The Role of Attention During Encoding in Implicit and Explicit Memory

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In 5 experiments, participants read study words under conditions of divided or full attention. Dividing attention reduced performance on the general knowledge test, a conceptual implicit test of memory. Likewise, dividing attention reduced conceptual priming on the word-association task, as well as on a matched explicit test, associate-cued recall. In contrast, even very strong division of attention did not reduce perceptual priming on word-fragment completion, although it did reduce recall on the matched explicit test of word-fragment-cued recall. Finally, dividing attention reduced recall on the perceptual explicit tests of graphemic-recall and graphemic recognition. The results indicate that perceptual implicit tests rely minimally on attention-demanding encoding processes relative to other types of memory tests. The obtained pattern of dissociations is not readily accommodated by the transfer-appropriate-processing (TAP) account of implicit and explicit memory. Potential extensions of the TAP view are discussed.

Attention during encoding plays a critical role in later memory performance. Dividing attention during encoding reduces performance on many measures of memory, including free and cued recall and recognition (e.g., Baddeley, Lewis, Eldridge, & Thomson, 1984; Broadbent, 1958; Cherry, 1953; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Fisk & Schneider, 1984; Moray, 1959; Murdock, 1965; Norman, 1969b). The prevalence of these findings encouraged earlier researchers to posit that attention is required for the formation of durable memory traces (e.g., Broadbent, 1958; Cherry, 1953; MacKay, 1973; Moray, 1959; Norman, 1969a). A similar, central role for attention in encoding has also been espoused in more recent work (e.g., Bentin, 1994; Cowan, 1988, 1995; Craik, 1989; Craik et al., 1996; Fisk & Schneider, 1984).

The memory experiments that gave rise to this traditional view generally used explicit (or direct) tests of memory. In such tests, participants are directed to think back and try to recall information about some specific (usually experimenter-provided) event. Memory may be assessed with implicit (or indirect) tests of memory, as well (Roediger & McDermott, 1993; Schacter, 1987). In these tests, memory for prior events is inferred from the enhanced reprocessing of recently experienced stimuli, a phenomenon known as repetition priming. Research on implicit memory has garnered great notice because repetition priming often differs from performance on explicit tests in important ways. First, there have been numerous reports of population dissociations between implicit and explicit test performance, in which participants from populations impaired on explicit memory tests (e.g., people with amnesia, depression, or schizophrenia and older adults) show normal or near-normal levels of repetition priming on implicit memory tests (e.g., Denny & Hunt, 1992; Elliott & Greene, 1992; Light, 1991; Schwartz, Rosse, & Deutsch, 1993; Shimamura, 1986, 1993). Second, a number of experimental manipulations, such as levels of processing, the read-generate manipulation, and study modality, also have produced dissociations between repetition priming and performance on explicit tests (see Roediger & McDermott, 1993, for a review).

Given the centrality of attention in theories of memory encoding, it is of great interest that dividing attention during encoding may also dissociate performance on implicit and explicit tests. Several studies have reported that dividing attention during encoding can reduce explicit test performance while leaving repetition priming unaffected (Bentin, Kutas, & Hillyard, 1995; Gabrieli et al., 1996; Isingrini, Vazou, & Leroy, 1995; Jacoby, Woloshyn, & Kelley, 1989; Kellogg, Newcombe, Cammer, & Schmitt, 1996; Mulligan & Hartman, 1996; Parkin, Reid, & Russo, 1990; Parkin & Russo, 1990; Russo & Parkin, 1993; M. E. Smith & Oscar-Berman, 1990; Szymanski & MacLeod, 1996). Other studies have demonstrated that retention of very poorly attended stimuli is more likely to be detected with implicit than explicit memory tests (Bornstein, Leone, & Galley, 1987; Eich, 1984; Hawley & Johnston, 1991; Jelicic, Bonke, Wolters, & Phaf, 1992; MacKay, 1973; Mandler, Nakamura, & Van Zandt, 1987; Merikle & Reingold, 1991; Seamon, Marsh, & Brody, 1984). These results are so compelling that some researchers have suggested that implicit test performance largely reflects automatic encoding processes (Ben-
tests benefits from different types of encoding procedures (Gabrieli, Stone, Shackleton, et al., 1996; Light & Prull, 1995b; Mulligan, 1997; Mulligan & Hartman, 1996; Wood, Stadler, & Cowan, in press) suggests that this view is insufficient. To provide a framework for describing and summarizing the relevant research, the transfer-appropriate-processing (TAP) account of implicit and explicit memory (e.g., Blaxton, 1989, 1992; Craik, Moscovitch, & McDowd, 1994; McDermott & Roediger, 1996; Roediger, 1990; Roediger, Weldon, & Challis, 1989; Weldon, Roediger, Beitel, & Johnston, 1995) is useful. I first describe this framework and then review the relevant studies on attention and implicit memory.

The TAP framework is predicated on the notion that performance on a memory test is enhanced to the extent that encoding processes are reengaged at the time of retrieval (Blaxton, 1989; Roediger, 1990; Roediger et al., 1989), an assumption consistent with the encoding-specificity principle (Tulving & Tomson, 1973). Consequently, the TAP framework proposes that memory tests should be characterized primarily by the types of mental processes that they engage rather than by test instructions (i.e., implicit vs. explicit). Toward this end, the TAP framework differentiates between two broad classes of cognitive processes: perceptual processes, defined as the analysis of perceptual or surface-level features (but may also include other representations required for stimulus identification; e.g., Weldon, 1991), and conceptual processes, defined as the analysis of meaning or semantic information.

The most widely used implicit memory tests involve the identification or completion of degraded or ambiguous perceptual cues, such as word fragments or stems, briefly presented words, or fragmented pictures. The TAP framework posits that these tests are primarily dependent on perceptual processes during retrieval and, as a consequence, are sensitive to variation in perceptual processes at encoding but relatively insensitive to variation in conceptual processes. In contrast, commonly used explicit tests (e.g., free recall and recognition) are assumed to primarily use conceptual processes during retrieval (Craik et al., 1994; Roediger et al., 1989). The TAP framework accounts for dissociations between implicit and explicit tests in terms of the differences between underlying processes rather than in terms of task instructions. Specifically, because the most common implicit and explicit memory tests rely differentially on conceptual and perceptual processes, performance on these two types of tests benefits from different types of encoding procedures and is thus dissociable.

However, note that not all implicit tests are perceptual and not all explicit tests are conceptual. With the appropriate combinations of memory cues and task instructions, conceptual implicit tests and perceptual explicit tests may be constructed. The TAP framework proposes that dissociations occur between conceptual and perceptual tests, regardless of their implicit-explicit status. This parsimonious approach has had a good deal of success in accounting for and predicting dissociations among memory tests (see Roediger & McDermott, 1993, for a review).

Finally, a strength of this theory is that theorists need not rely on intuition to categorize a test as perceptual or conceptual. Rather, the TAP framework proposes a set of criterial variables for operationally defining memory tests as primarily conceptual or perceptual. A central criterion is how test performance is affected by the read-generate study manipulation. In this manipulation, some study words are presented intact to be read, whereas others study words are not physically presented but must be produced by the participant from a conceptual cue (e.g., an antonym). In the read condition, the perceptual characteristics of the study word are processed to a greater degree than in the generate condition, whereas in the generate condition, the conceptual characteristics of the word are processed to a greater degree (e.g., Jacoby, 1983b). In the TAP framework, memory tests that exhibit the typical generation effect, in which the generate condition leads to superior performance to that of the read condition (e.g., Slamecka & Graf, 1978), are assumed to reengage primarily conceptual processes and are classified as conceptual memory tests. Memory tests exhibiting the reverse generation effect, in which the read condition leads to greater performance than the generate condition, are assumed to reengage primarily perceptual processes and are classified as perceptual memory tests (e.g., Blaxton, 1989; Roediger, 1990; Roediger & McDermott, 1993; Roediger et al., 1989). Other primary criterial variables are the study-modality manipulation and the levels-of-processing manipulation (e.g., Blaxton, 1989; Roediger, 1990; Roediger & McDermott, 1993).1

With regard to the effects of divided attention, the TAP distinction between perceptual and conceptual processes has two implications. If, as is traditionally assumed, dividing attention at study reduces the amount of semantic or conceptual processing (e.g., Broadbent, 1971; Craik, 1983; Craik & Byrd, 1982; Craik et al., 1996; Eagle & Ortof, 1967; Koriat & Feuerstein, 1976; Norman, 1969a) but has little or no effect on perceptual identification processes, then the TAP framework predicts (a) that divided attention should have little or no effect on perceptual tests and (b) that divided attention should reduce performance on conceptual tests.

With regard to perceptual implicit tasks, the prediction of the TAP framework has been largely borne out. Provided the manipulation of attention does not disrupt stimulus identification, dividing attention leaves priming unaffected on the perceptual tests of word-fragment completion (Mulligan &

1 Although perceptual implicit tests are typically unaffected by the levels-of-processing manipulation (Roediger & McDermott, 1993), at least some of these tests are sensitive to this manipulation under some conditions (Challis & Brodbeck, 1992; Thapar & Greene, 1994; see Brown & Mitchell, 1994, for a review). The exact significance of these results for the TAP framework is a matter of current debate (e.g., Challis & Brodbeck, 1992; Thapar & Greene, 1994).
Hartman, 1996; Parkin et al., 1990), picture-fragment completion (Parkin & Russo, 1990; Russo & Parkin, 1993), lexical decision (Kellogg et al., 1996; M. E. Smith & Oscar-Berman, 1990; Szymbanski & MacLeod, 1996), and perceptual identification (Gabrieli, Stone, Shackleton, et al., 1996; see Mulligan & Hartman, 1996, for a review). These results imply that perceptual priming has minimal reliance on attentional resources (beyond those necessary for stimulus identification; see Mulligan & Hartman, 1996, and Stone, Ladd, Vaidya, & Gabrieli, 1996, for discussion). The only exception is priming in word-stem completion, which appears to be reduced by divided attention (Gabrieli, Stone, Shackleton, et al., 1996). However, the nature of this implicit test is in dispute; some researchers argue that this test is primarily perceptual, whereas others argue that it is primarily conceptual (cf. Gabrieli et al., 1994; Keane, Gabrieli, Pennena, Growdon, & Corkin, 1991; Roediger, Weldon, Stadler, & Riegler, 1992).

