

# Perceptual Representation Systems and Implicit Memory

## Toward a Resolution of the Multiple Memory Systems Debate<sup>a</sup>

DANIEL L. SCHACTER

*Department of Psychology  
University of Arizona  
Tucson, Arizona 85721*

Consider the following experimental situations. In the first, subjects are shown a list of familiar words and are instructed to carefully study each of them. After performing a variety of unrelated tasks for several minutes, they are told to think back to the study list and recall as many of the presented words as possible. Subjects are then shown a series of words—half were presented in the study list, half were not—and are instructed to say “yes” if they remember having studied the items, and “no” if they do not remember them. In the second situation, subjects also study a word list and then engage in unrelated activities for a few minutes. However, instead of then being asked to remember previously studied items, the subjects are asked to write down the first word that comes to mind in response to a series of 3-letter word stems; some can be completed with previously studied words, and some cannot.

The first of these two hypothetical situations reflects the way in which cognitive psychologists have traditionally studied human memory: by assessing subjects’ intentional or *explicit memory* for information acquired during a study episode with standard recall and recognition tests. In the second situation, memory is inferred from an enhanced tendency to complete 3-letter stems with previously studied words; this is often referred to as “repetition priming” or “direct priming” (cf., Cofer, 1967; Tulving & Schacter, 1990). Priming effects need not and often do not involve any conscious or explicit recollection of a prior episode, and thus can be said to reflect *implicit memory* for previously studied information (Graf & Schacter, 1985; Schacter, 1987).

Priming has been assessed with a variety of implicit memory tasks that do not require explicit recollection of a specific prior episode. One common type of implicit test involves completing word stems or word fragments with the first word that comes to mind, as in the foregoing example (e.g., Graf & Mandler, 1984; Light, Singh & Capps, 1986; Roediger & Blaxton, 1987a, b; Schacter & Graf, 1986a, b; Tulving, Schacter & Stark, 1982). Another frequently used implicit task involves word identification: Subjects are required to try to identify a word from a brief (e.g., 50-msec) perceptual exposure, and priming is indicated by more accurate identification of a recently studied item than of a new, nonstudied item (e.g., Jacoby, 1983a, b;

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Jacoby & Dallas, 1981; Light & Singh, 1987; Winnick & Daniel, 1970). Similar completion and identification tasks have been used to assess priming of nonverbal information, such as pictures of familiar objects: Subjects are required to complete fragmented pictures by indicating what object the fragment represents, or are required to identify an object from a brief exposure (e.g., Mitchell & Brown, 1988; Snodgrass, 1989; Weldon & Roediger, 1987). Priming has also been assessed with the lexical decision task, where subjects decide whether a string of letters represents a real word or nonword; priming is indicated when subjects make lexical decisions more quickly for recently studied words or recently studied nonwords than for new words or new nonwords that were not previously presented in the experiment (e.g., Kirsner, Milech & Standen, 1983; Scarborough, Gerard & Cortese, 1979).

Although the exact requirements of the various implicit tasks that are used to assess priming differ from one another, priming is generally said to occur if the probability of identifying previously studied items is increased, or the latency of an identification response is decreased, relative to similar measures for nonstudied items. The magnitude of priming, then, is indicated by the size of the difference between accuracy or latency of response to studied items and accuracy or latency of response to nonstudied items.

The most striking outcome of recent priming studies is that implicit and explicit memory can be sharply dissociated: Several experimental variables affect the two forms of memory differently, and subject populations that are characterized by impaired explicit memory exhibit intact priming or implicit memory (see below for examples; for extensive reviews, see Richardson-Klavehn & Bjork, 1988; Schacter, 1987). The existence of such dissociations, together with the observations of parallels between implicit and explicit memory in some situations, has led to extensive theoretical discussion concerning the underlying bases of implicit and explicit memory. In particular, there has been heated debate as to whether the data necessitate the postulation of different memory systems underlying implicit and explicit memory, or whether the results can be more usefully conceptualized in terms of different processes operating within a unitary system (cf., Cohen, 1984; Hayman & Tulving, 1989; Jacoby, 1983a, b; Moscovitch, Winocur & McLachlan, 1986; Roediger *et al.*, this volume; Roediger & Blaxon, 1987a; Schacter, 1987; Schacter & Moscovitch, 1984; Sherry & Schacter, 1987; Tulving, 1983; Tulving *et al.*, 1982).

The purpose of the present article is to put forward a possible resolution to the multiple memory systems debate. The suggested resolution accommodates some of the main points put forward by unitary system, process-oriented theorists, yet also argues for the usefulness of postulating entities that can be broadly conceived of as multiple memory systems, and is thus in the general spirit of other recent attempts to integrate the two approaches (cf., Hayman & Tulving, 1989). More specifically, I will propose that priming effects on a variety of implicit memory tests rely heavily on a class of modular processors or subsystems that have been identified in recent research by cognitive neuropsychologists and that together form what I will refer to as a *perceptual representation system*, or PRS for short (see also, Schacter, Cooper & Delaney, 1990a, 1990b; Schacter, Delaney & Merikle, in press; Tulving & Schacter, 1990). These subsystems have been described in various sectors of neuropsychological research (Ellis & Young, 1988; Morton & Patterson, 1980; Riddoch, Humphreys, Coltheart & Funnell, 1988), but I will focus largely on studies of reading disorders

(i.e., alexia) and perceptual dysfunctions (i.e., agnosia). Observations from these patient populations have not been previously brought to bear on, or thought of as related to, implicit memory research. By the present view, however, data from alexic, agnostic, and other patients in which PRS is either spared or impaired can provide important clues concerning the nature and architecture of the systems that play an important role in implicit memory.

The paper consists of four main sections: (1) a brief overview of some key dissociations observed in studies of implicit memory for verbal materials that suggest that priming is a presemantic phenomenon, (2) an attempt to relate these dissociations to observations concerning patients with acquired reading disorders (alexia) and (3) object-processing disorders (agnosia) that provide the central motivation for the PRS hypothesis, and (4) a summary of some recent research from my laboratory concerning nonverbal implicit memory that provides a link to the agnosia data and empirical support for the proposed ideas.

### PRIMING: A PRESEMANTIC PHENOMENON

A number of experimental manipulations have produced implicit/explicit dissociations and delineated various features of priming (see Richardson-Klavehn & Bjork, 1988; Schacter, 1987). For purposes of this discussion, I focus on one aspect of priming on various implicit memory tests that distinguishes it from explicit memory: Priming appears to be a *presemantic* phenomenon, in the sense that (a) it occurs whether or not subjects perform semantic encoding operations, and (b) it is quite sensitive to changes in perceptual properties of target information. Explicit memory, on the other hand, is generally dependent on, and greatly enhanced by, semantic encoding operations and is less sensitive to changes in perceptual properties of target information.

