Failing to find context-dependency in perceptual implicit memory:

Evidence against an episodic view?

by

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INTRODUCTION

In what ways can previously encountered and stored information affect present behavior? That is, how does memory affect behavior, particularly when one is not consciously attempting to remember the previously encountered information? The answers to this question about memory have been guided by the growth in research on a phenomenon called *implicit memory* (see Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; and Schacter, 1987, for extensive reviews). Implicit memory is demonstrated when previously studied information affects performance on a current task without the individual's consciously recollecting the information (Schacter, 1987). Implicit memory research also has led researchers to take seriously differences among different types of memory tests (Blaxton, 1989; Roediger, Weldon, & Challis, 1989; Schacter, 1987). The differences among the kinds of memory tests appear have important theoretical implications for developing plausible frameworks for conceptualizing memory.

Overview

This dissertation tested a new framework for conceptualizing a specific kind of memory—perceptual implicit memory. It begins by discussing different kinds of memory and memory tests, with a focus on four major frameworks of perceptual implicit memory. Following this, some problems with the standard, accepted view of perceptual implicit memory are noted. A new, broader framework is introduced that views perceptual implicit memory as episodic decision memory. Four experiments designed to test the new framework are reported. Finally, the implications of these four experiments for the proposed framework and for other frameworks of perceptual implicit memory are discussed.

Background

Kinds of Memory Tests

Memory tests have been categorized into four major classes based upon the type of instructions (explicit vs. implicit) given to participants taking the test and upon the type of processing (conceptual vs. perceptual) invoked by the test (Blaxton, 1989; Schacter, 1987). Explicit tests instruct participants to consciously recollect information that had been studied during a prior episode and to use that information on the present task. For example, on a standard recall memory test, participants are instructed to remember words studied previously and to write down as many of those words as they can. Memory is directly measured in terms of success at the task. Implicit tests do not instruct participants to consciously recollect information that has been studied during a prior episode. Rather, participants are just given a task to complete. In these tests, memory for previously studied information is inferred when the previously studied information affects performance on the present task (Schacter, 1987). For example, in a perceptual identification task (a form of implicit memory test), participants are shown words for a very brief time (33-50 ms, before a pattern mask) and the participants are asked to report the words they see. Memory is inferred in this task when participants report more words that had been previously studied (old words) than words that had not been previously studied (new words).

Conceptual tests are memory tests that require the participant to engage in semantic or conceptual processing of words to successfully complete the task. The recall test described previously is an example of a conceptual test. Perceptual tests are memory tests that require the participant to engage in data-driven or perceptual processing of words to successfully complete the task. The perceptual identification task described previously is an example of a perceptual test. The presence or absence of a generation effect on test performance has been used as a "litmus test" to classify a test as conceptual or perceptual in nature (e.g., Blaxton, 1989). To determine if there is a generation effect, words are studied in one of two conditions: the read and generate conditions. In the read condition, the word is presented alone (XXX – *cold*). In the generate condition, the word is generated by the participant (hot - ?) in response to a related cue (cf., Jacoby, 1983). Because the generate condition requires the participant to engage in semantic, conceptual processing, tests in which performance is better when words are generated at encoding are called conceptual tests. Because the read condition requires participants to do the greatest amount of perceptual processing of the word, tests in which performance is better when words are read alone at encoding are called perceptual tests (Blaxton, 1989; Jacoby, 1983).

Using these two dimensions, four classes of tests have been identified. *Conceptual explicit* tests include the standard memory tests of recall and recognition[1]. These are direct tests in which the instructions to participants are to use their memory for a prior encoding episode and performance is better for items originally studied in the generate than in the read condition. *Conceptual implicit* tests include general knowledge tests in which participants are asked questions that can be answered with words that had been previously studied, but participants are not instructed to use previously studied words to answer the questions. Performance is better for items originally studied in the generate condition than in the read condition. *Perceptual explicit* tests include graphemic cued recall tests in which participants are asked to complete three-letter word stems with a word that they had previously studied. Thus, the instructions are to use memory for previously studied words, but performance is better for items originally studied in the read than in the generate condition. *Perceptual* *implicit* tests include a number of tests. The perceptual identification test described previously is one example. A second example is a word stem completion test in which participants are required to complete three-letter word stems with the first word that comes to mind. A third example is a lexical decision test in which participants are required to decide if a stimulus is a word or a nonword. In none of the perceptual implicit memory tests are participants instructed to use previously studied words, but having previously studied the words does improve performance on the tests. In addition, performance is better with words originally in the read than the generate condition. The focus of the current research is on perceptual implicit memory test performance.

Although perceptual implicit memory tests are like other types of memory tests in that they appear to rely on some minimal level of attentional, controlled processing at encoding (e.g., Crabb & Dark, 1999a, 1999b; Hawley & Johnston, 1991; MacDonald & MacLeod, 1998), they are also different. Supporting this are studies demonstrating that perceptual implicit memory for words requires the accessing of the lexical unit at encoding (Weldon, 1991) and is affected by manipulations of the perceptual characteristics of the word (e.g., its modality or font) between encoding and test (e.g., Graf & Ryan, 1990; Jacoby, Levy, & Steinbach, 1992; Roediger & Blaxton, 1987). Coupled with its sensitivity to lexical/perceptual manipulations is the insensitivity of perceptual implicit memory to semantic manipulations like the generation effect (e.g., Blaxton, 1989; Jacoby, 1983), which affect conceptual tests. Finally, manipulations of divided attention appear to separate perceptual implicit memory tests from all other tests—dividing attention at encoding affects both explicit and implicit conceptual tests and also affects explicit perceptual tests, but does not affect perceptual implicit tests (e.g., Mulligan, 1997; Mulligan & Hartman, 1996; Smith

& Oscar-Berman, 1990). Thus, perceptual implicit memory tests appear to be quite different from other types of memory tests.

Models of Perceptual Implicit Memory Test Performance

The distinctive nature of perceptual implicit memory test performance compared to performance on other types of memory tests requires an explanation and several explanatory models appear in the literature. The conceptualizations of perceptual implicit memory test performance in the literature can be classified by whether they view the representations underlying perceptual implicit memory test performance as abstract or episodic in nature (Tenpenny, 1995). Episodic representations reflect information from specific events while abstract representations do not. As applied to words, a memory that encoded the occurrence of a particular word on a particular list in a particular context would be an episodic representation, while a memory that encoded the occurrence of the word without reference to its context would be an abstract representation. Abstract representations are entries in a mental lexicon.

The question over the episodic versus abstract nature of representations is not just important in perceptual implicit memory research, but has become a central question in a number of areas of research within cognitive psychology. For example, researchers have posited episodic and abstract theories in negative priming (e.g., Neill, Valdes, & Terry, 1995, vs. Tipper & Cranston, 1985), categorization (e.g., Nosofsky & Palmeri, 1997, vs. Rosch & Mervis, 1975), and automatization (e.g., Logan, 1988, vs. Shiffrin & Schneider, 1977). Indeed, the fact that this episodic/abstract debate is so widespread suggests that it is an important issue to be investigated as theories in a field are developed.

What follows is a discussion of four major models/frameworks of perceptual implicit memory test performance. The four models are categorized by how they conceptualize the underlying representations: two abstract views (Ratcliff & McKoon, 1997; Tulving & Schacter, 1990) and two episodic views (Masson & MacLeod, 1992; Roediger, Weldon, & Challis, 1989).

Abstract Models

There are two major models of perceptual implicit memory that posit that the representations underlying perceptual implicit memory are abstract in nature. The models differ in the nature of the abstract representations they posit. They also differ in whether or not the representations are part of a single memory system (the counter model) or are part of a memory system that is distinct from other memory systems (the multiple memory system view).

The Multiple Memory System View. Tulving and Schacter (1990) proposed a multiple memory system view that posits the existence of at least four major memory systems: an episodic memory system, a semantic memory system, a procedural memory system, and a perceptual representation memory system (PRS). According to this view, different memory tests tap into the different memory systems. Episodic memory tests (e.g., recall and recognition) tap directly into the episodic memory system, semantic tests (e.g., general knowledge questions) tap directly into the semantic system, motor-skill tasks (e.g., riding a bicycle) tap directly into the procedural system, and perceptual implicit memory tests (e.g., perceptual identification) tap directly into the PRS. Supporting this view are neurological studies demonstrating that damage to one of these systems does not affect the performance of the other systems (e.g., Gabrieli, Fleischman, Keane, Reminger, & Morrell, 1995). The representations within the PRS are distinct from those in the episodic and semantic systems in that they lack "...stored focal traces..." (Tulving & Schacter, 1990, p. 302). Rather, these representations appear to consist of abstract, global structural descriptions of the stimuli (words or objects) that are not tied to specific prior episodes (Schacter, Cooper, & Delaney, 1990; Tulving & Schacter, 1990).

The Counter Model. Ratcliff and McKoon (1997) proposed a counter model of performance on perceptual identification, a specific perceptual implicit memory test. According to the model, abstract representations of words act as counters that attract counts when words are presented. Prior exposure to a word at encoding allows a representation to function as an even stronger attractor when the word is again presented at test. Thus, prior exposure allows a representation to attract and collect more counts than it normally would (and more than other representations) when a word is subsequently shown. Counts are collected until one representation reaches a criterion (measured relative to other representations), resulting in a decision about the word. The decision is a perceptual decision or identification of the word. Although the counters are affected by prior exposure, they are not themselves episodic representations. They are similar to Morton's (1969, 1979) *logogens*. Prior exposure turns them into attractors and it is their status as attractors that leads to perceptual implicit memory.

Episodic Models

Two major episodic models of perceptual implicit memory will be discussed. Both models posit that all memory tests reflect the operation of a single memory system. Both views emphasize the importance of cognitive processes. The models differ in the kind of processes that are important for perceptual implicit memory.

The Transfer Appropriate Processing Framework. Roediger and colleagues (Roediger, 1990; Roediger & Blaxton, 1987; Roediger et al., 1989) proposed a Transfer-Appropriate Processing (TAP) framework that posits that perceptual implicit memory performance is episodic in nature. According to TAP, performance on any memory test is a function of the degree to which the cognitive processing engaged in at test recapitulates the cognitive processing engaged in at encoding. Within this framework, two major classes of processing were proposed: perceptual and conceptual. Perceptual (or data-driven) processing focuses on the surface-form and lexical representations of words while conceptual processing focuses on the meaning of a word and how its memory representation relates to other memory representations. Regardless of whether a test is implicit or explicit in nature, perceptual test performance (e.g., perceptual identification, graphemic cued recall) is a function of the perceptual processing of words during a prior episode and conceptual test performance (e.g., general knowledge, recall) is a function of the conceptual processing of words during a prior episode (Blaxton, 1989).

The Interpretation Framework. Masson and MacLeod (1992) proposed an interpretation framework for viewing perceptual implicit memory test performance that also posits that perceptual implicit memory is episodic in nature. According to Masson and MacLeod, encoding can be roughly split into two phases: interpretive processing and elaborative processing. Interpretive processes are context-sensitive processes that enable one to gain an initial interpretation of a stimulus. Interpretive processes are not restricted to orthographic or lexical processes and often will include semantic information if such information is necessary for a proper interpretation of the stimulus. Elaborative processing then takes the established interpretation and relates it to previously stored memory representations. It is important to note that this distinction is orthogonal to the perceptual/conceptual distinction of the TAP framework (Roediger et al., 1989). According to Masson and MacLeod, both interpretive and elaborative processing may use either, or both, perceptual and conceptual characteristics of a stimulus. Thus, semantic processing of the word at encoding will increase later perceptual implicit memory, but only if the semantic processing at encoding was a part of the initial interpretation of the word. The framework posits that interpretive processes underlie perceptual implicit memory test performance and elaborative processes underlie explicit memory test performance.

