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Perceptual and Conceptual Cueing in Implicit and Explicit Retrieval

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Subjects saw or heard words in a list (e.g. limerick) and then took two successive tests. The first was a yes/no recognition test in which auditory/visual modality of test words was manipulated orthogonally to the study modality. The second test varied with experimental conditions: subjects produced words to either perceptual (fragment) cues (l– –e–ick) or conceptual cues (What name is given to a lighthearted five-line poem?), under either explicit or implicit retrieval instructions. The major findings were: (a) that regardless of the type of retrieval cue (perceptual or conceptual) the degree of dependency between recognition and cued recall was greater than that between recognition and implicit retrieval; and (b) that modality shifts adversely affected perceptually cued explicit and implicit retrieval, whereas they had no effect either on conceptually cued retrieval or on recognition. These results suggest that the memory system subserving, and the processes involved in, conceptual priming differ from those underlying recognition and perceptual priming.

INTRODUCTION

In recent years a good deal of research has focused on direct or repetition priming—the phenomenon of implicit memory whereby an encounter with a perceptual object, such as a word, facilitates subsequent identification of the same object or similar objects. Although such priming can be shown to have its origin in a single study episode, it is governed by principles rather different from those that govern explicit retrieval of previously studied information, as assessed

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on tests such as recall and recognition. Relevant empirical facts and theoretical explanations have been reviewed by Shimamura (1986), Schacter (1987), Richardson-Klavehn and Bjork (1988), and Roediger (1990).

To date, in the majority of work on priming, a target item presented at study (e.g. the word CHEETAH) has been cued at test by its fragmented or 'perceptually degraded' form, as in word fragment completion (–H– –T–H), stem completion (CHE————), or tachistoscopic presentation of the word. Because the cue in these tests specifies the perceptual form of the studied stimulus word, the beneficial effect of study on test performance is labelled perceptual priming.

In fewer studies to date, the cue at test has been conceptually related to the studied stimulus word, in the absence of any perceptual similarity between them. Examples of such tasks include answering general knowledge questions (What is the fastest animal on earth?) and generating exemplars to a category cue (animals ————) (eg. Blaxton, 1989; Hamann, 1990; Srinivas & Roediger, 1990). The increased likelihood that subjects will produce the target word (CHEETAH) if it was presented at study is labelled conceptual priming (Tulving & Schacter, 1990).

There is evidence to suggest that perceptual and conceptual priming represent distinctive forms of learning (Tulving & Schacter, 1990). The evidential basis for the distinction is the same as that between implicit and explicit retrieval, namely empirical dissociations. These dissociations between perceptual and conceptual priming include the following: (1) in perceptually cued implicit tests, reading words at study leads to higher performance than generating them from a conceptual cue at study (e.g. Jacoby, 1983), whereas in conceptually cued implicit tests, generation at study is more effective than reading (e.g. Blaxton, 1989; Srinivas & Roediger, 1990); (2) levels of processing (e.g. making a semantic *vs* a graphemic judgement about a word) affects conceptual priming (e.g. Hamann, 1990; Srinivas & Roediger, 1990) but not perceptual priming (e.g. Graf & Mandler, 1984; Jacoby & Dallas, 1981; although for complications see Challis & Brodbeck, 1992); (3) differences in typography of study and test words affect perceptual priming but not conceptual priming (e.g. Blaxton, 1989); (4) conceptual priming is higher for categorically organised than for unorganised lists, whereas perceptual priming is not affected by list organisation (Rappold & Hashtroudi, 1991); and (5) visual presentation produces greater perceptual priming than auditory presentation (e.g. Jacoby & Dallas, 1981), whereas modality of presentation has little effect on conceptual priming (e.g. Blaxton, 1989; Srinivas & Roediger, 1990). The two forms of priming have been reviewed by Roediger, Srinivas, and Weldon (1989).

A notable feature of the observed dissociations between perceptual and conceptual priming is that they are very similar to comparable dissociations between perceptual priming and measures of explicit memory, with conceptual priming behaving rather like explicit recall and recognition. Thus, like recall and recognition, conceptual priming is sensitive to levels of processing, generation of target words at study, and categorical organisation of lists; and like recall and recognition, it is not affected by the study modality or typography, or changes in them between study and test. (See Richardson-Klavehn & Bjork, 1988, for a review). These parallel effects of study variables on conceptual priming and explicit retrieval naturally lead to the question as to the status of the concept of conceptual priming: Is it possible that the subjects' performance on conceptually cued implicit tests does not reflect priming at all, and that it is, at least partly, a consequence of conscious recollection of study-list items? Although the experimenter may believe that priming is being measured when subjects are asked simply to answer a general knowledge question (e.g. Blaxton, 1989) or produce an examplar to a category cue (e.g. Hamann, 1990), the subjects may in fact engage in cued recall. The subjects' reliance on such an 'explicit strategy' would then explain (a) the parallel effects observed in comparisons of (putative) conceptual priming and explicit retrieval, and (b) the observed dissociations between perceptual and (putative) conceptual priming.

One fact that stands in the way of this parsimonious explanation of conceptual priming is the finding of conceptual priming in amnesic subjects. These subjects cannot rely on explicit retrieval strategies, because their episodic memory is gravely impaired. Nevertheless they exhibit stable and sometimes robust conceptual priming effects (e.g. Gardner, Boller, Moreines, & Butters, 1973; Hamann, 1989; Shimamura & Squire, 1984; Tulving, Hayman, & Macdonald, 1991). Hamann (1989) observed conceptual priming in the amnesic subject K.C. who has no functioning episodic memory (Tulving, 1989; Tulving, Schacter, McLachlan, & Moscovitch, 1988). Although these amnesia data support the idea that conceptual priming represents a distinct form of learning, they do not speak directly to the distinction between perceptual and conceptual priming in normal subjects. It is still possible that normal subjects rely on explicit retrieval strategies when engaged in putatively conceptually cued implicit retrieval. This is why evidence from normal subjects is more directly relevant.

Two such pieces of evidence have been reported to date. First, Rappold and Hashtroudi (1991) found that performance in free recall and category-cued recall was related to the normative frequency of category instances, whereas conceptual priming was not. These same authors also reported that the organisational effects that they observed were shorter lived in conceptual priming than in free and cued recall.