Most of the studies on implicit memory and divided attention have used perceptual priming tasks. The few studies using conceptual implicit tests have produced mixed results. Consistent with the prediction of the TAP framework, Mulligan and Hartman (1996) recently reported that dividing attention during encoding reduced later conceptual priming on the category-exemplar production task, as well as reducing recall on a comparable explicit test, category-cued recall (see Gabrieli, Stone, Shackleton, et al., 1996; Light & Prull, 1995b, for similar findings). However, Isingrini et al. (1995), using a similar experimental design and the same memory tests, found no effect of divided attention on category-exemplar production, although category-cued recall was reduced. Because the division-of-attention task in Isingrini et al. appeared to be a weaker manipulation of attention than that used by Mulligan and Hartman and Gabrieli, Stone, Shackleton, et al. (1996) and because Isingrini et al. (1995) reported a nonsignificant reduction in priming for all of the divided-attention groups (Isingrini et al. compared full vs. divided attention in each of four age groups), Mulligan (1997) hypothesized that the strength of the attention manipulation was important in accounting for the divergent results. Using a memory-load paradigm to divide attention over several levels, Mulligan found that category-cued recall was reduced in all the divided-attention conditions, whereas in the category-exemplar production task, priming was reduced (in fact, eliminated) only for the strongest division of attention but not for milder divisions. This appears to resolve the discrepancy between Mulligan and Hartman’s results and those of Isingrini et al. Conceptual priming in the category-exemplar production task is affected by divided attention, but the division of attention in Isingrini et al.’s study was too mild to reveal this. In summary, conceptual priming in category-exemplar production appears to be dependent on attention.

Experiments 1 and 2 tested the generality of the TAP prediction that conceptual priming should be diminished by divided attention by examining the effects of this manipulation on the conceptual implicit tests of general knowledge questions (Experiment 1) and word association (Experiment 2). The implications of the TAP framework derived earlier focus this inquiry on the role of attention in postperceptual aspects of memory encoding. Consequently, the attentional manipulations used in these and subsequent experiments do not prevent the identification of the study stimuli. Participants in divided-attention conditions were asked to identify study words as well as carry out a secondary task. Furthermore, given the findings of Mulligan (1997), strong division of attention seems important if one is to maximize the probability of observing divided-attention effects on conceptual priming. Consequently, procedures were used that were similar to those used by Mulligan and Hartman (1996, Experiment 1) and Gabrieli, Stone, Shackleton, et al. (1996) in uncovering effects of divided attention on conceptual priming in the category-exemplar production test. Two groups of participants were visually presented with a set of words under either full- or divided-attention conditions. The divided-attention task was a digit-monitoring task in which participants were asked to monitor an aurally presented series of digits for sequences of three odd numbers. This task provides a rigorous division of attention, eliminating priming in the category-exemplar production task (Mulligan & Hartman, 1996). The results of Mulligan (1997), which used various memory loads to divide attention, are consistent with this characterization. The digit-monitoring task in Mulligan and Hartman reduced conceptual priming to the same (approximately zero) level as the strongest divided-attention condition in Mulligan (1997).

In Experiment 1, the memory test consisted of a set of questions, presented as a general knowledge test. The answers to some of the questions were presented in the study list. Within the TAP framework, the general knowledge test is considered conceptual because it is affected by conceptual encoding manipulations, such as the generation manipulation (Blaxton, 1989, 1992) and levels of processing (Hamann, 1990), and is unaffected by perceptual encoding manipulations, such as varying study modality (Challis et al., 1993). The TAP framework implies that this implicit test should be affected by divided attention during encoding.

Experiment 1

Method

Participants. Sixty-four undergraduates at Illinois State University participated in exchange for extra credit in psychology classes.

Design and materials. The experiment used a 2 X 2 design in which study status (old vs. new) was manipulated within subjects and attention at encoding (full vs. divided) was manipulated between subjects.

The study and test materials were extracted from the set developed by Blaxton (1989). One hundred general knowledge questions and their single-word answers (e.g., “What is the fastest animal on earth?” Cheetah) were chosen from this source. The 100 answers were randomly divided into two sets of 50. These critical items were preceded by a primacy buffer and followed by a recency buffer of 4 unrelated words each, yielding two study lists of 58 words. The general knowledge test consisted of the 100 questions corresponding to the critical items (50 corresponding to studied, or old, items and 50 to new items), plus 8 filler questions, also drawn from Blaxton’s materials. The resulting 108 questions were randomly ordered.
The task used in the divided-attention condition was a digit-monitoring task (as used in Mulligan & Hartman, 1996; see Craik, 1982; Jacoby, 1991). Participants monitored a tape-recorded series of random digits, attempting to detect target sequences of three odd digits in a row. The digits were played at the rate of 1 digit per 1.5 s. There were 32 target sequences randomly distributed through the series of 180 digits, subject to two constraints: (a) A minimum of 1 and a maximum of 5 numbers occurred between the end of one target sequence and the beginning of the next, and (b) not more than 2 even digits occurred in sequence. The list of 180 digits was recorded six times from beginning to end without pause between repetitions.

Procedure. Participants were tested individually. The experiment began with the study phase, in which each study word was displayed in the center of a computer screen for 3 s. Participants were instructed to read each word out loud and to try to remember the words for a later, unspecified memory test. This was the sole task for participants in the full-attention condition. Participants in the divided-attention condition simultaneously performed the digit-monitoring task. These participants were told to monitor the digits for strings of three odd numbers in a row and to tap a pen on the desk whenever they detected a target string. If a participant missed a target sequence, the experimenter prompted the participant by saying "Miss." The experimenter monitored and recorded errors in reading the words and detecting target sequences of digits. Task instructions emphasized that the digit-monitoring task and reading and remembering the words were both equally important. Participants in the divided-attention condition were allowed approximately 30 s of practice on the digit-monitoring task before the start of the study list.

A 3-min distractor task followed the study phase. The task was used to disguise the relationship between the study session and the subsequent memory test by making the memory test appear to be a series of unrelated tasks. The distractor task was a city names completion task. Participants were presented with a set of index cards, on each of which was printed the first three letters of a U.S. city (e.g., Bos — for Boston). The participants were asked to complete each city word stem with the name of a U.S. city.

The general knowledge test followed the distractor task. Participants were presented with a test booklet consisting of the general knowledge questions. Participants were instructed to try but were not required to answer each question. Answers were to be written in the space provided next to each question. Participants were given 15 s per question. Time was kept with an audiocassette tape that emitted a beep every 15 s. No mention was made of the relationship between this task and the studied words.

Results and Discussion

During the study task, participants in the divided-attention condition correctly identified 97% of the study words and detected 88% of the target digit strings. Thus, participants in the divided-attention condition were able to identify the vast majority of the study words while simultaneously identifying almost all of the target sequences. However, the identification of study words was not quite perfect in the divided-attention condition. Consequently, the test data in this and all subsequent experiments were analyzed in two ways, conditioned on correct identification at study and unconditioned. In all cases, the two analyses led to identical conclusions. Only the unconditioned results are reported below.

The results of the general knowledge test are summarized in Table 1. Mean proportions of correct answers are presented as a function of attention at encoding and study status. The results are straightforward: Dividing attention reduced the amount of priming in the general knowledge test. The proportions correct were submitted to a 2 × 2 analysis of variance (ANOVA), using study status (old vs. new) as a within-subjects variable and attention at encoding (full vs. divided) as a between-subjects variable. The significance level for this and subsequent analyses was .05.

The analysis produced two significant effects. First, the main effect of study status was significant, $F(1, 62) = 60.25$, $MSE = 0.0068$, indicating significant overall priming. Second, and more important for present purposes, the Study Status × Attention interaction was significant, $F(1, 62) = 5.17$, $MSE = 0.0068$, indicating greater priming in the full-than divided-attention condition. Follow-up $t$ tests indicated a significant effect of study status (i.e., priming) in both the full- and divided-attention conditions, $t(31) = 6.89$ and $t(31) = 4.01$, respectively.

The results of the present experiment were consistent with Gabrieli, Stone, Shackleton, et al. (1996), Mulligan and Hartman (1996), and Mulligan (1997), indicating that a strong division of attention reduces conceptual priming in both the category-exemplar production task and in the general knowledge test. However, one potential problem with using the general knowledge test as a measure of conceptual priming is that it may be more susceptible to explicit contamination than other conceptual implicit tests (Vaidya, Gabrieli, Demb, Keane, & Wetzal, in press; Vaidya et al., 1996). For example, amnesics are frequently impaired on this test, which may be an indication of explicit contamination (Blaxton, 1992; Experiment 1; Vaidya et al., in press). In Experiment 2, the effects of divided attention were assessed on the conceptual implicit memory test of word association. This task is arguably a better measure of implicit memory and one in which amnesics perform comparably to nonamnesics (Graf, Shimamura, & Squire, 1985; Schacter, 1985). In addition, Experiment 2 used a posttest questionnaire to determine whether participants were aware of the relationship between the study episode and the implicit test and the extent to which they had deliberately tried to retrieve study items (Bowers & Schacter, 1990; Light & Albertson, 1989; Mulligan & Hartman, 1996). As is shown, the results from the posttest questionnaire indicated that the word-association task was minimally contaminated by explicit influences.

The word-association task has been used in prior research to assess the effects of divided attention. Anooshian (1989) concluded that dividing attention reduced conceptual priming in a variant of the traditional word-association task. In

| Table 1: Proportions of Correct Responses in the General Knowledge Test as a Function of Study Status and Attention at Encoding |
|---------------------------------|---------------|---------------|---------------|
| Attention condition            | Study status  | Old | New | Old − new |
| Full attention                 | .30           | .15 | .15 |
| Divided attention              | .25           | .17 | .08 |
this study, participants were aurally presented with homophones embedded in phrases biasing their less common meaning. The phrases were presented either in focally attended questions or on the unattended channel in a dichotic listening task. Participants were later asked to free associate to a set of old and new aurally presented homophones. The interpretations of the homophones were inferred from the free associations produced. Anooshian found that old homophones were more frequently interpreted in line with their less common meaning than were new homophones and that this difference was larger for the focally attended than unattended condition (i.e., greater conceptual priming in a full-attention condition). However, in this study the implicit word-association test followed an explicit test of homophone recognition, which may have jeopardized the implicit status of the word-association task.