Consider first the evidence concerning the effects of semantic encoding on implicit and explicit memory. It has been known since the classic studies of Craik and others in the 1970s (e.g., Craik & Tulving, 1975) that performance on standard recall and recognition tests is significantly higher following semantic study than following nonsemantic study of to-be-remembered information. Thus, for example, when subjects are given a semantic encoding task (e.g., to rate the pleasantness of a word, answer a question about its meaning, and so on) subsequent probability of explicitly remembering the word is generally much higher than if subjects perform a nonsemantic or structural encoding task at the time of study (e.g., counting the number of vowels or consonants in the word). By contrast, several studies have shown that priming effects of similar magnitude are observed following semantic and nonsemantic study tasks.

In an experiment by Jacoby and Dallas (1981), for instance, study processing was manipulated by having subjects either answer questions about the meaning of target words or decide whether or not a word contained a particular letter. Explicit memory was then assessed with a yes/no recognition test, and implicit memory was assessed with a word identification task in which subjects attempted to identify previously studied words and new words from a brief exposure. Priming on the latter task is indicated when subjects identify more studied than nonstudied words. Jacoby and

Dallas (1981) found significant priming on the word identification test, and most important, observed that the magnitude of the effect was the same following the semantic and nonsemantic study tasks. Recognition memory, by contrast, was considerably more accurate following semantic than nonsemantic encoding.

Graf and Mandler (1984) observed a similar pattern of results with different implicit and explicit memory tests. On a stem completion test in which subjects wrote down the first word that came to mind in response to 3-letter cues, priming effects were just as large following semantic and nonsemantic study tasks; however, explicit recall of studied words was significantly higher following semantic than nonsemantic encoding. Similar patterns of results have been reported in other studies that have compared priming effects on completion and identification tasks with explicit recall and recognition performance (e.g., Graf, Mandler & Haden, 1982; Jacoby, 1983a, b; Roediger & Blaxton, 1987a; Winnick & Daniel, 1970). Note, however, that some forms of semantic study processing do facilitate implicit memory performance in certain situations (e.g., Graf & Schacter, 1985; Masson, 1989; Schacter & Graf, 1986a, b); this is an important point that I will return to later.

A second key observation is that changing various kinds of surface features of to-be-remembered items between study and test impairs performance on implicit tests more than on explicit tests. Several different types of evidence bear on this general point. The first and perhaps most firmly established finding is that a study/test shift in sensory modality—that is, presenting the material in one modality and testing it in another—either reduces or eliminates priming. This phenomenon has been observed both with shifts from auditory study (i.e., hearing the word) to visual test (i.e., seeing the word; e.g., Graf, Shimamura & Squire, 1985; Jacoby & Dallas, 1981; Kirsner, Milech & Standen, 1983; Morton, 1979; Roediger & Blaxton, 1987a, b; Schacter & Graf, 1989) and from visual study to auditory test (e.g., Jackson & Morton, 1984).

In addition to modality effects, study/test changes in at least three types of surface feature information *within* the visual modality appear to impair performance on implicit tests while having less effect, or in some cases opposite effects, on explicit recall and recognition. First, several experiments have shown that when target items are presented for study in pictorial form (e.g., a drawing of a chair), priming effects on a variety of implicit tests—including lexical decision (Scarborough, Gerard & Cortese, 1979), word identification (Durso & Johnson, 1979; Kirsner, Milech & Stumpf, 1986; Winnick & Daniel, 1970), and fragment completion (Weldon & Roediger, 1987)—are either entirely absent or significantly reduced relative to conditions in which the word itself is presented for study. By contrast, explicit remembering of words is enhanced by pictorial presentation relative to verbal presentation (Weldon & Roediger, 1987). Second, studies of bilingual subjects have shown that when words that have been studied in one language are then tested in another language on identification, completion, or lexical decision tasks, priming effects are severely reduced relative to when the words are presented in the same language at study and test (e.g., Durgunoglu & Roediger, 1987; Kirsner, Smith, Lockhart, King & Jain, 1984; for more detailed discussion, see Kirsner & Dunn, 1985; Roediger & Blaxton, 1987b).

Third, a number of studies have shown that priming can be reduced even by changes in the specific physical format of a word. Thus, for example, Roediger and

Blaxton (1987a) found that priming effects on a fragment completion test were smaller when target items that had been studied in handwritten form were subsequently tested in typed form than when they were tested in handwritten form. Jacoby and Hayman (1987) reported that study/test changes in typeface reduced priming on a word identification test. Recent studies using the fragment completion test have shown that even small changes in certain aspects of word orthography can have a dramatic impact on priming (see Gardiner, Dawson & Sutton, 1989; Hayman & Tulving, 1989). However, other studies have failed to find evidence of such format specific effects (e.g., Carr, Brown & Charalambous, 1989; Tardif & Craik, 1989). Recent experiments by Graf and Ryan (in press) suggest that priming is reduced by study/test changes in the precise physical format of a word when unusual typefaces are used and when subjects focus on the physical appearance of a word at the time of study.

Although a number of questions remain to be resolved concerning the role of semantic and structural factors in priming, two relatively unambiguous points emerge from the foregoing studies: (1) robust priming occurs on word completion and word identification tests following study tasks that do not require any semantic processing; (2) priming effects on these and other implicit memory tests depend critically on reinstating information about the perceptual form of target items.

### THEORETICAL ACCOUNTS OF SEMANTIC AND SURFACE FEATURE DISSOCIATIONS

How can we account for the finding that performance on most implicit tests is independent of semantic vs. nonsemantic processing during study and is highly dependent on surface feature information, whereas performance on most explicit tests is dependent on semantic processing and less affected by surface feature manipulations? Schacter (1987) has delineated three classes of explanations for these and other implicit/explicit dissociations: activation, multiple memory systems, and processing accounts. For purpose of this discussion, I will focus on just one type of activation view, most prominently associated with Morton (1979), that can be considered as a subclass of the multiple memory systems explanation. Processing views will be considered as examples of a unitary memory system account.

#### *Multiple Memory System Views*

One of the earliest accounts of repetition priming effects was derived from Morton's (1969) logogen model. Logogens, according to Morton's initial formulation, are modality-independent, abstract lexical units that can be activated by presentation of a word. The logogen's threshold for firing is lowered temporarily by such activation; hence presentation of a word makes it easier to detect that word on a subsequent identification test. This model, however, was unable to accommodate modality-specific priming effects, so Morton (1979) revised it by postulating the existence of separate visual and auditory input logogen systems: The former contains a representation of the visual form of a word, the latter of its spoken form. Since

written presentation of a word activates only the visual input logogen, and the spoken presentation activates only the auditory input logogen, modality-specific priming effects can be accommodated. Both visual and auditory logogens are held to be independent of a "cognitive system" that is involved in semantic processing and, presumably, in explicit or episodic remembering. Thus, the visual and auditory input logogens can in some sense be thought of as separate memory systems that represent modality-specific lexical information.