Second, Cabeza (in press) recently reported the results of an experiment in which the method of triangulation (Hayman & Tulving, 1989a) was used to compare conceptual priming and conceptually cued recall. His results showed differential dependency, that is, larger dependency between recognition and conceptually cued recall than between recognition and conceptual priming, although the difference between the two critical values was not quite statistically significant. In Cabeza's experiment, differential dependency was found under conditions in which all relevant variables that can affect performance were held constant, with the single exception of retrieval instructions (Graf & Mandler, 1984; Neely, 1989; Neely & Payne, 1983). These results suggest that retrieval in conceptually cued implicit tests is not based on conscious recollection of the studied items. If it were, similar dependencies would have been observed with explicit and implicit retrieval instructions. Hence it looks as if conceptual priming is a valid concept.

In the present experiment, subjects studied a list of visually or auditorily presented words, and were then tested twice in succession. The first test was always one of yes/no recognition, with test words presented visually or auditorily. The second test, in which subjects had to produce target words to cues, varied between different experimental conditions. These conditions were defined in terms of orthogonal combinations of (a) the type of cue (either perceptual or conceptual), and (b) the kind of retrieval instructions (either for explicit or implicit retrieval).

The experiment served several purposes. Its first purpose was to garner further evidence for the hypothesis that subjects do not treat a conceptually cued implicit test simply as a cued recall test. As in Cabeza's (in press) experiment, the design of the present experiment follows the logic of the method of triangulation (Hayman & Tulving, 1989a). This method allows one to assess the relation between two memory tests through the examination of their relation to a common, third, reference test. The two tests of particular interest in this experiment were conceptually cued recall and the conceptually cued implicit retrieval of studied words; the reference test was the recognition test. In the two conceptually cued tests, all variables that can affect performance are held constant, except one, namely retrieval instructions.

We had two expectations regarding the dependency relations between recognition and various second tests based on earlier results. First, we expected the dependencies to be moderately positive for all second tests involving explicit retrieval, regardless of the study and recognition test modalities (auditory or visual), and regardless of the type of retrieval cue (perceptual or conceptual). This expectation was based on a large number of experiments on explicit retrieval in which recognition and cued recall have been tested successively, and in which the results have shown moderate positive dependency between the tests (e.g. Flexser & Tulving, 1978; Hayman & Tulving, 1989a; Nilsson, Law, & Tulving, 1988; Tulving & Wiseman, 1975), as well as experiments in which the successive tests have involved uncorrelated retrieval cues (Hayman & Tulving, 1989b; Le Voi et al., 1983). Second, on the hypothesis that conceptual priming is mediated by processes different from those mediating explicit retrieval of stored information, we expected the relation between recognition and implicit retrieval of target words to be essentially one of independence, again regardless of sensory modalities of study and recognition, and regardless of the type of retrieval cue. This expectation was based on similar findings from a number of experiments showing that successive tests are largely independent as long as one of the two tests is one of implicit retrieval (e.g. Cabeza, in press; Hayman & Tulving, 1989a; Tulving et al., 1991; Tulving, Schacter, & Stark, 1982; Witherspoon & Moscovitch, 1989).

The second purpose of the experiment was to test the replicability of the results of earlier experiments that used the triangulation method to assess contingency relations between recognition and fragment-cued retrieval (e.g. Tulving & Hayman, 1989a, 1989b; Tulving et al., 1982). These earlier experiments had shown that the relation between recognition and fragment-cued retrieval varied systematically with the single manipulated variable, namely implicit *vs* explicit retrieval instructions: recognition and fragment completion were stochastically independent, whereas recognition and fragment-cued recall were moderately dependent. The present experiment served to test the replicability of the results.

The third purpose of the experiment was to examine the generality of the contingency relations across study and test conditions varying in the sensory modality of presentation of cues and targets. Previous experiments have demonstrated that modality shifts between study and test detrimentally affect perceptual priming, whereas they affect neither explicit retrieval or conceptual priming. The experiment was designed to provide relevant information on this issue.

The fourth purpose of the experiment concerned the effect of modality on implicit and explicit measures of memory. As noted earlier, a distinctive feature of most reported dissociations between perceptual and conceptual priming is that they are very similar to comparable dissociations between perceptual priming and explicit retrieval, with conceptual priming behaving in a similar fashion to recall and recognition. It has been shown that under visual test conditions, visual presentation produces greater perceptual priming than auditory presentation (e.g. Challis & Sidhu, 1993; Jacoby & Dallas, 1981; Roediger & Blaxton, 1987b), whereas modality of presentation has no effect on conceptual priming (e.g. Blaxton, 1989; Challis & Sidhu, 1993; Srinivas & Roediger, 1990). Similarly, it has been found that modality does not affect conventional explicit tests such as free and cued recall, and recognition (e.g. Blaxton, 1989; Kirsner, Milech, & Standen, 1983; Nelson & McEvoy, 1979; Sipos, 1969). However, there are two apparent exceptions to this general pattern of findings.

The first one concerns the effect of modality on recognition. Available relevant evidence on this issue is equivocal (see Richardson-Klavehn & Bjork, 1988, for partial review). In the relevant experiments, researchers have usually varied modality (visual or auditory) and tested recognition in a visual modality. Modality effects have been reported in some experiments (e.g. Gathercole & Conway, 1988; Hashtroudi, Ferguson, Rappold, & Chrosniak, 1988; Jacoby & Dallas, 1981) but not in others (e.g. Challis & Sidhu, 1993; Kirsner, et al., 1983; Roediger & Blaxton, 1987a).

Second, it has been reported that modality of presentation affects performance on perceptually cued explicit tests. For instance, Blaxton reported that modality of presentation affected performance on a graphemic cued recall test (e.g. *chopper* as a cue for COPPER). Other researchers (e.g. Challis & Sidhu, 1993; Nelson & McEvoy, 1979) have reported a similar effect of modality on fragment-cued recall (e.g. *ime* or *d− −e* as a cue for DIME). In these studies, modality of presentation did not affect performance on standard explicit tests of free recall and semantic cued recall (e.g. *bronze* as a cue for COPPER, or *coin* as a cue for DIME). These reports of modality effects on perceptually cued recall are similar to the effects of modality on perceptual priming, suggesting that the perceptual nature of the test cue may determine the modality effect observed on these perceptually cued recall tests (cf. Weldon, Roediger, & Challis, 1989).

We examined the role of study and test modality in (a) recognition, and (b) perceptually and conceptually cued implicit and explicit retrieval. Crossing the study modality with the test modality allowed us to assess the role of modality in recognition, with a much larger number of observations than were available in previous studies in which a complete 2×2 design has been used (e.g. Kirsner, 1974; Sipos, 1967). And the fact that subjects took either an implicit or an explicit test involving perceptual or conceptual cues, always presented in the visual modality, after they had encountered the target words visually or auditorily, or both, in the earlier study and recognition-test phases of the experiment, allowed us to assess the relevance of the study (and earlier recognition-test) modality for perceptually and conceptually cued explicit and implicit retrieval.

