RICE UNIVERSITY

Specificity of Transfer-Appropriate Processing in
Indirect Memory

by

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ABSTRACT

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Studies of hyperspecific transfer of processing in indirect memory tests are reviewed. A procedure for deriving a comprehensive assessment of priming of indirect memory is then proposed. The procedure is illustrated in Experiment 1, in which prior study of randomly selected words presented with no item-specific context and what could be construed as neutral instructions primed their identification more in a perceptual (fragment completion) task than in a conceptual (semantic cuing) task. Experiments 2 and 3 failed to provide evidence for hyperspecific (i.e., sublexical) transfer of processing in an indirect memory task that called for rapid identification of gradually presented words. Experiment 4 also failed to provide evidence of hyperspecific transfer of processing, despite following more closely the procedure of an experiment (Hayman & Tulving, 1989, Experiment 4) that has provided such evidence. It appears that hyperspecific transfer of processing may be more elusive than sometimes assumed.
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Specificity of Transfer-Appropriate Processing in Indirect Memory

Prominent among contemporary conceptions of memory are the notions of level of processing and transfer-appropriate processing. The levels of processing framework, put forward by Craik and Lockhart in 1972, assumes that memory is the result of a series of processes with a shallow level of processing followed by the deeper levels, and that a deeper level of processing leads to more durable memory than just a shallow level.

There is much evidence in support of this theory. For example, Hyde and Jenkins (1973) brought level of processing under experimental control by imposing orienting tasks during the presentation of word lists. Some subjects checked each word for the presence of a certain letter, others classified the words according to part of speech (e.g., noun or verb), others rated the words according to frequency of everyday usage, and yet others rated the words according to the pleasantness of their referents. Assuming that it increases progressively from the first to the last of these tasks, depth of processing was directly related to performance in a later recall test.

Although successful as far as it goes, the levels-of-processing framework focuses exclusively on the encoding phase of the remembering process, and says nothing about the recall phase. Thus, it cannot explain the effect of the recall context or type of test, and more particularly it runs afoul of findings that, under certain test conditions, encoding tasks that can reasonably be presumed to be shallow result in greater recall than tasks that can reasonably be presumed to be deep. Explaining such findings requires assumptions beyond the province of the levels-of-processing framework, and one of the more prominent conceptions to meet this requirement is the notion of transfer-appropriate
processing. On this conception, prior experience facilitates performance at test only to the extent that the processing required at test matches that engaged during the prior experience. For example, Morris, Bransford, and Franks (1977) presented words in the context of phonemic and semantic orienting tasks. The standard levels-of-processing effect of better performance for words studied in the semantic context was obtained when memory was evaluated in a conventional recognition test, but not when evaluated in a rhyme cueing test. Such findings do not fit into a levels-of-processing framework, but fit nicely into a transfer-appropriate processing framework.

Transfer-Appropriate Processing in Direct and Indirect Memory Tests

For two decades or so memory theorists have drawn a fundamental distinction between direct and indirect memory tests\(^1\). Direct memory tests call for recollection of a specific event, and they take such familiar forms as recognition tests (in which items presented in the study phase have to be picked out from among other items) and various kinds of recall test. By contrast, indirect memory tests assess the priming, or facilitatory, effects of prior exposure to the target items (or items related to the target items) on a task that makes no reference to the prior presentation. The task may, for example, be to name words as rapidly as possible (e.g., Scarborough, Cortese, & Scarborough, 1977), or to identify words presented fleetingly (e.g., Jacoby; MacLeod & Masson, 1997) or with letters deleted (e.g., Tulving, Schacter, & Stark, 1982) or otherwise degraded (e.g., Moscovitch, Winocur, & McLachlan, 1986). Priming by prior presentation of the items

\(^1\)Explicit memory and implicit memory are frequently used as synonyms of direct and indirect tests, respectively, but because these terms are also frequently used for putative underlying "forms" or "systems" of memory, they will not be used here.
(in readily identifiable form) is indexed by the extent to which performance on such tests is more successful for previously presented items than for new items.

By and large, direct and indirect memory function quite differently. For example, Tulving, Schacter, and Stark (1982) found that increasing the study-to-test delay from 1 hour to 1 week sharply reduced direct memory (specifically, recognition performance) but had no discernible effect on indirect memory (word fragment completion). Similarly, Graf and Schacter (1987) found both retroactive and proactive interference of direct memory (cued recall) but not of indirect memory (word fragment completion). More dramatically, Jacoby (1983) presented words under one of three conditions: a no context condition (e.g., woman); a context condition, in which the words appeared along with their semantic opposites (man–woman); and a generate condition, in which the words had to be produced from their opposites (man - w _ _ _ _). Either a recognition (direct memory) test or perceptual identification (indirect memory) test was then given, and a cross-over effect obtained, with perceptual identification decreasing and recognition increasing from the no-context, through the context, to the generate conditions.

Roediger and his colleagues (e.g., Roediger & Blaxton, 1987; Roediger, Weldon, & Challis, 1989) have proposed an elegant account of such dissociations in terms of transfer-appropriate processing: indirect tests call for a sufficient study-to-test match of perceptual processing whereas direct tests call for a sufficient study-to-test match of conceptual processing. Thus, in indirect tests, the identification of flashed or degraded items is assumed, plausibly enough, to depend dominantly on perceptual processing, and priming is assumed to derive from whatever perceptual processing occurred in the study
phase of the procedure. By contrast, a study-to-test match of perceptual processing is assumed to play little if any role in direct memory tests; rather, recollection of the items presented in the study phase is assumed to require conceptual processing of a sort that creates a mental state sufficiently similar to the mental state during the study phase.

As Roediger and his associates now concede this formulation is oversimplified (e.g., Roediger & McDermott, 1993; Roediger, 2002). Consider again the assumption that performance on direct memory tests is conceptually-based. This assumption seems appropriate in the case of, say, free recall tests, for an instruction simply to recall as many items as possible from the study list bears no perceptual relation to the target items themselves. It seems less appropriate, however, for direct tests involving graphemic cues. An experiment by Blaxton (1989, Experiment 2) includes such a test: subjects studied words (such as bashful), and then were given graphemically similar words (bushel) as recall cues for the target study words. Given that these cues effected recall at a rate that, though not high (.38), was much higher than for unstudied targets (.05), and given that the relation between cues and targets (bushel and bashful) was more perceptual than conceptual, it seems that direct tests as well as indirect tests can be at least largely based on perceptual processing. The same issue arises in recognition tests, or at least recognition tests in which the study and test items are presented in the same sensory modality (usually auditory or visual), for here the nominal identity of study and test items should guarantee similar if not identical perceptual processing. And, indeed, recognition is widely assumed to be based in part on a greater fluency in the perceptual identification of the target items compared to the lure, or distractor, items (e.g., Atkinson & Juola,
1974; Mandler, 1980). In short, it is now generally accepted that, although most direct memory tests may rely largely or even entirely on a study-to-test match in conceptual processing, some rely at least in part on a study-to-test match in perceptual processing.