Although the foregoing account can handle results on modality-specific priming, it has considerable difficulty explaining the finding that *within* the visual modality priming effects are disrupted by study/test changes in the surface features of words. The logogen is held to be a pre-existing, abstract representation of the visual form of a word; therefore, the specific manner in which the word is presented should not influence logogen activation. Priming effects thus ought to be invariant across changes in surface feature information. But, as discussed above, priming is often quite sensitive to such changes (cf., Jacoby, 1983b; Roediger & Blaxton, 1987b). Another problem with this view is that priming effects on various implicit tests can last a long time—hours, days, weeks, and even years (e.g., Jacoby, 1983a; Mitchell & Brown, 1988; Sloman, Hayman, Ohta & Tulving, 1988; Tulving *et al.*, 1982)—whereas logogen activation is thought to decay within seconds or minutes (cf., Jacoby, 1983a; Roediger & Blaxton, 1987b; Schacter, 1987).

I have discussed the logogen view in some detail in order to highlight that its main difficulties as a general account of implicit memory phenomena stem from the model's failure to accommodate the *specificity* and *temporal persistence* of some priming phenomena. I will suggest later, however, that other aspects of this model can be useful for conceptualizing the underlying bases of implicit memory phenomena.

Other, rather different, multiple memory system accounts have also been put forward. Thus, for example, several investigators have argued that various implicit memory phenomena reflect the operation of a procedural memory system (or systems) that differs fundamentally from the declarative system involved in explicit remembering: implicit memory effects are thought to reflect on-line modifications of encoding procedures or operations, whereas explicit remembering depends on representations of the outcome of those procedures (cf., Cohen 1984; Squire, 1987). It has also been suggested that priming effects reflect the operations of a "quasi-memory system" that does not operate on focal memory traces or representations (Hayman & Tulving, 1989; Tulving, 1983, 1985). These and other multiple memory system accounts (cf., Johnson, 1983; Mitchell & Brown, 1988; Sherry & Schacter, 1987) cite data on experimental dissociations between implicit and explicit memory in normal subjects as well as demonstrations of preserved implicit memory in amnesic patients to support the claim of multiple memory systems (see Sherry & Schacter, 1987; Squire, 1987; Tulving, 1985).

### *Processing Views*

In contrast to the foregoing, processing views maintain that both implicit and explicit remembering are based on newly created episodic representations within a unitary memory system. Experimental dissociations between implicit and explicit

memory are viewed as special cases of the general principles of encoding specificity and transfer appropriate processing, which state that memory performance is determined by the degree of overlap or match between encoded attributes of memory representations and the processing demands of a memory test (e.g., Jacoby, 1983b; Masson, 1989; Roediger & Blaxton, 1987b; Roediger, Weldon & Challis, 1989; Witherspoon & Moscovitch, 1989). To accommodate the data on the differential effects of semantic versus surface feature processing on implicit and explicit tests, the distinction between data-driven and conceptually driven processing has been invoked (Jacoby, 1983b; Roediger & Blaxton, 1987a, b). By this view, most of the standard explicit memory tests require a good deal of *conceptually driven* processing: semantically based, subject-initiated reconstructive retrieval activity. In contrast, performance on such implicit tests as word identification, and stem and fragment completion, is largely *data driven*; that is, processing is determined largely by the physical characteristics of test cues. Accordingly, it follows that explicit but not implicit memory should benefit from semantic study processing (which is thought to support conceptually driven processing), whereas implicit but not explicit memory should be strongly dependent on matching of surface features between study and test (for more detailed discussion, see Masson, 1989; Richardson-Klavehn & Bjork, 1988; Roediger *et al.*, 1989; Schacter, 1987)

#### *Problems with Existing Views*

Both multiple memory system and processing views can account for many of the key empirical findings, but both have their drawbacks (Schacter, 1987). The main problems with multiple memory system accounts, according to processing theorists, are that (a) postulation of separate systems is not necessary to account for the data, and (b) simply identifying a task with a particular system does not illuminate the nature of the phenomenon in any interesting way. In addition, relatively little has been said by multiple system theorists about the *functions* of the system alleged to underly priming effects on implicit tests. Sherry and Schacter (1987) have argued that postulation of multiple memory systems is justified when a case can be made that the two putative systems perform distinct and incompatible functions—a condition that they referred to as *functional incompatibility* between systems. Sherry and Schacter contended that functional (as well as empirical) considerations support a distinction between a system involved in incremental habit/skill learning and a system underlying explicit recall and recognition. However, functional considerations have for the most part not been brought to bear on the question of whether single-trial priming effects on implicit tasks are mediated by a different system from the one involved in explicit, episodic remembering.

A major problem with most processing views is that they do not provide a satisfying account of why implicit memory is often preserved in severely amnesic patients (cf., Hayman & Tulving, 1989). This problem is particularly important because the finding that amnesic patients show normal priming on a variety of implicit tests—despite their poor performance on explicit tests of recall or recognition or their frequent inability to remember the study episode itself (e.g., Graf *et al.*, 1985; Schacter, 1985; Warrington & Weiskrantz, 1974)—probably constitutes the single most important basis for the distinction between implicit and explicit memory.

One possibility would be that amnesic patients are deficient in their ability to engage in conceptually driven processing. However, there is no evidence to support this view, and since most amnesic patients exhibit normal intellectual functions (and some patients who show robust priming effects possess superior intelligence [Cermak, Bleich & Blackford, 1988]) this possibility seems unlikely. Moreover, amnesic patients show intact priming effects on implicit tests that would appear to involve a great deal of conceptually driven processing, such as category instance production (Gardner, Boller, Moreines & Butters, 1973; Graf *et al.*, 1985) and free association (Schacter, 1985; Shimamura & Squire, 1984). A satisfying account of implicit memory phenomena ought to accommodate data from both normal and amnesic subjects.

### PRS AND IMPLICIT MEMORY PHENOMENA

In this section I sketch a theoretical framework that incorporates aspects of both the processing and multiple memory system views. The key idea motivating this framework is that a class of modular subsystems, which together form what I have referred to as PRS, are critically involved in priming effects that are observed on many (though not all) implicit tests. An important feature of these subsystems, and PRS more generally, is that they process and represent information about the *form* and *structure* of words, objects, and other kinds of stimuli, but do not represent *semantic* or *associative* information about them (e.g., Ellis & Young, 1988; Riddoch *et al.*, 1988; Warrington & Shallice, 1980). PRS does, however, have connections with semantic and other systems. In this respect, the notion of PRS is similar to the logogen systems discussed by Morton (1979). As noted earlier, however, a logogen view does not provide a satisfactory account of the specificity and temporal persistence of implicit memory phenomena. If, however, we assert that priming is not based solely on the temporary activation of some old, abstract unit in the logogen system and argue instead that priming often reflects the establishment of new and highly specific representations within a particular perceptual system, these problems can be circumvented easily. To provide a fuller analysis of these ideas, let us turn first to research concerning acquired reading disorders for evidence concerning the nature of PRS.