In sum, then, the experiment had four main purposes. The experiment: (1) examined the nature of the relation between conceptually cued recall and conceptually cued implicit retrieval through the triangulation method, with recognition as the reference test; (2) checked the replicability of previously reported differences between the relation of recognition and fragment completion, on the one hand, and the relation of recognition and fragment-cued recall, on the other hand; (3) assessed the generality of contingency relations across different sensory modalities; and (4) evaluated the impact of study and test modalities and modality shifts on implicit and explicit retrieval with perceptual or conceptual cues, and on recognition.

METHOD

Subjects

Ninety-six subjects participated in the experiment. The first 48 subjects were associates of the experimenters (e.g. fellow students) who participated on a voluntary basis. The second group of 48 subjects were enrolled in an introductory psychology course at the University of Toronto and received credit for their participation.

Materials

A set of 120 target words (e.g. molasses) were selected as study items. For each of these target items, a word fragment (m – – – ss – s) and a general knowledge question (What is the syrup drained from raw sugar?) were selected as test items. These target and test items were selected from the set of materials used by Blaxton (1989). Three additional fragments and three general knowledge questions were selected as practice items on the tests. An additional set of 80 words, with word length and frequency similar to the target words, were collected to serve as buffer items in the visual and auditory study lists.

Design and Counterbalancing

The experiment was a 2 × 2 × 2 × 2 mixed factorial design, with study modality (visual *vs* auditory), recognition-test modality (visual *vs* auditory), and type of test cue (word fragment *vs* general knowledge question) as within-subject factors. Retrieval instruction (explicit *vs* implicit) was a between-subject factor. The experiment involved a study phase, a recognition test, and two successive tests, one with fragment cues and the other with question cues.

The 120 target words were randomly separated into four lists of 30 items. Each of these lists was randomly assigned to one of the four conditions defined by the 2 × 2 orthogonal combination of study modality and test modality. The four modality combinations of study and recognition-test presentations were visual–visual (V–V), auditory–visual (A–V), visual–auditory (V–A), and auditory–auditory (A–A). Within each of the four lists, ten words were presented in the study and recognition phases (i.e. targets on the recognition test), ten words were not presented at study but occurred on the recognition test (i.e. distractors) and ten words were not presented in either the study or recognition phase (i.e. nonpresented). On the successive tests that followed the recognition test, an equal number of words in the various presentation conditions were tested with fragment and question cues, and the counterbalancing procedure ensured that target words occurred equally often in the various conditions. In addition, items occurred equally often across the two instructional conditions (explicit *vs* implicit retrieval).

A complete counterbalancing of items across these various study and test conditions required 12 subjects, and the counterbalancing procedure was completed four times with the first 48 subjects. Then the 120 target items were randomly separated into four lists of 30 items, and the counterbalancing procedure was followed with a second group of 48 subjects. With the first group of 48 subjects, the order of study modality was constant across all subjects (auditory and then visual). With the second group of 48 subjects, the order of study modality was counterbalanced, with 24 subjects receiving auditory and then visual presentation, and 24 subjects receiving visual then auditory presentation.

The order of item presentation in study and test lists was determined randomly. One order was established for the first 48 subjects and a second random order for the second 48 subjects.

Procedure

Subjects were tested individually. The experiment consisted of three phases. In the first phase, subjects studied the target words. They were told that one list of words would be presented by means of the tape recorder, and another on the computer screen. They were told to do their best to learn each word, as their memory for these words would be tested later. No mention was made of the specific nature of the memory test. A list of 60 words was presented auditorily, at an interval of one second per word. The first 20 and last 20 items served as buffer items. A list of 60 words was presented visually at the rate of one word per second. The first and last 20 items were buffer items. The order of auditory and visual presentations varied according to the aforementioned counter-balancing scheme. Following the auditory and visual presentations, subjects were given a distractor task in which they wrote the names of countries of the world. The second phase of the experiment began after the five-minute distractor task.

In the second phase, subjects took a recognition test. They were told that they would receive a recognition test for the words presented earlier via the tape recorder or on the computer screen. Subjects were informed that some test words would be presented visually and others would be presented auditorily. Half the 94 test words were presented on the computer screen and the other half were presented via·the tape recorder. The mode of presentation alternated from auditory to visual. The first two items and the last 12 items of the 94-item list were buffer items not presented during the study phase. Subjects were told that for each word presented, they were to respond "yes" or "no", indicating that the word was or was not presented in the study list. Following each "yes" response, subjects indicated the modality in which the item was presented in the study list. Subjects were told that they must respond within five seconds, guessing if necessary. (Performance on the modality judgment task did not relate to the main issue, so it will not be discussed further in this paper.)

Upon completion of the recognition test, subjects were given two successive tests. The first test, for one set of items, involved question cues and the second test, for another set of items, involved fragment cues. Each of the two sets contained 63 items, with the first three serving as practice items. All test cues were presented visually on the computer screen. Half the subjects received explicit retrieval instructions before each of the two successive tests; the other half received implicit retrieval instructions before each successive test. The nature of the retrieval instructions was similar for the two successive tests. In the case of implicit retrieval instructions, subjects were instructed to solve as many fragments (or answer as many questions) as possible. They were told that although some of the solutions to the fragments (or some of the answers to the questions) had been presented earlier, many others had not, and that they should complete a fragment by naming the solution that came to mind (or provide the answer to the question that came to mind). Subjects were given eight seconds to solve each fragment (or answer each question). The instructions were illustrated with an example and subjects completed several practice items.

In the explicit retrieval condition, subjects were told that they were receiving a memory test for the words in the study list presented with the tape recorder or on the computer screen at the beginning of the experiment. They were told that, to help them remember the words, some cues in the form of word fragments or general knowledge questions would be provided. If they remembered a word from the study list when presented with a cue, they were to say the word aloud. They were informed that some of the solutions to the fragments (or answers to the questions) were words not presented in the study list, and if they could think of a solution to a fragment (or an answer to a question), but did not remember seeing or hearing the word in the study list, then the word should not be said aloud. It was emphasised that they should be very confident that the word was presented in the study list before responding. It was also pointed out that whether or not a word had occurred in the recognition test was irrelevant. Subjects were given eight seconds to respond to each fragment (or question). These instructions, too, were illustrated with an example and subjects completed several practice items.