The assumption that memory revealed in indirect memory tests is perceptually driven is also an oversimplification. Although plausible for many tests, it is implausible for others. Consider again Blaxton’s (1989) experiment. In addition to the direct perceptually-based test (in which, e.g., bushel was presented as a recall cue for bashful), it included a perceptually-based indirect test (in which subjects completed fragments of the target words, such as b-sh-u-, with the first word that came to mind), and two conceptually-based tests. One of the conceptually-based tests called for free recall, and was hence a direct test. More interestingly, the other was an indirect conceptual test. Specifically, it consisted of general knowledge questions (e.g., “Which of the seven dwarves comes first alphabetically?”) as cues for both studied and unstudied words. Prior study of a target word increased its probability of being produced in this test (from .24 to .37), demonstrating that priming can occur in indirect conceptual tests. Other manifestations of conceptual priming include findings of prior exposure to a target item enhancing the likelihood of generating the target as an exemplar of a stimulus category, such as the target exemplar Bolivia to the category Country (Isingrini, Vazou, & Leroy, 1995), or of generating the target as an associate to a stimulus word, such as the target chair to the stimulus table (Shimamura & Squire, 1984).

If what has been characterized as perceptual priming really does derive from a study-to-test match in perceptual processing, then it should be modulated by variables that can
plausibly be assumed to affect perceptual processing but not by variables that can be plausibly assumed to affect only conceptual processing. And conversely, if what has been characterized as conceptual priming really does derive from a study-to-test match in conceptual processing, then it should be modulated by variables that can plausibly be assumed to affect conceptual processing but not by variables that can be plausibly assumed to affect only perceptual processing. These assumptions have been confirmed in many studies of both direct and indirect memory. For example, consider yet again Blaxton’s (1989; see also Weldon, 1991) experiment. As already noted, it included four kinds of test, an indirect and a direct perceptually driven test and an indirect and a direct conceptually driven test. In addition, for each of these four kinds of test, the prior study list was sometimes presented visually and sometimes auditorily, for a total of eight conditions. Assuming that presentation modality is essentially a perceptual as opposed to a conceptual manipulation, transfer-appropriate processing theory implies that its effect should occur in the perceptually-based tests, whether direct (bushel as a recall cue for bashful) or indirect (“Complete b-sh-u- with the first word that come to mind”), but it should not occur in either the direct (free recall) or indirect (“Which of the seven dwarves comes first alphabetically?”) conceptually-based task. Moreover, as would be predicted from transfer-appropriate processing theory, priming was greater when the prior exposure was visual. This prediction was confirmed.

Conversely, manipulations that can reasonably be considered as primarily modulating conceptual processing during the prior exposure should, according to transfer-appropriate processing theory, affect performance in conceptually-based tests but
not in perceptually-based tests. This prediction, too, has been confirmed (e.g., Hamann, 1990; Rappold & Hastroud, 1991). Clearly, perceptual and conceptual priming are, to a substantial extent, functionally distinct. Indeed, some have claimed them to be stochastically independent. For example, Cabeza and Ohta (1993) found stochastic independence (the phenomenon that the joint probability of two events is indistinguishable from the product of their simple probabilities) between a perceptual priming test (word fragment completion) and a conceptual priming test (category association test).

The impressive literature on both perceptual and conceptual priming effects notwithstanding, little if any research has been designed to compare the relative magnitudes of these two sorts of effects. In some sense, the quest for such a comparison is futile; as is clear from the research already reviewed, the amount of priming will depend on which of an infinite panoply of both study and test formats are adopted, and no less importantly on the relation between the two. The problem is similar to that faced by levels-of-processing theorists in establishing the relative effects of structurally- and semantically-based orienting tasks. There can be no definite answer, not only because different orienting tasks of the same type (structural or semantic) are likely to have different effects for any given test, but also because the relative effects of any two orienting tasks, even if one is structurally based and the other semantically based, will depend on the type of test used to assess the effects (Tulving, 2001). And yet it can be argued that there is at least heuristic value in the claim that semantic orienting tasks result in better memory than do structurally orienting task (Watkins, 2002). In the same way, it
might be of value to compare perceptual and semantic priming effects of prior study of
the target items. More modestly, it might be of value to compare priming in what might
reasonably be considered as typical perceptual and conceptual priming tests following
what could reasonable pass for a “neutral” study condition. Experiment 1 was designed
to do just this. Prior exposure of the targets involved presenting them in random order
with no deliberate attempt on the part of the experimenter to induce perceptual,
conceptual, or any other sort of encoding, and no warning of an upcoming memory test.
The memory tests called for completion of word fragments and the production of words
in response to semantic cues. Before detailing this experiment, however, the specificity of
transfer-appropriate processing needs to be considered.

Specific transfer-appropriate processing in indirect memory

The transfer-appropriate processing account of memory serves to underscore the
distinction between perceptually-based and conceptually-based tests, but there is much
evidence suggesting that the distinction is too coarse (see Roediger & Srinivas, 1993;
Roediger, Gallo, & Geraci, 2002). Thus, the transfer may occur to one direct memory test
but not to another, or to one indirect memory test but not to another.

For example, Cabeza (1994) dissociated two indirect conceptual tests by
administering first either a category classification task or a word association production
task, and then either a category association or free-association indirect memory test.
Priming in the category association test was larger for words studied in the category
classification task than for words studied in the production task, whereas the opposite was
true in the free-association test. The implication, clearly, is that conceptual processing is not a unitary phenomenon.

The same conclusion derives from a series of experiments reported by Franks, Bilbrey, Lien, and McNamara (2000). In each of the two phases of these experiments, subjects judged words as quickly as they could according to whether their referents were animate or inanimate, large or small, hard or soft, or the like. Second phase judgments were more primed if they were the same as in the first phase (e.g., in the second phase, berry was judged to be small more quickly if its first phase judgement was also according to size rather than, say, hardness).

