ceiling effect

caused by the very fast RTs in this task, as compared with the simultaneous task of Experiment 1.

Finally, we examined whether the association-specific effect interacted with frequency. In the speeded-recognition task, a significantly larger association-specific effect (i.e., intact was more accurate than recombined) was found for high-frequency pairs (18%) than for low-frequency pairs (11%), $F(1, 17) = 4.87, MSE = 0.004, p = .041$. In the lexical-decision task, however, frequency did not interact with pair type, $F(1, 17) < 1$. This three-way interaction of frequency with pair type and test type achieved significance, $F(1, 34) = 5.03, MSE = 0.002, p = .032$. For the latency data, however, this three-way interaction failed to achieve significance, $F(1, 34) = 3.76, MSE = 25,001, p = .061$.

In summary, for the lexical-decision task, the advantage of intact over recombined pairs was equivalent for pairs in which both members of the pair were low-frequency words and for pairs in which both members of the pair were high-frequency words. In the speeded-recognition task, however, pairs consisting of high-frequency words produced a larger association-specific repetition effect than pairs consisting of two low-frequency words (see also Clark, 1992). This pattern of results, of an attenuated association-specific repetition effect in the speeded-recognition task, but not in the lexical-decision task, replicated our findings in Experiment 1 and suggested that the implicit and explicit tests were likely mediated by different underlying processes. It is noteworthy, however, that in Experiment 1 the association-specific attenuation effect was exhibited only for the latency data, whereas in Experiment 2 it was displayed only for the accuracy data.

General Discussion

In this article, association-specific repetition effects for newly formed associations were demonstrated in a test involving lexical decisions to two simultaneously presented words. Three separate findings suggest that this effect is perceptually based. First, in previous research, we found that the effect was eliminated when modality was crossed between study and test (Goshen-Gottstein & Moscovitch, 1995b). Crossing modality of presentation between study and test does not alter the concept's underlying semantic representation. However, the perceptual realization of the concept is greatly altered. Because repeating the identical concept under cross-modal presentation is insufficient to produce the effect, the locus of the effect must be at a level of the representation that is strongly influenced by perceptual factors.

Second, we have shown that the association-specific repetition effect was not diminished by shallow encoding relative to an elaborative encoding condition (Experiment 1). This again suggests that conceptual information does not contribute to the production of the effect and that the locus of the effect is likely at an early, presemantic, stage of processing.

Third, we also demonstrated that the association-specific repetition effect depends on preserving the perceptual gestalt of the stimuli across study and test (Experiment 2). Even though participants made their decision regarding both items, the sequential nature of the test presentation did not enable the relevant perceptual information to emerge, thereby eliminating the effect.

Table 3

Experiment 2: The Standard Lexical-Decision Procedure: Mean Reaction Times (RTs; in Milliseconds) and Proportion Correct by Pair Type Under Sequential Test Presentation With Responses to Only Target Items

		Pair type			
Intact		Recombined		Control	
RT	P	RT	P	RT	P
586	.99	588	.984	607	.972

Note. P = proportion correct.

Beyond demonstrating the perceptual nature of the associative repetition effect when lexical decision is used, four functional dissociations between the implicit lexical-decision task and an explicit recognition test have been obtained. First, we found that modality specificity was a determining factor on implicit but not explicit tests for newly formed associations (Goshen-Gottstein & Moscovitch, 1995b, Experiment 1). Second, the association-specific effect was affected little by levels of processing on the implicit test but produced an advantage favoring newly formed associations only when items were elaborately encoded on the explicit recognition test (Experiment 1). Third, format specificity was not a critical variable on explicit tests for newly formed associations (Experiment 2), although it clearly was important for implicit tests. Finally, we found in both experiments that only for the lexical-decision task was the advantage of intact over recombined pairs equivalent for pairs in which both members of the pair were low-frequency words and for pairs in which both members of the pair were high-frequency words. In the speeded-recognition task, however, pairs consisting of high-frequency words produced a larger association-specific effect than pairs consisting of two low-frequency words. Together, these four functional dissociations provide evidence that conscious recollective processes did not mediate implicit test performance on the simultaneous lexical-decision task.

Although an associative repetition effect was produced under shallow encoding, as consistent with the perceptual contiguity hypothesis, it is still difficult to explain why shallow encoding was not sufficient to produce this effect when the stem completion task was used (Graf & Schacter, 1985). As suggested by Reingold and Goshen-Gottstein (in press), the advantage of intact over recombined pairs in the stem completion task is entirely attributable to conscious recollective processes (see the introduction section for further evidence). However, if the stem completion task is mediated by conscious recollective processes, it is surprising that functional dissociations were observed between performance on the implicit and explicit versions of the task (Graf & Schacter, 1987, 1989; Schacter & Graf, 1986a, 1989). Specifically, it is not apparent why certain manipulations, such as modality shift (Schacter & Graf, 1989), produced dissociations in performance between implicit and explicit versions of the stem completion task that were otherwise identical except for retrieval instructions (cf. Schacter, Bowers, & Booker, 1989).