Upon completion of the second test, subjects were debriefed. The experimental session lasted about one hour.

RESULTS

Summaries of the results are presented in Tables 1–4. Preliminary analyses performed on the appropriate subsets of data indicated that the order of study modality (visual then auditory, or vice versa) was not a significant factor and consequently the data were collapsed over this variable.

The results are discussed in terms of the four main purposes of the experiment, beginning with the three issues related to contingency relations between successive tests: (1) the nature of the relation between conceptual priming and conceptually cued recall, as revealed through the relation of each to recognition; (2) the replicability of previous findings concerning the relation between recognition and fragment-cued retrieval; and (3) the generality of contingency relations across different sensory modalities. The data presented in Table 1 address these three issues. We then consider the implications of the results for the fourth purpose of the experiment, namely the effects of modality on (a) recognition memory and (b) implicit and explicit retrieval with perceptual or conceptual cues. The data presented in Tables 2–4 address these respective issues.

Contingency Relations

For each subject, items were presented in the study phase, and tested on the recognition and one of the two successive tests involving word-fragment cues or question cues. With two possible outcomes on the recognition test (correct or not), and with two possible outcomes on the second test, each subject-item can be assigned to one of four mutually exclusive categories. The dependency relation between the two tests can then be determined. The joint probabilities for study-list words are presented in Table 1 as a function of type of retrieval instructions and retrieval cue in the second test, and the study × recognition-test modality. The Yule's Q statistic, which has a range from +1 to −1 (see Hayman & Tulving, 1989a; 1989b), provided a measure of dependency between successive tests. The Q values and associated chi-square values for the various conditions are presented in the right-hand columns of Table 1.

(All effects reported as significant in this report had p values of 0.05 or less.)

Conceptual Priming and Conceptually Cued Recall

The data for question cues are presented in the top half of Table 1. The relevant entries here are the Q values and their associated chi-squares presented in the right-hand columns. The important comparisons are the Q values in explicit versus implicit conditions. The main finding was of differential dependency between conceptual priming and conceptually cued recall: the dependency between recognition and cued recall was higher than the dependency between recognition and implicit retrieval. These data replicate and extend the results of differential dependency between recognition and fragment-cued retrieval reported previously (Hayman & Tulving, 1989a).

The log odds–ratio chi-square statistics recommended by Hayman and Tulving (1989a) revealed that the Q values for the four modality conditions of conceptually cued recall showed significant dependency, whereas the Q values for conceptual priming were not reliably different from zero (see Table 1). The dependencies across the four study × recognition-test modality conditions were compared (see Hayman & Tulving, 1989a) within the two instructional conditions. In both instructional conditions, the Q values were not reliably different from one another, with χ^2 (1, N = 240) values of less than 1.08. Therefore, the dependencies for explicit and implicit retrieval, collapsed across study and recognition-test modality, were compared ($Q = 0.57$, $\chi^2 = 59.55$ and $Q = 0.25$, $\chi^2 = 12.83$, respectively). The difference in dependency between explicit and implicit retrieval was significant, χ^2 (1, N = 960) = 11.90.

The contingency analyses in the V–V conditions in the present experiment were similar to those reported by Cabeza (in press) who used visual modality in both study and test. Cabeza compared conceptual priming and conceptually cued recall for visually presented and visually tested words with the method of triangulation. His results showed a larger dependency between recognition and

TABLE 1
Dependence Between Recognition and Responses to Studied Items on the Cued Tests

Test 2			*Joint Probabilities*					
Test Cue	*Instructions*	*Study-Test 1 Modality*	*Rn, T2*	*Rn,* $\bar{T}2$	$\bar{R}n$*, T2*	$\bar{R}n$*,* $\bar{T}2$	*Q*	χ^2
Questions	Explicit	V – V	0.29	0.39	0.07	0.25	0.45	9.42**
		V – A	0.27	0.38	0.06	0.29	0.55	13.81**
		A – V	0.37	0.32	0.07	0.24	0.60	18.75**
		A – A	0.35	0.37	0.05	0.23	0.62	17.35**
	Implicit	V – V	0.34	0.34	0.13	0.19	0.19	1.84
		V – A	0.36	0.38	0.09	0.17	0.28	3.63
		A – V	0.37	0.34	0.11	0.18	0.28	3.74
		A – A	0.35	0.34	0.12	0.19	0.24	2.95
Fragments	Explicit	V – V	0.43	0.25	0.09	0.23	0.63	24.15**
		V – A	0.40	0.28	0.06	0.26	0.72	30.00**
		A – V	0.50	0.23	0.10	0.17	0.57	18.45**
		A – A	0.31	0.40	0.09	0.20	0.27	3.25
	Implicit	V – V	0.41	0.25	0.19	0.15	0.13	0.87
		V – A	0.43	0.29	0.13	0.15	0.26	3.44
		A – V	0.48	0.21	0.17	0.14	0.31	4.83*
		A – A	0.35	0.40	0.11	0.14	0.05	0.13

Dependence between recognition (Test 1) and responses to studied items on explicit and implicit tests involving word-fragment and question cues (Test 2), across different study x recognition-test modalities.

V = visual modality and A = auditory modality; Rn = correct responses to a target in recognition; $\bar{R}n$ = incorrect responses in recognition; T2 = successful productions of the target in Test 2; $\bar{T}2$ = unsuccessful productions of the target in Test 2; *Q* = Yule's *Q*, a measure of association with a (1, – 1) range; χ^2 = log odds–ration chi-square statistic, testing independence; * indicates $p < 0.05$ and ** indicates $p < 0.01$; *N* for each row = 240.

conceptually cued recall than between recognition and conceptual priming. Although the difference between the two critical values in Cabeza's experiment was not quite statistically significant, the difference in the dependencies between conceptual priming and conceptually cued recall that he observed (0.25) was similar to that observed in the V–V condition of our experiment (0.26). In our experiment this difference was statistically significant.

The finding of differential dependency between explicit and implicit retrieval suggests that subjects in the conceptually cued implicit tests either do not rely on conscious recollection of the studied items, or rely on it to a smaller extent than they do in explicit tests. If subjects receiving implicit retrieval instructions had relied on conscious recollection to the same extent, similar dependency relations would have been observed between recognition and cued retrieval, under both implicit and explicit instructions.