Such specificity of transfer-appropriate processing has been found with perceptually-driven as well as with conceptually-driven tasks. Indeed, some of the findings in the perceptually-driven domain imply what may be dubbed hyperspecificity. For example, Hayman and Tulving (1989, Experiment 1) presented a list of words (e.g., ARDVARK), and then gave two fragment completion tests for these words, with the same or different fragments in the two tests. For example, A_ _ D_ _ RK might be used in both tests or A_ _ D_ _ RK in Test 1 and _ AR_ VA_ _ in Test 2. When the same fragment was used, performance on the two tests was correlated; when the fragment was changed for the second test, it was not correlated. Hayman and Tulving proposed that different fragment completions made different processing demands, and the difference was sufficient to preclude process transfer.

Also demonstrating hyperspecific transfer-appropriate processing in perceptually-driven tasks is a study by Gardiner, Dawson, and Sutton (1989). In their first experiment,
participants were shown target words in a matching semantic context. The target words were either intact (e.g., *Single unmarried man* BACHELOR) or fragmentary (*Single unmarried man* B_ _E_OR). The participants read the intact words or else generated the words from the contexts and fragments. There followed a word fragment completion test, which included fragments of both studied and unstudied words; the fragments of the studied words were either the very fragments used in the study phase or they comprised either one letter fewer or one letter more. Fragment completion was primed more when the words had been generated at study than when they had been merely read. Of more interest, the fragments repeated from the study phase primed more than the modified fragments. The second experiment called for the anagram solutions of a single set of words in each of two tests. In the first test, the anagram was presented in the context of a semantic cue (e.g., "*Political killer* SNANSISS" for the target word assassin). In the second test, the anagram was presented out of context, and it was either the same (SNANSISS) or different (IAASSSNS) from that used in the first test. Unchanged anagrams were more likely to be solved than were changed anagrams. In short, both of Gardiner et al.'s experiments demonstrated hyperspecific priming.

Olofsson and Nilsson (1992) reported what was essentially a replication of Gardiner et al.'s (1989) first experiment, except that in the study phase the fragment was shown not only in the “generate” condition (*Single unmarried man* B_ _E_OR), but also in a “read” condition, in which the full target word was inserted (*Single unmarried man BACHELOR* B_ _E_OR) and the subjects decided whether the fragment fitted the full word. The test phase called for completion of word fragments shown without context. As
in Gardiner et al.'s experiment, priming at test from generation of the target word in the study phase was more pronounced when the fragment remained the same from study to test than when it changed, but no such difference occurred in the read condition, in which the fragment had been accompanied by the full word at study. Apparently, such priming as occurred in the read condition was not hyperspecific.

**Four New Experiments: An Overview**

Described herein are four experiments that explore the specificity of processing transfer presumed to underlie cognitive priming. Experiment 1 sought to directly compare the magnitude of perceptually-based and conceptually-based priming of words by prior exposures under conditions that were not contrived to bias encoding one way or the other. In particular, the prior exposure consisted of presenting the words in a randomly ordered sequence without word-specific contexts, with the instructions stating merely that the words be studied. The study phase was followed by a test phase, in which target words, including those from the study list, were produced from perceptual or conceptual cues. A second purpose of Experiment 1 was to illustrate a procedure for obtaining a comparatively detailed assessment of priming. To this end, four versions of both the perceptual and conceptual test items were prepared for each target word. These were presented in sequence, from hardest to easiest.

Experiment 2 explored the phenomenon of hyperspecific transfer of processing in a perceptually-based task. It had two objectives: to apply the analytic procedure developed for Experiment 1 to obtain a more detailed picture of such transfer than is currently available, and to seek such transfer under conditions that might be reasonably
considered as perceptually enriched, and thereby to obtain an enhanced transfer effect. In the study phase words were presented one at a time but, rather than being shown all at once, they were shown letter by letter, with the letters being added in random order. The test items, which included both words from the study list and new words, were presented in the same fashion. As in the successive tests in the Hayman and Tulving (1989) study, the previously exposed words were sometimes presented in exactly the same letter sequence as in the study sequence or else in a different sequence. The task was to identify the word as soon (i.e., with as small a fragment) as possible. At issue was whether priming occurred (i.e., whether studied words were identified more quickly than unstudied words), and more particularly whether such priming was hyperspecific (i.e., whether studied words were identified more quickly when the order of letter presentation for the test items matched that for the presentation of the study items). Experiment 3 was a replication of Experiment 2 except that the words were “unfolded” more quickly.

Experiment 4 was a fairly close replication of Hayman and Tulving’s (1989) experiment, but with the unfolding word procedure used in Experiments 1-3 rather than the single-fragment procedure. Thus, words were presented normally (intact and all at once) in the study phase, and were unfolded in either the same or different ways in two consecutive tests. At issue was whether performance in the second test would be more primed when the unfolding was the same as in the first test.

**Experiment 1**

**Method**

*Subjects.* The subjects were 48 Rice University undergraduates.
Materials. A total of 112 8-letter words were selected from the Brown Corpus, a pool of words sampled from various genres (such as general fiction, romance, science fiction, humor, and religion) published by Kucera and Francis (1967; see also Francis & Kucera, 1982). Selection of each word was in accordance with two criteria: (i) it was specifiable by a 4-letter fragment, consisting of the first letter and three others, that did not fit any other words in the parent pool, and (ii) four apt semantic cues could be created without undue difficulty. For each word, four versions of both fragment and semantic

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Table 1. Fragment and semantic cues for the target word EXERCISE (Experiment 1)

<table>
<thead>
<tr>
<th>Fragment Cues</th>
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<tbody>
<tr>
<td>Level 1 Cue:</td>
</tr>
<tr>
<td>E _ E _ _ S E</td>
</tr>
<tr>
<td>Level 2 Cue:</td>
</tr>
<tr>
<td>E _ E R _ _ S E</td>
</tr>
<tr>
<td>Level 3 Cue:</td>
</tr>
<tr>
<td>E _ E R _ I S E</td>
</tr>
<tr>
<td>Level 4 Cue:</td>
</tr>
<tr>
<td>E X E R _ I S E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semantic Cues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1:</td>
</tr>
<tr>
<td>physical activity</td>
</tr>
<tr>
<td>Level 2:</td>
</tr>
<tr>
<td>physical activity; something performed for training and practice;</td>
</tr>
<tr>
<td>Level 3:</td>
</tr>
<tr>
<td>physical activity; something performed for training and practice; an act done to strengthen and improve;</td>
</tr>
<tr>
<td>Level 4:</td>
</tr>
<tr>
<td>physical activity; something performed for training and practice; an act done to strengthen and improve; “to prepare for the Olympics, the athlete had to _____ almost every day.”</td>
</tr>
</tbody>
</table>

cues were prepared such that the information presented in each cue subsumed that of the
prior cues. An example for each cue type is shown in Table 1.