#### *Reading Disorders and the Word Form System*

Research concerning reading disorders constitutes one of the most active areas of cognitive neuropsychology (for reviews, see Coltheart, Patterson & Marshall, 1980; Coltheart, Sartori & Job, 1987; Ellis & Young, 1988). A wide variety of classes and subclasses of deficits have been identified, but two types of patients are particularly relevant to the present concerns. Consider first a patient described by Schwartz, Saffran, and Marin (1980), who was unable to gain access to the meaning of words that were presented to her. Thus, for example, the patient could not classify words into semantic categories nor could she match a word to its pictorial equivalent. Yet despite her inability to understand the meaning of printed words, the patient



could read them aloud quite accurately. Most important, this patient was able to read *irregular* words accurately (e.g., *blood*, *climb*, *gone*). The ability to read irregular words indicates that the patient had access to a stored representation of the word's visual form, because irregular words (unlike regular words) cannot be read on the basis of grapheme-to-phoneme conversion. Therefore, this case can be interpreted as demonstrating a dissociation between representations of the visual form of a word and the meaning of that word. Similarly, Funnell (1983) described a study in which the patient was unable to make semantic relatedness judgments about familiar words that she could read aloud. In addition, the patient could not read aloud pronounceable non-words (e.g., *blik*), thereby indicating that her reading of familiar words was not based on grapheme-to-phoneme conversion strategies. Sartori, Masterson, and Job (1987) studied a similar patient who could read aloud familiar words but could not sort these words into appropriate semantic categories; as in Funnell's (1983) case, the ability to read non-words was severely impaired.

These findings provide support for the idea that information about the visual form of a word is represented by a different system or subsystem than the one that handles semantic information about the word. An argument for a similar distinction has been made within the auditory domain on the basis of observations with a different set of patients (see Ellis & Young, 1988, Chapter 6). Warrington and Shallice (1980) have referred to the visually based system as the *visual word form system*, and I will adopt their terminology here. In the present scheme, the word form system is viewed as a component subsystem of PRS that deals with the visual form and structure of words, just as other component subsystems of PRS deal with other kinds of form and structure information, as will be discussed shortly.

Several cases have been reported that indicate that the word form system can be damaged selectively. Thus, for example, patients with surface dyslexia rely on grapheme-to-phoneme conversion strategies and read irregular words as if they were regular (e.g., *trough* is read as "truff"). These regularization errors suggest that a stored representation of the visual word form either has been lost or is inaccessible, and thereby imply damage to some aspect of the word form system (e.g., Marshall & Newcombe, 1973; Shallice, Warrington & McCarthy, 1983).

In addition to data from neuropsychological studies of patients with reading disorders, converging evidence for the existence of a visual word form system has been provided by research using positron emission tomography (PET). Petersen, Fox, Posner, Mintum, and Raichle (1988) have shown that simple reading of familiar words selectively activates regions of occipital cortex, whereas semantic processing of the words selectively activates more anterior regions of the left hemisphere. Petersen *et al.* argue on the basis of their data for a distinction between a visual word form system on the one hand and a semantic association system on the other (see also Posner, Peterson, Fox & Raichle, 1988).

Given these independent lines of evidence for the existence of a system that processes and represents information about the visual form of words, independent of semantics, what are the implications for studies of priming and implicit memory? In view of the finding that priming effects on such visual implicit tests as stem completion, fragment completion, and word identification are crucially dependent on encoding of visual surface feature information and are relatively independent of semantic encoding, I suggest that the visual word form system plays a significant role

in these effects. More specifically, it is hypothesized that visual processing of a word (or a word pair) creates a representation of its particular visual features in the word form system. If we accept the idea that processing on standard completion and identification tests includes a major data-driven component—that is, performance is influenced heavily by the visual form of the test stimulus—then it seems reasonable to argue further that the visual word form system is engaged during implicit test performance.

If a specific representation has been created in the word form system during study, and the test stimulus matches critical visual features of that representation, then subjects will be better able to identify the word from a brief exposure or will be more likely to produce the word in response to a graphemic fragment. However, access to a word form representation does not entail retrieval of time and place information about when and where the word was encountered or the products of elaborative study processing. Accordingly, such access does not provide a basis for contextually specific explicit remembering. Because the word form system does not represent semantic/elaborative information, prior semantic study processing of a word should not lead to any more priming than nonsemantic study processing on completion, identification, and similar implicit tests, as is generally observed in the literature.

Although the foregoing ideas are in some respects similar to Morton's logogen notions, the critical difference is that by the present view, priming effects for the most part do not reflect the short-lived activation of some pre-existing, abstract representation. Instead, priming is held to be based largely on a specific, newly created visual representation in the word form system. Accordingly, the present view has no difficulty accommodating the fact that priming frequently exhibits a good deal of specificity and temporal persistence. But as stated earlier, specificity effects are not always observed, so it seems likely that under some circumstances activation of pre-existing representations plays a role in priming. It is possible that within the word form system, both activation of pre-existing, abstract representations and creation of novel, specific representations contribute to priming; the importance of each process may be determined by the nature of the target materials and the encoding operations required by a particular study task. Thus, when target words are presented for study in unusual formats or subjects are required by a study task to attend to the physical features of the words, priming may be based largely on novel word form representations; when words are not presented in unusual formats and study tasks do not require processing of a word's physical features, activation of pre-existing representations may play a more prominent role.

If implicit memory for words and other verbal materials depends crucially on creating and accessing representations in the word form system, what about explicit remembering of these items? Why, for example, are recall and recognition less sensitive to surface feature manipulations than are completion and identification performance? The answer, according to the present view, has to do with the manner in which retrieval is initiated. On implicit tests, subjects do not think back to the study episode intentionally; the task is to identify or complete a word, and their attention is focused on physical properties of the cue while performing this task. A simple way to carry out such tasks as word identification and completion is to rely on the output of the word form system. On an explicit test, in contrast, the task for

subjects is to recollect what was studied during a particular episode. Attention is not focused exclusively on the physical properties of the cue; rather, the cue is used as a *guide* to aid reconstruction of the target item. The kinds of information that are typically useful for performing this task—elaborations concerning the target items, and contextual information about the time and place that the word was encountered—are not represented in the word form system. Thus, retrieval queries must be directed to a system or systems other than the word form system. The one that is most likely to be useful when performing explicit retrieval tasks is roughly equivalent to the episodic memory system discussed by Tulving (1972, 1983). (Note that the word form system and other components of PRS are “episodic” in the sense that they represent individual bits of information that are acquired during an episode. They do not, however, represent elaborative information that links an event to pre-existing knowledge nor do they represent time and place information; I use the term “episodic” only in reference to the system[s] that performs these functions). Even though the output of the word form system (or other subsystems of PRS) is not alone sufficient to support a “full-blown” re-experiencing of a recent episode, it might well support a rudimentary form of familiarity or perceptual fluency (cf., Jacoby & Dallas, 1981; Mandler, 1980): a recently established word form representation may pop to mind quickly, thereby providing a basis for a feeling of familiarity under some conditions. Accordingly, PRS likely contributes to recognition memory performance that is based on perceptual fluency or familiarity, rather than on contextual retrieval.