An early study by Koriat and Feuerstein (1976), using the traditional version of word association, suggests a different conclusion. Koriat and Feuerstein presented participants with an auditory study list either under intentional learning instructions or under incidental learning instructions coupled with a distractor task. This latter (divided attention) condition reduced performance on the explicit memory tests of free recall and recognition but did not reduce priming on the conceptual implicit test of word association. Thus, unlike Gabrieli, Stone, Shackleton, et al. (1996) and Mulligan and Hartman (1996), Koriat and Feuerstein found an apparent dissociation between conceptual priming and conceptual explicit memory. Specifically, Koriat and Feuerstein's results imply that conceptual priming may not rely on attentional encoding processes.

There are several potential reasons for the divergent results of Gabrieli, Stone, Shackleton, et al. (1996) and Mulligan and Hartman (1996), on the one hand, and Koriat and Feuerstein (1976), on the other. The most obvious has to do with the differences between the word-association and the category-exemplar production tests. The word-association task typically makes use of highly associated items (e.g., doctor-nurse), whereas the examples in category-exemplar production are typically less strongly associated with the category cues (in both Gabrieli, Stone, Shackleton, et al., 1996, and Mulligan & Hartman, 1996, the studied examples did not rank in the 10 most frequently produced instances, according to the norms of Battig & Montague, 1969). It is possible that the use of very strong associates eliminates the need for elaborative processing to produce relatively accessible memory traces (Bentin et al., 1995; Rabinowitz, Craik, & Ackerman, 1982).

A second difference among the studies is that they used different tasks to divide attention. A digit-monitoring task was used by Gabrieli, Stone, Shackleton, et al. (1996) and by Mulligan and Hartman (1996), a memory-load task was used by Mulligan (1997), and a digit symbol task was used by Koriat and Feuerstein (1976). The results of Mulligan (1997) underscore the importance of the strength of the divided-attention manipulation. A memory test dependent on attention during encoding may not appear so if attention has been weakly divided. It is difficult to gauge whether Koriat and Feuerstein's manipulation was as strong a division of attention as that used by Gabrieli et al. and by Mulligan and Hartman.

A final consideration is that Koriat and Feuerstein (1976) did not use parallel explicit and implicit memory tests. Consequently, it is not possible to determine if the dissociating effects of divided attention are due to the manipulation of test instructions (implicit vs. explicit) or to other differences between the word-association task and the free-recall and recognition tests (e.g., type of memory cue or response demands). As demonstrated by Craik et al. (1996), different explicit tests are differentially reliant on (i.e., sensitive to) attention at encoding. To be more confident that divided attention dissociates implicit and explicit test performance, one should use a robust division of attention and demonstrate its effects on the explicit test before one can confidently interpret a null result on the parallel implicit test (Mulligan & Hartman, 1996).

Further investigation of the word-association test is important for two reasons. First, it is important to further test the generality of the TAP prediction that conceptual priming will be diminished by divided attention. Second, the Koriat and Feuerstein (1976) results have been interpreted as evidence that attention may not be required for intact conceptual priming (e.g., Jacoby, Toth, & Yonelinas, 1993; Jacoby, Wolsolyn, & Kelley, 1989; Smith & Oscar-Berman, 1990). In Experiment 2, we addressed some of these issues to determine if conceptual priming in the word-association task is sensitive to a strong division of attention. We used procedures similar to those used by Mulligan and Hartman (1996, Experiment 1) and Gabrieli, Stone, Shackleton, et al. (1996) in uncovering effects of divided attention on conceptual priming in the category-exemplar production test. These same procedures were used in the present Experiment 1, in which divided attention reduced priming in the general knowledge test. Participants were visually presented with a list of words under the same full- or divided-attention conditions as in Experiment 1. As noted earlier, the digit-monitoring task provides a strong division of attention, eliminating priming in the category-exemplar production task (Mulligan & Hartman, 1996).

Retention of the studied words was tested with the implicit test of word association and with its explicit counterpart, associate-cued recall. The cued-recall task was identical to the word-association task in all ways except instructions. Thus, it was possible to determine if the divided-attention task was strong enough to reduce performance on a parallel explicit test.

### Experiment 2

#### Method

**Participants.** Sixty-four undergraduates at Illinois State University participated in exchange for extra credit in psychology classes.

**Design and materials.** The experiment used a $2 \times 2 \times 2$ design in which study status (old vs. new) was manipulated within subjects and attention at encoding (full vs. divided) and memory test (word association vs. associate-cued recall) were manipulated between subjects.

Fifty critical cue–response word pairs were chosen from the...
Shapiro and Palermo (1968) word-association norms. Each response word was the primary response to its associated cue. The normative associative probabilities of the word pairs varied from .19 to .61, with a mean of .34. The study lists were composed of the response word from each pair. The response words were randomly divided into two groups of 25 critical words each. Eight additional words were used as primacy and recency buffers, 4 preceding and 4 following the critical words, creating two study lists of 33 words each.

Both the word-association test and the cued-recall test consisted of the 50 critical cue words, 25 corresponding to studied words (the old words) and 25 to nonstudied words (the new words). The critical cue words were intermixed with 44 filler cues (also chosen from Shapiro & Palermo, 1968), creating a test list of 94 cue words.

The divided-attention task was identical to that used in Experiment 1.

Procedure. The study and distractor phases were identical to Experiment 1. After the distractor task, participants completed either the word-association test or the cued-recall test. For the word-association test, participants were told that this was a normative word-association study and that we would use their responses to develop materials for future research. The participants were asked to read each cue word and write down the first word that came to mind, working rapidly through the list. Participants responded to each cue word in this task. No mention was made of the relationship between this task and the studied words. After finishing the word-association task, participants were given an awareness questionnaire. The experimenter asked a series of increasingly specific questions, to assess whether participants noticed the relationship between the study task and the memory test and the extent to which they had deliberately tried to retrieve study items.

For the cued-recall task, participants were informed that this was a memory test for the words that were read aloud earlier in the experiment. These participants were told to use the cue words to try to remember related studied words but that many of the cues were not related to studied items. Participants were asked to go through the cue words in order, writing down remembered words next to the cue. As is standard in this task, participants were not required to respond to each cue. Both the cued-recall and word-association tasks were self-paced.

Results and Discussion

During the study task, participants in the divided-attention condition correctly identified 99.5% of the study words and detected 95% of the target digit strings. Mann–Whitney U tests indicated that the percentages of study words identified and target strings detected did not significantly differ as a function of subsequent test condition (ps > .5), as would be expected. Participants in the divided-attention condition were able to identify virtually all study words while simultaneously identifying the vast majority of the target sequences.

Table 2 summarizes the results of the memory tests. Proportions of critical items produced are presented as a function of test type, attention at encoding, and study status. It can be seen from the table that dividing attention produced strong effects on associate-cued recall and conceptual priming in the word-association task. Statistical analyses confirm this summary. The data from the word-association and cued-recall tests were submitted to separate 2 × 2 ANOVAs, using study status (old vs. new) as a within-subjects variable and attention at encoding (full vs. divided) as a between-subjects variable. For the word-association task, the analysis revealed two significant effects: (a) a main effect of study status, F(1, 30) = 10.81, MSE = 0.0027, and (b) an interaction between study status and attention, F(1, 30) = 5.25, MSE = 0.0027. Overall, significant priming was obtained, but crucially, priming was greater in the full- than divided-attention condition. Follow-up t tests indicated a significant effect of study status (i.e., priming) in the full-attention condition, t(15) = 4.23, but not in the divided-attention condition (p > .5). Thus, priming was obtained in the full-attention condition but not in the divided-attention condition.

Analysis of the cued-recall data also yielded significant effects of study status, F(1, 30) = 56.63, MSE = 0.0067, and the Study Status × Attention interaction, F(1, 30) = 6.92, MSE = 0.0067. These results indicated that recall of old words exceeded the guessing rate for new words (i.e., participants showed above-chance retention) but that divided attention reduced the difference between old and new items. Therefore, divided attention also affected the explicit version of the word-association task. In both the full-attention condition and the divided-attention condition, t tests indicated an effect of study status, t(15) = 6.08 and 4.44, respectively. In contrast to the implicit version of this test, there was evidence of retention in both the full- and divided-attention conditions in the cued-recall test.

The current results indicate that divided attention has a very similar effect on the implicit and explicit versions of the word-association task. In fact, the present results are precisely in accord with Mulligan and Hartman's (1996, Experiment 1) finding that conceptual priming in the category-exemplar production task was also reduced to (essentially) zero in an identical divided-attention condition. The current results contrast with the findings of Koriat and Feuerstein (1976) and imply that given a strong manipulation of attention, conceptual priming in the word-association task is greatly affected by divided attention.

Whenever parallel implicit and explicit tests are affected in similar ways, there is always the potential concern that the putative implicit test has been compromised by intentional retrieval strategies. In the present case, it is possible that the results are due to more effective use of intentional retrieval in the full-attention condition of the word-association task. One way to assess the extent to which intentional retrieval...
influences the results of a nominally implicit memory test is with the use of posttest questionnaires (e.g., Bowers & Schacter, 1990; Light & Albertson, 1989; Mulligan & Hartman, 1996). In the present study, none of the word-association participants reported using intentional retrieval at test. In fact, only 4 of the 16 full-attention participants and 2 of the 16 divided-attention participants reported that they were aware that some of the words that they had produced were from the study list (the proportion of aware participants did not significantly differ across the full- and divided-attention conditions: Fisher’s exact test, \( p > .3 \), one-tailed). Excluding the aware participants from the analysis does not alter the results. The 12 unaware participants in the full-attention condition produced 36% of the old items and 28% of the new items, whereas the 14 unaware participants in the divided-attention condition produced 26% of the old and 25% of the new items. The amount of priming was significantly greater in the full- than divided-attention condition, \( F(1, 24) = 7.78, MSE = 0.0045 \). In addition, significant priming was obtained in the full-attention condition, \( t(11) = 3.53 \), but not in the divided-attention condition (\( p > .5 \)).