*Design.* For each subject, all 112 words were cued in the test phase. Eight were used in the practice phase of the test and the remaining 104 words were randomly assigned to four 26-word blocks of the test proper. For both the practice phase and the test proper, the words were cued in the same order for all subjects. For the test proper, half of the subjects (Group 1) were tested on fragment cues in the first and the final blocks and on semantic cues in the second and the third blocks; the other half of the subjects (Group 2) were tested on semantic cues in the first and the final blocks and on fragment cues in the second and third blocks. In the practice phase of the test, Group 1 subjects were given fragment cues for first four words and semantic cues for the remaining four words, whereas for Group 2 this order was reversed.

For the study phase, half the subjects of Group 1 and half those of Group 2 were shown two of the four words to be cued in each half of the practice test and half of the words of each test block proper in random order. Selection of these words from the total set was random. The remaining subjects were shown the other half of the words in the study phase.

*Procedure.* The subjects were tested up to four at a time on desktop computers. They were shown a series of 56 words, which followed one another in the center of the screen in Geneva size 24 font at a 2-second rate. They were told simply to study the words.
In the test phase, which followed directly, each word from the study list and an equal number of new words were cued with up to four fragment or semantic cues. Each cue was shown in the center of the screen for 5 seconds and was followed immediately by the next cue. Each fragment of a given word was replaced directly by the next, which had the perceptual effect of constructing the word letter by letter. Each semantic cue for a given word was shown beneath the previous one. Thus, in both cases the information in each cue was subsumed by that in the next. For both types of cue, subjects clicked the mouse, regardless of cursor position, as soon as they thought they could identify the word, and then typed the word in a box that appeared in response to the click. If the typed word was correct, the screen flashed and the first cue for the next word was presented; if the typed word was incorrect, the next cue for the same word was presented. The subjects were first tested on the 8 practice words and then encouraged to ask questions. The test sequence of the experiment proper comprised four blocks of 26 words, two with fragment cues and the other two with semantic cues. Between blocks, the subjects were informed which kind of cues would be used in the next block, and they clicked a button to proceed.

**Results**

Table 2 shows the proportion of words that were correctly identified for each of the four levels of each type of cue. The proportions are cumulative, so that, for example, the proportion for the Level 2 cues includes, not only those words produced in response to Level 2 cues, but also those produced in response to the Level 1 cues. The priming score is the proportion correct for the studied words minus the proportion correct for the unstudied words.
Table 2. Mean Cumulative Proportions of Correctly Identified Words for Each Combination of Cue Level and Cue Type (Experiment 1)

<table>
<thead>
<tr>
<th></th>
<th>Fragment Cues</th>
<th></th>
<th>Semantic Cues</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Studied Words</td>
<td>.41</td>
<td>.66</td>
<td>.86</td>
<td>.97</td>
</tr>
<tr>
<td>Unstudied Words</td>
<td>.22</td>
<td>.51</td>
<td>.76</td>
<td>.94</td>
</tr>
<tr>
<td>Priming</td>
<td>.19</td>
<td>.15</td>
<td>.10</td>
<td>.03</td>
</tr>
</tbody>
</table>

For all levels of both types of cue, the studied words were significantly more likely to be identified than the unstudied words ($p < .01$ for all eight comparisons). Clearly, then, there was robust priming from prior study. Table 2 shows the priming effect to be generally greater for fragment cueing than for semantic cueing, although averaged across levels the difference was not statistically significant, $t(47) = 1.35, p = .18$. The difference was statistically significant, however, at both Levels 1 and 2, $t(47) = 6.09, p < .001$, and $t(47) = 2.24, p = .03$, respectively. At level 3 the fragment and semantic cues showed equal priming. At level 4 the difference was statistically significant, $t(47) = 3.63, p < .001$, but in this case the advantage lay with the semantic cues.

The data of Table 2 and their statistical analyses are, however, not readily interpretable. The problem is that the simple difference in probabilities of identifying studied and unstudied words is likely to reflect the base-rate probability (i.e., the rate for unstudied words). For example, the probability of identifying Level 3 fragments of unstudied words was .76, and that for studied words was .86, for a priming effect of .10.
The probability of identifying Level 4 fragments of unstudied words was .94, a level that was so high that it precluded even the possibility of a priming effect equal to that for Level 3. It thus makes little sense to compare the priming effect of prior study by comparing the simple arithmetic advantage of identifying studied over unstudied words across conditions associated with different baseline identification rates. Notice in this regard that, overall, the identification rates for the fragment cues were substantially greater than for the semantic cues. No theoretical interest attaches to this discrepancy, for there is no reason why any given level of the fragment cues should be of comparable difficulty to the same level of the semantic cues. Thus, any difference in priming between a given level of fragment and semantic cues is likely to reflect the difference in the difficulty of the two types of cues.

One approach to addressing this problem is to assess the effect of priming in terms, not of the advantage in the identification rate for studied over unstudied words, but rather of the extent to which identification of the studied words is discriminable from that of the unstudied words. Commonly referred to as “effect size,” such discriminability is measured with any of a variety of indices. For present purposes, the effect of prior study was indexed by chi-square. Specifically, for each type and level of cue, each subject’s data were arranged in a 2 (unstudied and studied) x 2 (identified and unidentified) contingency table, and a chi-square value computed.