Evaluation of and Problems with Current Models

Although their accounts of memory are different, all four of the major views described posit that perceptual implicit memory for words is dependent upon changes in some perceptual, lexical system that underlies word identification. Tulving and Schacter (1990) view this as a memory system that is functionally (and anatomically) distinct from other memory systems. Ratcliff and McKoon (1997) view this system as consisting of a number of abstract lexical counters. The TAP framework (Roediger et al., 1989) emphasizes the class of processing that is required to make changes in this system (perceptual processing). Masson and MacLeod (1992) view the necessary processing to make changes in the system as interpretive, rather than just perceptual. Yet, while the particulars of the views are different, many of their conclusions and predictions are the same. Specifically, only manipulations that affect this perceptual, lexical system should have an effect on perceptual implicit memory. Thus, the view that perceptual implicit memory reflects changes within a perceptual, lexical system has become a standard view in implicit memory research.

Much of the research in perceptual implicit memory supports this standard view. The research showing no levels-of-processing effect on perceptual implicit memory coupled with effects of perceptual manipulations on perceptual implicit memory provides strong support for the standard view (see previous discussion). However, the literature is not perfectly clear. In fact, recent research suggests that there might be more to perceptual implicit memory than has been posited by the standard view. Mulligan (1999) reported that making two responses to a word at encoding leads to lower perceptual implicit memory than making one response to the word at encoding. Because making one versus two responses should not produce differences in the perceptual, lexical system, this finding cannot be handled by the standard view. Crabb and Dark (1999c) demonstrated that making an overt, vocal response to a word at encoding leads to increased perceptual implicit memory when the perceptual implicit memory test (perceptual identification) also requires an overt, vocal response. Taken together, these studies show that perceptual implicit memory appears to be affected by processing outside of the perceptual, lexical system; it appears to reflect at least response processing as well.

An Episodic Decision Memory Approach

If perceptual implicit memory reflects more than just changes within a perceptual, lexical system, the standard view of perceptual implicit memory test performance is not adequate. What is needed is a new way of conceptualizing perceptual implicit memory test performance. As a first step in developing a new view, consider what actually happens during a perceptual implicit memory task. During a perceptual implicit memory task, participants are shown a stimulus (often in a degraded form) and asked to make some kind of a decision on the stimulus (e.g., "what is this word?" in perceptual identification, "what word starts with these letters?" in word stem completion, or "is this a word?" in lexical decision). Usually, either the stimuli are quickly presented or a speeded decision is required. One is able to make the decision more accurately or more quickly if one has interacted with the stimulus in the past. The standard view focuses on the facilitation of the perceptual processing preceding the decision. The proposed view broadens the focus to include the actual decision.

According to this new view, perceptual implicit memory is best viewed as episodic decision memory, reflecting the beneficial effect of prior decisions about the present stimulus when it was presented in similar circumstances. If this view is appropriate, it might provide new insights into the nature of perceptual implicit memory. However, before considering such a view, it would be useful to find evidence that prior decisions about a stimulus aid an individual's processing and decision making in a present task.

In classical theories of decision making (e.g., Kahneman & Tversky, 1979), individuals make a decision by surveying a set of solutions, assigning a weight to each of the solutions, and choosing the most appropriate solution. Although such theories are powerful in predicting much decision-making behavior, it is not apparent that this is the most appropriate class of model to use in explaining the type of decision making that occurs in a perceptual implicit memory test. Decisions in a perceptual implicit memory test usually occur very quickly (within a few hundred milliseconds), making it difficult to generate multiple solutions, weight each, and select the best solution. In addition, the instructions in many perceptual implicit memory tests explicitly tell participants to respond with the first, rather than the best, solution that comes to mind. Thus, classical decision theories do not seem to capture the type of decisions that are made during perceptual implicit memory tests.

There is a relatively new class of decision-making theories that might be capable of capturing the kind of decision making that occurs during a perceptual implicit memory test. Theories in this class attempt to capture the decision making processes that occur in naturalistic settings and they operate from a very different set of assumptions than classical theories (Orasanu & Connolly, 1993). One naturalistic theory of decision making is Klein's Recognition-Primed Decision model of rapid decision making (Klein, 1993). The goal of Klein's theory is to describe how experts make decisions in time-pressured situations (e.g., the decision of a firefighter on how to fight a specific fire). According to Klein, when experts make a decision in a time-sensitive situation, they do not engage in the decision-making processes posited by classical theories. Rather than generating multiple solutions and choosing the best among alternative solutions, experts appear to generate a single, plausible solution and to initiate actions based upon the solution.

Central to Klein's model is the role of situation assessment. There are four components to this situation assessment: a) an understanding of the goals to be accomplished in the present situation, b) an increasing salience of the important, physical cues in the environment, c) formation of expectancies to check the accuracy of the assessment, and d) identification and selection of appropriate actions. In some manner, these four components work to generate one workable solution that is acted upon until completed or the situation changes, requiring the generation of another solution. In a sense, the idea is that an expert uses prior episodes to recognize the present situation as typical of a certain class of problems. Generated with this recognition is a single plausible solution to that class of problem.

Klein's (1993) model has been supported by naturalistic studies of experts, often fire-fighting commanders (Klein, Calderwood, & Clinton-Cirocco, 1986). When commanders enter the scene of a fire, they gather information on the nature of the fire (e.g., where it is located in the building, how long it has been burning, are there people in the building). As they gather the information, they generate actions to be carried out (e.g., where to position firefighters, what area of the building to cover, etc.). When asked to describe how they make decisions, commanders state that they do not generate multiple actions and choose the best one as is posited by classical theories of decision making. Rather, they report that they choose the first course of action that comes to mind and follow it until either the fire is out or the nature of the fire changes requiring a change in the course of action. The commanders' reports are in line with Klein's model.

If one can accept the assumption that situation assessment relies on memories of prior fires, one can see parallels between the situation assessment by expert firefighters and the cognitive processes underlying the tasks examined in perceptual implicit memory research. Just as with the participants in Klein's research, the participants in perceptual implicit memory tasks with words as stimuli are experts, in this case they are expert readers. In addition, the participants are required to make quick decisions in time-pressured situations. The proposed view is that the decisions made during these time-pressured perceptual implicit memory tests are affected by previous decisions made on the stimuli presented during the test. If the proposed view is supported, it would not only be relevant to models of perceptual implicit memory, but might also be of importance to researchers in naturalistic decision making. The lack of a description of the cognitive mechanisms underlying situation assessment in Klein's (1993) model has been identified as a major drawback to the theory (Doherty, 1993). If the proposed view is supported, it might indicate the nature of at least one of the mechanisms underlying situation assessment in Klein's model.

THE CURRENT RESEARCH

Introduction

The current research tested the hypothesis that perceptual implicit memory is affected not just by the prior perceptual processing, but also by the prior decisions resulting from the perceptual processing. A number of positions concerning the nature of perceptual implicit memory are implied by this hypothesis. First, perceptual implicit memory is a form of episodic memory. Specifically, perceptual implicit memory is a result of retrieving a prior *decision* episode. The level of displayed perceptual implicit memory is a direct function of the degree to which the prior decision context is instantiated in the subsequent test. In the extant literature, typically the decision made about the stimulus in a prior context (i.e., at encoding) is similar to the decision to be made in the subsequent context (i.e., at test). According to the proposed view, three aspects of the context potentially can affect the level of perceptual implicit memory—the physical context (what are the characteristics of the surroundings in which the stimulus occurs and a decision is made?), the decision processing context (what kind of decision is being made about the stimulus?), and the response context (what action is taken based upon the decision that is reached?).

The proposed view is similar to the extant views in a number of ways. It is similar to the counter model (Ratcliff & McKoon, 1997) in that perceptual implicit memory reflects a decision process, but in the proposed view the nature of the decision is much broader. The decision process described in the counter model is simply a perceptual decision of what the stimulus is. In the proposed view the decision includes identification of the stimulus but also includes the kind of decision that is made and the response that is produced. The proposed view also has similarities with the TAP framework (Roediger et al., 1989) and the interpretation framework (Masson & MacLeod, 1992), but it extends these views. The proposed view focuses on the nature of the processing underlying memory tests, just as do the TAP and interpretation frameworks, but the nature of the processing underlying perceptual implicit memory is more broadly conceptualized. It is not just lexical, perceptual processing or just interpretative processing. In a sense, the proposed view is an extension of Tulving's encoding specificity hypothesis (Tulving & Thomson, 1973) in which the relevant context is the context of the decision process.

The proposed view falls into a class of episodic memory models called instance theories[2] (e.g., Hintzman, 1986; Logan, 1988, 1990). In Logan's instance theory of automatization, performance on a task (e.g., reading) can be accomplished either by computing an algorithm (determining the letters, translating those to morphemes/phonemes, accessing the lexical representation, and making the correct response) or by retrieving a prior instance (or episode) that includes the perceptual features of the word and the response of reading the word. Upon presentation of a word, the algorithm and the retrieval processes "race" to determine which will guide the current reading response. In general, retrieval of an instance is faster than computation of an algorithm, so retrieval will usually win the race (provided that there are a sufficient number of instances of reading the word stored in memory). When there are multiple instances, each of the instances races with the others and the instance that is most similar to the present situation is the one that usually wins. Thus, in Logan's model of automaticity, similarity to a prior episode or instance is critical in determining how a current response is accomplished. Logan (1990) has suggested that perceptual implicit memory also reflects the operation of an instance-based memory system.

The proposed view adds to Logan's view by positing that the instance being retrieved includes the decision made in the prior episode.

One general problem with instance theories is determining what constitutes an instance. Instances appear to reflect discrete episodes of time. Time, however, progresses continuously, with potential "episodes" flowing into one another, making it difficult to determine when one episode begins and where one ends. In the proposed view, the instance that is retrieved and that guides performance on a perceptual implicit memory task includes both the initial perceptual processing of the stimulus, the initial decision made upon the stimulus, and the response made to the stimulus. Thus, the retrieved instance contains information about processes that began with presentation of the stimulus and ended with the decision that was reached. Viewed in this way, the proposed view accepts as partially correct the standard view (namely that perceptual implicit memory reflects changes in a perceptual/lexical processing system), but also states that the memory representations underlying perceptual implicit memory are episodic in nature and include decision and response processes.

Predictions

Three predictions of the proposed view were tested. The first prediction is that higher levels of perceptual implicit memory should be found when the decision made concerning the word at test matches the decision made concerning the word at encoding. The second prediction is that higher levels of perceptual implicit memory should be found when the response made to the word at test matches the response made to word at encoding. The third prediction is that higher levels of perceptual implicit memory should be found when the physical context surrounding the word at encoding is important to the decision processes and matches the test context.

The predictions were tested in three experiments. Each of the experiments tested for the presence of a context-dependency effect in perceptual implicit memory. A context-dependency effect is found when the level of memory is higher when the context (or circumstances) at encoding and test match (Smith, 1988) than when they mismatch. An example of what a context-dependency effect on perceptual implicit memory might look like is shown in Figure 1. Perceptual implicit memory is usually measured by the improvement

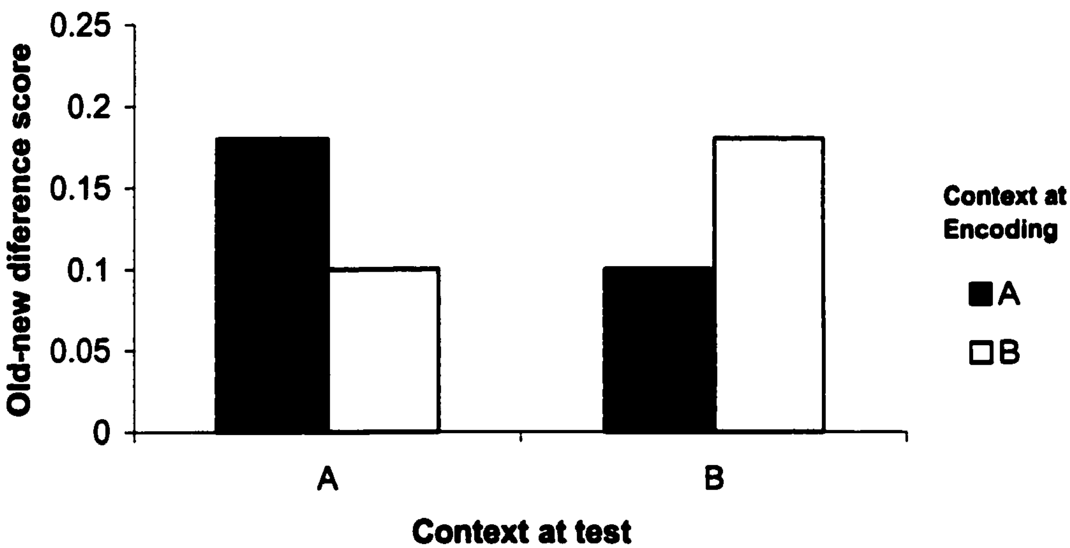

Figure 1. An example of a context dependency effect on perceptual implicit memory.

in performance on old (previously presented) items over new (not previously presented) items. The improvement is indicated by the magnitude of the old-new difference score. Figure 1 shows context-dependency because a higher level of perceptual implicit memory (i.e., a larger old-new difference) is found when some aspect of the context at test matches the same aspect of the context in which words were presented at encoding.