Consistent with this assessment is the finding that divided attention reduces conceptual priming to approximately zero but leaves associate-cued recall substantially above zero. (Mulligan & Hartman, 1996, Experiment 1, reported the same result for category-exemplar production and category-cued recall.) If performance on the word-association test were badly contaminated by intentional retrieval, then priming in the divided-attention condition would likely be significant. This finding lends further credence to the proposal that these implicit and explicit tests do not rely entirely, at least) on the same retrieval processes or memory encodings.

As an aside, we note that the word-association task seems to give rise to lower levels of intentional retrieval and test awareness, as measured by the posttest questionnaire, than category-exemplar production, which is a more widely used conceptual priming test. In Mulligan and Hartman (1996, Experiment 1), the proportions of test-aware participants were 93% and 57% in the full- and divided-attention conditions, respectively (the corresponding proportions claiming intentional retrieval were 50% and 14%). For the young adults in Light and Albertson’s (1989) study (most comparable with the full-attention condition here), 88% reported being test aware whereas 34% reported an intentional retrieval strategy. These figures compare with 25% and 12.5% of the word-association participants claiming test awareness in the full- and divided-attention conditions, respectively (as noted above, 0% claimed an intentional retrieval strategy). To the extent that the posttest questionnaire is a measure of the purity of an implicit test, these results suggest that the word-association task may be a superior measure of conceptual implicit memory, at least in this regard.

In summary, the results of this experiment add to the findings of Experiment 1 and the previously cited work (Gabrieli, Stone, Shackleton, et al., 1996; Mulligan, 1997; Mulligan & Hartman, 1996) indicating that dividing attention at study reduces conceptual priming in the word-association task, as well as the category-exemplar production and general knowledge tasks. The present results are important in demonstrating that when the division of attention is strong enough to reduce performance on the explicit test of associate-cued recall, the comparable implicit test of word association is also affected. This is significant because it is not known whether Koriat and Feuerstein’s (1976) divided-attention task, which had no measurable impact on word association, would have affected a comparable cued-recall test.

The effects of divided attention on priming are generally consistent with the predictions of the TAP framework. Recall that the TAP view predicts that for divisions of attention that do not disrupt identification, perceptual priming will be unaffected but conceptual priming will be reduced. Several studies indicate that this prediction holds for perceptual priming on tests such as word-fragment completion, picture-fragment completion, lexical decision, and perceptual identification (Gabrieli, Stone, Shackleton, et al., 1996; Kellogg et al., 1996; Mulligan & Hartman, 1996; Parkin et al., 1999; Parkin & Russo, 1990; Russo & Parkin, 1993; M. E. Smith & Oscar-Berman, 1990; Szymanski & MacLeod, 1996). In contrast, conceptual priming on tasks such as category-exemplar production, word association, and the general knowledge test is reduced by divided attention. The results of Mulligan (1997) and (arguably) the results of Experiment 2 underscore the importance of the strength of the divided-attention manipulation, indicating that weaker manipulations may not reduce conceptual priming.

This last point raises the possibility that strong division of attention may also affect perceptual priming tasks, even if the attentional manipulation does not disrupt stimulus identification. To develop this possibility, first consider that some divided-attention studies used dual-task manipulations in which the identification of study items either was substantially reduced or was not required (Bentin et al., 1995; Hawley & Johnston, 1991; Light & Prull, 1995a; Weldon & Jackson-Barrett, 1993). Generally, these studies indicate that manipulations that reduce the likelihood of stimulus identification also reduce the amount of perceptual priming (Hawley & Johnston, 1991; but see Bentin et al., 1995, for an important exception). These studies were excluded from our earlier discussion because they may represent a qualitatively different type of manipulation than divided-attention tasks that disrupt only postperceptual encoding operations. For example, reductions in perceptual priming observed in these studies may result from disruptions in lexical access, as argued by Weldon and Jackson-Barrett (1993, p. 523). Such an account does not apply to the present results or to those reviewed earlier, because overt identification of study words (presumably requiring lexical access) was required in both the full- and divided-attention conditions.

The lexical-access account and other accounts that attribute decreased perceptual priming to truncated perceptual analysis are in accord with the TAP framework. Specifically, the TAP view posits that any manipulation disrupting perceptual processes will reduce perceptual priming. The
alternative view is that divided-attention tasks that disrupt stimulus identification represent especially strong divisions of attention and that the resulting division of attention makes a unique contribution to the reduction of perceptual priming beyond the simple disruption of perceptual processing (Hawley & Johnston, 1991). If so, a strong manipulation of attention may reduce perceptual priming, even in tasks that have heretofore been unaffected by divided attention and even when the attentional manipulation does not prevent stimulus identification. This contrasts with the TAP framework, which views the strength of the attentional manipulation as irrelevant, provided perceptual identification processes are not disrupted.

Mulligan and Hartman (1996, Experiment 2), using study procedures identical to Experiments 1 and 2, found that dividing attention with the digit-monitoring task had no effect on perceptual priming in word-fragment completion but significantly reduced recall on the matched explicit test of word-fragment-cued recall. In Experiment 3, I examine the generality of this finding by using a short-term memory-load paradigm to vary attention during encoding. In this experiment, each study word was preceded by a short-term attentional load consisting of zero (the full-attention condition), three, five, or seven digits and letters. Participants were instructed to maintain the digits and letters in memory until a RECALL signal was presented a few seconds later. This technique has been used to control the division of attention over several levels (e.g., Baddeley & Hitch, 1974; Engle, Conway, Tuholski, & Shisler, 1995; Logan, 1979; Mulligan, 1997). The particular attentional loads were chosen on the basis of prior research. Using this memory-load paradigm, Mulligan (1997) found that an attentional load of five not only reduced but eliminated conceptual priming in the category-exemplar production task. In addition, these results indicated that the attentional load of five produced comparable levels of priming and cued recall as the digit-monitoring task used to divide attention in Mulligan and Hartman (1996) and in the present Experiments 1 and 2 (see Mulligan, 1997, Table 1). Considering an attentional load of five as a strong division of attention, I included that level of load, as well as an even stronger division (i.e., the seven load).

Implicit memory for the study words was assessed with the perceptual implicit test of word-fragment completion. As noted above, this perceptual test has not been affected by other (although possibly weaker) manipulations of attention. In the event that the present manipulation did not affect this test, it would be important to determine if the manipulation affected a comparable explicit test. Consequently, a separate group of participants were given a word-fragment cued-recall test.

**Experiment 3**

**Method**

**Participants.** Fifty-six undergraduates at Illinois State University participated in exchange for extra credit in psychology classes.

**Design and materials.** The experiment used a 4 × 2 design in which attentional load (zero, three, five, or seven) was manipulated within subjects and memory test (word-fragment completion vs. word-fragment-cued recall) was manipulated between subjects.

The critical study materials consisted of 96 relatively low-frequency words (mean frequency of 13; Kučera & Francis, 1967), from 5 to 10 letters in length. Two master study lists of 48 items each were created by randomly dividing the study materials in half. Within each master file, the words were randomly divided into four groups (each consisting of 12 words), and each group was rotated through each of the attentional load conditions. This produced four study lists from each master list, for a total of eight study lists. The words in each study list were randomly ordered. Twelve additional (noncritical) words were also used; 4 were presented before the list, as practice items, and 4 were placed at the beginning and end of each list as primacy and recency buffers. Each study list was presented to equal numbers of participants.

Each study item was preceded by an attentional load. Nonzero loads were constructed by randomly selecting items from the set of digits (1–9) and a set of letters (A, B, C, D, E, F, G, H, J, K, L) according to the following rules: (a) Digits and letters occupied alternating positions, with a digit in the first position, and (b) no repetition of digits or letters occurred within a load. These materials and rules were used in an attempt to minimize chunking of the loads.

The memory tests consisted of a total of 102 word fragments. The fragments consisted of between 2 and 6 letters, with underscores in the place of missing letters. The fragments were constructed to have only one legitimate completion. This was verified with the spellcheck and dictionary facilities of the WordPerfect program (Version 5.1), which indicated that all fragments were consistent with only one English word completion. In addition, the experimental participants never completed a fragment with any word other than the intended one. Of the 102 fragments, 96 corresponded to the critical items from the two master lists, 48 of which corresponded to old items and 48 to new items. Fragments from an additional 6 words were used as filler items. The fragments were randomly ordered with the constraint that there be no more than 2 items in a row of any single type (old, new, or filler). The old and new items were counterbalanced so that across participants, each word appeared equally often in the old and new conditions.

**Procedure** Participants were tested individually. The experiment consisted of a study task and a memory test. The study task was based on the procedures of Mulligan (1997). Each study trial began with a ready prompt that was displayed for 500 ms. Next, the digit–letter string constituting the attentional load (or a dash in the zero-load condition) was presented for 3,250 ms. For the non-zero-load trials, participants were instructed to read the digit–letter string aloud and retain it in memory until the recall signal was given. For the zero-load trials, participants were simply instructed to say “blank” in response to the dash. Next, the study word was presented for 3 s. Participants were instructed to read the word aloud and try to remember it for a later, unspecified memory test. Finally, either the word RECALL (in the non-zero-load conditions) or the word BLANK (in the zero-load condition) appeared for 2,750 ms. Participants were instructed either to recall the digits and letters (in the non-zero-load conditions) or to again say “blank” (in the zero-load condition).

2 Consistent with this view is the finding that explicit test performance may exceed chance following study conditions that eliminated perceptual priming (e.g., Hawley & Johnston, 1991; Weldon & Jackson-Barrett, 1993). This result may be problematic for the lexical-access account and other accounts positing truncated perceptual processing because above-chance explicit memory implies that stimulus identification or lexical access occurred for at least some study items.
After the study task, participants were given either the word-fragment-completion or word-fragment cued-recall test. For both tests, participants were given a sheet of paper with the 102 fragments, which were numbered and arranged in columns. In the word-fragment-completion task, participants were asked to try to complete each fragment with an appropriate English word. Examples of a fragment and an appropriate completion were provided. No mention was made of the relationship between this task and the study task. In the word-fragment cued-recall test, participants were informed that their memory was being tested. They were also informed that some of the fragments corresponded to words from the study list and some did not. The participants were asked to try to recall words from the study list that completed the fragments and, if they could not do so, to complete the fragment with any appropriate word that came to mind. These were the same guessing instructions used by Mulligan and Hartman (1996, Experiment 2) in an attempt to equate response requirements across the implicit and explicit tests. This renders the two memory tests comparable in all ways except test instructions (i.e., implicit vs. explicit).