The foregoing ideas can accommodate data from normal subjects showing dissociable effects of semantic and surface feature manipulations on implicit and explicit tasks, specificity of priming effects within the visual modality, and long-lasting implicit memory effects, while at the same time providing a reasonable account of the amnesia data. With respect to the latter issue, the idea is that amnesic patients do not have impairments in the word form system, so they should show intact priming effects when an implicit task draws exclusively on this system. Therefore, the locus of amnesic patients’ deficits would be either at the level of a damaged episodic system or an episodic system whose outputs are disconnected from awareness (see Schacter, 1989).

Additional support for the role of the word form system in priming is provided by a recent study of a letter-by-letter reader, PT. (Schacter, Rapsack, Rubens, Tharan & Laguna, in press). Letter-by-letter readers are generally unable to engage in “whole word” reading but can read if they are allowed to use a slow process of serially identifying successive letters of a word (e.g., Patterson & Kay, 1982; Warrington & Shallice, 1980). Once a word is identified, comprehension of word meaning is intact. In some cases of letter-by-letter reading, the deficit may be attributable to an impaired word form system (Warrington & Shallice, 1980), whereas in other cases the deficit appears to be attributable to an impairment in parallel (but not serial) transmission of letter information to an otherwise preserved word form system (Patterson & Kay, 1982). Neuropsychological assessment of patient PT provided strong evidence for preservation of the word form system (see Schacter *et al.*, in press, for details).

According to the present hypothesis that the word form system plays an important role in priming, PT ought to show robust priming effects on a task such as word identification, where studied and nonstudied words are exposed briefly and the

patient attempts to read them. We investigated this hypothesis by allowing PT to study a list of target words by reading each word letter-by-letter; we then gave her a word identification test in which studied and nonstudied words were exposed briefly (i.e., 500 msec) and PT attempted to identify them. Despite the fact that the patient could only read correctly about 5–10% of nonstudied words on the basis of a 500-msec exposure, she showed a large priming effect in several experiments: PT identified from 30–45% of previously studied words from the 500-msec exposure. The priming effect was modality specific; no priming was observed following auditory study of words. Additional experiments showed that priming could not be attributed to explicit memory strategies, nor could it be attributed to letter-level processes (see Schacter *et al.*, in press). These results are both consistent with and provide additional empirical support for the idea that the word form system is critically involved in priming. In addition, this study illustrates the heuristic usefulness of the PRS framework: The present ideas led directly to testing a prediction about priming in a type of patient (a letter-by-letter reader) in which priming had not been studied previously.

It is important to point out at this juncture that the present argument does not hold that the word form system or PRS plays a key role in priming effects on *all* implicit memory tests. As noted above, implicit tests such as category instance production contain a large conceptually driven component. By the present view, priming effects on such tests reflect modifications of, or additions to, semantic knowledge and are based on systems other than PRS. The previously mentioned finding that some implicit memory effects are dependent on semantic study processing can be considered in light of this idea. One such effect is the phenomenon of implicit memory for newly acquired associations described by Graf and Schacter (1985, 1987; Schacter & Graf, 1986a, b, 1989). In these experiments, subjects studied unrelated word pairs (e.g., SHIP-CASTLE) and then performed a cued stem completion test in which they wrote down the first word that came to mind in response to a 3-letter stem that appeared next to a whole-word cue. Graf & Schacter found that subjects showed more priming when target word stems appeared with their study list cues (e.g., SHIP-CAS\_) than when they appeared with other cues (e.g., MOTHER-CAS\_), thereby indicating that a new association between the words influenced stem completion performance. Significantly, however, this associative effect was observed only when subjects had engaged in a study task that required processing of a meaningful link between the two target items (Graf & Schacter, 1985; Schacter & Graf, 1986a). In addition, this associative effect was significantly reduced by a study/test modality shift (Schacter & Graf, 1989). The modality specificity of this phenomenon fits well with the present view, but the fact that it depended on some type of semantic study processing may appear problematic: If the visual word form system—a nonsemantic system—is significantly involved in stem completion performance, why should semantic study processing be necessary to observe associative priming in the Graf and Schacter paradigm?

A possible resolution to this apparent paradox consists of the following notions: (a) the word form system drives completion performance on this task, so priming depends on a test cue matching a newly established representation of the visual features of the target pair and is therefore modality sensitive; (b) the cued stem completion task also induces some conceptually driven processing (more than the

standard stem completion task), since the presence of the context word may lead subjects to try to retrieve semantically related items; and (c) the representation in the word form system does not itself contain semantic information, but can provide *access* to the system (be it episodic or semantic) that represents newly acquired semantic information about the pairs. Interactions between the word form system and the semantic system are crucial in reading (e.g., Schwartz *et al.*, 1980; Shallice & Saffran, 1986), and it seems likely that similar interactions could occur if an implicit memory task induced both data-driven and conceptually driven processing, as appears to be the case with the cued stem completion task. As long as we assume that the word form system can *interact* with other memory and cognitive systems, the Graf and Schacter data can be accommodated. Moreover, the notion that implicit memory for new associations entails an interaction between the word form system and either an episodic or semantic system may explain why associative effects in the Graf and Schacter paradigm are not shown by many amnesic patients (cf., Cermak *et al.*, 1988a, b; Schacter & Graf, 1986b; Shimamura & Squire, 1989): Damage to components of these systems may prevent the occurrence of associative effects.

### *Visual Object Agnosia and the Structural Description System*

As mentioned earlier in the chapter, cognitive neuropsychological research has identified a number of subsystems of PRS in both the visual and auditory modalities. Accordingly, it is important to emphasize again that the present account does not maintain that implicit memory phenomena should be identified exclusively with the activities of the word form system or that this subsystem constitutes the sole basis of implicit memory. PRS represents just one type of system that can support implicit memory; for example, motor systems are likely involved in the ability of amnesic patients to learn motor skills without remembering the episode in which they acquired the skills (e.g., Milner, Corkin & Teuber, 1968). Moreover, the word form system is, in turn, just one of several subsystems of PRS that have been described. I will now consider another such subsystem, referred to as the *structural description system* (Humphreys, Riddoch & Quinlan, 1988; Riddoch, Humphreys, Coltheart & Funnell, 1988). This subsystem may support a rather different type of implicit memory effect from that attributable to the word form system.

The structural description system represents information concerning the form and structure of common visual objects. Importantly, however, this system does not represent associative or functional information about what an object means or how it is used; such information is represented in a semantic system with which the structural description system interacts. Evidence for a distinction between the representation of structural and semantic information about objects has been provided by studies of patients with various forms of *visual agnosia*—an inability to recognize familiar objects (for review and theoretical discussion, see Humphreys & Riddoch, 1987; Warrington, 1982). Consider, for example, a case described by Riddoch and Humphreys (1987a, b). Their patient was characterized by a modality-specific deficit in naming and recognizing objects from vision. Thus, when exposed visually to an object the patient could not name it, although he was reasonably good at providing the name from an auditory description. The patient also performed extremely poorly on various tasks that required access to semantic knowledge about

an object from vision: he could not answer questions that probed stored functional knowledge (e.g., when shown a picture of an animal he could not accurately say whether it was kept as a pet) or associative knowledge (e.g., he could not say whether an animal was associated with a particular country); he also was extremely poor at matching pictures of objects to appropriate category names. His performance on all these semantic tasks improved considerably when they were carried out entirely in the auditory modality.