A difficulty in implementing this approach arises when, as occasionally happened, a subject identified either none or all of the words in one or other combination of cue type and level. In such cases chi-square is indeterminate. To resolve this difficulty, the data were combined over pairs of subjects, effectively reducing the 48 subjects to 24
“supersubjects.” Pairing was achieved by obtaining the sum of all eight identification probabilities (one for each combination of cue type and cue level) for each subject, ranking the subjects according to these sums, and pairing the highest ranking subject with the lowest ranking subject, the second highest with the second lowest, and so on. The chi-square values for each combination of cue type and level, averaged over the supersubjects, are shown in Table 3. Averaged over cue levels, chi-square was greater for the fragment cues (3.60) than for the semantic cues (2.45), but not significantly so, $t(23) = 1.53, p = .14$. For Level 1, chi-square was significantly greater for the fragment cues, $t(23) = 2.37, p = .03$; for Levels 2 and 3 chi-square again favored the fragment cues but not significantly so, $t(23) = 1.13, p = .27$ and $t(23) = 0.58, p = .57$, respectively; for Level 4 chi-square favored the semantic cues, albeit not significantly so, $t(23) = 0.61, p = .55$.

| Table 3. Mean Chi-Square Values for 2 (Studied and Unstudied) x 2 (Identified and Unidentified) Contingency Tables for Each Combination of Cue Level and Cue Type (Experiment 1) |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
|                                 | Fragment Cue                    |                                 | Semantic Cue                    |                                 |
|                                 | 1  2  3  4                       |                                 | 1  2  3  4                       |                                 |
| Cue Level                       | 5.50 4.21 3.07 1.61              |                                 | 2.54 2.80 2.48 1.99              |                                 |

Although doubtless an improvement over the raw difference in identification rates for studied and unstudied words, the use of chi-square as an index of priming is less than ideal. Certainly comparisons of fragment and semantic chi-square values for a given cue level make little sense, for fragment cues of a given level may not be of the same
difficulty level as semantic cues of the same level and this difference in difficulty level could affect chi-square regardless of the "true" effect of prior study. Thus, as in the case of raw differences in recall rates, the substantial overall difference in the effectiveness of

![Graph showing the proportion of studied and unstudied words identified.]

*Figure 1. Priming effect at each of four cue levels of fragment and semantic cues (Experiment 1).*

the two types of cue thus renders a chi-square comparison of their susceptibility to priming spurious.

A less problematic solution is captured in Figure 1. Here, for each of the four levels of both fragment and semantic cues, the probability of identifying studied words is plotted against the probability of identifying unstudied words. Also plotted is a diagonal, which is the locus of equal identification levels for studied and nonstudied words, and hence the line of zero priming. Aside from random effects, or "noise," any point above the diagonal represents priming and, roughly speaking, the extent to which it is above the diagonal indicates the degree of priming. Clearly, the fragment function suggests more
priming than the semantic function. To assess the statistical significance of this
difference, the area under the semantic function was subtracted from the area under the
fragment function for each subject. In computing these areas, the functions were given
polygonal form (i.e., the points, including the 0.0,0.0 and 1.0,1.0 points, were connected
with straight lines). The mean difference in area was .045. Since the area above the
diagonal is .5 (i.e., half of the total area of the graph), the difference in priming on a scale
from 0.0 (no priming) to 1.0 (maximum priming) requires that this figure to be divided by
half (i.e., doubled). The resulting priming advantage for the fragment cue over the
semantic cue (.09) was statistically significant, \( t(47) = 2.24, p = 0.03 \).

Discussion

At least under the conditions of this experiment, prior study primes word production
from fragment cues more than it primes word production from semantic cues. This
finding was, perhaps, not entirely predictable. If anything, the instruction to study a list of
randomly ordered words presented with no deliberate effort to draw attention to
orthography and without word specific contexts might reasonably have been assumed to
induce predominantly semantic processing. If so, by the principle of transfer-appropriate
processing, priming should have been more pronounced in the semantic cueing condition.

Experiment 1 also illustrates a procedure for obtaining a more comprehensive
assessment of priming than hitherto available. This method proved more sensitive in
detecting statistical significance in the difference in fragment and semantic priming than
either the conventional method based on the raw difference in proportions or effect-size
analyses. Moreover, it is relatively comprehensive by virtue, not only of the multiple
criteria, but also of providing priming operating characteristics. These operating characteristics underscore the danger of drawing conclusions from the standard measure of priming effects, namely the raw difference in performance for previously exposed and new items. Thus, it might be concluded from Table 1 that, with the relaxed criterion of Level 4 cues, semantic cueing is primed more than fragment cueing. But Figure 1 shows that, to the contrary, fragment cueing is more sensitive to priming than is semantic cueing regardless of difficulty level.

Experiment 2

The purpose of the Experiment 2 was to explore the phenomenon of hyperspecific transfer-appropriate processing in indirect tests of word memory using a dynamic form of item presentation and the data analysis procedure developed in Experiment 1. Rather than being presented as a whole, both the study and test words were presented one letter at a time. In the test phase, the subjects' task was to identify the test items as early in their presentation as they could. It was conjectured that the letter-by-letter presentation would make for a comparatively enriched perceptual experience and, consequently, for enhanced transfer of processing from study to test. More particularly, spreading the presentation over time was predicted to render the perceptual experience of each word presentation more distinctive, which in turn should support more hyperspecific transfer of processing. Given that previous findings of hyperspecific transfer of processing (e.g., Hayman & Tulving, 1989; Gardiner et al., 1989; Olofsson & Nilsson, 1992) have been obtained with static item presentations (i.e., with each study and test item being shown all
at once), it was expected that the present experiment would yield unprecedented levels of
hyperspecific transfer-appropriate processing. At issue, then, was the speed of identifying
test words “unfolded” in the same letter order as in the study phase relative to the speed
of identifying words unfolded in a different letter order.

Method

Subjects. The subjects were 24 Rice University undergraduates.

Materials. A total of 126 8-letter common words were selected from the same word
pool used in Experiment 1. Two “unfoldings” were prepared for each word, as in
Experiment 1. For INSTINCT, for example, they were _ _ T _ _ _ , _ N _ T _ _ _ ,
_N_T__C_ , _N_T__C_T , _N_TI_C_T , I_N_TI_C_T , I_N_TI_N_C_T
and _ _ S _ _ _ _ , _ _ S _ _ N _ _ , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N ,
I_S_S_N_N , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N , I_S_S_N_N ,
and _ _ S _ I N C_T , I N S _ I N C_T . Six words were used in the practice phase and the
remaining 120 in the experiment proper.

Design. As for Experiment 1, the design is perhaps best understood with reference
to the test phase. All 126 words appeared as test items, and each was presented in the
same order for all subjects. For any given word, one unfolding was used for half of the
subjects, and the other unfolding for the other half. For each subject, two thirds (i.e., 80)
of the test words of the experiment proper had been presented in the study phase of the
procedure, with a half (i.e., 40) of these unfolded the same way as at test, and half
unfolded differently. Counterbalancing measures ensured that, across each of six equal-
sized groups of subjects, each word appeared equally often in each of three test
conditions, referred to as the same unfolding, different unfolding, and new conditions.

The practice test comprised two words in each of these three conditions.