The improvement in memory when the context at test and encoding match is thought to occur because the context from the encoding episode that is reinstated at test works as a retrieval cue to help retrieve the prior episode from memory (Smith, 1988). Most context-dependency studies have examined explicit memory, primarily recall. The proposed view predicts that reinstating the context of a prior *decision* episode during a perceptual implicit memory test will improve performance on the test.

Researchers have identified different kinds of context that might have an effect on memory (e.g., Baddeley, 1982; Geiselman & Bjork, 1980; Mori & Graf, 1996). Geiselman and Bjork (1980) contrasted *intra-* and *extra-*item contexts. Intra-item context refers to features intrinsic to the stimulus (e.g., color, modality, language, font). Extra-item context refers to aspects of the environment that are separate from the stimulus (e.g., location, background, the internal state of the individual). Baddeley (1982) distinguished between *integrated* contexts that affect the manner in which an individual encodes the stimulus and *isolated* contexts that do not affect the manner in which an individual encodes the stimulus and does not have a direct connection to the stimulus. Research has found both intra- and extra-item context-dependency effects on explicit memory (particularly recall), especially when integrated contexts are used (Smith, 1988). The proposed view predicts both intra- and extra-item context-dependency effects, but only when the context is an integral part of the decision process.

Overview of Experiments

As stated earlier, three major aspects of the decision episode context were investigated. Others have found evidence for intra-item context-dependency effects on perceptual implicit memory. For example, higher levels of perceptual implicit memory are found when the modality (Kirsner, Milech, & Standen, 1983) and the font (e.g., Graf & Ryan, 1990) are the same at encoding and at test. Thus, the present research attempted to find three different kinds of extra-item context-dependency effects. Experiment 1 tested for the presence of a decision process context-dependency effect. Experiment 2 tested for the presence of a response process context-dependency effect. Experiments 3a and 3b tested for the presence of a physical (environmental) context-dependency effect. The general procedure in each of the experiments was the same. Participants engaged in three tasks. First, participants engaged in an encoding task. Second, participants engaged in a five-minute distractor task in which they solved simple arithmetic equations. This served to separate the encoding task from the perceptual implicit memory tests. Third, participants engaged in one or more perceptual implicit memory tests. In all experiments, manipulations of context at encoding and test were done within-subjects.

Experiment 1: Decision Context-Dependency

If perceptual implicit memory relies on prior decisions made concerning the present stimulus, greater perceptual implicit memory should be found when the perceptual implicit memory test invokes the same decision processes at test that were invoked at encoding. That is, there should be a decision context-dependency. Of the four major models discussed in the introduction, the TAP framework addresses this kind of situation most directly. The proposed view predicts something more than the TAP framework. The TAP framework states that perceptual implicit memory is affected by the match in perceptual processing between test and encoding (Roediger et al., 1989). To the extent that the decision comes after perceptual processing, there should not be an effect of type of decision. The proposed view predicts differences in the level of perceptual implicit memory even when the same level of perceptual processing is engaged in at encoding and test if there is a difference in the decision made between encoding and test. The proposed view predicts higher levels of perceptual implicit memory when the decision made concerning a stimulus at test matches the decision made at encoding.

To test the prediction, participants engaged in two encoding tasks that required the same response (saying the word) but required two different kinds of decisions. In one encoding task, participants engaged in a word identification task. They saw words presented on a computer screen and indicated the word they saw by saying it aloud. In the other encoding task, participants engaged in a vocal lexical decision task. They saw words and nonwords presented on a computer screen and indicated the presence of a word by saying it aloud. Perceptual implicit memory was then measured for the words on a perceptual identification task and a vocal lexical decision task. It should be noted that nonwords did not appear during the block of the encoding task in which participants engaged in the word identification task. Because participants engaged in the same amount of perceptual processing (and performed the same response) for both tasks at encoding, the TAP framework does not predict a difference in later perceptual implicit memory between the encoding tasks on either test. The proposed decision view does predict a difference in perceptual implicit memory--higher levels of perceptual implicit memory should be found when the same decision was made at encoding and at test (when the tasks at encoding and test are either both word identification or both lexical decision).

Method

Participants and Design

Participants were 32 undergraduate students enrolled in introductory psychology courses. They received extra credit for their participation. Decision at encoding and at test was manipulated within-subjects.

Stimuli

A pool of 120 nouns from Roediger, Weldon, Stadler, and Reigler (1992, Experiment 3) was divided into four sets of 30 words each such that the sets were approximately equal along the dimension of reportability on a perceptual identification test as assessed by an earlier study (Crabb & Dark, 1999a). For each participant, 60 of these words appeared in the initial encoding task. Thirty of the words appeared in each of the encoding conditions for each participant. The other 60 words were used as the baseline (or new) words in the perceptual implicit memory tasks. Words were counterbalanced such that each word appeared as an old and new word an equal number of times. Fifty-three other words were also presented as filler words. Forty-three appeared as filler words in the encoding task and 10 were used as filler words in the perceptual identification task (5 of these 10 were used as fillers in the lexical decision test). In addition, 161 pronounceable nonwords were presented during the encoding and lexical decision tasks. Thirty-six appeared as fillers during the lexical decision condition of the encoding task and 125 appeared on the lexical decision task.

Apparatus

The Micro Experimental Laboratory Professional software (Schneider, 1988) was used to display the stimuli for all tasks on a Pentium computer. A condenser microphone and response box were used to register when a verbal response was made. An experimenter recorded verbal accuracy. All stimuli were presented as white characters on a black background. Participants were seated approximately 40 cm from the monitor.

Procedure

Participants were told that they were taking part in an experiment to determine their ability to make decisions about briefly presented stimuli. Participants engaged in four tasks: the initial encoding task, a math filler task, and two perceptual implicit memory tasks: perceptual identification and lexical decision. At the end of the experiment, participants were debriefed as to the true purpose of the experiment.

Encoding Task. Participants were presented two blocks of 72 trials. On each trial a fixation (++) was presented for 200 ms, followed by a stimulus for 500 ms. There was a 500 ms intertrial interval. In order to guard against potential primacy and recency effects, the first and last six trials of each block were buffers. The remaining 60 trials in each block were presented in a random order. For one block of trials, the 60 trials consisted of 30 words that later served as the old words on the perceptual implicit memory tasks and 30 pronounceable nonwords. During this block, participants were instructed to search for words and to indicate the presence of a word by saying it aloud. For the other block of trials, the 60 trials consisted of 30 words that later served as the old words on the perceptual implicit memory tasks and 30 other filler words. Participants were instructed to read the words aloud. Order of the blocks was counterbalanced across subjects. No feedback was given during the encoding task.

Math task. Following the encoding task, participants engaged in a 5-minute math task. Participants were required to determine whether simple arithmetic equations (e.g., 2+2=5) are true. Each problem was presented on the computer screen and participants were required to respond by key press as quickly and accurately as possible ("1" for "true" and "2" for "false"). The next problem was presented immediately after the response. The math task served as a distraction task designed to clear working memory and to disconnect the subsequent memory test from the encoding task.

Following the math task, participants engaged in the perceptual identification and lexical decision tasks. The order of the two tasks was counterbalanced across participants.

Perceptual Identification. In the perceptual identification task, 70 trials were presented. Each trial began with a fixation point (++) for 500 ms. Following fixation, a word was presented for 33 ms. Each word was followed by a mask, which consisted of a row of Xs and which remained on until a response was made. Because perceptual identification is a difficult task, the first 10 trials were inserted as practice trials before participants encountered the critical trials. Thus, the first 10 trials contained filler words that were not analyzed. Of the remaining 60 trials, 30 were the old words from the encoding task (15 from each encoding condition) and 30 were new words. Participants were instructed to name the words aloud and the experimenter recorded their responses.

Lexical decision. In the lexical decision task, 130 trials were presented. Each trial began with a fixation point for 200 ms. Following fixation, either a word or a pronounceable nonword was presented for 500 ms. A 1500 ms blank screen was then presented. Responses that were not made within 2000 ms after the stimulus was presented were counted as errors. The first 10 trials were inserted as practice trial before participants encountered the critical trials and were not analyzed. Of the remaining 120 trials, 30 were old words from the encoding task (15 from each condition), 30 were new words, and 60 were pronounceable nonwords. Participants were instructed to determine if the stimulus on each trial was a word. If the stimulus was a word, participants were instructed to say the word as quickly as they could. An experimenter recorded the accuracy of their responses and the computer recorded latency of their responses.

Results

An alpha level of .05 was used for all analyses.

Encoding Tasks

Because the standard view predicts differences in the level of perceptual implicit memory as a function of the proportion of words at encoding whose lexical representations are accessed (e.g., Mulligan, 1997; Weldon, 1991), performance at encoding was analyzed in terms of the proportion of critical words (the words that were later tested on the perceptual implicit memory tests) overtly identified at encoding. Because the set of critical words overtly identified at encoding is necessarily a subset of the set of critical words lexically processed at encoding, the proportion of critical words overtly identified at encoding should be considered a conservative estimate of the actual proportion of critical words lexically processed. If the proportion of words identified at encoding between the two conditions is equivalent, the standard view predicts no difference in the level of later perceptual implicit memory.

The proportion of overtly identified critical words in the word identification encoding task was .963 ($\underline{SE}$ = .008) and in the lexical-decision encoding task was .937 ($\underline{SE}$ = .012). Although the proportion of overtly identified words was high in both conditions, it was reliably higher in the word identification condition, $t(31) = 2.27$, $SE = .011$, $p = .030$. The lower rate of overt identification in the lexical decision condition is not surprising because the decision that was required was more difficult than the decision in the word identification task.

Perceptual Implicit Memory Tasks

Perceptual Identification. The proportion of old words that were identified and the proportion of new words that were identified are shown in Table 1 for each of the encoding conditions. Perceptual implicit memory was indexed as a difference score by subtracting the

Table 1. Performance on the Perceptual Identification Task in Experiment 1 as a Function of Encoding Task and Type of Word.

	Encoding Task			
	Word Identification		Lexical Decision	
Type of Word	M	SE	M	SE
Old	.60	.04	.63	.04
New	.46	.04	.46	.04
Difference	.14*	.02	.17*	.03

* Reliably different from zero, $p < .05$.

proportion of new words identified from the proportion of old words identified. There was no difference in the level of perceptual implicit memory as a function of decision at encoding, $t(31) = -1.37$, $SE = .024$, $p = .180$. However, as predicted by both the proposed and standard view, the level of perceptual implicit memory in both conditions was reliably greater than chance, $t(31) = 6.12$, $SE = .023$, $p < .001$, and $t(31) = 6.52$, $SE = .027$, $p < .001$, for the word identification and lexical decision encoding conditions, respectively.