In contrast to his inability to gain access to semantic knowledge about objects from vision, the patient performed normally on tasks that tapped knowledge of object structure. Thus, for example, Riddoch and Humphreys tested the patient on an *object decision* task in which he had to decide whether a line drawing represented a real object or not. Some of the drawings depicted actual objects; others depicted nonobjects that were created by deleting critical features from real objects or adding incorrect features to them. The patient performed normally on this task, thereby indicating that he retained intact access to structural knowledge about objects (see Riddoch & Humphreys, 1987a, b, for other tasks revealing intact structural knowledge). On the basis of this and other cases (e.g., Sartori & Job, 1988; Warrington, 1975; Warrington & Taylor, 1978), several investigators (e.g., Humphreys & Riddoch, 1987; Riddoch & Humphreys, 1987; Riddoch *et al.*, 1988; Warrington, 1982; Warrington & Taylor, 1978) have argued that knowledge of the form and structure of objects is represented in a structurally based system that is distinct from, but interacts with, a semantic system that represents associative and functional knowledge about objects (for a different view, see Shallice, 1987). The structural description system, then, can be thought of as a subsystem of PRS that performs functions in the object domain that are similar to those performed by the word form system in the verbal domain.

### *Structural Descriptions and Implicit Memory for Visual Objects*

Although the evidence from agnostic patients suggests the existence of a pre-semantic object representation system, the critical question for present purposes is whether this system can be implicated in implicit memory—that is, whether evidence exists that priming of visual objects depends on the structural description or some similar system. As argued elsewhere in an extensive review of studies on nonverbal priming (Schacter, Delaney & Merikle, in press), there have been few attempts to address this question. Moreover, many of the published studies are difficult to interpret because of failures to rule out the possibility that observed priming effects are attributable to explicit memory processes. In two recent lines of research, my colleagues and I have provided evidence that implicates the structural description system in priming of visual objects.

In one study, Schacter and Merikle (in preparation) examined whether nonsemantic study processing is sufficient to produce priming of familiar visual objects, just as nonsemantic study processing is sufficient to produce priming of familiar words in studies that were discussed earlier (e.g., Graf & Mandler, 1984; Jacoby & Dallas, 1981). Although studies of object priming have been reported, little attention has been paid to the question of whether such priming is a pre-semantic phenomenon (see Schacter *et al.*, in press, for discussion). To examine the issue, Schacter and

Merikle used a set of line drawings of familiar objects and perceptually degraded fragments of the same objects (the drawings and fragments were compiled by Merikle & Peterson [in preparation]). In the experiment, subjects initially viewed 14 line drawings (e.g., a whistle, a flower) for 5 sec per drawing. For half the drawings, subjects performed a *semantic* orienting task in which they generated functions for the depicted object; for the other half of the drawings, subjects performed a *structural* orienting task in which they counted the number of vertices in each object.

To assess priming, perceptual fragments of studied objects were presented together with an equal number of fragments that represented nonstudied objects. In previous studies using fragmented pictures, subjects have usually been asked to try to identify each object (e.g., Snodgrass, 1989; Warrington & Weiskrantz, 1968; Weldon & Roediger, 1987). However, such instructions allow and may even encourage subjects to use explicit memory strategies to aid object identification; that is, when subjects are asked to identify a fragment of an object, they will likely make use of any information that can aid task performance, including episodic information that is accessed through intentional, explicit retrieval strategies. Consistent with this idea,

TABLE 1. Object Completion and Object Recall Performance as a Function of Study Task<sup>a</sup>

Type of Test	Study Condition	
	Semantic	Structural
Completion	0.45	0.46
Recall	0.83	0.69

NOTE: On the completion test, subjects completed perceptual fragments of objects with the first object that came to mind; on the recall test, subjects were given the same fragments and were asked to remember the previously studied objects. For the completion test, baseline rate of completing fragments representing nonstudied objects with a target object was 0.22.

<sup>a</sup>From Schacter, D. L. & E. P. Merikle, in preparation.

Schacter *et al.* (in press) have noted that it has been difficult to obtain strong dissociations between priming and explicit memory with the traditional picture fragment completion paradigm.

To circumvent the foregoing problem, Schacter and Merikle altered the instructions for the fragment completion task so that subjects were told to respond to each perceptual fragment with *the first object that comes to mind* (see also Heindel, Salmon & Butters, in press). It was emphasized that there was no correct or incorrect answer on this task, and that any object that popped into mind in response to the fragment would be an acceptable response. To discourage further the use of explicit memory strategies, perceptual fragments were presented for 500 msec and subjects were instructed to respond as quickly as possible. A separate group of subjects was given an explicit memory test in which the same perceptual fragments were presented as cues, but subjects were instructed to think back to the study list and indicate which studied object they were reminded of by the test fragment.

The results of the experiment, depicted in TABLE 1, yielded three key outcomes: (1) significant priming was observed for studied objects relative to nonstudied

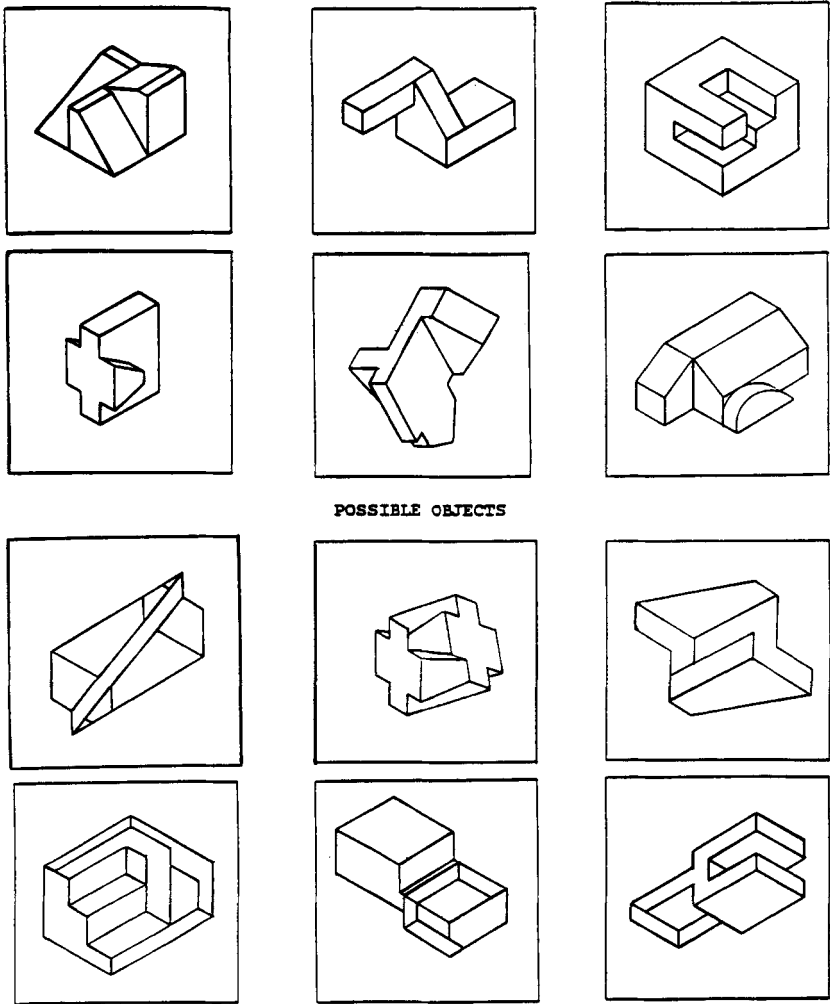
objects; (2) the magnitude of priming was essentially the same in the semantic and structural encoding conditions; and (3) explicit memory performance was significantly higher in the semantic than in the structural encoding condition. The finding that the encoding manipulation affected recall but not completion performance indicates that the priming effect cannot be attributed to explicit memory; if priming were based on explicit retrieval, it, too, should have been affected by the encoding manipulation. The finding that priming was equivalent following the vertex-counting and function-generation tasks indicates that nonsemantic, structural study processing is sufficient to support implicit memory. These results are thus consistent with, and provide direct empirical support for, the hypothesis that priming of familiar visual objects depends on a presemantic perceptual system that can be dissociated from explicit memory.