Perceptual Priming and Perceptually Cued Recall

The overall pattern of contingency relations with word-fragment cues was rather similar (with a couple of exceptions) to that with question cues: differential dependency, with greater dependency under explicit than implicit instructions, and independence under the implicit instructions. The relevant data are presented in the lower half of Table 1. As with the conceptual cues, the dependency for explicit and implicit instructions, collapsed across study × recognition-test modality, were compared ($Q = 0.54$, $\chi^2 = 62.85$ and $Q = 0.15$, $\chi^2 = 4.44$, respectively). The difference in dependency between explicit and implicit instructions was significant, χ^2 $(1, N = 960) = 18.46$.

Differential dependency as a function of retrieval instructions was obtained in three of the four study × recognition-test modalities, with higher dependency under the explicit than implicit instructions (see Table 1). One exception was the lower than expected dependency in the A–A modality condition under explicit instructions. A comparison of Q values among the four modality conditions under the explicit instructions revealed significant differences between A–A versus V–V and V–A conditions, with χ^2 $(1, N = 240)$ values of 4.83 and 8.11, respectively. The discrepant finding in the A–A condition may represent a Type II error, as suggested by our failure to replicate this finding in a subsequent experiment conducted in an undergraduate teaching laboratory: the Q value for the A–A recognition and fragment-cued recall was 0.49 with χ^2 $(1{,}480) = 20.25$. Another exception to an overall pattern was a significant dependency in the A–V condition with implicit instructions. Comparisons showed that the Q value in the A–V condition was reliably greater than in the A–A condition, χ^2 $(1, N = 240) = 4.83$. Again, the outcome may be spurious. Apart from these two exceptions, the overall pattern is one of differential dependency, with greater dependency between recognition and perceptually cued recall than between recognition and perceptual priming—with the latter relation not reliably different from independence.

The contingency analyses replicated previous studies (e.g. Hayman & Tulving, 1989a). In these earlier studies, the modality of study and test presentation was visual (equivalent to the V–V condition). Hayman and Tulving (1989a) found moderate dependency between recognition and a test involving fragment cues with explicit instructions, whereas with implicit instructions the outcome was essentially one of independence. Hayman and Tulving's Q values were comparable to those obtained in the present experiment. For example, in Experiment 1 of Hayman & Tulving, the Q values for high constraint fragments (the most comparable to those used in the present experiment) were 0.55 with explicit instructions and 0.18 with implicit instructions, as compared to 0.63 and 0.13 in the respective conditions in the present experiment.

In sum, the salient findings with respect to contingency relations were threefold: First, the degree of dependency was larger between recognition and conceptually cued recall than that between recognition and conceptual priming. Second, as in previous experiments, recognition and implicit fragment completion were stochastically independent, whereas recognition and fragment-cued recall were moderately dependent. Third, across various study × recognition-test modality conditions, and with both conceptual and perceptual retrieval cues, the degree of dependency between recognition and cued recall was larger than that between recognition and implicit tests.

We now turn to the issue of modality effects on (a) recognition and (b) implicit and explicit retrieval with perceptual or conceptual cues.

Modality Effects

Recognition Performance. In the experiment, subjects studied words presented visually or auditorily and then took a yes/no recognition test. Modality of study and test words was manipulated orthogonally. Mean measures of recognition performance (hits, false alarms, and adjusted scores) as a function of study and test modality are presented in Table 2.

The essential finding was that recognition performance was unaffected by modality of presentation at study and test. Several 2 × 2 (study modality × test modality) analyses of variance (ANOVA) were performed. There were no main effects of study modality or test modality, and no interaction between them for recognition hits (F [1,95] = 2.0, MSe = 0.036, $F < 1$, and $F < 1$, respectively), false alarms (in all cases $F < 1$) or adjusted scores (F [1,95] = 2.56, MSe = 0.044, $F < 1$, and $F < 1$, respectively). Although this is a null finding, the results were based on over 11,000 subject-item observations, and the numerical differences in mean values were negligible and did not show a meaningful pattern. A measure of relative treatment magnitude indicated that modality had no effect on recognition (omega squared = 0) and an estimate of power implied that the absence of a modality effect on recognition was not due to a lack of power

TABLE 2
Recognition Performance as a Function of Study and Test Modality

	Study – test Modality			
Measure	*V – V*	*V – A*	*A – V*	*A – A*
Hits	0.67	0.69	0.70	0.71
False alarms	0.23	0.25	0.22	0.24
Adjusted	0.44	0.44	0.48	0.47

V = visual modality and A = auditory modality; adjusted = hits – false alarms; items for which false alarms occur do not have a study modality, but false alarms were reported according to an item's assignment to a study/test modality when it was studied.

(Keppel, 1982). It seems safe to conclude, therefore, that recognition was unaffected by modality of presentation at study and test, especially as the manipulation of modality did have a readily detectable effect on subsequent memory tests.

In some previous experiments examining the effects of modality on recognition, researchers have typically varied modality at study (visual or auditory) and tested in a visual modality, and the findings have been somewhat mixed (Richardson-Klavehn & Bjork, 1988). In some studies, modality of presentation did not affect recognition (e.g. Challis & Sidhu, 1993; Kirsner, et al., 1983; Roediger & Blaxton, 1987a). In other studies, recognition was higher in the matched modality condition (V–V) than in the cross-modality condition (A–V) (e.g. Jacoby & Dallas, 1981; Hashtroudi et al., 1988), which suggests that sensory modality can play a role in recognition under certain conditions. On the other hand, some researchers (e.g. Gathercole & Conway, 1988) have reported an advantage of auditory study when recognition is tested visually, raising further questions as to the nature of recognition memory.

In sum, reports of modality effects on recognition are mixed. In previous experiments, modality of presentation was varied, and test modality was held constant. In comparison, the present experiment provided a more complete assessment of modality effects on recognition by varying study and test modality orthogonally, and showed that modality and modality shifts did not affect recognition.

Implicit and Explicit Retrieval with Perceptual or Conceptual Cues. On a second test, subjects produced words to either perceptual cues or conceptual cues, under either explicit or implicit instructions. On the second test, target items corresponding to the test cues were: (a) study-list words, encountered twice (once in the study list and once in the recognition test) in different modality combinations (V–V, V–A, A–V, and A–A); (b) recognition-test distractors, encountered once (on the recognition test) in visual or auditory modality (V or A); or (c) nonpresented words. For implicit retrieval, the proportions of correct completions of previously presented words, and priming scores (presented–nonpresented) for each test, are presented in Table 3. For the explicit retrieval condition, the proportions of correct completions of previously presented words, and adjusted scores (presented–nonpresented) for each test, are presented in Table 4.