A possible explanation is that the implicit associative stem completion task is influenced by conscious recollective processes, but to a lesser extent than the explicit version of the tasks. It is this difference in degree of involvement of conscious recollection that may account for the dissociations observed between implicit and explicit versions of the stem completion task. For our argument to hold, association-specific repetition effects must be observed on the explicit tests, as indeed they were.

This interpretation, however, cannot be applied to the functional dissociation we obtained between the implicit and explicit task in the shallow encoding condition (Experiment 1). In this encoding condition, no advantage for intact over recombined pairs was obtained in the explicit version of the task. It cannot be argued, therefore, that the processes

mediating performance on the explicit version could have contributed to the advantage that intact pairs had over recombined pairs in the implicit version of the task (see also Reingold & Merikle, 1990).

Whatever interpretation finally makes sense of the puzzling discrepancies in associative stem completion, it is important to realize that these discrepancies are task specific and do not apply to the lexical-decision task. Perhaps because lexical decision is a speeded task, it offers less opportunity for contamination by conscious recollective processes (Hasher & Zacks, 1979; Posner & Snyder, 1975; Shiffrin & Schneider, 1977).

Other evidence also indicates that the lexical-decision task is not open to conscious retrieval processes. In particular, Goshen-Gottstein and Moscovitch (1995a) have recently obtained data from 10 amnesic patients, 8 of whom showed an association-specific repetition effect. This pattern of consistency is identical to that observed in Experiment 1 with normal participants.

Notwithstanding these arguments, it is noteworthy that the lexical-decision task has both a perceptual basis and a semantic basis (Chumbley & Balota, 1984; see also Gordon, 1983). Therefore, if it were possible to modify the lexical-decision task so that the semantic component is dominant, then the pattern of results might resemble more closely that found for the stem completion task.

One other lexical-decision study has preserved format of presentation across study and test. Carroll and Kirsner (1982) presented word pairs simultaneously: one above the other for lexical decision both at study and at test. Nonetheless, they did not obtain the association-specific repetition effect as would be predicted by the perceptual contiguity hypothesis. One possible critical difference between their study and the experiments reported in this article concerns encoding instructions, which emphasized relational properties among pair members in the present study but not in Carroll and Kirsner's study. In our study, participants were asked to relate the items either by forming sentences or by comparing the number of vowels of the pair members. These instructions are relational in the sense that items must be viewed in reference to one another. In contrast, in Carroll and Kirsner's study, participants performed a simultaneous lexical-decision task at study and may have not related the two words together. Rather than leading participants to relate the word to each other, the lexical-decision task may have emphasized the item information so that each word was individually perceived rather than in relation to its partner. Contributing to the effect of being perceived as individual entities in Carroll and Kirsner's study is the fact that pair members were presented one above the other rather than beside each other.

If this is correct, then perceptual contiguity cannot bind pair members together, as long as items are not perceived at study as belonging to the same spatial-temporal arrangement. This need for a relational task, however, is required only at encoding. As demonstrated in this article, simultaneous presentation of word pairs, although probably not sufficient to bind items at encoding, is sufficient to reveal them at test. Once items are conjoined together in memory, any task may be sufficient to reveal a repetition effect, so long as the perceptual format of both items is maintained across study and test.

Finally, we would like to raise a question regarding the

properties of perceptual contiguity that are necessary for binding items together. Because items may be contiguous in space, in time, or in both, it must be determined whether time, space, or both serve to bind items together. Our manipulations of format (sequential and simultaneous) and modality (visual simultaneous and auditory sequential) altered temporal features as well as spatial ones. To investigate the precise nature of contiguity, however, researchers must manipulate space independently of time. Word pairs may, for example, be presented together at the same time at different locations than at study, or pairs may appear one after the other in time but remain together once they appear. Such manipulations may help specify the parameters under which perceptual contiguity operates and are critical for the formation and subsequent reactivation of new associations in memory.

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1995 Research Awards in Experimental Psychology

The American Psychological Association's Division of Experimental Psychology (Division 3) announces the following awards, presented at the Annual Convention in New York in August 1995. The awardees were determined by review of the research submitted to or published in the APA's Journals of Experimental Psychology in the past year by relatively new investigators. The intention is to provide early recognition for new scholars whose research contributions are especially promising.

Hilary A. Broadbent

Young Investigator Award
Animal Behavior Processes

Daniel Read

Young Investigator Award
Applied Psychology

Robert Goldstone

Young Investigator Award
General Psychology

Steven Lindsay

Young Investigator Award
Human Perception and Performance

Robert Goldstone

Young Investigator Award
Learning, Memory, and Cognition