In a second line of research on object priming, we have provided evidence in a series of studies that suggests that the structural description system is involved in priming of *novel* visual objects (Schacter, Cooper & Delaney, 1990a, b). In these experiments subjects were first exposed to a series of line drawings that depict unfamiliar and rather unusual 3-dimensional objects (see FIG. 1). Although none of the drawings represent actual objects, some of them depict *possible* objects whose surfaces and edges are connected in such a manner that they *could* exist as 3-dimensional entities in the real world; other drawings depict *impossible* objects that contain subtle structural violations that would prohibit them from actually existing in 3-dimensional form. Implicit memory for the objects was assessed with an object decision test in which subjects were given a 100-msec exposure to studied and nonstudied possible and impossible objects and were required to classify each object as possible or impossible. This task does not require explicit reference to, or conscious recollection of, the prior study episode. Thus, if object decision performance is higher for studied than for nonstudied items, there would be some evidence of implicit memory for the objects.

To perform the object decision test accurately, subjects must gain access to information about the global structure of each object: Classification of an object as "possible" or "impossible" requires a thorough analysis of the structural relations among components of the object. We believe that this task engages the structural description system. Therefore, object decision performance should be facilitated by prior study of an object if the study task involves encoding of global object structure; by the present view, such encoding will produce a new representation of the object in the structural description system. We examined this idea in our first experiment. One group of subjects performed an encoding task that required analysis of global object structure: They had to decide whether each object faced to the left or to the right. A second group was required to indicate whether each object had more horizontal or vertical lines; this task required encoding only local features of the object. Subjects were then given either an object decision test or a standard yes/no recognition test; subjects in the recognition group were in addition given an object decision test following the recognition test (for further methodological details, see Schacter *et al.*, 1990a). We expected that object decision performance would be facilitated by the left/right task, but not by the horizontal/vertical task.

The results generally conformed to this hypothesis. The data in TABLE 2 show the object decision data as a function of encoding task, studied versus nonstudied items,





POSSIBLE OBJECTS

IMPOSSIBLE OBJECTS

**FIGURE 1.** Sample objects taken from Schacter, Cooper & Delaney (1990a). The drawings in the upper rows depict *possible* objects that could exist in 3-dimensional form; the drawings in the lower rows depict *impossible* objects that contain structural violations that would prohibit them from actually existing in 3-dimensional form. See text for further explanation (copyright, American Psychological Association).

and test order (i.e., whether the object decision test was given alone [first test] or after recognition [second test]). Only the results for the possible objects are depicted; there was no evidence of priming for impossible objects in any of our experiments (see Schacter *et al.*, 1990a, for discussion). As indicated by TABLE 2, object decision performance was considerably more accurate for studied than nonstudied items following the left/right task, but there was weak and nonsignificant evidence of priming following the horizontal/vertical task; a significant interaction between type of study task and studied/nonstudied objects was observed. These data support the hypothesis that implicit memory for unfamiliar objects depends on access to a structural description of the target objects. In addition, performance on the object decision task was about the same in the first and second test conditions. This means that the appearance of studied and nonstudied items on the recognition test did not facilitate subsequent object decision performance—that is, deciding whether an object is old or new apparently does not entail the kind of structural encoding that is necessary to facilitate object decision performance. This finding suggests that a highly specific form of structural analysis is necessary in order to produce priming on an object decision test. The recognition test data revealed a nonsignificant difference between the left/right task (0.67 hit rate) and the horizontal/vertical task (0.61) although the difference in performance after these two tasks was significant on the object decision task. Moreover, a contingency analysis of the relation between object decision and recognition performance revealed stochastic independence between the two tests—the probability of responding correctly on the object decision task was uncorrelated with the probability of responding correctly on the recognition task. These results indicate that recognition and object decision performance rely on different types of underlying representations.

Further evidence indicating a dissociation between object decision and recognition performance, and also highlighting the presemantic nature of object decision priming, was provided by a second experiment in which we compared the left/right study task to an elaborative encoding condition. On the latter task, subjects were required to think of a real-world object that each drawing reminded them of most. We reasoned that this task would require subjects to achieve a meaningful interpretation of the object, generate their own elaborations, and relate the object to pre-existing knowledge of structures. These kinds of semantic encoding activities ought to enhance explicit *recognition* of the objects even more than does the left/right

TABLE 2. Object Decision Performance as a Function of Study Task, Test Order, and Item Type<sup>a</sup>

Item Type	Encoding Condition/Test Order					
	Left/Right			Horizontal/Vertical		
	First	Second	<i>M</i>	First	Second	<i>M</i>
Studied	0.81	0.81	0.81	0.72	0.63	0.67
Nonstudied	0.63	0.71	0.67	0.64	0.64	0.64
<i>M</i>	0.72	0.76		0.68	0.64	

NOTE: Each number in the table reflects the proportion of possible objects classified correctly on the object decision test.

<sup>a</sup>Adapted from Schacter, Cooper & Delaney (1990a).

TABLE 3. Object Decision and Recognition Performance as a Function of Study Task and Item Type<sup>a</sup>

Item Type	Encoding Condition			
	Object Decision Test		Recognition Test	
	Left/Right	Elaborative	Left/Right	Elaborative
Studied	0.78	0.76	0.69	0.88
Nonstudied	0.66	0.73	0.26	0.19

NOTE: For the object decision test, each number reflects the proportion of studied or nonstudied possible objects classified correctly. For the recognition test, the first row indicates the proportion of studied possible objects called "old" (hit rate) and the second row indicates the proportion of nonstudied possible objects called "old" (false alarm rate).