For both memory tests, the participants were given 12 s for each fragment. Time was kept with an audiotor that emitted a beep every 12 s. Participants were instructed to use the entire 12 s on the current fragment, not to work backward, and to move on to the next fragment only after hearing the beep. The participants were given a cover sheet to keep their place.

Thirty-two of the participants were given the word-fragment completion test, and the other 24 were given the word-fragment cued-recall test.

Results and Discussion

During the study task, the mean proportion of attentional load items recalled was .99, .94, and .76 for the three-, five-, and seven-load conditions, respectively. Because these data deviated substantially from the normal distribution (especially in the three- and five-load conditions), a nonparametric test (Friedman's test of ranks) was used. This test revealed significant differences across loads. Pairwise sign tests indicated that all three load conditions significantly differed from one another. In addition, Mann-Whitney U tests performed within load conditions found no significant effects of subsequent test condition (all ps > .1). The mean proportion of study words correctly identified was .99 and did not vary as a function of attentional load (p > .5) or subsequent test condition (p > .25). Thus, participants were able to identify virtually all study words while simultaneously maintaining the attentional loads.

The results of the memory tests are presented in Figure 1. Mean proportions of fragments completed are presented as a function of test type and attentional load. As statistical analyses confirm, attentional load had a significant impact on performance in the explicit test of word-fragment cued recall but not in the comparable implicit test of word-fragment completion.

To measure retention, the proportion of completed new fragments was subtracted from the proportion of completed old fragments in each of the load conditions. The resulting data from the word-fragment cued recall and word-fragment completion were submitted to separate ANOVAs, using attentional load as a within-subjects variable. The effect of attentional load was significant for cued recall, \( F(3, 69) = 3.62, \text{MSE} = 0.0258 \), but not for word-fragment completion (\( p > .5 \)). For the cued-recall test, pairwise comparisons of the load conditions indicated significantly greater performance in the zero- than the seven-load condition, \( t(23) = 2.51 \); in the three- than five-load condition, \( t(23) = 2.30 \); and in the three- than seven-load condition, \( t(23) = 2.65 \). No other differences were significant (all other \( ps > .15 \)). Performance in each of the load conditions was significantly greater than for new fragments, all \( t(23) > 3.37 \). For the word-fragment completion, performance in each of the load conditions was significantly greater than for new fragments; that is, priming occurred in all load conditions, all \( ts(23) > 6.84 \).

Finding that dividing attention had a significant impact on word-fragment cued recall but no measurable impact on word-fragment completion is theoretically important. Before continuing, however, it is important to evaluate the power of the latter statistical test. Power calculations were performed (following Kirk, 1995, pp. 259–264) using a to-be-detected effect size estimated from the cued-recall data. The estimated effect size of attentional load on the cued recall is \( f = 0.29 \), somewhat larger than Cohen's (1988) definition of a "medium" effect size of \( f = 0.25 \). With alpha equal to .05 and a sample size of 32, the power of detecting an effect of attentional load on word-fragment completion of the same size as that obtained with cued recall was .84.

Because earlier research has demonstrated the importance of the strength of attentional manipulations in the study of attention and implicit memory (Mulligan, 1997), one motivation for this experiment was to provide a range of divided-attention conditions, from mild to very strong, within one experiment. A potential concern was that whereas it is reasonable to claim that increasing loads represent increasing division of attention, the present method did not guarantee that the participants would maintain increasing amounts of information in working memory. Consequently, the possibility that nominally different load conditions do not actually tax working memory to different extents must be entertained. One way to evaluate this is to examine the average number of items retained by participants in the different load conditions by converting percentage of load items recalled (given above) into raw numbers of load items recalled. The average numbers of load items recalled significantly increased across load conditions: 2.97, 4.70, and 5.32, in the three-, five-, and seven-load conditions, respectively; Friedman's test of ranks: \( \chi^2(2, N = 32) = 88.32 \). Not surprisingly, sign tests indicated that significantly more items were retained in either the seven- or five-load condition than in the three-load condition (both \( Zs = 7.35 \)). More important for present purposes, significantly more items were maintained in the seven- than five-load condition (\( Z = 2.81 \)). This is consistent with the assertion that the seven-load condition represents a stronger division of attention than either the three- or five-load condition.

Another way to address this issue would be to limit the analysis of the test data to only those participants showing high levels of performance in the seven-load condition at study. As a cutoff, I included only those participants that recalled an average of more than five items in the seven-load
This guaranteed that the resulting set of participants maintained more information in working memory in the seven- than the five-load condition. Fourteen of the 24 (58%) cued-recall participants and 18 of the 32 (56%) word-fragment completion participants exceeded this cutoff. On average, these participants recalled 2.99, 4.84, and 6.13 items, in the three-, five-, and seven-load conditions, respectively. For each participant, the average number of load items recalled increased in each successive load condition. An analysis of the test data for this subset of participants revealed the same pattern of results as that obtained with all participants. Attentional load had a significant impact on the
explicit memory test of word-fragment cued recall, \( F(3, 39) = 3.15, MSE = 0.0323 \), but not on the comparable implicit test of word-fragment completion (\( p > .5 \)).

Thus, even when attention is very strongly divided during encoding, as in the five- and seven-load conditions of the present experiment, later performance on the perceptual priming task is unaffected. This result is consistent with the results of Mulligan and Hartman (1996, Experiment 2), in which attention was divided with the digit-monitoring task used in the present Experiments 1 and 2. Of course, the criticism could always be raised that an even more rigorous division of attention could be implemented (say, a nine-load condition), which would reduce later perceptual priming without reducing study-word identification, a possibility difficult to rule out. However, using the memory-load paradigm, it is questionable whether larger load conditions would actually have the effect of more rigorously dividing attention. Preliminary results from our laboratory indicate that for loads exceeding seven, retention of load items decreases markedly, producing functional loads that may not differ from the seven-load condition. Other methods of dividing attention may circumvent this problem. In any event, these results are consistent with the view that perceptual priming has minimal requirements of attention-demanding postperceptual encoding processes. In addition, these results provide additional evidence that divided attention dissociates perceptual priming and explicit memory performance, even when the implicit and explicit tests are matched in terms of memory cues and response requirements (Mulligan & Hartman, 1996).

The TAP framework has thus far been successful at predicting and accounting for the effects of attention on implicit memory. However, the TAP framework, as initially proposed, was posited as a general theory of both implicit and explicit memory performance (e.g., Blaxton, 1989; Roediger, 1990; Roediger et al., 1989). This framework emphasizes the importance of the types of processes engaged by a memory test rather than the nature of the test instructions (i.e., implicit vs. explicit). Consequently, dissociations are expected when perceptual and conceptual tests are compared, but tests within one of the categories (e.g., perceptual tests) are generally expected to be similarly affected by experimental manipulations.\(^3\) For example, the TAP framework implies that explicit perceptual tests should react more like perceptual implicit tests than conceptual explicit tests. This has been found with respect to several experimental manipulations, including read–generate, study modality, imagery versus no-imagery instructions, and typographic manipulations (e.g., Blaxton, 1989; see Roediger & McDermott, 1993, for a review). A strong interpretation of the TAP view (which appears consistent with the theory’s initial form) implies that because perceptual implicit tests are unaffected by divided attention, perceptual explicit tests should be similarly unaffected. Later versions of the TAP framework present a somewhat more differentiated view, proposing that explicit retrieval instructions may make a memory test more reliant on prior conceptual processing (e.g., Craik et al., 1994; Roediger et al., 1992; we return to this issue in the General Discussion).

The final two experiments examine these issues. Experiment 4 uses the graphemic-cued-recall test, an explicit memory test that has been classified as perceptual (see Blaxton, 1989; Roediger, 1990; Roediger et al., 1989). Experiment 5 uses the graphemic recognition test, a new memory test that appears to be primarily perceptual in nature (Challis, Velichkovsky, & Craik, 1996). In these memory tests, participants are presented with memory cues bearing graphemic similarity to studied items (e.g., cheetohs as a cue for the studied word cheetah). In the graphemic-cued-recall test, participants are informed of this relationship and asked to use the cues to try to recall studied words. In the graphemic recognition test, participants are asked to recognize words that have a similar appearance to studied words, without having to recall the studied words.

The results of Experiment 3 and Mulligan and Hartman (1996, Experiment 2) are relevant to Experiments 4 and 5. In these studies, the effects of divided attention were assessed on an explicit version of a perceptual implicit test. Specifically, word-fragment cues were coupled with explicit test instructions. Dividing attention reduced recall on the resulting word-fragment cued-recall test. This may be taken as evidence that perceptual explicit tests are negatively affected by divided attention. However, it should be pointed out that word-fragment cued recall has not been categorized as a perceptual test according to the TAP criterial variables. Also, as noted above, refinements to the TAP view suggest that explicit retrieval instructions render memory tests sensitive to prior conceptual processing (e.g., Craik et al., 1994; Roediger et al., 1992). Consistent with this view, Roediger et al. (1992) found that word-fragment cued recall was sensitive to a levels-of-processing manipulation that left word-fragment completion unaffected. A more complete evaluation of the TAP view would use an explicit memory test categorized as perceptual according to the TAP criteria. Graphemic-cued recall has been so categorized because it exhibits the reverse-generation effect (i.e., the read condition leads to higher performance than the generate condition), the purported signature of a perceptual memory test (Blaxton, 1989; Roediger, 1990). Consequently, Experiment 4 investigates the effects of divided attention on this perceptual explicit test. A strong interpretation of the TAP framework implies that this test will be relatively insensitive to divided attention.