Lexical Decision. The proportion correct and mean reaction times for accurate responses to old words and to new words are shown in Table 2 for each of the encoding conditions. Perceptual implicit memory was indexed as a difference score by subtracting the reaction time to new words from the reaction time to old words. As with perceptual identification, there was no difference in the level of perceptual implicit memory as a function of decision at encoding, $t(31) = -.35$, $SE = 16.97$, $p = .731$. As predicted by both the proposed and standard view, the level of perceptual implicit memory in both conditions was reliably greater than chance, $t(31) = 3.41$, $SE = 9.80$, $p = .002$ and $t(31) = 1.87$, $SE = 14.72$, $p = .045$, for the word identification and lexical decision encoding conditions, respectively. Because numerically more old than new words were correctly classified, there was no indication of a speed-accuracy tradeoff.

Table 2. Mean Response Times and Proportion Correct on the Lexical Decision Task in Experiment 1 as a Function of Encoding Task and Type of Word.

	Encoding Task					
	Word Identification			Lexical Decision		
Type of Word	M	SE	PC	M	SE	PC
Old	703	15	.94	709	15	.93
New	737	14	.91	737	13	.91
Difference	33*	12		27*	12	

* Reliably different from zero, $p < .05$.

Discussion

The findings of the this experiment do not support the proposed view of perceptual implicit memory. The proposed view predicted a reliable effect of type of decision at encoding on both the perceptual identification and lexical decision tasks, with higher levels of perceptual implicit memory when the decision at test matched the decision made at encoding. No effect of type of decision at encoding was found. There was evidence of perceptual implicit memory in all conditions, but the level of perceptual implicit memory did not depend on the match in decision processes between encoding and test. Further the lack of an effect was found with both measures of perceptual implicit memory: perceptual identification and lexical decision.

Although there was a small but reliable difference in the proportion of words overtly identified at encoding between the two encoding tasks, there was no indication of an effect of encoding task on the magnitude of later perceptual implicit memory. However, identification was quite high in both encoding conditions. It is possible that the words that were not overtly identified during lexical decision did receive equivalent levels of perceptual/lexical processing, but just were not recognized as English words. Because of this, the standard view would not make a strong claim about the effect of the encoding conditions on the later perceptual implicit memory tasks. At most, the standard view would predict either no difference in the level of perceptual implicit memory (because identification was so high) or perhaps a slightly lower level of perceptual implicit memory (for both perceptual implicit memory tasks) for words initially presented in the lexical-decision encoding task.

The failure to find an effect of decision process context-dependency on perceptual implicit memory would appear to support the standard view that perceptual implicit memory reflects changes in a perceptual, lexical processing system. According to this view, the present results demonstrate that type of decision made about a stimulus at encoding does not appear to be a part of the memory trace underlying perceptual implicit memory.

Although the standard view provides a straightforward account for the results in this experiment, the data also can be interpreted so that they fit with the proposed view. It is possible that the type of decision process is incorporated into the memory trace underlying perceptual implicit memory, but that the manipulation of type of decision process was not strong enough to elicit a measurable effect. Indeed, the decisions used in this experiment are quite similar. Perhaps the decision processes were not distinct enough to have differential effects on perceptual implicit memory. It is also possible that the rest of the context (e.g., the environmental and response contexts) was too similar between encoding and test and that the similarity masked any difference produced by the match or mismatch in decision process context. A more sensitive design in which the contexts are made as different as possible along as many dimensions as possible might provide a better test of whether reinstating the decision process context at test improves perceptual implicit memory.

Although the explanations for the lack of a type of decision process context-dependency effect discussed in the previous paragraph might be accurate, there is little support for them in the data because no evidence for context-dependency was found. If there was a decision process context-dependency effect but it was being masked by other factors, one would expect at least a trend in the data suggesting that such an effect was there. There was no such trend. The burden of proof is clearly on the proposed view. The most parsimonious account is that provided by the standard view. The proposed view must find evidence of decision context-dependency in some experimental situation before its explanations for the lack of an effect in the present experiment should be considered.

Experiment 2: Response Context-Dependency

It is possible that making any decision at encoding improves later perceptual implicit memory. The memory trace might be affected by a previously made decision, without the exact decision process being incorporated into the memory trace. Future research might check to see if making ANY decision improves perceptual implicit memory. Forster and Davis (1984) presented evidence that when a word is the target of a response (and thus the focus of a decision) at encoding, higher levels of perceptual implicit memory were found than when a word was not the target of a response. However, the evidence consisted of a comparison of performance across two different experiments that differed along more dimensions than just whether or not the word was the target of a response. Thus, further research must determine if simply making a decision improves later perceptual implicit memory. While finding higher levels of perceptual implicit memory when a decision is made at encoding versus when no decision is made at encoding would still not support the kind of individual instance view proposed here, it also would not be predicted by the standard accounts of perceptual implicit memory. Indeed, finding that making a decision about a word at encoding improves perceptual implicit memory when the amount of perceptual processing is equivalent would cause problems for the standard view of perceptual implicit memory.

Crabb and Dark (1999c) showed greater perceptual implicit memory when the response at encoding and at test were both vocal. At encoding, participants were presented words one at a time. In one condition, participants read aloud words that later appeared as old words in a perceptual identification task. In another encoding condition, participants did not read aloud the words. In two different experiments (Experiments 1 & 2), higher levels of perceptual implicit memory (as measured by a perceptual identification task) were found when the words were read aloud at encoding. However, in another experiment (Experiment 3) in which participants either did or did not press a key in response to a word at encoding, there was no increase in the level of perceptual implicit memory (as measured by a perceptual identification task) for words that had been responded to at encoding.

One interpretation of this finding is that saying a word at encoding enhances the perceptual/lexical processing of the word, which in turn leads to better perceptual implicit memory. That is, saying a word allows the individual to hear the word, allowing for more perceptual/lexical processing than is possible when just silently reading the word or when pressing a key in response to the word. This interpretation would be in agreement with the standard view that perceptual implicit memory is the result of changes within a perceptual/lexical processing system. Although this interpretation might seem plausible, it relies upon finding an effect of hearing a word at encoding on a later visual perceptual implicit memory task. This is problematic because the lack of such cross-modal priming is a hallmark of perceptual implicit memory (Roediger & McDermott, 1993).

A second interpretation is that saying the word at encoding left an articulatory memory trace that improved later perceptual implicit memory because a similar vocal response was required at test. This interpretation fits with the proposed view that the memory trace underlying perceptual implicit memory includes the response that was made to the stimulus. That is, the second interpretation is that the effect of vocal response observed by Crabb and Dark (1999c) is due to the match in response between encoding and test. The second interpretation does not fit with the standard view because it posits an effect of nonperceptual/lexical processing at encoding on perceptual implicit memory.

The two interpretations differ in terms of how they generalize to other types of response. For example, if the proposed view is correct, higher levels of perceptual implicit memory should be found when a manual response is made both at encoding and at test. The standard view does not predict such an effect if the same amount of perceptual processing occurs at encoding. The present experiment tests whether a response context-dependency effect can be found on a perceptual implicit memory test that requires a manual response and on a perceptual implicit memory test that requires a vocal response.

To test for a response context-dependency effect on perceptual identification, at encoding participants engaged in a word identification task in two blocks of trials. During one block, participants identified words by saying them aloud. During the other block, participants identified words by writing them on a piece of paper. Perceptual implicit memory was then measured for the words on two perceptual implicit memory tasks: vocal perceptual identification (in which participants identified words by saying them aloud) and manual perceptual identification (in which participants identified words by writing them on a piece of paper). The proposed view predicts an effect of response modality at encoding (verbal and manual) on each type of task, with the highest perceptual implicit memory when the response at encoding and test match. Thus, on the one hand, perceptual implicit memory should be higher for words spoken at encoding when it is measured by a vocal perceptual identification task. On the other hand, perceptual implicit memory should be higher for words written at encoding when it is measured with a manual perceptual identification task.

Method

Participants and Design

Participants were 32 undergraduate students enrolled in introductory psychology courses. They received extra credit for their participation. Response modality at encoding and response modality at test were manipulated within-subjects.

Stimuli

The same pool of 120 words from the decision context-dependency experiment was used. For each participant, 60 of these words appeared in the initial encoding task. Thirty of the words appeared in each of the encoding conditions for each participant. The other 60 words were used as the baseline (or new) words in the perceptual implicit memory tasks. Words were counterbalanced such that each word appeared as an old and new word an equal number of times. Eighty-four other words were presented during the encoding task, 42 per block. Ten other words were used as fillers in the perceptual implicit memory tasks.

Apparatus

The apparatus was identical to that of Experiment 1.

Procedure

Participants were told that they were taking part in an experiment to determine their ability to make decisions about briefly presented stimuli. Participants engaged in four tasks: the initial encoding task, a 5-min. math task, and two perceptual implicit memory tests: vocal perceptual identification and manual perceptual identification. At the end of the experiment, participants were debriefed as to the true purpose of the experiment.

Encoding Task. Participants were presented two blocks of 72 words. On each trial a tone sounded for 200 ms to alert participants that a new trial was starting. After 500 ms, a fixation (++) was presented for 500 ms, followed by a word for 500 ms. There was a 4000 ms intertrial interval, to allow time for participants to write the words when they were in the block that required them to do so. In order to guard against potential primacy and recency effects, the first and last six words of each block were buffer words. Of the remaining 60 words, 30 were critical words that served as the old words on the perceptual implicit memory tasks and 30 were filler words.

Participants were instructed to identify the words as they were presented. For one block, participants were instructed to identify the presented word by saying it aloud. An experimenter recorded their responses on a response sheet. In the other block, participants were instructed to identify the presented words by writing the words on a different response sheet. Order of the blocks was counterbalanced across subjects. No feedback was given during the encoding task.

Math task. The math task was the same as the one used in Experiment 1.

Vocal perceptual identification. The vocal perceptual identification task was the same as the perceptual identification task used in Experiment 1.

Manual perceptual identification. The manual perceptual identification task was similar to the perceptual identification task used in Experiment 1, except that participants identified words by writing them on a response sheet. If participants did not know what word was presented, they wrote a "?" on the response sheet. After writing their response, participants pressed the space bar to continue to the next trial.

Results

An alpha level of .05 was used in all analyses.

Encoding Task

As in Experiment 1, performance at encoding was analyzed in terms of the proportion of critical words (the words that were later tested on the perceptual implicit memory tests) overtly identified at encoding. As expected participants overtly identified a high proportion of words and there was no difference in the proportion of words overtly identified between when participants read the words aloud ($\underline{M}$ = .987, $\underline{SE}$ = .005) and when participants wrote the words ($\underline{M}$ = .992, $\underline{SE}$ = .003), $\underline{t}$ (31) = -1.04, $\underline{SE}$ = .005, $\underline{p}$ = .305. Because participants identified equivalent proportions of words in the two encoding conditions, the standard view would predict no difference in performance on the perceptual implicit memory tasks as a function of encoding condition.

Perceptual Identification

The proportion of old words that were identified and the proportion of new words that were identified are shown in Table 2 for each of the conditions. Perceptual implicit memory

Table 3. Performance on the Perceptual Identification Tasks in Experiment 2 as a Function of Response Modality at Encoding and Response Modality at Test.

	Response Modality at Encoding					
	Vocal		Written		New	
Response Modality at Test	M	SE	M	SE	M	SE
Vocal	.63	.04	.65	.04	.47	.04
Written	.68	.04	.64	.04	.48	.04

was indexed as a difference score by subtracting the proportion of new words identified from the proportion of old words identified. The difference scores are shown in Figure 2[3]. An Analysis of Variance (ANOVA) with response modality at encoding and response modality at test as within-subjects variable failed to find reliable main effects of response modality at encoding, $F(1, 31) = 0.57$, $MSE = .011$, $p = .457$, or response modality at test, $F(1, 31) = 0.25$, $MSE = .015$, $p = .624$.