Modality of previous encounters had a dissociative effect on perceptual versus conceptual priming. Modality had a large effect on perceptual priming: a word seen at least once visually exhibited greater perceptual priming than a word only heard in the auditory modality. In contrast, conceptual priming was not affected by modality of presentation.

The finding that modality had different effects on perceptual and conceptual priming was supported by several analyses. The interaction between modality

TABLE 3
Proportions Correct in Fragment-cued and Question-cued Implicit Tests, and Priming Scores, for Targets and Recognition-test Distractors

	Targets				*Distractors*	
	Study–Recognition Test Modality				*Recognition Test Modality*	
Test Cue	*V – V*	*V – A*	*A – V*	*A – A*	*V*	*A*
Questions						
Presented	0.47	0.45	0.48	0.47	0.43	0.40
Nonpresented	0.28	0.26	0.27	0.28	0.28	0.27
Priming	0.18	0.19	0.20	0.19	0.15	0.12
Word-fragments						
Presented	0.60	0.56	0.64	0.46	0.60	0.42
Nonpresented	0.25	0.29	0.32	0.31	0.29	0.30
Priming	0.35	0.27	0.32	0.15	0.31	0.12

V = visual modality and A = auditory modality; priming = presented–nonpresented; targets were presented twice, once in a study list and once on a recognition test, whereas distractors were presented only once on a recognition test; nonpresented items do not have a study or test modality, but nonpresented items were reported according to the item's assignment to a study/test modality when it was presented.

TABLE 4
Proportions Correct in Fragment-cued and Question-cued Explicit Tests, and Adjusted Scores, for Targets and Recognition-test Distractors

	Targets				*Distractors*	
	Study–Recognition Test Modality				*Recognition Test Modality*	
Test Cue	*V – V*	*V – A*	*A – V*	*A – A*	*V*	*A*
Questions						
Presented	0.36	0.33	0.44	0.40	0.26	0.24
Nonpresented	0.05	0.04	0.05	0.04	0.05	0.04
Adjusted	0.31	0.28	0.39	0.37	0.21	0.20
Word-fragments						
Presented	0.52	0.46	0.60	0.40	0.35	0.20
Nonpresented	0.08	0.08	0.06	0.06	0.08	0.07
Adjusted	0.44	0.37	0.54	0.34	0.28	0.13

V = visual modality and A = auditory modality; adjusted = presented–nonpresented; target items were presented in a study list and on a recognition test, whereas distractor items occurred on a recognition test; nonpresented items do not have a study or test modality, but nonpresented items were reported according to an item's assignment to a study/test modality when it was presented.

and type of cue was significant with once-presented words and twice-presented words, $F(1,47) = 4.65$, $MSe = 0.07$, and $F(3,141) = 2.70$, $Mse = 0.10$, respectively. One-way ANOVAs that included each of the four repetition conditions and the two single presentation conditions as a within-subject factor were performed on the priming scores for each test. In contrast to conceptual priming, $F(5,235) < 1$, the analysis was significant with perceptual priming, $F(5,235) = 9.09$, $Mse = 0.038$. Post-hoc analyses (LSD = 0.08) indicated that presenting a word at least once visually (V, V–V, V–A, A–V) produced greater perceptual priming than an item presented only auditorily (A or A–A). There was significant priming in all study conditions of both tests, $F\text{s} > 15.00$.

These results replicate and extend previous work on the effects of sensory modality on implicit and explicit retrieval. First, visual presentation produced greater priming than auditory presentation in word fragment completion (e.g. Donnelly, 1988; Roediger & Blaxton, 1987b; Srinivas & Roediger, 1990; Weldon, 1991), as in other perceptually cued implicit tests such as word stem completion (e.g. Graf, Shimamura, & Squire, 1985), and perceptual identification (e.g. Hashtroudi et al., 1988; Jacoby & Dallas, 1981; Weldon, 1991). Second, modality affected perceptual priming but not conceptual priming (e.g. Srinivas & Roediger, 1990). Third, modality affected perceptual priming, but not conceptual priming or explicit retrieval (e.g. Blaxton, 1989; Challis & Sidhu, 1993). For instance, Blaxton (1989) showed that modality affected perceptual priming (fragment completion) but not conceptual priming (answering of general knowledge questions) or free recall. We replicated Blaxton's findings with recognition instead of recall as the explicit measure of memory.

A central question motivating the experiment was whether subjects in a conceptually cued implicit test rely on conscious recollection of studied items. One approach to this question is to administer implicit and explicit instructions with the same conceptually cued test cues, and evaluate the effects of a study variable on performance. A differential effect of the study variable across the implicit and explicit instructions implies that subjects do not perform the task in the same manner in the two test instruction conditions.

In experiments conforming to this paradigm, researchers have examined the effects of levels of processing (e.g. Graf & Mandler, 1984) with perceptual cues and the effects of study list organisation with conceptual cues (Rappold & Hashtroudi, 1991). In these cases the study variable had a differential effect on priming as compared to cued recall, suggesting that subjects did not treat the implicit retrieval task as an explicit one. With respect to the present experiment, the question was how modality affected conceptually and perceptually cued recall performance.

Modality of presentation affected recall of target items. In the case of fragment cues, target items presented visually on the recognition test were better recalled than items presented auditorily (0.56 *vs* 0.43, respectively). With question cues, modality of presentation in the study list was important, as items presented auditorily were recalled better than items studied visually (0.42 *vs* 0.34, respectively). For fragment cues, a 2 × 2 (study modality × test modality) ANOVA revealed only a main effect of test modality, F (1,47) = 9.81, MSe = 0.087, whereas similar analyses for question cues showed only a main effect of study modality, $F(1,47) = 4.49$, $MSe = 0.064$. A three-way ANOVA that included test cue as a factor revealed a significant interaction between cue and test modality, $F(1,47) = 4.40$, $MSe = 0.080$.

As expected, there were fewer responses to nonpresented words in explicit than implicit tests, with fragment (0.07 *vs* 0.29) and question (0.05 *vs* 0.27) cues, Fs > 100.00. Recognition-test distractors were produced more often than nonpresented items (Fs > 90.00). In addition, recall of distractor words under explicit instructions varied with the modality, as shown by the significant interaction between test cue and modality, $F(1,47) = 8.54$, $MSe = 0.022$. The pattern of the interaction is similar to that observed in perceptual and conceptual priming (see Table 3). The finding of parallel modality effects in the retrieval of recognition-test distractors under both explicit and implicit instructions suggests that the false recall of distractors is mediated by the same processes as those mediating the observed priming effects. In contrast, the presence of a modality effect on conceptually cued explicit retrieval of studied words, juxtaposed with the absence of a similar effect in conceptually cued implicit retrieval, suggests that implicit retrieval was not 'contaminated' by conscious recollection of the study list.