However, it has recently been reported that the graphemic-cued-recall test is affected by the traditional levels-of-processing manipulation (Challis et al., 1996; Thapar &

\[^3\] This does not mean that the TAP view never predicts dissociations between perceptual tests. If two perceptual tests cue memory by means of different modes or modalities (e.g., picture-fragment completion vs. word-fragment completion), the TAP view predicts that certain study manipulations (e.g., studying pictures vs. words) will dissociate the tests (see Roediger, 1990, for discussion). In the present discussion, I restrict consideration to perceptual tests that cue memory in the same mode and modality (e.g., all test cues are visually presented words or word fragments). Without further refinement, the default prediction of the TAP view is that such tests should be similarly affected by study manipulations.
Recall that the primacy and recency buffers consisted of filler items. The primacy and recency portions of the study list were provided. To-be-recalled words was explained, and three examples from the present with either the graphemic- or semantic-cued-recall test. Experiments 1 and 2. After the distractor task, participants were conditions. Across participants, cues were equally often in the old and new...Production of new items served as the estimate of guessing rate. The graphemic- and semantic-cued-recall tests consisted of the...were derived from Blaxton's (1989) materials, I refer to this test by the same name used in Blaxton's article rather than calling it an associate-cued-recall test. 4 The semantic-cued-recall test is similar to the associate-cued-recall test of Experiment 2 in that both tests use semantic associates as cues. Because the semantic-cued-recall test used in Experiment 4 was derived from Blaxton's (1989) materials, I refer to this test by the same name used in Blaxton's article rather than calling it an associate-cued-recall test. 

Results and Discussion

During the study task, participants in the divided-attention condition correctly identified 97% of the study words and detected 90% of the target digit strings. Mann-Whitney U tests indicated that the percentages of study words identified and target strings detected did not significantly differ as a function of subsequent test condition (ps > .10), as would be expected. As in the earlier experiments, participants in the divided-attention condition were able to identify the vast majority of the study words while simultaneously identifying almost all of the target sequences.

Table 3 summarizes the results of the memory tests. Proportions of critical items produced are presented as a function of test type, attention at encoding, and study status. The table demonstrates that dividing attention during acquisition has strong effects on both the semantic- and graphemic-cued-recall tests. The data from the memory tests were submitted to separate 2 X 2 ANOVAs, using study status (old vs. new) as a within-subjects variable and attention at encoding (full vs. divided) as a between-subjects variable. Beginning with the semantic-cued-recall test, all three effects were significant: (a) a main effect of attention, F(1, 18) = 5.92, MSE = 0.0017; (b) a main effect of study status, F(1, 18) = 32.86, MSE = 0.0022; and (c) an interaction between study status and attention, F(1, 18) = 4.49, MSE = 0.0022. The results indicated that more critical items were produced in the full- than divided-attention condition, that recall of old words exceeded the guessing rate for new words (i.e., participants showed above-chance retention), and that the difference between old and new items (i.e., the measure of retention) was greater in the full- than divided-attention condition. Follow-up t tests indicated an effect of study status both in the full-attention condition, t(9) = 4.85, and the divided-attention condition, t(9) = 3.07, indicating above-chance retention in both the full- and divided-attention conditions. In summary, the results of the semantic-cued-recall test indicated that dividing attention produced the expected effect on this conceptual explicit memory test: It reduced memory for old items.

The results of the graphemic-cued-recall test are identical to the results of the semantic-cued-recall test. The analysis...
yields significant effects of attention, \( F(1, 22) = 6.18, \text{MSE} = 0.0093 \); study status, \( F(1, 22) = 73.40, \text{MSE} = 0.0057 \); and the Study Status \( \times \) Attention interaction, \( F(1, 22) = 9.51, \text{MSE} = 0.0057 \). These results reveal the same pattern as above. Specifically, more critical items were produced in the full- than divided-attention condition, recall of old words exceeded the guessing rate for new words, and the difference between old and new items was greater in the full- than divided-attention condition. As with the semantic-cued-recall test, \( t \) tests indicate an effect of study status in both the full- and divided-attention conditions, \( t(11) = 6.26 \) and 7.52, respectively, indicating above-chance retention in both attention conditions.\(^5\) To summarize, the perceptual explicit test of graphemic-cued recall suffered the same deleterious effects of divided attention as semantic-cued recall, a conceptual explicit test.

A final and somewhat surprising aspect of the results in Table 3, although of less importance for present purposes, is that performance tended to be higher on the graphemic- than the semantic-cued-recall test. To investigate, old–new difference scores were submitted to a 2 \( \times \) 2 ANOVA, using test (graphemic- vs. semantic-cued recall) and attention at encoding as between-subjects variables. This analysis revealed significant main effects of attention, \( F(1, 40) = 13.81, \text{MSE} = 0.0082 \) (indicating, as above, that divided attention reduced retention), and of test, \( F(1, 40) = 14.69, \text{MSE} = 0.0082 \). The latter effect indicates greater recall of studied items when graphemic cues were provided at test. In addition, the graphemic test led to significantly greater performance on new items (i.e., a higher guessing rate), \( F(1, 42) = 5.73, \text{MSE} = 0.0013 \).

Although surprising, there is precedence for the finding of greater recall with the graphemic than semantic cues with Blaxton’s (1989) materials. We restrict consideration only to those experiments and conditions that are most comparable to the full-attention condition in the present experiment (e.g., intentional learning instructions, visual study presentation, same type font for study words and test cues, and no imagery, elaborative, or generative encoding instructions). In Blaxton’s (1989) Experiment 2 (visual study condition), the mean old–new difference scores for the graphemic- and semantic-cued-recall tests were .41 and .33, respectively. In Blaxton’s Experiment 3 (same type font at study and test, averaged over elite–elite and italic–italic conditions, see pp. 665–666), the comparable means were .23 and .11, respectively. These results are similar to the results in the present full-attention condition, in which the respective means were .26 and .11 (see Table 3). Other relevant data come from the no-context condition of Blaxton’s (1992) Experiments 1 and 2. This condition was similar to the present experiment in that participants read study words in isolation (as opposed to generating study words or reading them in a semantic context). In the no-context condition, the graphemic-cued-recall test led to greater mean difference scores than the semantic-cued-recall test for control participants (the exact figures are not provided in the article, but estimates from graphs of the data indicate the graphemic advantage was at least .20). The same pattern of results was obtained for temporal lobe epileptics (Blaxton, 1992). The only comparable experiment producing conflicting results is the no-context condition in Blaxton’s (1989) Experiment 1, in which performance on the semantic-cued-recall test was somewhat higher than on the graphemic-cued-recall test.

There are quite likely several factors that differ across these experiments that play a role in accounting for the precise relationship between graphemic- and semantic-cued recall (as well as accounting for the variability in overall performance levels). For example, the graphemic and semantic cues in the Blaxton (1989) materials, from which the present materials were drawn, were not equated on such variables as cue–target associative strength or search set size, both factors that can affect recall (see Nelson, Schreiber, & McEvoy, 1992, for a review). However, taken as a group, these results indicate that for the Blaxton (1989) materials, the graphemic cues may be more effective than the semantic cues when nonelaborative–nongenerative encoding strategies are used. The opposite appears to be true for elaborative or generative encoding strategies (see Blaxton, 1989, 1992).

To the extent that this summary accurately describes the relationship between the efficacy of the graphemic and semantic cues, it is in accord with general TAP tenets. Specifically, to the extent that conceptual or elaborative processes are invoked at encoding, tests using semantic cues (which presumably reengage conceptual processes) should have an advantage over tests using nonsemantic cues.

Although this aspect of the results may be in accord with the TAP framework, this digression should not obscure the main point of the present experiment: Perceptual as well as conceptual explicit tests have at least some reliance on attention at encoding. Contrary to the TAP expectation, division of attention has similar effects on perceptual and

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<td>.03</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td>Divided attention</td>
<td>.07</td>
<td>.02</td>
<td>.05</td>
</tr>
</tbody>
</table>

\(^5\) This pattern of \( t \) values occurred because the divided-attention condition had lower variance than the full-attention condition, despite producing a smaller mean effect of study status. Although the difference in variances across the full- and divided-attention conditions was not significant by Levene’s test, it was nevertheless prudent to reexamine the data with a nonparametric test. The old–new difference scores were submitted to the Mann–Whitney \( U \) test, resulting in a significant difference between attention conditions (\( U = 26.0 \)). Thus, the nonparametric test produced the same conclusion as the parametric tests reported in the text: Divided attention reduces retention in the graphemic-cued-recall test.
Results and Discussion

As noted earlier, a potential limitation of the present study is that the graphemic-cued-recall test can be affected by the levels-of-processing manipulation (Challis et al., 1996; Thapar & Greene, 1994). Consequently, a stronger test of the hypothesis that divided attention affects perceptual explicit memory may be garnered by using an explicit test that is not affected by levels of processing. Graphemic recognition is such a test (Challis et al., 1996), and it is used in Experiment 5.

Experiment 5

Method

Participants. Sixty-four undergraduates at Illinois State University participated in exchange for extra credit in psychology classes.

Design and materials. The experiment used a 2 X 2 X 2 design in which study status (old vs. new) and test-associate type (graphemic vs. semantic) were manipulated within subjects and attention at encoding (full vs. divided) was manipulated between subjects.

The study materials and digit-monitoring task were the same as those used in Experiment 4. The graphemic-recognition test was modeled after Challis et al. (1996). The test lists were created from the same set of graphemic and semantic cues used in Experiment 4. Specifically, each test list consisted of all 100 graphemic associates (50 corresponding to the old words and 50 to the new words) and 50 of the 100 semantic associates (25 corresponding to old and 25 to new words). Four test lists were created, so that both the graphemic associates and the semantic associates were counterbalanced over study status (i.e., old vs. new). The test items were randomly ordered on the test sheet. The participant's task was to circle test items that looked like the words presented during the study phase. For this test, the correct answers are the 50 graphemic associates of the old words. All other circled test items are false alarms. The graphemic associates of new words served as the false-alarm rate for graphemic recognition. The semantic associates were included to determine if participants adhered to instructions and circled only graphemically similar and not semantically similar test items (Challis et al., 1996). If participants followed instructions, then false-alarm rates for the semantic associates of old words would be no higher than the false-alarm rate for the semantic associates of new words (the result obtained by Challis et al., 1996).

Procedure. The study and distractor phases were identical to Experiment 4. Following the distractor task, participants were presented with the graphemic-recognition test. Following Challis et al. (1996), participants were told that some of the words on the test sheet looked like words that had been read in the earlier study phase. Participants were told to focus on the appearance of the test words and ignore their meaning, circling those test items that looked like words from the study phase. Two examples from the primacy and recency portions of the study list were provided. As in the earlier experiments, the primacy and recency buffers consisted of filler items that were not tested. Participants were instructed to take their time and try to be as accurate as possible. The memory test was un-paced.