The interaction between the two variables was marginally reliable, $F(1, 31) = 2.93$, $MSE = .012$, $p = .098$, but the direction of the interaction was opposite that predicted by the proposed view. As predicted by both the proposed and standard view, the level of perceptual implicit memory was reliably greater than chance in all conditions, all t's > 4.

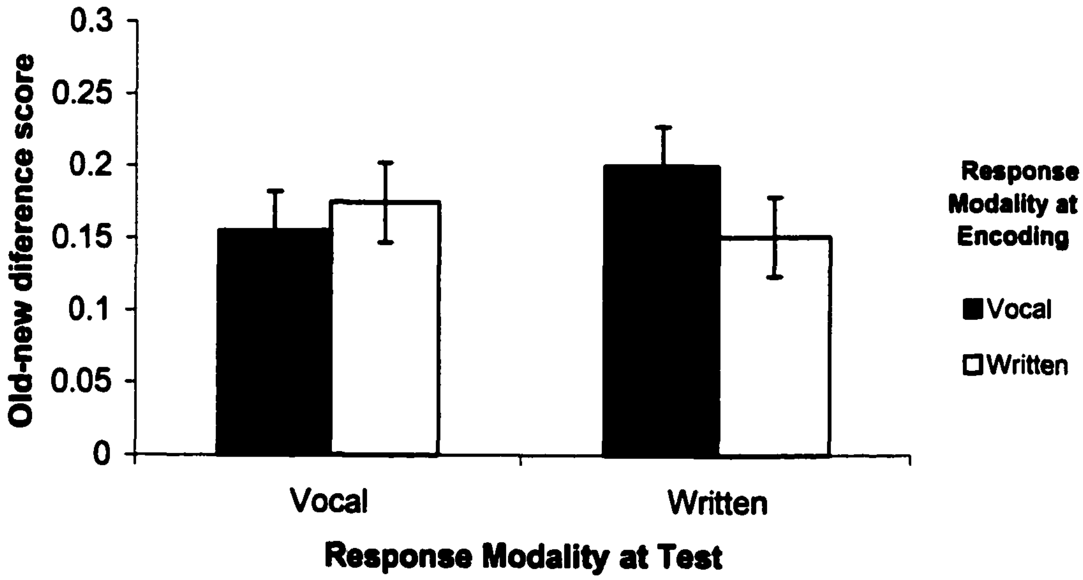

Figure 2. Old-new difference scores on perceptual identification in Experiment 2 as a function of response modality at encoding and response modality at test.

Discussion

The findings of this experiment do not support the proposed decision view of perceptual implicit memory. The proposed view predicted a reliable interaction between the modality of the response at encoding and the modality of the response at test, with higher levels of perceptual implicit memory when the response modality at test matches the response modality at encoding (see Figure 1). No reliable interaction was found. Not only did the level of perceptual implicit memory not depend on the match in response modality between encoding and test, but a numerically greater level of perceptual implicit memory was found when the response modality at encoding and the response modality at test did *not* match.

The failure to find a response context-dependency effect on perceptual implicit memory would appear to support the standard view that perceptual implicit memory reflects changes in a perceptual, lexical processing system. According to this view, the present results demonstrate that the modality (and perhaps any aspect) of the response made to a stimulus does not appear to be a part of the memory trace underlying perceptual implicit memory. The standard view (and the TAP view in particular) predicted similar levels of perceptual implicit memory among the conditions because the amount of perceptual processing at encoding was similar between the two encoding conditions. This was what was found.

Although no effect of response modality was found, the level of perceptual implicit memory in this experiment was quite high when compared with other studies that have used vocal perceptual identification with the same set of words but did not require an overt response from participants at encoding (Crabb & Dark, 1999b; the silent conditions in Crabb

& Dark, 1999c). No overt response was required at encoding because the critical words were not targets and difference scores in the vocal perceptual identification task ranged between .06 and .10. In the present research (including the decision and environmental context-dependency experiments) and in the vocal conditions in Crabb and Dark (1999c) in which participants did make an overt response at encoding, difference scores ranged between .15 and .20. This increase in the size of the difference scores might indicate, as suggested by Forster and Davis (1984), that making an overt response at encoding does improve perceptual implicit memory. However, the data do not reveal why overt responding at encoding improves later perceptual implicit memory, and, in fact, other studies have shown that the type of response at encoding has no direct effect on later perceptual implicit memory (e.g., Downes, et al., 1996; MacDonald & MacLeod, 1998).

The apparent increase does not appear to be because the response itself is part of what is stored in the memory trace, as would be suggested by the proposed view and other individual instance theories (e.g., Logan 1988, 1990). If that were the case, there should have been a response modality context-dependency effect. Rather, the apparent overt response effect could be indicative of the importance of the word at encoding. Saying or producing a word might make the word important (the target of decisional processing). This might explain why Crabb and Dark (1999c) found an effect of some response versus no response at encoding, but there was no effect of the type of response (i.e., response modality) in this experiment. That is, the results of this experiment and Crabb and Dark (1999c) might indicate that making a decision about a word at encoding does have an effect on the memory representations underlying perceptual implicit memory, but without the specifics of the decision (e.g., the kind of decision made, the type of response made) being incorporated into the representation. A potential mechanism for this is presented in the general discussion.

Experiment 3a: Environmental Context-Dependency—Perceptual Identification

The role of physical (or environmental) context in at least some forms of explicit memory is well established. A large number of studies have demonstrated that recall performance is best when the physical context at test is the same as the physical context at encoding (see Smith, 1988, for a review). The improvement in recall performance when the physical context at encoding and test match is called environmental context-dependency. The context-dependency is assumed to reflect the retrieval of an episodic memory trace. If perceptual implicit memory depends on retrieval of an episodic memory trace, then it seems that it too should demonstrate a similar context-dependency.

The results of studies on context-dependency effects in perceptual implicit memory are not straightforward (see Tenpenny, 1995, for a review). An early study showed that when words are studied alone, rather than as part of a meaningful paragraph, higher levels of perceptual implicit memory are found when the perceptual implicit memory test presents words alone (Oliphant, 1983). Although the study was originally interpreted in terms of a context-dependency effect (words alone or in a paragraph at encoding and words alone at test), a recent study suggests that the effect more likely is due to the lower level of perceptual processing that words receive when they are presented in a sentence compared to when they are presented alone (Masson & MacLeod, 1996).

Many studies that have found context-dependency in perceptual implicit memory have used paradigms in which word-pairs are presented together at encoding and test (e.g., Graf & Schacter, 1985; Schacter & Graf, 1986). Context is manipulated in these studies by pairing the word at test with either the same word or a new word. These studies often (but not always) find higher levels of perceptual implicit memory when the word is paired with the same word at encoding and test. However, it is possible that such manipulations are more than just a manipulation of environmental context, the manipulation might be affecting the kind of processing that the target word receives at encoding and test. That is, such a manipulation might affect the kind or amount of conceptual vs. perceptual processing that a word receives at encoding and test. If this is true, the TAP and Masson and MacLeod (1992) frameworks would explain the effects in terms of the amount or kind of processing rather than in terms of context-dependency.

Smith, Heath, and Vela (1990) found an effect of environmental context-dependency on homophone spelling (a perceptual implicit memory task). In one of two rooms, participants heard or read word pairs in which the first word biased participants to think of a lower frequency spelling of a homophone (e.g., vegetable-BEET). Participants then either went to the other room or went back into their original room and engaged in a task in which they were to spell homophones they heard on an audiotape. Smith et al. found that participants were more likely to spell the homophones with the lower frequency spelling when they were in the same room than when they were in a different room. Although intriguing, Smith et al.'s results are not conclusive evidence of an effect of environmental context on perceptual implicit memory because the homophone spelling task is not a common perceptual implicit memory task and might be vulnerable to explicit contamination (i.e., participants might explicitly remember the presentation of the lower frequency spelling and spell the word in the same manner). Because of the problems with the Smith et al. study, a stronger case for an environmental context-dependency effects require that the effect be found with a well accepted perceptual implicit memory task.

Mori and Graf (1996) attempted to find an environmental context-dependency effect in perceptual implicit memory , as measured by perceptual identification, in four experiments; they failed to find an effect in any of the experiments. At encoding, participants saw words presented on a colored background. For each word, participants were required to determine how appropriate the background color was to the concept represented by the word (e.g., *banana* was presented on a yellow background or *swan* was presented on a green background). At test, participants engaged in a perceptual identification task. Words were presented with either the same or different color background. Because the encoding task encouraged participants to integrate the background color with the word, Mori and Graf expected to find an environmental context-dependency effect. They did not.

The proposed view of perceptual implicit memory predicts an environmental context-dependency effect when the physical context is a part of the decision processes at encoding and test. Thus, if the physical context in which a word appears at encoding is important in the decision an individual makes at encoding, reinstating that physical context at test should increase the level of perceptual implicit memory. The Mori and Graf (1996) study appears to show that a context-dependency effect is not found, even if the environmental context is important to the decisions made at encoding. However, the kind of decision being made required participants to engage in deliberative, elaborative processing of the words (i.e., they had to consider the characteristics of the underlying concept to make their decision). Thus, it is likely that the environmental context was incorporated into the memory trace produced by this deliberative, elaborative processing. Because perceptual implicit memory is insensitive to changes in this kind of elaborative, conceptual processing (e.g., levels-of-processing manipulations do not effect perceptual implicit memory), it is not clear that the lack of an effect in the studies by Mori and Graf is due to a lack of environmental context-dependency. That is, the decision participants engaged in at test might not have used the memory representations produced by the encoding task and because they did not use these representations, they were not affected by differences in the environmental context.

The proposed view predicts an environmental context-dependency effect, particularly when the decision process engaged in at encoding involves an early, nondeliberative kind of processing, unlike that required in Mori and Graf (1996). To test this prediction, participants viewed white words on either a red or blue background at encoding. In one encoding condition, participants were instructed to say the word only if it was on a blue background. In the other encoding condition, participants were instructed to say the word only if it was on a red background. In this way, the color of the background (the physical context in which the word appeared) was important to the decision that the participants made (to say the word or to not say the word). Perceptual implicit memory was tested using perceptual identification. The proposed view predicts higher levels of perceptual implicit memory when the background at test is the same color as the background in which the words were presented at encoding.

Method

Participants and Design

Participants were 32 undergraduate students enrolled in introductory psychology courses. They received extra credit for their participation. The background color at encoding and the background color at test were manipulated within subjects

Stimuli

The same pool of 120 words from Experiment 1 was used. For each participant, 60 of these words appeared in the initial encoding task. Thirty of the words appeared in each of the encoding conditions for each participant. The other 60 words were used as the baseline (or new) words in the perceptual identification task. Words were counterbalanced such that each word appears as an old and new word an equal number of times. Another 94 words that were not analyzed were presented as filler words. Eighty-four appeared as fillers in the encoding task and 10 appeared as practice during the perceptual identification task.

Apparatus

The apparatus was identical to that used in Experiment 1. The color of the background was controlled by selecting the blue and red background choices in the MEL software package (Schneider, 1988).

Procedure

Participants were told that they were taking part in an experiment to determine their ability to make decisions about briefly presented stimuli. Participants engaged in three tasks: the initial encoding task, a 5-min. math task, and a perceptual implicit memory task. At the end of the experiment, participants were debriefed as to the true purpose of the experiment.

Encoding Task. Participants were presented with two blocks of 72 words. Each word was presented for 500 ms with either a blue or a red background (50% of trials in each block were of each color) with a 500 ms intertrial interval. In order to guard against potential primacy and recency effects, the first and last six trials of each block were filler words. The remaining 60 trials in each block were presented in a random order. Of these words, 30 were critical words that were tested later on the perceptual identification task. The other thirty words were filler words. In each block, the critical (to be tested) words were presented only on trials containing the background color that indicated a response was to be made. During one block of the encoding task, participants were instructed to say the word if it was presented with a red background and on the other block, participants were instructed to say they word if it was presented with a blue background. The order of the two blocks was counterbalanced across participants.