GENERAL DISCUSSION

The experiment examined: (1) the nature of the relation between conceptual priming and conceptually cued recall through the method of triangulation; (2) the replicability of previous findings concerning the relation between recognition and fragment-cued retrieval; (3) the generality of contingency relations across different sensory modalities; and (4) the effects of modalities and modality shifts on implicit and explicit retrieval with perceptual or conceptual cues, and on recognition. We discuss these issues and then turn to other theoretical implications of the findings.

One main purpose of the experiment was to assess, by using the method of triangulation, the relation between conceptual priming and conceptually cued recall. The results showed that the degree of dependency was larger between recognition and conceptually cued recall than it was between recognition and conceptual priming. This relation was observed in four different study × recognition-test modality conditions. Thus, the relation between recognition and conceptually cued implicit retrieval seems to be essentially one of independence, regardless of the sensory modalities of study and recognition. In contrast, recognition and conceptually cued recall of target words are moderately dependent, regardless of sensory modalities of study and recognition.

These results suggest that, contrary to the hypothesis that we mentioned in the introduction, the implicit test of conceptual priming is not simply a conceptually cued explicit memory test in disguise. If it were, similar dependencies would have been observed under both explicit and implicit retrieval instructions. Thus, conceptual priming differs from conceptually cued recall, even in normal healthy subjects, and seems to represent a distinct form of learning. Previous relevant evidence has been observed primarily in studies with amnesic subjects (e.g. Gardner et al., 1973; Hamann, 1989; Shimamura & Squire, 1984; Tulving et al., 1991).

The second purpose of the present experiment was to check the reliability of the results of earlier experiments in which the contingency relations between recognition and fragment-cued retrieval had been examined (Hayman & Tulving, 1989a, 1989b; Tulving et al., 1982). These earlier results had shown that the relation between recognition and fragment-cued retrieval varies systematically with retrieval instructions: recognition and fragment-cued recall are more dependent than are recognition and fragment completion. The present experiment replicated these results.

The third purpose of the experiment was to examine the generality of the contingency relations across study and test conditions varying in the sensory modality of presentation of cues and targets. A large number of explicit memory experiments have tested recognition and cued recall successively and found moderate positive dependency between the tests (e.g. Flexser & Tulving, 1978; Hayman & Tulving, 1989a; Nilsson et al., 1988; Tulving & Wiseman, 1975). In contrast, a number of experiments have shown that successive tests are largely independent as long as one of the two tests is that of priming (e.g. Hayman & Tulving, 1989a; Tulving, et al., 1991; Witherspoon & Moscovitch, 1989). A common feature of these experiments was that study and test items were limited to the visual modality.

The results of the present experiment established that the relation between recognition and cued recall is moderately positive for all explicit second tests, across various study and recognition test modalities (auditory or visual), and that this relation is independent of the type of retrieval cue (perceptual or conceptual). Also, the results showed that the relation between recognition and implicit retrieval of target words is largely one of independence, and that this relation is independent of the relation between study and test modality, and also independent of the type of retrieval cue.

The fourth purpose of the present experiment was to examine the effects of modality, and modality shifts, on recognition, and on implicit and explicit retrieval. Despite our extensive data base, no evidence was obtained of any modality effects in recognition. The relevant results in implicit tests showed that study and test modality interacted with the type of cue in the subsequent test: visually studied words had an advantage over auditorily studied words with perceptual cues, but there was no difference between the two modalities with conceptual cues. This finding replicates previous reports (e.g. Blaxton, 1989; Srinivas & Roediger, 1990). In the present experiment, as in most previous experiments, the fragment cues were presented visually, so that the visual advantage in perceptual priming indicates that modality match between study and test produces more priming than does mismatch. In line with this view, it has been found (e.g. Bassili, Smith, & MacLeod, 1989) that auditorily presented items show higher perceptual priming than visually presented items when the cues at test are presented auditorily.

For items presented only once (as distractors on the recognition test), both perceptually cued recall and perceptual priming were affected by modality of presentation, whereas both conceptually cued recall and conceptual priming were not affected by modality of presentation. This pattern of findings implies that the nature of the test cue (perceptual *vs* conceptual) may play an important role with respect to modality effects (cf. Weldon et al., 1989). However, perceptually and conceptually cued recall of twice-presented items (once in the study list and once on the recognition test) were affected by study or recognition-test modalities, which implies that perceptually and conceptually cued recall may differ in some respects from perceptual and conceptual priming.

We now turn from the four main issues motivating the experiment and consider broader implications of the findings. One such concerns the use of contingency analyses in memory research—a somewhat contentious issue for some time now. Recently, Hintzman and Hartry (1990) showed that contingency relations between successive tests of recognition and word fragment completion varied for different subsets of words, and asserted that measures of association derived from contingency analyses in a successive testing paradigm are of little scientific value. (For the debate, see Flexser, 1991; Gardiner, 1991; Hintzman, 1991). Our experiment has some bearing on the issue in so far as it has yielded evidence of systematic and disciplined variability in the contingency relations between various tests. Such systematic variability in the relation between tests cannot be attributed to the variables that were held constant in the experiment. Specifically, Hintzman and Hartry's (1990) demonstration of different relations between recognition and cued recall for different subsets of items, and their attendant arguments, have no relevance for our findings of variable relations between recognition and the four different second tests, because we held the target words constant in all conditions of the experiment. A fixed variable cannot account for systematic variability in another variable.

More recently, Ostergaard (1992) presented selected data from published experiments in support of the hypothesis that many reported findings of stochastic independence may represent artefactual consequences of low levels of learning or priming. Although Ostergaard's reasoning is correct, and although it is true that in some experiments the 'memory' effects have been too small to allow unequivocal conclusions, the proposed hypothesis cannot account for findings of stochastic independence in experiments in which priming effects are large. For example, the rates of fragment completion in Experiment 1 of Hayman and Tulving (1989a) were 0.56 and 0.42 for two categories of studied words, and 0.24 and 0.17 for the two corresponding categories of nonstudied words; however both conditions yielded stochastic independence between recognition and primed fragment completion. Similarly, in the experiment with the amnesic patient K.C., Tulving et al. (1991) observed large study effects coupled with stochastic independence. To give just one of many possible examples, K.C.'s fragment-completion performance in Session 7 was 0.56 for studied items and 0.06 for nonstudied items (Tulving et al., 1991, Table 2), and his conceptually cued retrieval of the same set of target words in Session 22 was 0.59 for the studied items and 0.09 for the nonstudied items. Despite these large 'memory' effects, the contingency analysis yielded stochastic independence, as shown by the Q value of −0.10 (Tulving et al., 1991, Table 8).