Data from the graphemic and semantic test items were submitted to separate 2 X 2 ANOVAs, using study status as a within-subjects variable and attention at encoding as a between-subjects variable. For the semantic test items, none of the effects were significant (all ps > .1), consistent with the claim that participants were able to follow the instructions and did not differentially endorse test items that were semantically similar to old items. The analysis of the graphemic items revealed two significant effects, a main effect of study status, F(1, 62) = 131.83, MSE = 0.0065, and an interaction between study status and attention, F(1, 62) = 7.62, MSE = 0.0065. The results indicated that recognition of items graphemically similar to old words (i.e.,

Table 4

<table>
<thead>
<tr>
<th>Test-associate type</th>
<th>Study status</th>
<th>Old</th>
<th>New</th>
<th>Old – New</th>
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</thead>
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<tr>
<td>Graphemic</td>
<td>Full attention</td>
<td>.33</td>
<td>.13</td>
<td>.20</td>
</tr>
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<td></td>
<td>Divided attention</td>
<td>.28</td>
<td>.16</td>
<td>.12</td>
</tr>
<tr>
<td>Semantic</td>
<td>Full attention</td>
<td>.12</td>
<td>.10</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>Divided attention</td>
<td>.15</td>
<td>.13</td>
<td>.02</td>
</tr>
</tbody>
</table>
hits) exceeded the guessing rate for items graphemically similar to new words (i.e., false alarms). This indicated that participants showed above-chance retention. More important, the difference between old and new items (i.e., the measure of retention) was greater in the full- than divided-attention condition. Follow-up t-tests indicated an effect of study status in both the full- and the divided-attention conditions, t(31) = 11.24 and 5.64, respectively.

In summary, the results of the graphemic recognition test converge with the results of Experiment 4, indicating that dividing attention reduces memory for old items in perceptual explicit tests. Moreover, these results make it unlikely that divided attention reduced graphemic-cued recall solely because this test has some sensitivity to prior conceptual processing (as indicated by its sensitivity to the levels-of-processing manipulation). The graphemic recognition test, which uses the same overt memory cues as graphemic-cued recall but is unaffected by prior conceptual processing (indicated by its lack of sensitivity to the levels-of-processing manipulation), is nonetheless very affected by divided attention.

General Discussion

This article reports five experiments on the role of attention during encoding on later implicit and explicit memory. Integrating the present findings with prior research yields a generally coherent set of findings, summarized here in terms of the TAP taxonomy. First, as described in the introduction, attentional state at encoding has pervasive effects on traditional tests of memory, such as free recall, recognition, and cued recall, all conceptual explicit tests in the TAP nomenclature (e.g., Baddeley et al., 1984; Craik et al., 1996; Fisk & Schneider, 1984; Moray, 1959; Murdock, 1965; Norman, 1969b). Although not in great need of replication, this finding was reproduced in Experiments 2 and 4, in which dividing attention reduced performance on cued-recall tests. More important, Experiments 4 and 5 showed that performance on the perceptual explicit tests of graphemic-cued recall and graphemic recognition are also reduced by divided attention. Coupled with the finding that word-fragment-cued recall (arguably a perceptual explicit test; see Blaxton et al., 1996) is also affected by divided attention (the present Experiment 3; Mulligan & Hartman, 1996), the pattern of results supports the more general conclusion that performance on explicit tests, whether perceptual or conceptual, is dependent on attention at encoding.

Turning to implicit tests of memory, it appears that perceptual priming is relatively unaffected by divided attention, provided that stimulus identification is not disrupted (see discussion of Experiment 2). In Experiment 3, such results were found for word-fragment completion, even using a very strong division of attention (see Gabrieli, Stone, Shackleton, et al., 1996; Mulligan & Hartman, 1996; Parkin et al., 1990, for similar findings). Similar results have been reported for perceptual identification (Gabrieli, Stone, Shackleton, et al., 1996), picture-fragment completion (Parkin & Russo, 1990; Russo & Parkin, 1993), and lexical decision making (Kellogg et al., 1996; M. E. Smith & Oscar-Berman, 1990; Szymanski & MacLeod, 1996). In contrast to perceptual implicit tests, priming in conceptual implicit tests generally appears to be reliant on attention at encoding, especially when attention is strongly divided (Mulligan, 1997). Division of attention can reduce conceptual priming on tests such as category-exemplar production (Gabrieli, Stone, Shackleton, et al., 1996; Mulligan, 1997; Mulligan & Hartman, 1996), word association (Experiment 2), and general knowledge questions (Experiment 1).6

Before considering the theoretical implications of these results, I discuss two related methodological considerations in examining the role of attention in implicit and explicit memory. First, the results underscore the importance of using matched implicit and explicit tests when interpreting dissociations (Neely, 1989; Schacter, Bowers, & Booker, 1989). Before one can confidently assert that the attentional requirements of implicit memory differ from those of explicit memory, it is important that dissociations be based on comparable implicit and explicit tests, ideally tests that differ only in task instructions. Second, the use of strong manipulations of attention, coupled with multiple levels of attention as in the memory-load paradigm of Experiment 3 (also see Mulligan, 1997), is quite useful because memory tests differ in the extent to which they are sensitive to attentional manipulations during encoding (e.g., Craik et al., 1996).

The relevance of these considerations is made clear by considering some of the details of the results of Experiment 3, in which the attentional load variable significantly reduced performance on word-fragment-cued recall but not on word-fragment completion. Consider the zero- (i.e., full attention) and three-load conditions. It is known from prior research (Mulligan, 1997) that manipulation of attention over this range reduces performance on the explicit test of category-cued recall (it is reasonable to assume that other explicit tests, such as free recall, would be likewise affected). If Experiment 3 had consisted of only the word-fragment-completion test and only the zero- and three-load conditions, an inappropriate conclusion may have been derived; to wit, division of attention dissociates implicit and explicit tests of memory. That this conclusion is too strong can be seen by considering the results of the matched explicit test, word-fragment-cued recall. Over the same memory loads, this explicit test is also unaffected by divided attention. Over that range of the attentional manipulation, there is no dissociation of explicit and implicit memory tests that use word-fragment cues, even though other explicit tests, such as category-cued recall, are affected. In fact, the attention manipulation does dissociate word-fragment completion and word-fragment-cued recall, but this is not apparent unless the larger attention loads (i.e., stronger divisions of attention) are considered.

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6 This summary may be complicated by two recent conference presentations indicating that the semantic verification task, a priming task requiring a conceptual decision, is unaffected by divided attention and levels of processing (Gabrieli, Stone, Vaidya, et al., 1996; Light & Prull, 1995b).
This discussion is relevant to the conflicting results concerning the word-association test. As noted earlier, Koriat and Feuerstein (1976) found no effect of divided attention on word association, whereas the present Experiment 2 did. However, the Koriat and Feuerstein study did not include a matched explicit test, and the strength of the attentional manipulation was unclear. In the present Experiment 2, a comparable explicit test was used (the associate-cued recall), and the attentional manipulation was strong enough to reduce performance on that explicit test. Under these circumstances, priming in the word-association test was reduced, essentially to zero. Although there may well be other important differences between the discrepant studies, the results of Experiment 2 strongly imply that priming in the word-association task relies on attention, at least under the present circumstances.

Next, I consider some of the theoretical implications of the present results. As noted in the introduction, some theorists have suggested that recollective memory (presumed to underlie explicit test performance) is crucially dependent on attention at encoding, whereas nonrecollective, or fluency, aspects of memory do not rely (or have minimal reliance) on attentional encoding (Bentin, 1994; Bentin et al., 1995; Besson et al., 1992; Isingrini et al., 1995; Jacoby, Toth, & Yonelinas, 1993; Jacoby, Woloshyn, & Kelley, 1989; Jelicic et al., 1992; Parkin et al., 1990; Parkin & Russo, 1990; Szymanski & MacLeod, 1996; see Shallice et al., 1994, for a similar assumption). The present results, coupled with the results of Gabrieli, Stone, Shackleton, et al. (1996) and Mulligan and Hartman (1996), are inconsistent with this view. The present results indicate that if prior conceptual–elaborative processing influences the expression of nonrecollective memory, as it does on conceptual implicit tests, then attention at encoding is crucial for that expression.

A related issue is the attentional requirements for encoding semantic information. What aspects of meaning, if any, are encoded as a mere consequence of identifying a word (i.e., automatically)? There is substantial evidence for automatic semantic activation during the course of word identification (e.g., Balota, 1983, 1990; Carr, 1992; Durante & Hirshman, 1994; Hirshman & Durante, 1992; Neely, 1977, 1991), but the effects of such activation are typically short-lived (e.g., Neely, 1977). Are there automatic semantic encodings that lead to longer term retention? Rabinowitz et al. (1982) and Bentin (1994; Bentin et al., 1995) argued that core (or context-invariant) semantic features of words are encoded automatically and impact long-term memory tests. In contrast, elaborative encoding processes and the integration of words with the contexts in which they occur (both of which also influence long-term retention) are hypothesized to require attention (Bentin, 1994; Bentin et al., 1995; Rabinowitz et al., 1982).

The results of this and previous studies (Gabrieli, Stone, Shackleton, et al., 1996; Mulligan, 1997; Mulligan & Hartman, 1996) are relevant to this viewpoint. To review, divided attention reduced conceptual priming on three implicit tests: category-exemplar production (Gabrieli, Stone, Shackleton, et al., 1996; Mulligan, 1997; Mulligan & Hartman, 1996), general knowledge questions (Experiment 1), and word association (Experiment 2). In two of these (category-exemplar production and word association), priming was reduced essentially to zero. The encoding of what might be called core semantic features would appear to be an important determinant of performance in these tasks. It could be argued that truly core semantic features do not mediate priming in the category-exemplar production task, in which the critical exemplars are typically not the most common category examples from the category norms (Mulligan & Hartman, 1996; Rappold & Hashtroudi, 1991). However, core semantic features are presumably crucial for priming in the general knowledge test, in which many of the questions are essentially definitions of the to-be-produced item, and in the word-association task, in which the critical response term is the most common associate to the cue. In these cases, prior processing of what must be considered core semantic features is crucial. In all cases, this prior processing appears to be importantly dependent on attention. Passive identification of the study words does not produce conceptual priming on these tasks either at all or at least at much lower levels than in full-attention conditions. This implies either (a) that contrary to Bentin (1994; Bentin et al., 1995) and Rabinowitz et al. (1982), the encoding of core semantic features requires attention, or (b) that the memorial vestiges of automatic semantic processing during word identification influence only some long-term memory tests.