Math task. The math task was the same as that used in Experiment 1.

Perceptual Identification. The perceptual identification task was the same as that used in Experiment1 except half of the words were shown with a blue background and half of the words were shown with a red background.

Results

An alpha level of .05 was used in all analyses. Twelve participants who did not identify any words in one of the perceptual identification blocks were replaced.

Encoding Task

As in Experiment 1, performance at encoding was analyzed in terms of the proportion of critical words (the words that were later tested on the perceptual implicit memory tests) overtly identified at encoding. Almost all words were overtly identified at encoding and there was no difference in the proportion of words overtly identified between when the words were presented with a red background (M = .986, SE = .005) and when the words were presented with a blue background (M = .986, SE = .005), t (31) = 0.00, SE = .004, p = .999. Because participants identified equivalent proportions of words in the two encoding conditions, the standard view would predict no difference in performance on the perceptual implicit memory tasks as a function of encoding condition.

Perceptual Identification

The proportion of old words that were identified and the proportion of new words that were identified are shown in Table 3 for each of the encoding conditions. Perceptual implicit memory was indexed as a difference score by subtracting the proportion of new words identified from the proportion of old words identified. The difference scores are shown in Figure 3. An ANOVA with color at encoding and color at test as within-subjects variables showed a reliable main effect of color at test, F(1, 31) = 6.66, MSE = .026, p = .015, with higher perceptual implicit memory for words shown in the blue background. The main effect

Table 4. Performance on the Perceptual Identification Tasks in Experiment 3a as a Function of Color at Encoding and Color at Test.

	Color at Encoding					
	Red		Blue		New	
Color at Test	M	SE	M	SE	M	SE
Red	.26	.04	.25	.04	.16	.03
Blue	.46	.05	.45	.05	.29	.03

of color at encoding was not reliable, F (1, 31) = .72, MSE = .007, p = .402. Critically, the interaction between the two variables was not reliable, F (1, 31) = 0.00, MSE = .005, p = .999. Thus, there was no indication of a context-dependency effect (see Figure 1). As predicted by both the proposed and standard view, the level of perceptual implicit memory as reliably greater than chance in all conditions, all t's > 3.

The main effect of color at test on perceptual identification was unexpected. In fact, as suggested in Table 4, fewer words overall were identified when the words were presented with a red background, t (31) = 6.99, SE = .023, p < .001.

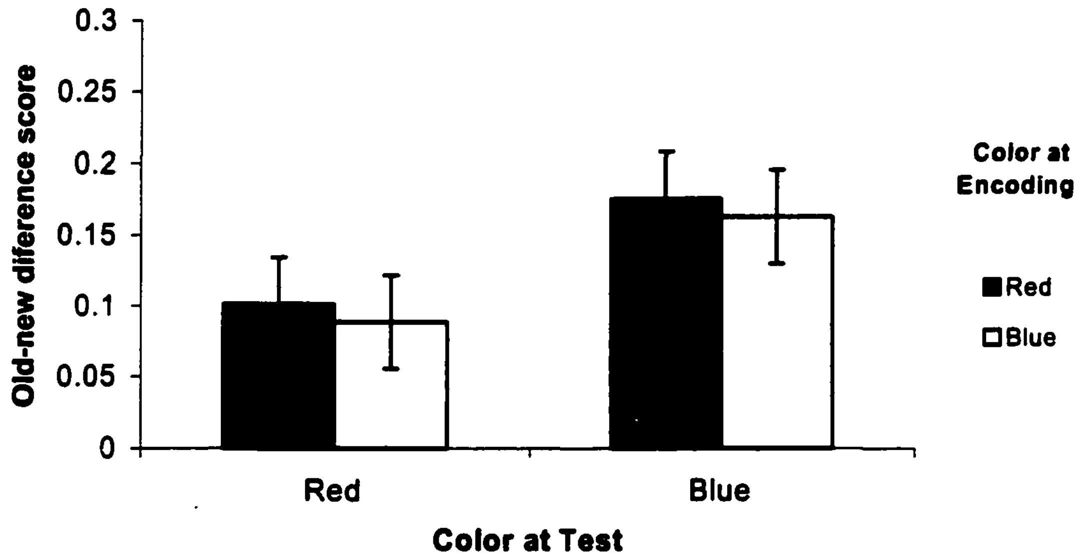

Figure 3. Old-new difference scores on perceptual identification in Experiment 3a as a function of color at encoding and color at test.

Discussion

The findings of this experiment do not support the proposed view of perceptual implicit memory. The proposed view predicted a reliable interaction between the color of the background at encoding and the color of the background at test, with higher levels of perceptual implicit memory when the background color at test matched the background color at encoding. No interaction was found. The level of perceptual implicit memory did not depend on the match in background color between encoding and test, even though the color at encoding was important to the decision.

The failure to find an effect of environmental context-dependency on perceptual implicit memory would appear to support the standard view that perceptual implicit memory reflects changes in a perceptual, lexical processing system. According to this view, the present results demonstrate that background information that occurred when a stimulus is presented does not appear to be a part of the memory trace underlying perceptual implicit memory. The standard view (and the TAP view in particular) predicted similar levels of perceptual implicit memory among the conditions because the amount of perceptual processing at encoding was similar between the two encoding conditions. This was what was found.

The main effect of color at test was not predicted by either the proposed view or the standard view. Indeed, the literature does not suggest that higher perceptual implicit memory should be found when a blue background rather than a red background is used at test. A closer look at the results, however, suggests that the color at test is not affecting the level of perceptual implicit memory directly. Rather, the reliable difference in the proportion of new words identified suggests that the red background appeared to affect the overall performance on the task. Fewer words were identified with the red background at test than with the blue background, suggesting that there were differences in the perceptual quality of the information available to the participants. If true, then the two test conditions might not be equally sensitive to perceptual implicit memory. Yet, even with a sensitivity difference, the proposed view predicts a context-dependency effect.

As stated in the introduction, studies that have found context-dependency using paradigms in which word-pairs are presented together at encoding and test are potentially contaminated by differences in the type of processing among the words. Experiment 3a did not use this kind of manipulation of context and there should not have been processing differences. Thus, it was, in a sense, a purer test of environmental context-dependency than many other studies. In this purer test, no evidence of environmental context-dependency was found. This finding agrees with the findings of Mori and Graf (1996) that no extra-item integrated context-dependency is found. The present finding also suggest that the failure of Mori and Graf (1996) to find a context-dependency effect was not due to the type of decision participants engaged in at encoding, but rather illustrates that perceptual implicit memory does not exhibit such environmental context-dependency effects.

Before completely ruling out the possibility of an environmental context-dependency effect on perceptual implicit memory, another experiment was run to test for another possible explanation for the lack of environmental context-dependency on perceptual implicit memory.

Experiment 3b: Environmental Context-Dependency—Word-Stem Completion

One possible explanation for the lack of an environmental context-dependency in the previous experiment is that presenting the entire word in perceptual identification "overshadowed" a small, but real, context-dependency effect. The "overshadowing" hypothesis has been used as an explanation for why context-dependency effects are not often found with recognition (in which the word is presented to the participant), but are often shown in free recall (in which the word is not presented to the participant) (Smith, 1988). According to this hypothesis, presentation of the word is such a strong memory retrieval cue that any effect of context-dependency is overpowered. It is possible that the same occurred with perceptual identification. The memory trace underlying perceptual implicit memory test performance might include the environmental context, but the benefit of the reinstatement of environmental context might not be enough to be shown when perceptual identification is used as the perceptual implicit memory task.

To test whether "overshadowing" might have caused the lack of a context-dependency effect in the environmental context-dependency—perceptual identification experiment, this experiment used word stem completion as the perceptual implicit memory task. In word stem completion, only three-letter stems are presented to participants during the task and participants are instructed to complete the stem with the first word that comes to mind. Because the full word is not presented as it is in perceptual identification, there should be no overshadowing. Thus, if a context-dependency effect is found, it would suggest that the lack of an effect with perceptual identification might have been due to an "overshadowing" effect and that the memory trace underlying perceptual implicit memory does include the environmental context. If a context-dependency effect is not found, it would suggest that the lack of an effect with perceptual identification was not due to "overshadowing" and the memory trace underlying perceptual implicit memory does not include the environmental context.

Method

Participants and Design

Participants were 32 undergraduate students enrolled in introductory psychology courses. They received extra credit for their participation. The background color at encoding and the background color at test were manipulated within subjects.

Procedure

Participants were told that they were taking part in an experiment to determine their ability to make decisions about briefly presented stimuli. Participants engaged in three tasks: the initial encoding task, a 5-min. math task, and a perceptual implicit memory test: word stem completion. The apparatus, stimuli, encoding task, and math task were the same as those used in Experiment 3a. At the end of the experiment, participants were debriefed as to the true purpose of the experiment.

***Word Stem Completion*.** In the word stem completion test, 130 trials were presented. Each trial consisted of a three-letter word stem presented on the computer screen until a response was made. A 2500 ms intertial interval was used. As with the perceptual identification task, the first 10 trials were inserted as practice trials. Thus, the first 10 trials contained stems that were not analyzed. Of the remaining 120 trials, 60 contained stems that could be completed by old words from the encoding task (30 from each background color condition) and 60 contained stems that could be completed by new words. Participants were instructed to say the first word they could think of to complete the stem. Half of the stems were presented with a blue background and half were presented with a red background. Because participants could adopt an explicit retrieval strategy in word stem completion (causing the task to no longer be a pure perceptual implicit memory task), during debriefing participants were asked three questions to determine the degree to which they were aware of the connection between the encoding and word stem completion task and to determine if they used an explicit retrieval strategy. Participants were asked: a) if they noticed any connection between the first and last task, b) if they noticed that some of the stems could be completed with words from the first task, and c) if they tried to complete the stems with words they remembered from the first task.

Results

An alpha level of .05 was used in all analyses.

Encoding Task

As in the previous experiments, performance at encoding was analyzed in terms of the proportion of critical words (the words that were later tested on the perceptual implicit memory tests) overtly identified at encoding. Almost all the words were overtly identified and there was no difference in the proportion of words overtly identified between when the words were presented with a red background ($\underline{M}$ = .980, $\underline{SE}$ = .007) and when the words were presented with a blue background ($\underline{M}$ = .990, $\underline{SE}$ = .007), $\underline{t}$ (31) = -1.62, $\underline{SE}$ = .006, $\underline{p}$ = .118. Because participants identified equivalent proportions of words in the two encoding conditions, the standard view would predict no difference in performance on the perceptual implicit memory tasks as a function of encoding condition.

Word Stem Completion

The proportion of stems completed with old words and the proportion of stems completed with new words are shown in Table 4 for each of the conditions. There was no difference in the proportion of overall words identified, as there was with perceptual identification. Perceptual implicit memory was indexed as a difference score by subtracting

Table 5. Performance on the Word stem Completion Task in Experiment 3b as a Function of Color at Encoding and Color at Test.