Procedure. The subjects were tested up to four at a time, with each seated in front
of a desktop computer. They were shown a series of 8-letter words, which were unfolded
letter by letter at a rate of 1 letter per second. The presentation of each word followed that
of the previous word without pause. The subjects clicked the mouse as soon as they
identified the words. Unbeknown to the subjects, the click was not recorded, its purpose
being merely to encourage attention to the unfolding presentations.

The test phase followed directly. The subjects identified words from unfolding
presentations as quickly as they could. As soon as they thought they had identified a
word, they clicked the mouse, regardless of cursor position, and thereby brought up a
response box. If the subject's typed response was correct, the screen flashed and
presentation of the next word began; if it was incorrect, the fragment to which the
response was made was increased by one letter. The test procedure began with six
practice items. A brief pause was allowed midway through the test.

Results

As in Experiment 1, performance was scored according to multiple criteria. Table 4
shows the proportion of words that were correctly identified for each of the seven levels
of cues in each of the three test conditions, namely, in same unfolding, different
unfolding, and new conditions. The proportions are cumulative, just as in Experiment 1.

For each subject the number of letters required for identification of each test item
was recorded and, by averaging over subjects and items, an identification function was
derived in the manner described in Experiment 1. Thus, in Figure 2, for each subject, same-unfolding and different-unfolding functions were obtained from the proportions of

<table>
<thead>
<tr>
<th>Cue Level</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Unfolding</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.09</td>
<td>.35</td>
<td>.73</td>
<td>.92</td>
</tr>
<tr>
<td>Different Unfolding</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.10</td>
<td>.33</td>
<td>.71</td>
<td>.94</td>
</tr>
<tr>
<td>New</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.15</td>
<td>.55</td>
<td>.88</td>
</tr>
</tbody>
</table>

identifications at each of the seven cue levels (1 to 7 letters). The data for the first two or three levels were uninformative, since performance was very low. Both same-unfolding and different-unfolding functions demonstrated priming, \( t(23) = 9.89 \) and 10.59 respectively, \( p < .001 \) in both cases. Hyperspecificity of transfer was measured by subtracting the area under the different-unfolding function from the area under the

*Figure 2.* Priming effect at each of four cue levels of same and different unfoldings (Experiment 2).
same-unfolding function. As is obvious from the graphs, the same and different unfolding conditions showed virtually identical priming; the priming in the same unfolding condition exceeded that in the different unfolding condition by a mere .01, which, of course, was not statistically significant, \( t(23) = 0.43, p = .67 \).

**Discussion**

The primary result from this experiment was its failure to yield evidence of hyperspecific transfer-appropriate processing. This null result is, perhaps, surprising given previous evidence for hyperspecific transfer in indirect memory (e.g., Hayman & Tulving, 1989; Gardiner et al., 1989). This previous evidence was obtained with single word fragments as cues, and since the transfer is assumed to depend on a match between the test and previous processing, it was expected that perceptually enriched "unfolding" presentations of this experiment would result in appreciably enhanced hyperspecific transfer.

Perhaps a partial explanation of the failure to find hyperspecific transfer could be sought in the rate at which the words were unfolded. More particularly, perhaps the full second delay between the presentation of successive letters precluded the perceptual integrity of the unfolding dynamic. To explore this possibility was the purpose of Experiment 3.

**Experiment 3**

Experiment 3 was identical to Experiment 2 except that (i) the rate at which the words were unfolded was increased from one letter every second to one letter every quarter second, and (ii) the length of the study and test sequences was doubled.
Method

Subjects. The subjects were 18 Rice University undergraduates.

Materials. A total of 246 common 8-letter words were selected from the word pool used in Experiment 1 and 2. As before, two 1- to 7-letter fragment “unfoldings” were prepared for each word. Six words were used in the practice phase and the remaining 240 in the experiment proper.

Design. The design was essentially as in Experiment 2. All 246 words appeared as test items, and they were presented in the same order for all subjects. For any given word, one unfolding was used for half of the subjects, and the other unfolding for the other half. For each subject, two thirds of the test words (i.e., 160 for the experiment proper plus 4 for practice) had been unfolded in the study phase of the procedure; of these, half (80 plus 2) had been unfolded in the same way as at test and half the other way. Counterbalancing measures ensured that, across each of six equal-sized groups of subjects, each word had appeared equally often in each of three test conditions, referred to as the same unfolding, different unfolding, and new conditions.

Procedure. The procedure was just as in Experiment 2, except that, in both the study and test phases, words were unfolded at a rate of one letter every quarter second. In both phases, the subjects clicked the mouse as soon as they thought they had identified the words. In the study phase the clicks did not affect the word presentation; in fact, although the subjects were led to think otherwise, they were not even recorded. In the test phase, the clicks brought up a response box, in which the subjects typed their response. If the response was correct, presentation of the next word began immediately; if it was
incorrect, the fragment to which the response had been made was increased by one letter.

The test procedure began with six practice items. A brief pause was allowed midway through the test proper.

**Results**

The data analysis was as Experiment 2. Table 5 shows the cumulative proportion of identified words for each of the seven levels of cues under each of the three test conditions.

<table>
<thead>
<tr>
<th>Table 5. Mean Cumulative Proportions of Correctly Identified Words for Each Combination of Cue Level and Cue Type (Experiment 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cue Level</strong></td>
</tr>
<tr>
<td>Same Unfolding</td>
</tr>
<tr>
<td>Different Unfolding</td>
</tr>
<tr>
<td>New</td>
</tr>
</tbody>
</table>

Figure 3 was created by averaging performance over subjects and items, just as in Experiment 2. For the data summarized in Figure 3, in which the scores corresponded directly to the cue levels, significant priming occurred for both same-unfolding and different-unfolding conditions, $t(17) = 6.61$ and $6.64$ respectively, $p < .001$ in both cases.

Hyperspecificity of transfer was measured by subtracting the area under the different-unfolding function from the area under the same-unfolding function, and doubling the result.

In fact, there was no advantage for the same unfolding condition. Such difference as occurred
Figure 3. Priming effect at each of four cue levels of same and different unfoldings (Experiment 3).

favored the different-unfolding condition, but it was tiny (.007), and not significant, \( t(17) = 0.36, p = 0.72 \).

**Discussion**

The intent of this experiment, like that of Experiment 2, was to use a dynamic and hence, presumably, perceptually enriched mode of item presentation to obtain a heightened level of hyperspecific transfer of processing. In an attempt to increase the perceptual integrity of the dynamic presentation, the rate of item presentation was increased from that used in Experiment 2. Yet the result was the same. Not only did the procedure fail to produce an elevated level of hyperspecific transfer of processing, but it failed to produce any at all.