In this last section, I discuss the ramifications of the present results for the TAP framework. The TAP framework has been successful in accounting for much of the data from implicit and explicit research (see Roediger, 1990, and Roediger & McDermott, 1993, for reviews). Despite this success, a growing body of research, to which this study adds, indicates that the TAP dichotomy between perceptual and conceptual processing is not rich enough to account for the data from implicit and explicit memory research, even, unfortunately, in broad strokes. Because the TAP view posits common perceptual processes underlying perceptual implicit and explicit tests and common conceptual–elaborative processes underlying conceptual implicit and explicit tests, this view suggests that dissociations between memory tests are more likely to fall along the perceptual–conceptual dimension than the dimension of implicit–explicit test instructions.

A first objection (noted by Roediger, 1990) has been that population dissociations are far more likely to occur along the latter dimension than the former (e.g., Cermak, Verfaellie, & Chase, 1995; Gabrieli, Stone, Shackleton, et al., 1996; Light & Albertson, 1989; Schwartz et al., 1993; see Moscovitch, Goshen-Gottstein, & Vriezen, 1994, and Moscovitch, Vriezen, & Goshen-Gottstein, 1993, for reviews; although see Blaxton, 1992, for application of the TAP framework to population dissociations). For instance, amnesics, older adults, and schizophrenics all show normal levels of conceptual priming on category-exemplar production but reduced performance on the matched explicit tests of category-cued recall, when compared with appropriate controls (Keane, Gabrieli, Monti, Cantor, & Noland, 1993; Light & Albertson, 1989; Schwartz et al., 1993). Likewise, amnesics show
normal conceptual priming on the word-association test but reduced recall on the matched-associate-cued recall test (Cermak et al., 1995). Finally, amnesics frequently show normal levels of priming on perceptual implicit tests but not on the perceptual explicit test of graphemic-cued recall (Cermak et al., 1995).

The TAP framework has had greatest success in accounting for experimental dissociations in research with healthy, normal participants (see Roediger & McDermott, 1993, for review). Even in this arena, recently obtained dissociations have failed to honor the perceptual–conceptual distinction in much the same way as population dissociations. Weldon and Coyote (1996) found a picture-superiority effect on conceptual explicit tests (category-cued recall and associate-cued recall) but not on comparable implicit tests (category-exemplar production and word association, respectively). A similar dissociation was reported by Mulligan (1996) in an investigation of the perceptual interference effect in memory. Under certain circumstances, interfering with (but not preventing) stimulus perception at study can increase performance on later explicit memory tests. Mulligan (1996) reported that perceptual interference enhanced recall on the category-cued-recall test but had no effect on conceptual priming in the category-exemplar production test. The results of Weldon and Coyote (1996) and of Mulligan (1996) are both examples of experimental dissociations between conceptual implicit and explicit tests. McDermott and Roediger (1996) recently reported that both exact and conceptual repetition of study items influenced free recall but not category-exemplar generation or category-cued recall. Although not a dissociation of comparable implicit and explicit tests, the results are a dissociation of different types of conceptual memory tests. Similarly, Cabeza (1994) reported a dissociation between two conceptual implicit tests.

To summarize, there exist (a) population variables that dissociate performance on conceptual implicit and explicit tests, (b) population variables that dissociate performance on perceptual implicit and explicit tests, (c) experimental manipulations that dissociate conceptual implicit and explicit tests (i.e., the picture-superiority and perceptual-interference effects), (d) other experimental manipulations that dissociate conceptual explicit tests from one another (i.e., exact and conceptual repetition), and (e) still other experimental manipulations that dissociate conceptual implicit tests from one another (see Cabeza, 1994). To this set of results, may now be added a sixth: The experimental manipulation of divided attention dissociates performance on perceptual implicit and explicit tests.

As noted by several researchers (e.g., McDermott & Roediger, 1996; Mulligan, 1996; Weldon & Coyote, 1996), dissociations within the class of conceptual tests or within the class of perceptual tests are problematic for the TAP view and suggest that its continued viability requires further refinement. These refinements may take any of several forms (or, perhaps, multiple refinements may be necessary to accommodate all the data). Here, we consider two refinements to the TAP framework in terms of how they might account for the effects of divided attention on implicit and explicit tests of memory, as well as the other dissociations listed above.

First, dissociations that appear problematic for the TAP view may simply indicate that memory tests are not purely conceptual or purely perceptual in nature (Blaxton, 1989; Weldon & Coyote, 1996; Weldon et al., 1995). If so, then an important challenge to the TAP framework is to establish a principled characterization of the mixture of perceptual and conceptual processes involved in a given memory test (see Roediger & McDermott, 1993, for discussion).

Weldon et al. (1995; see also Craik et al., 1994; Roediger et al., 1992) proposed a refinement to the TAP framework along these lines by positing that conceptual processes play a larger role in explicit than implicit tests of memory, independent of the nature of the memory cues (e.g., Graf & Mandler, 1984). If explicit test instructions encourage conceptual retrieval processes, then this would account for dissociations between perceptual implicit tests and comparable explicit tests, such as the dissociation between word-fragment completion and word-fragment-cued recall caused by dividing attention at study. Specifically, if divided attention reduces conceptual encoding processes, then word-fragment completion, which engages perceptual retrieval processes, would be unaffected by the variation in prior conceptual processing. However, coupling the word-fragment cues with explicit retrieval instructions renders a test that engages both perceptual and conceptual retrieval processes. Consequently, word-fragment-cued recall would be sensitive to the divided attention manipulation (see Mulligan & Hartman, 1996, for related discussion). This version of the TAP framework may well account for other dissociations between perceptual implicit and explicit tests (e.g., Roediger et al., 1992; Weldon et al., 1995).

However, such a modification of the TAP framework faces three problems. First, by itself, it does not account for the observation that some perceptual explicit tests, like graphemic-cued recall and word-fragment-cued recall, are sensitive to the levels-of-processing manipulation, whereas others, such as graphemic recognition, are not (Challis et al., 1996; Roediger et al., 1992; Thapar & Greene, 1994). Second, it does not seem to account for dissociations between conceptual implicit and explicit tests. According to the TAP framework, conceptual tests, either implicit or explicit, are assumed to be sensitive to the same underlying conceptual processes. The proviso that explicit test instructions engage a common set of conceptual processes more fully does suggest that conceptual explicit tests may render more sensitive measurement of prior conceptual processes (see Mulligan, 1997, for discussion), but without further specification, this view does not explain why a conceptual implicit test may be completely insensitive to a manipulation that has a marked effect on a comparable explicit test. A complementary approach, suggested by Cabeza (1994), is to articulate subclasses of conceptual processes and determine both how encoding manipulations influence the subclasses...
and how the subclasses map onto the various implicit and explicit tests (this is similar to the component-process model of Moscovitch, 1992; see also Moscovitch et al., 1993; Vriezen, Moscovitch, & Bellos, 1995).

A third problem with this modification of the TAP framework is that it renders the TAP criterial variables superfluous. Recall that in the TAP framework, memory tests are classified as primarily perceptual or conceptual according to how they are influenced by a set of criterial variables, such as the read—generate manipulation and manipulations of study modality. Part of the power of the TAP framework is that it allows predictions to be made on the basis of the classification. For instance, a memory test classified as perceptual is predicted to be unaffected by any of a large number of conceptual encoding manipulations. If we add the proviso that explicit test instructions encourage conceptual retrieval processes, then the TAP framework does not generate unambiguous predictions for explicit tests designated as perceptual by the criterial variables.\(^7\)

Another way to extend the TAP framework is based on the overt episodic nature of explicit tests of memory. In particular, it is commonly assumed that spatiotemporal context plays a more important role in explicit than in implicit tests (e.g., Bower, 1996; Humphreys, Bain, & Pike, 1989; Humphreys, Wiles, & Dennis, 1994; Jacoby & Hollingshead, 1990; Light & LaVoie, 1993; Schwartz et al., 1993). According to this view, conceptual implicit and explicit tests are both sensitive to prior conceptual—elaborative processing, but in addition, conceptual explicit tests are also sensitive (or are at least more sensitive) to prior encoding of study context (Mulligan, 1997). Likewise, this view states that perceptual implicit and explicit tests may be sensitive to the same prior perceptual processing, but in addition, explicit tests are sensitive to contextual information. Such a refinement parsimoniously supplements the conceptual—perceptual processing distinction and provides an account for the effects of divided attention. There is good evidence that dividing attention disrupts conceptual and contextual encoding (e.g., Craik, 1989; Rabinowitz et al., 1982; see Cowan, 1995, for a review). To the extent that perceptual processes are unaffected by divided attention, this account predicts that dividing attention will disrupt tests that rely on contextual encoding (i.e., perceptual and conceptual explicit tests), as well as tests that are sensitive to conceptual processing (i.e., conceptual implicit or explicit tests).

A final point concerning this extension of the TAP framework is that it suggests that implicit tests should be relatively unaffected by manipulations of spatiotemporal context. To my knowledge, there are only two published studies on this topic, and they produced conflicting results. Jacoby (1983a) reported that a change in environmental context had no effect on the implicit test of perceptual identification. In contrast, S. M. Smith, Heath, and Vela (1990) found that manipulating environmental context substantially reduced priming in the homophone-spelling task. Additional research on this topic, including studies of the influence of environmental context on conceptual implicit tests, is required to more fully evaluate this extension of the TAP framework.

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\(^7\) One way around this problem is to expand the set of criterial variables. This has two consequences for the utility of the TAP framework. First, it increases the chances of conflicting outcomes (i.e., some criterial variables indicate that the test is perceptual, and others indicate that it is conceptual, as in the case of graphemic—cued recall), thus decreasing the number of memory tests for which unambiguous predictions may be made. Second, as the set of criterial variables increases, the utility of classification decreases. Specifically, if we must evaluate a memory test on increasingly larger sets of variables before classification, this necessarily reduces the number of variables about which the theory makes predictions.

References


Parkin, A. J., & Russo, R. (1990). Implicit and explicit memory and