	Color at Encoding					
	Red		Blue		New	
Color at Test	M	SE	M	SE	M	SE
Red	.39	.02	.39	.02	.18	.01
Blue	.36	.02	.35	.02	.21	.02

the proportion of stems completed with new words from the proportion of words completed with old words. The difference scores are shown in Figure 4. An ANOVA with color at encoding and color at test as within-subjects variables showed a reliable main effect of color at test, $F(1, 31) = 5.67$, $MSE = .025$, $p = .024$. The main effect of color at encoding was not

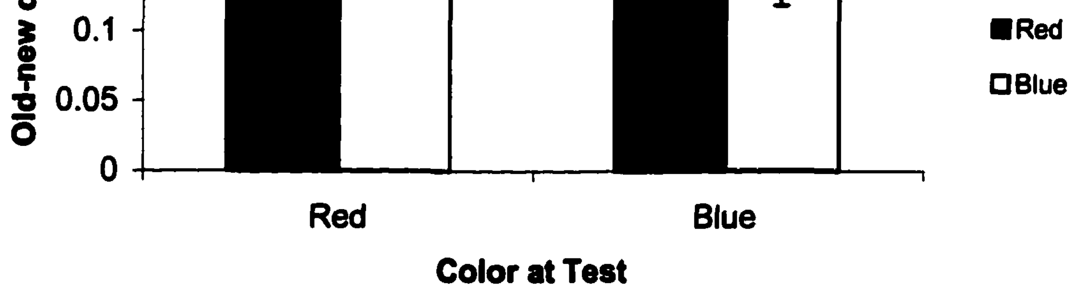

Figure 4. Old-new difference scores on word-stem completion in Experiment 3b as a function of color at encoding and color at test.

reliable, F (1, 31) = 0.21, MSE = .006, p = .651. Critically, the interaction between the two variables was not reliable, F (1, 31) = 0.02, MSE = .008, p = .897. As predicted by both the proposed and standard view, the level of perceptual implicit memory was reliably greater than chance in all conditions, all t's > 5. Nineteen participants reported that they were aware of a connection between the encoding and word stem completion test. Twenty-eight participants reported that they were aware that some of the words on the word stem completion test had also appeared on the encoding task. Eleven participants reported that they consciously attempted to complete some of the stems with words that they remembered from the encoding task.

Discussion

The findings of this experiment do not support the proposed view of perceptual implicit memory. The proposed view predicted a reliable interaction between the color of the background at encoding and the color of the background at test, with higher levels of perceptual implicit memory when the background color at test matched the background color at encoding. No interaction was found. The level of perceptual implicit memory did not depend on the match in background color between encoding and test.

The failure to find an effect of environmental context-dependency on perceptual implicit memory would appear to support the standard view that perceptual implicit memory reflects changes in a perceptual, lexical processing system. According to this view, the present results demonstrate that background information that occurred when a stimulus is presented does not appear to be a part of the memory trace underlying perceptual implicit memory. The standard view (and the TAP view in particular) predicted similar levels of perceptual implicit memory among the conditions because the amount of perceptual processing at encoding was similar between the two encoding conditions. This was what was found.

The main effect of color at test was not predicted by either the proposed view or the standard view and cannot be attributed to overall differences in overall performance at test. Indeed, the effect of color at test is opposite that found in Experiment 3a, which examined environmental context-dependency with a perceptual identification test. The main effect of color at test appears to reflect the fact that stems were completed with old words just a bit more when the background was red and stems were completed with new words just a bit less when the background was red. Why this occurred is a puzzle because the literature does not suggest that higher perceptual implicit memory should be found when a red background rather than a blue background is used at test.

The findings of this experiment suggest that the lack of a context-dependency effect with perceptual identification was not due to an "overshadowing" effect from the presentation of the entire word in perceptual identification. Along with the Mori and Graf (1996) study, the present results strongly suggest that the representations underlying perceptual implicit memory are not environmentally context dependent. This is in contrast to the memory representations underlying explicit memory, which do seem to be context dependent. Indeed, the 11 participants in the present experiment who reported using an explicit strategy of consciously attempting to recall words to complete the word stems, showed a slight indication of a context-dependency effect (see Appendix B for the analyses).

GENERAL DISCUSSION

Conclusions from Current Research

The current research was designed to test the view that perceptual implicit memory reflects decision memory. Taken together, the results provide no support for the proposed view. The proposed view predicted that perceptual implicit memory would be higher when the decision invoked by the perceptual implicit memory task matched the decision produced at encoding. No evidence for such a decision context-dependency was found. The proposed view predicted that perceptual implicit memory would be higher when the response required by the perceptual implicit memory task matched the response produced at encoding. No evidence for such a response context-dependency was found. The proposed view predicted that perceptual implicit memory would be higher when the color of the background in which a word appeared in the perceptual implicit memory task matched the decision-relevant color of the background in which a word appeared in at encoding. No evidence for such an environmental context-dependency was found. The failure to find any of the effects predicted by the proposed decision view strongly suggests that the view is wrong.

The results of the current research provide support for the standard view of perceptual implicit memory. According to the standard view, perceptual implicit memory reflects changes within a perceptual, lexical processing system. Thus, only manipulations at encoding that affect the processing within that system should have an effect on a later perceptual implicit memory task. The encoding manipulations used in the experiments in the current research should not have affected the processing within the perceptual, lexical system according to any of the four frameworks discussed in the introduction. Because of this, the standard view predicted reliable levels of perceptual implicit memory in all encoding conditions, but no differences in the level of perceptual implicit among the encoding conditions. This prediction held in all experiments. In each case, there were reliable levels of implicit memory, with no difference in the levels of perceptual implicit memory among the encoding conditions.

The levels of perceptual implicit memory were equivalent across conditions in each experiment, but they were also quite high compared with previous studies that used the same set of words (Crabb & Dark, 1999a,b,c). While the current research does not clearly delineate why the level of perceptual implicit memory was high, there are some intriguing possibilities. Because an overt response was made to all words at encoding, it is possible that the high level of perceptual implicit memory in the current experiments reflects the impact of making an overt response at encoding. This would be in agreement with previous research demonstrating that making a task-relevant overt response at encoding does improve later perceptual implicit memory (Crabb & Dark, 1999c; Forster & Davis, 1984). It also is possible that the high levels of perceptual implicit memory reflect the fact that words were the target of decisional processing at encoding. That is, saying words (or writing them) at encoding makes the word a target of a decision. Perhaps the status of the words as decision targets in the current research led to the high levels of perceptual implicit memory. Indeed, in the previous studies that have shown an effect of response versus no response at encoding, the words that were not responded to at encoding (and that demonstrated lower levels of perceptual implicit memory) also were not the target of decisional processing at encoding. They were distractors. To discriminate between these two explanations, future research must unconfound response and word status (target or not a target of decisional processing). Both of these possibilities would suggest that the standard view might not do a complete job of explaining perceptual implicit memory. However, neither provides evidence for the proposed view, at least as currently stated.

Is An Episodic Theory Appropriate?

The proposed view posited that perceptual implicit memory was a type of episodic memory. The results of the current research failed to find support for the proposed view. The results of the current research are consistent with the standard view that perceptual implicit memory reflects changes within a perceptual, lexical system. As discussed in the introduction, there are at least four models that propose the standard view. These models can be classified by whether they posit episodic or abstract representations underlying perceptual implicit memory. The results of the current research can be interpreted as suggesting that episodic models (such as the TAP, interpretation, and individual instance views), which posit that perceptual implicit memory is the result of retrieving information tied to a specific prior event or episode, are not appropriate models of perceptual implicit memory. Rather, the results of the current research suggest that the more appropriate class of models is abstract models (such as the multiple memory system and counter views, as well as another view discussed later), which posit that perceptual implicit memory is the result of changes in the activation or the strength of connections between abstract lexical representations.

In her review of episodic and abstract theories of perceptual implicit memory, Tenpenny (1995) questioned whether abstract representations are needed to explain perceptual implicit memory. It might be informative to flip this question on its tail: in the light of the present research, are episodic representations needed to explain perceptual implicit memory? It could be argued that the lack of context-dependency might be an indication that the episodic representations underlying perceptual implicit memory are item-specific; they do not incorporate any processing that is not directed to the identification of the word. Thus, episodic theorists might state that no effect of context was found in the current research because the context was encoded separately from the items (words). Only the processing devoted to identification of the item itself is reflected in the episodic representations underlying perceptual implicit memory. However, most of the power of episodic theories stems from the assumption that traces incorporate all aspects of a processing episode, including context. Thus, the lack of context-dependency might be an indication that the representations underlying perceptual implicit memory are not episodic in nature.

The results of the present research (especially the response context-dependency experiment) present some serious problems for Logan's (1988, 1990) instance theory in particular. According to Logan's theory, the response made to a stimulus at encoding should have been incorporated into the memory representation. Thus, Logan would predict a reliable response context-dependency effect in the current research. No such effect was found.

Episodic theorists could argue that the lack of context-dependency effects in the current research does not logically require a rejection of the episodic view. Recognition memory tests, which tap into episodic representations, also do not always show a context-dependency effect (Smith, 1988). Indeed, much of Tenpenny's (1995) argument in favor of episodic theories rested on findings of intra-item (i.e., the characteristics of the item itself—its font, color, etc.) and extra-item (i.e., the characteristics external to the item itself—surrounding words, physical environment, etc.) context-dependencies in perceptual implicit memory. However, many of the examples of intra-item context dependencies are only found when unusual stimuli are used. For example, changes in font only have an effect when strange fonts are used (Graf & Ryan, 1990). Indeed, the only intra-item context-dependency effect that is routinely found for words in perceptual implicit memory is modality of presentation, with greater perceptual implicit memory found when the modality in which words were presented at test matches the modality in which words were presented at encoding (Tenpenny, 1995). Modality effects are not necessarily indicators of an underlying episodic representation, however, because many abstract models of memory posit that the representations are modality specific or are reached through modality-specific processing pathways (Bower, 1986, 1996; Morton, 1969; 1979). In addition, many of the studies that have reported finding extra-item environmental context-dependencies have manipulated the words that are paired with the critical words in the experiment (e.g., Graf & Schacter, 1985; Jacoby et al., 1992). As discussed earlier, the results of these experiments can be explained in terms of differences in processing rather than differences in context. Indeed, the current research demonstrated that a "purer" test of environmental context-dependency on well-accepted tests of perceptual implicit memory does not show any effect of reinstating context (the environmental context-dependency experiments). Thus, the growing number of studies that have failed to find any context-dependency effect in perceptual implicit memory and the fact that abstract views predict no context-dependency effects, provide serious problems for an episodic view.

Is An Abstract Theory Appropriate?

The problems that the present research and other studies have posed for episodic theories of perceptual implicit memory lead one to consider whether an abstract theory might be the best way to conceptualize perceptual implicit memory. Both abstract frameworks discussed in the introduction (the counter model of Ratcliff & McKoon, 1997; the multiple memory system view of Tulving & Schacter, 1990) would predict the results of the current research, as well as the overall lack of context-dependency effects on perceptual implicit memory. In both views, the representations underlying perceptual implicit memory are abstract in nature and so are not tied to the specific context of a prior episode. Because of this, reinstating the original context at test should have no effect on the level of perceptual implicit memory. However, there are problems with both of these accounts.

The counter model was designed to account for one specific kind of perceptual implicit memory test: perceptual identification. In fact, it was designed to account for performance on a specific kind of perceptual identification test, one in which after a quick, masked presentation of a word the participant is presented with two words and asked to select the one that had just been presented. Ratcliff and McKoon (1997) found that participants were biased in their selection if they had seen one of the words on a previous task. For example, if participants were presented *died* for 33ms followed by a mask, and then were forced to choose between *lied* and *died*, they were more likely to choose *lied* if it had been presented on a previous task than if it had not. Although the counter model posits that the same mechanisms underlie performance on other perceptual implicit memory tasks (e.g., word-stem completion), this has yet to be verified. Thus, until it is generalized to other types of perceptual implicit memory tasks, the counter model is not a complete model of perceptual implicit memory.

According to the multiple memory system view of Tulving and Schacter (1990), the memory representations underlying perceptual implicit memory for words are abstract lexical units stored in a memory system that is distinct and separate from other memory systems.

Similarly, the memory representations underlying perceptual implicit memory for objects are abstract structural descriptions stored in a memory system that is distinct and separate from the processing system used to identify objects, as well as other memory systems. Although this conceptualization seems plausible, recent evidence from Williams and Tarr (1997) suggests that the phenomenon of perceptual implicit memory for objects might not be best explained in terms of an abstract object memory system that is distinct from other memory systems. Rather, perceptual implicit memory for objects appears to reflect the operation of an abstract object recognition system that is integrated with other memory systems. It is possible that perceptual implicit memory for words reflects a similar abstract system that is used to identify words.