It is unclear how this null result should be reconciled with the findings of Hayman and Tulving (1989) and Gardiner et al. (1989). The procedural details of these studies differed from those of Experiment 2 and 3 in many ways other than in the static versus
dynamic mode of item presentation, and perhaps it was one of these differences rather
than the mode of item presentation that caused the discrepant outcome. The purpose of
the final experiment was to explore this possibility.

**Experiment 4**

This experiment was modeled more closely than the previous experiments on
Hayman and Tulving's (1989) first experiment. Thus, it included two successive tests,
with priming being measured from the first test to the second, rather than from the study
phase to a single test. But as in Experiments 1-3, the test items were unfolded letter by
letter rather than being presented as a single static fragment. The unfolding always
continued until identification occurred, even if this necessitated presentation of the entire
word. One consequence of this procedural detail is that it allowed the key
question—whether second-test items were more readily identified when unfolded
precisely as in the first test than when unfolded differently—to be addressed more
directly than with Hayman and Tulving's procedure. Specifically, the unfolding
technique, while retaining the generation requirement, ensured identification of all test
words. In the conventional generation task used by Hayman and Tulving, by contrast,
performance in the second test had to be conditionalized on performance in the first test,
for a failure to generate a target word in the first test could hardly be expected to prime its
generation in the second test, regardless of whether the fragments in the two tests were
the same or different.

On the basis of Hayman and Tulving's (1989) findings, it was expected that: (i) in
Test 1, items that had been included in the study list would be more readily identified
than new items, demonstrating item-specific priming; and (ii) in Test 2, items that had
been included in the study list would again be more readily identified than new items, but these items would be more readily identified by virtue of having occurred in Test 1 only if unfolded in the same way, demonstrating hyperspecific priming. By contrast, if the findings of Experiments 2 and 3 generalize to the double-test procedure of this experiment, Test 2 identification should benefit from inclusion in Test 1 regardless of whether the unfolding is the same or different, demonstrating a complete absence of hyperspecific priming.

**Method**

*Subjects.* The subjects were 50 Rice University undergraduates.

*Materials.* Word selection was much as in Hayman and Tulving's (1989) experiment. Thus, whereas that experiment included 128 target words and 96 buffer words (16 as primacy and 80 as recency study-list buffers) of 6 to 8 letters, the present experiment included 150 target words and 92 buffer words (12 primacy and 80 recency buffers) all of 8 letters. In both cases, the mean frequency of everyday usage of the selected items was 20 times per million according to the Thorndike-Lorge count. Two "unfoldings" were prepared for each word. Ten of the buffer words were used as practice test items.

*Design.* Although from the subject's perspective the study phase was followed by a single long test, and although with respect to the principal issue at hand there were two consecutive tests for each target item, the various control and counterbalancing measures called for three unequal test segments, or phases. These will be referred to as Phase I,
Phase II, and Phase III, as distinct from the target words' first and second tests, which will be referred to collectively as Test 1 and Test 2.

To construct the study list and the three phases of the test, the 150 target words were randomly assigned to 10 15-word sets, labeled A through J. The role of these 10 sets was rotated through 10 equal-sized groups of subjects according to a Latin square, so that across subjects, each set served in each role equally often.

Consider the assignment of the word sets for just one of the ten subject groups, Group 1. Word sets A, B, C, and D (i.e., 60 target words in all) were assigned to the study list, following the 12 primacy and preceding the 80 recency buffer words. In Phase I of the test, the words of two of the studied sets (A and B) were randomly mixed with those of two unstudied sets (E and F). In Phase II of the test, the four studied sets (A, B, C, and D) were randomly mixed with the two sets introduced in Phase I (E and F) and two new sets (G and H). The words of two of these sets (A and B) were thus cued for the second time (having already been cued in Phase I); the words of one of these sets (A) were cued with the same unfolding as in Phase I, and those of the other set (B) were cued with a different unfolding. Similarly, the words of one of the unstudied but previously tested sets (E) were cued with the same unfolding as in Phase I, and those of the other (F) were cued with a different unfolding. In Phase III, the words of the two studied sets that were cued in Phase II (C and D) and those of the two sets introduced in Phase II (G and H) were randomly mixed with those of the two remaining sets (I and J). The words of two of the previously tested sets (C and G) were unfolded the same way as before, and those of the other two previously tested sets (D and H) were unfolded in a different way. This
arrangement, which is summarized in Table 6, allowed contemporaneous first and second testing of studied and unstudied target words.

<table>
<thead>
<tr>
<th>Study Test</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>A</td>
<td>B</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>Phase II</td>
<td>A_S</td>
<td>B_D</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Phase III</td>
<td>C_S</td>
<td>D_D</td>
<td>G_S</td>
<td>H_D</td>
</tr>
</tbody>
</table>

*Note. The subscripts, shown for the second test, indicate that the unfolding was the same as (S) or different from (D) the unfolding in the first test.*

*Procedure.* The procedure blends that of Experiments 2 and 3 with that of Hayman and Tulving’s (1989) Experiment 1. Subjects studied a sequence of 152 8-letter words, presented at a rate of one every 4 seconds (the rate used by Hayman and Tulving) in Geneva size 24 font on a desktop computer. They then saw a long series of 8-letter words unfolded letter by letter at a rate of one letter every half second. Their task was to identify the word as quickly as possible. As soon as they thought they had identified a word, they clicked the mouse and typed the word in the resulting response box. If the typed word was correct, the screen flashed and the presentation of the next word began immediately; if it was incorrect, the fragment to which the response was made was increased by one letter. The first 10 words served as practice. A brief pause was allowed midway through the test proper. The test proceeded with no other interruption, and hence the three-phase structure of the test was not apparent to the subjects.

**Results**

Recall that the question of principal interest is whether identification of words presented in the test phase of the procedure for the second time is faster when unfolded in
the same way as in their first test presentation than when unfolded in a different way. Given that the primary purpose of this experiment was to apply the unfolding technique to Hayman and Tulving' (1989) experiment design, and given that in their experiment double testing was restricted to words that were included in the study list, this question will be posed first with respect to just the studied words. The relevant data are summarized in Table 7. Each row of data in the table gives the cumulative probabilities of identification for a particular combination of test (Test 1 or Test 2) and unfolding condition (same unfolding and different unfolding). Thus, for Subject Group 1 and with reference to Table 6, the successive rows correspond to word sets A and C, A_S and C_S, B and D, and B_D and D_D, respectively. The data are illustrated in Figure 4, although the first three fragment sizes were too weak to yield informative data and so are not represented. Both functions are significantly above the diagonal, t(49) = 10.67 for the same unfolding condition, and t(49) = 8.88 for the different unfolding condition, p < .001 in both cases, indicating that second test performance was facilitated, or primed, by the first test. No less obviously, the two functions are above the diagonal to a virtually identical extent (.18, as a proportion of total area above the diagonal, in both cases), which means that priming was unaffected by whether Test 2 unfolding was the same as or different from Test 1 unfolding.