Under the contentious circumstances, looking at the total picture is useful. As Gardiner (1991) has forcefully argued, measures of association from contingency analyses are scientifically useful in that they can give rise to findings from a large number of experiments that are meaningful, replicable, consistent, and theoretically intelligible. The contingency analyses we have reported in this article, too, have provided systematic facts not available from unidimensional measures of implicit and explicit memory performance. These findings can help us better interpret and understand the relation between explicit and implicit retrieval.

According to a 'pure' processing view (e.g. Graf & Ryan, 1990; Roediger, 1990; Roediger, Weldon, & Challis, 1989), memory tests benefit to the extent that the type of processing promoted at study overlaps with the type of processing required for performance of the test (Morris, Bransford, & Franks, 1977). In this view, explicit retrieval, on tests such as recall and recognition, as well as conceptually cued implicit retrieval, depend on conceptually driven processing for their completion. On the other hand, perceptually cued retrieval, such as word fragment completion, is assumed to rely heavily on data-driven processing for their completion. The dissociative effects of study and test modality on perceptual priming versus conceptual priming and recognition that we observed in our experiment are consonant with this processing view.

The processing view, however, has no gracious way of explaining some other relevant findings. One such is the differential dependency between conceptual priming and conceptually cued recall observed in our experiment. The finding that recognition and conceptually cued recall are more closely associated than are recognition and conceptually cued implicit retrieval does not fit readily with the idea that all three tests reflect the operation of the same conceptually driven process. The processing view also has difficulties accounting for the finding of dissociation between explicit retrieval and conceptually cued implicit retrieval by amnesic subjects (e.g. Gardner et al., 1973; Graf et al., 1985; Hamann, 1989; Shimamura & Squire, 1984; Tulving et al., 1991). Both kinds of findings suggest that factors other than the nature of processing—data-driven or conceptually driven—be included in explanatory schemes.

We prefer to interpret the findings reported in this article in terms of a theoretical account that combines the notions of multiple memory systems and differential processes (e.g. Hayman & Tulving, 1989a, 1989b; Roediger, 1990; Schacter, 1990; Tulving & Schacter, 1990). In this account, the systems views and the processing views of priming and other phenomena of implicit and explicit retrieval are seen as complementary rather than antagonistic. After all, different memory systems are characterised, among other things, by different processes and rules of operations (Sherry & Schacter, 1987; Tulving, 1984, 1991).

Perceptual priming is subserved by a perceptual representation system (PRS), or its particular subsystems, that represent modality-specific information of a pre-semantic or perceptual nature, and other surface variables such as typography (see Schacter, 1990; Schacter & Church, 1992; Tulving & Schacter, 1990, for details). Perceptual priming can be supported solely by the PRS, which mediates perceptually driven processes, and need not rely on other systems. Hence perceptual priming is not necessarily sensitive to manipulations of a conceptual or semantic nature. On the other hand, conceptual priming depends on a semantic memory system that represents information of a semantic or conceptual nature and is characterised by conceptually driven processes. Hence, conceptual priming would be affected by variables having to do with semantic elaboration or organisation (e.g. levels of processing, generating words from a conceptual cue relative to reading words), although they are insensitive to perceptual (surface) variables. Explicit measures of recall and recognition tap episodic memory (e.g. Tulving, 1983). Episodic memory also represents information of a conceptual or semantic nature, so that conceptual priming, and recall and recognition, would be similarly affected by study manipulations of a conceptual nature. However, conceptual priming manifests itself in nonconscious implicit retrieval, whereas recognition and recall tests involve conscious recollection.

Amnesic subjects, whose dysfunctional episodic memory system greatly impairs their explicit memory performance, can exhibit conceptual priming to the extent that their semantic memory processes are intact. Differential dependency between conceptual priming and conceptually cued recall reflects a situation in which the episodic memory system, with common traces, plays a predominant role in recognition and cued recall, and in which the episodic and semantic systems, each with different traces, are differentially involved in recognition and conceptual priming. More detailed discussion of the relations between and among the systems has been presented elsewhere (Hayman & Tulving, 1989b; Tulving, 1991; Tulving et al., 1991). The same kind of speculations may be offered for the interpretation of differential dependency between conceptual priming and conceptually cued recall, and may also be applied to differential dependency between perceptual priming and perceptually cued recall: recognition and perceptually cued recall involve one and the same (episodic) system, whereas recognition and perceptual priming depend on different memory systems.

SUMMARY

The principal findings can be summarised in terms of the four main purposes of the experiment. First, the degree of dependency between recognition and a second test was larger between recognition and conceptually cued recall than between recognition and conceptual priming, across all four study × recognition-test modality conditions. This finding supports the idea that conceptual priming involves different processes than those involved in conceptually cued explicit retrieval. The argument is that if these two tests were mediated by the same (conceptual, conscious) processes, then conceptually cued implicit retrieval should have turned out to be related to recognition to the same extent as conceptually cued recall. If, on the other hand, conceptually cued implicit retrieval reflects nonconscious priming processes similar to those that characterise perceptually cued implicit retrieval, then there is no necessity for it to be correlated with conceptually cued recall.

Second, as in previous experiments, recognition and primed fragment completion were essentially independent, whereas recognition and fragment-cued recall were moderately dependent. This finding supports the idea of a dissociation between perceptual priming and episodic memory.

Third, the degree of dependency between recognition and a subsequent test was larger between recognition and cued recall than it was between recognition and tests of implicit fragment completion and question answering, across all four study × recognition-test modality conditions. These findings illustrate the generality of contingency relations across visual and auditory modalities and type of retrieval cue.

Fourth, implicit and perceptually cued explicit retrieval were adversely affected by modality shifts, whereas implicit and explicit conceptually cued retrieval and recognition were not affected by changes in study and test modality.

The general conclusion drawn from these findings is that the memory system subserving, and the processes involved in, conceptual priming differ from those underlying recognition and perceptual priming.

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