Abstract frameworks of object recognition might aid in understanding the memory representation underlying perceptual implicit memory. There has been quite a bit of research using perceptual implicit memory paradigms to study the representations underlying object recognition (e.g., Biederman & Cooper, 1991; Cooper, Biederman, & Humble, 1992; Schacter, et al., 1990; Williams & Tarr, 1997). Strangely, though, there has been very little interaction between those researchers studying perceptual implicit memory for words and those researchers studying perceptual implicit memory for objects. This is in spite of neuropsychological evidence that the system responsible for recognizing objects appears to also be used for recognizing words (Farah, 1994). Because of this, it seems logical that the representations underlying word recognition (and thus perceptual implicit memory) should at least be similar in nature to those underlying object recognition. Perhaps a new and potentially better explanation of perceptual implicit memory for words can be constructed by borrowing from a theory of the representations underlying repetition priming in object recognition.

Biederman and colleagues (Biederman & Cooper, 1991; Cooper, et al., 1992) have found evidence that the representations underlying repetition priming in object recognition are abstract in nature. Their view is based on Biederman's (1987) Recognition-By-Components model of basic-level object recognition and Hummel and Biederman's (1992) neural network model of object recognition. According to these models, basic-level object recognition occurs by activating the appropriate structural description for the object. This structural description is represented in memory by the abstract parts of the object (stored as abstract geometrical primitive, or *geons*) and the spatial relationships among the parts that make up the object. A structural description is active when the subgroup of geons and their relationships making up the object are active in the network (Hummel & Biederman, 1992). Repetition priming in objects can be modeled by changes in the weights between groups of geons making up an object (including the relationships among them) and the complete structural description. Thus, repetition priming with objects is affected by manipulations that affect the processing of these assemblies of geons (e.g., deleting portions of objects necessary to determine the geons and their relationships within an object) and the consequent ability to access the appropriate structural description. Repetition priming in objects is not affected by manipulations that do not affect this processing (e.g., changes in size between encoding and test) (Biederman & Cooper, 1991).

It is possible that the representations underlying word recognition (and thus perceptual implicit memory for words) are similar to the representations posited by Biederman and colleagues. Indeed, both the letters (and phonemes/morphemes) and the spatial arrangement of the letters/phonemes/morphemes are important to word identification. Changing the spatial arrangement of the morphemes in a word either results in no lexical representation being activated (e.g., *abnormal* to *normalab*) or a change in the lexical representation(s) activated (e.g., *chambermaid* to *maid chamber*). Changing the morphemes between encoding and test leads to no evidence of perceptual implicit memory (Weldon, 1991). Weldon interpreted these results in an episodic framework (TAP), but they could also be an indication of an abstract "structural description" representation underlying word recognition and perceptual implicit memory.

Bower (1986; 1996) has proposed a similar model for perceptual implicit memory for words. According to Bower, perceptual implicit memory for words reflects changes in connection weights between different layers in a word recognition system. This system first processes the physical characteristics of the letters in a word, which then activate letters and morphemes/phonemes (Bower does not commit to one over the other) as well as the spatial location of the letters and morphemes/phonemes within a word. These then activate appropriate lexical representations, which leads to identification of the word. When a word is identified, the weights between these layers of the model change dramatically. This weight change slowly decays over a period time. If a word is again presented before the weight change has completely decayed, it is more quickly and accurately identified than if the word had not been recently identified. The system is modality-specific and the representations are abstract. As in Biederman's (1987) model of object recognition, identification of a word depends upon the parts of the word (letters/morphemes/phonemes) and their spatial location.

Bower's (1986, 1996) model has not been widely accepted among perceptual implicit memory researchers. The conclusion among researchers has been that views such as

Bower's that explain perceptual implicit memory in terms of activation within a network are not adequate (Schacter, 1987). However, in light of the present research, it might be appropriate to reevaluate such a view. Indeed, such an abstract view could provide a parsimonious account of the extant phenomena in perceptual implicit memory, as well as provide new predictions to be tested. This abstract view would state that no effects were found in the current research (other than the old-new effect) because the encoding manipulations did not affect the processing of letters/morphemes/ phonemes and their spatial relations. This approach might also similarly explain why levels of processing manipulations (among others) do not affect perceptual implicit memory. Further, this approach would predict that other manipulations like changes in size between encoding and test would not affect perceptual implicit memory (because they do not disrupt the ability to identify the parts of the word), but other manipulations like rotating or reverse spelling might affect perceptual implicit memory (because they disrupt the spatial relations among the parts of the word). Indeed, such a model might explain why high levels of perceptual implicit memory were found in the current research. When a word is the focus of decisional processing at encoding it is likely that much of the changes in the weight of the connections between components in the network will occur to the connections between components related to the lexical unit representing that word. However, when the word is not the focus of a decision at encoding, not as many changes in the weights of the connections will occur for the components related to the lexical unit representing that word. Rather, the weight changes will occur for components of the lexical units representing the words that were the focus of the decision at encoding. Because more changes in weights occur when a word is the focus of a decision at encoding, more perceptual implicit memory is found on a later perceptual implicit memory test. Future research will need to determine if this is a fruitful approach to conceptualizing perceptual implicit memory. If its predictions hold, it might provide a more parsimonious explanation of perceptual implicit memory than other extant episodic and abstract frameworks.

In the introduction, the potential relationship of perceptual implicit memory to naturalistic decision-making was discussed. The proposed view attempted to provide a way to integrate the perceptual implicit memory literature into models of naturalistic decision-making. The results of the present research do not support the proposed view, however, the present research might still be of benefit to decision-making researchers. The impact of the present research on the decision-making literature depends upon the nature of the representations guiding such decision-making. If they are context-specific, episodic representations (e.g., if firefighters retrieve memories of specific prior fires when they engage in situation assessment), then the present research suggests that they are not the same as the representations underlying perceptual implicit memory. If this is the case, perceptual implicit memory research will not aid in the understanding of the cognitive processes involved in naturalistic-decision making. If the representations are not context-specific and episodic (e.g., if firefighters retrieve an abstract prototype of a fire when they engage in situation assessment), then it is possible that they are similar to the representations underlying perceptual implicit memory and the understanding of the cognitive processes involved in naturalistic decision-making can be aided by research in perceptual implicit memory.

NOTES

[1] Some theorists consider recognition to have a perceptual implicit memory component as well as a conceptual explicit component (e.g., Gardiner & Parkin, 1990). However, recognition is widely used as an explicit memory task in perceptual implicit memory research and so is considered a measure of conceptual explicit memory.

[2] As indicated in the text, episodic theories need not be instance theories. However, the subtle differences between instance theories and other episodic theories are not large enough to make different predictions on perceptual implicit memory task performance. Because of this, the terms "episode" and "instance" are used as equivalent terms in the dissertation.

[3] For formatting ease, all figures were made with Microsoft Excel. Because Excel does not allow the use of different size error bars for each bar in a graph, the error bars in Figures 2-4 represent the largest standard error of the mean among the cells in the experiment. The exact means and standard errors are shown in Appendix A.

APPENDIX A. ADDITIONAL TABLES FOR EXPERIMENTS 2, 3A, AND 3B.

Table A-1. Old-New Difference Scores[a] on the Perceptual Identification Task in Experiment 2 as a Function of Response at Encoding and Response at Test.

	Response at Encoding			
	Vocal		Written	
Response at Test	M	SE	M	SE
Vocal	.15*	.02	.17*	.03
Written	.20*	.03	.15*	.03

[a] Values were obtained by subtracting the proportion of new words identified from the proportion of old words identified for each condition.
* Reliably greater than zero, $p < .05$.

Table A-2. Old-New Difference Scores[a] on the Perceptual Identification Task in Experiment 3a as a Function of Color at Encoding and Color at Test.

	Color at Encoding			
	Red		Blue	
Color at Test	M	SE	M	SE
Red	.10*	.02	.09*	.02
Blue	.18*	.03	.16*	.03

[a] Values were obtained by subtracting the proportion of new words identified from the proportion of old words identified for each condition.
* Reliably greater than zero, $p < .05$.

Table A-3. Old-New Difference Scores[a] on the Word-Stem Completion Task in Experiment 3b as a Function of Color at Encoding and Color at Test.

	Color at Encoding			
	Red		Blue	
Color at Test	M	SE	M	SE
Red	.22*	.02	.21*	.02
Blue	.15*	.03	.14*	.02

[a] Values were obtained by subtracting the proportion of stems completed with new words from the proportion of stems completed with old words for each condition.
* Reliably greater than zero, $p < .05$.

APPENDIX B. ADDITIONAL ANALYSIS FOR EXPERIMENT 3B

Eleven participants reported that they consciously attempted to recall previously studied words to complete at least some of the word stems. The proportion of stems completed with old words and the proportion of stem completed with new words are shown in Table B-1 for each of the conditions for these participants. Perceptual implicit memory

Table B-1. Performance on the Word stem Completion Task in Experiment 3b for Participants Who Attempted to Recall Words as a Function of Color at Encoding and Color at Test.

	Color at Encoding					
	Red		Blue		New	
Color at Test	M	SE	M	SE	M	SE
Red	.41	.03	.38	.04	.16	.02
Blue	.33	.05	.35	.04	.19	.02

was indexed as a difference score by subtracting the proportion of stems completed with new words from the proportion of words completed with old words. The difference scores are shown in Figure B-1. An ANOVA with color at encoding and color at test as within-subjects variables showed no reliable main effect of color at test, $\underline{F}(1, 10) = 2.71$, $\underline{MSE} = .034$, $\underline{p} = .131$, or color at encoding, $\underline{F}\ (1, 10) = 0.17$, $\underline{MSE} = .005$, $\underline{p} = .689$. The interaction between the two variables was not reliable, $\underline{F}\ (1, 10) = 0.55$, $\underline{MSE} = .009$, $\underline{p} = .474$, but the pattern across the means was consistent with the occurrence of a context-dependency effect. Whether the suggested interaction is real or not can only be determined through further research.

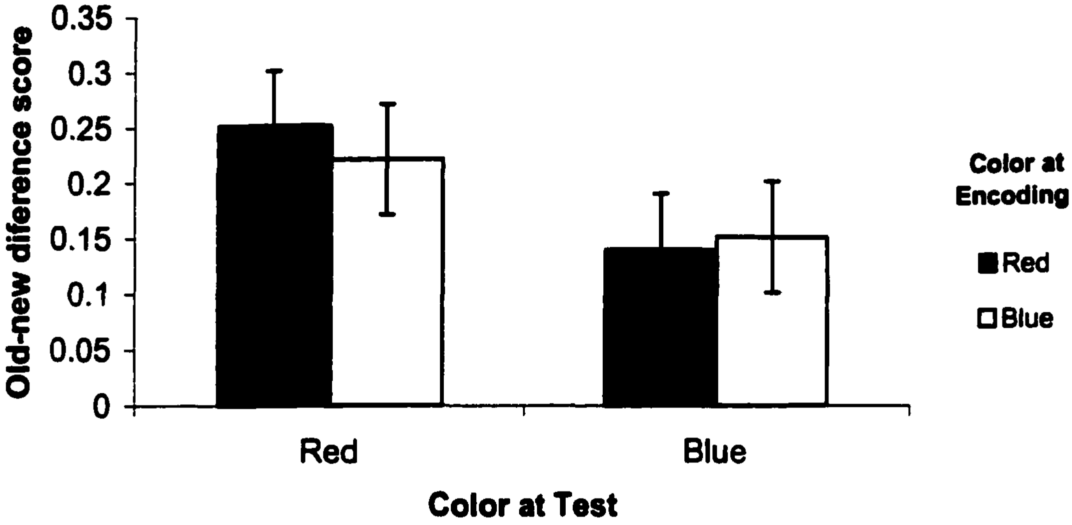

Figure B-1. Old-new difference scores on word-stem completion in Experiment 3a for participants who attempted to recall old words.

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