Consider now whether Test 2 performance was enhanced by same relative to different unfolding for those words that were not included in the study list. This question can be construed as identical to the question posed in Experiment 2 and 3. Thus, Test 1 item presentation for the unstudied words is equivalent to the study presentation in
Table 7. Mean Cumulative Proportions of Correctly Identified Studied Words for Each Combination of Cue Level and Cue Type (Experiment 4)

<table>
<thead>
<tr>
<th>Cue Level</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Unfolding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Test</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.04</td>
<td>.25</td>
<td>.65</td>
<td>.89</td>
</tr>
<tr>
<td>Second Test</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.11</td>
<td>.38</td>
<td>.75</td>
<td>.92</td>
</tr>
<tr>
<td>Different Unfolding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Test</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.05</td>
<td>.23</td>
<td>.62</td>
<td>.89</td>
</tr>
<tr>
<td>Second Test</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.10</td>
<td>.38</td>
<td>.73</td>
<td>.90</td>
</tr>
</tbody>
</table>

![Graph](image)

Figure 4. Priming effect at each of four cue levels of same and different unfoldings for studied words (Experiment 4).

Experiment 2 and 3, and Test 2 presentation for these items is equivalent to the (single) test presentation in Experiment 2 and 3. To see if the null effect of same versus different unfolding observed in Experiment 2 and 3 replicated in the present experiment, the probability of Test 2 identification of unstudied words was plotted against the probability of identification of new words. The relevant data are shown in Table 8 and Figure 5. Once again there was significant priming from prior unfolding, \( t(49) = 12.56 \) for the same
unfolding condition and \( t(49) = 13.65 \) for the different unfolding condition, \( p < .001 \) in both cases. But also once again, the degree of priming was identical for the same and different unfolding conditions (.24, as a proportion of total area above the diagonal, in both cases).

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same Unfolding</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.06</td>
<td>.29</td>
<td>.68</td>
<td>.90</td>
</tr>
<tr>
<td>Different Unfolding</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.07</td>
<td>.31</td>
<td>.68</td>
<td>.88</td>
</tr>
<tr>
<td>New</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.14</td>
<td>.51</td>
<td>.84</td>
</tr>
</tbody>
</table>

Table 8. Mean Cumulative Proportions of Correctly Identified Unstudied Words for Each Combination of Cue Level and Cue Type (Experiment 4)

![Graph](image)

*Figure 5. Priming effect at each of four cue levels of same and different unfoldings for unstudied words (Experiment 4).*
Conclusion

The purpose of this experiment was to apply the dynamic item presentation procedure used in the previous experiments to Hayman and Tulving’s (1989) experiment design in an effort to obtain a heightened degree of hyperspecific transfer of processing. The results not only fell short of this mark but, consistent with those of Experiments 2 and 3, they failed to yield hyperspecific transfer of processing in any measure whatsoever.

General Discussion

A method for assessing priming in memory has been described. By including multiple criteria, it is more comprehensive than the methods used hitherto.

The method was used in Experiment 1 to compare priming in semantic cueing and fragment completion tests following a study phase in which target words were presented with no word-specific contexts. Because presentation of the target items in the study phase of the procedure was under conditions that might plausibly be assumed to foster semantic processing more than orthographic processing, the transfer-appropriate processing principle suggests that priming should have been more pronounced in the semantic cueing test than in the fragment completion test. The results showed just the opposite. One interpretation of this finding is that, just as it can be argued (Watkins, 2002) that the levels of processing principle (i.e., semantic processing results in more durable memory than structural processing) retains heuristic value despite reports of its violation under certain combinations of study and test conditions, so too it can be argued that the principle that direct memory requires a study-to-test match of conceptual processing whereas indirect memory requires a study-to-test match of perceptual
processing (Roediger & Blaxton, 1987) retains heuristic value despite evidence that priming can occur in indirect semantic tests and that graphemic can be effective cues in direct tests (Blaxton, 1989).

Experiments 2 and 3 were designed to explore the phenomenon of hyperspecific transfer of processing, or sublexical priming. The design of these experiments was a simplified version of an experiment reported by Hayman and Tulving (1989, Experiment 1). This experiment involved a study-test-test procedure, with priming being measured from the first to the second test. In both tests the cues were single static presentations of fragments of the target words. Experiments 2 and 3 used a study-test procedure, with priming being measured from study to test. The test called for rapid identification of target words presented letter by letter. The two experiments differed only in the rate at which the letters were added. In Hayman and Tulving's experiment, identification of a target word in Test 1 predicted its identification in Test 2 only when the same cue was used in both tests. In Experiments 2 and 3, by contrast, prior study facilitated identification independently of whether the cue and test unfoldings were the same or different.

Because the findings of Experiments 2 and 3 conflicted with those of Hayman and Tulving (1989), a fourth experiment was designed with the same unfolding procedure used in the previous experiment, but with Hayman and Tulving's study-test-test design. Thus, target items were presented in normal fashion in the study phase and unfolded in the two ensuing tests. The results were as in Experiments 2 and 3: priming in Test 2 did not depend on whether the unfolding of the target words was the same or different from their unfolding in Test 1.
Just why Experiments 2 to 4 failed to show the hyperspecific transfer of processing documented in other studies (Gardinar et al., 1989; Hayman & Tulving, 1989; Olofsson & Nilsson, 1992) is unclear. Although the unfolding word procedure of the present experiment was devised in an attempt to enhance hyperspecific priming, it must now be conceded that it may have produced the opposite effect. Clearly more research is needed to check the possibility. In particular, the effects of static and unfolding presentation need to be compared in a single experiment. If such an experiment confirmed that the static cueing used in previous research yielded hyperspecific transfer of processing while the dynamic cueing of the present experiment did not, then it would be of interest to switch the kind of cueing between tests and thereby determine which the apparent inhibitory effect of unfolding presentations is localized at the priming event (Test 1) or the primed event (Test 2).
References


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