<sup>a</sup>Adapted from Schacter, Cooper & Delaney (1990a).

task. If priming of *object decision* performance is mediated by a structural description system that does not represent semantic information about objects, however, elaborative encoding should *not* lead to better object decision performance than does left/right encoding.

Relevant data are presented in TABLE 3, which displays the recognition results, as well as the object decision data collapsed across first and second tests (as in the first experiment, there were no differences between these conditions). These data reveal a clear dissociation between object decision and recognition performance: Whereas recognition memory was considerably higher following the elaborative encoding task than the left/right task, there was significantly less facilitation of object decision performance following elaborative than left/right encoding. In fact, although the overall level of performance in the elaborative condition was reasonably high (reflecting the high level of baseline performance even for nonstudied items), there was no difference between the studied and nonstudied objects. Thus, the same elaborative encoding manipulation that improved explicit memory for the objects eliminated implicit memory. This result is entirely consistent with, and provides support for, the notion that priming effects on the object decision task are mediated by a pre-semantic structural description system that does not handle semantic/associative information about objects.

### CONCLUDING COMMENTS

The main argument of this chapter is that many implicit memory phenomena reflect the operation of subsystems of PRS that are dedicated to the processing of structural and form information in various input domains. As stated throughout the article, PRS is not held to be involved in *all* implicit memory phenomena; implicit tests that require conceptually driven processing (cf., Masson, 1989; Roediger *et al.*, 1989; Schacter, 1987) likely tap semantic and perhaps episodic forms of memory. The key point of the present proposal is that nonsemantic implicit tests such as fragment and stem completion, word identification, object decision, and others draw heavily on PRS. Two subsystems of PRS—word form and structural description—have been considered, but other perceptual subsystems have been postulated on neuropsychological

logical grounds (e.g., Ellis & Young, 1988; Morton, 1979; Riddoch *et al.*, 1988). Though similar in some respects to Morton's logogen model, the present view holds that priming effects on many implicit tests are driven primarily by highly *specific, new* representations within a particular subsystem, rather than by the activation of *old, abstract* representations. It is possible to study the latter type of effect through the use of special masking procedures (e.g., Forster & Davis, 1984; Forster, Booker, Schacter & Davis, 1990), but activation of abstract nodes, units, or logogens cannot account for all the data reported in implicit memory experiments.

The ideas that have been put forward are here not so much inconsistent with existing notions as they are complementary to them. Although the present approach can be characterized as a multiple systems orientation, it incorporates the transfer-appropriate processing principle as a useful way of conceptualizing and describing implicit/explicit dissociations (cf., Hayman & Tulving, 1989). It also attempts to go beyond this, however, by drawing on relevant cognitive neuropsychological observations to specify more precisely the nature of the systems involved in implicit memory. And in agreement with processing views (cf., Roediger *et al.*, 1989; Witherspoon & Moscovitch, 1989), no claim is made that all implicit memory phenomena reflect the operation of a single memory system. In fact, the present view holds that implicit memory effects are linked to the activity of a variety of systems; precisely which system (or systems) contributes to performance depends crucially on the task that is used and the kind of knowledge that is tapped. Accordingly, the view adopted here (like processing approaches) allows for and even predicts the occurrence of dissociations among implicit tests, particularly between tests that tap PRS on the one hand and the semantic system on the other (cf., Blaxton, 1989). The present approach seeks to go beyond processing views, however, by placing some *structural constraints* on the processes involved in implicit memory. Similarly, most previous multiple system accounts of priming effects, though similar in spirit to this approach, have been somewhat vague regarding the exact nature and functions of the systems underlying implicit memory (e.g., Hayman & Tulving, 1989; Squire, 1987). By arguing that PRS plays a key role in many implicit memory tests, and specifying two candidate subsystems (word form and structural description), it is hoped that a sharper characterization of the systems involved in implicit memory can be achieved.

Finally, it is useful to consider more generally the manner in which the idea of "multiple memory systems" applies to the present formulation. Sherry and Schacter (1987) argued that the existence of independent processing modules that perform domain-specific computations need not be taken as *prima facie* evidence for the existence of multiple memory systems. For example, the modules could all output to a common memory system. Alternatively, even if each module had its own memory system, they could all operate according to similar rules. Sherry and Schacter suggested that it is only useful to talk about multiple memory systems when a case can be made that the systems operate according to different rules and perform distinct functions. One source of evidence for "different rules of operation" comes from empirical observations of dissociations produced by experimental variables and subject groups. However, this alone is not sufficient grounds for postulating multiple memory systems, because empirical dissociations *within* a system can be observed (e.g., Roediger, 1984). According to Sherry and Schacter (1987), it is also important to consider the *functions* that alleged systems perform. If the hypothesized systems

perform different and mutually incompatible functions, then one has a stronger basis for postulating multiple memory systems.

With respect to the present account, it seems justifiable on both empirical and functional grounds to argue that the word form and structural description subsystems should be conceptualized as distinct from, but interacting with, episodic and other memory systems. Numerous dissociations reported in the literature, plus the object-priming studies described here, indicate that these systems operate quite differently from episodic memory. In addition, the functions performed by these systems—representation of form and structure within lexical (word form system) and object (structural description system) domains—are distinct from, and perhaps incompatible with, functions performed by the episodic system (i.e., representation of meaningful events composed of numerous types of information in particular spatiotemporal contexts). It is less clear, however, whether the word form and structural description systems are characterized by different rules of operations, which is why it seems most prudent to characterize them as subsystems of PRS. At the very least, the idea that these and other PRS subsystems play a key role in implicit memory seems worthy of further investigation. From a heuristic point of view, the idea suggests that careful attention to alexia, agnosia, and other neuropsychological syndromes that involve disruption of perceptual representation systems should pay rich dividends for implicit memory research (Schacter *et al.*, 1990a).

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## DISCUSSION

J. FUSTER (*UCLA School of Medicine, Los Angeles, CA*): Did that patient with acquired dyslexia have an identifiable or documented lesion?

D. SCHACTER (*University of Arizona, Tucson, AZ*): Well, there have been three patients that I am familiar with in the literature so far. The original Schwartz, Marin, and Saffran patient had Alzheimer's disease, so there was obviously widespread pathology. There have not been precise lesion data provided for the two patients reported since then. One patient was reported by Funnel and one by Satori, Masterson, and Job. Both had left anterior strokes, so some general information is available. I can't give you a better answer to that question. The literature has not provided it yet.

FUSTER: Another question, a simple question: Why do you need to postulate dichotomies of the kind you do, when you might possibly be dealing with a gradual, graduated hierarchy, say, in cortex from the very concrete to the more general and

categorical that might form a continuum, where the presentations would be stacked up from the most concrete, most data-driven to the most general, most categorical?

SCHACTER: Yes, there might well be a continuum in there, but I think in order to make these things sharp, at least in the beginning, one should begin with a dichotomy. If the dichotomy breaks down, well, so be it, but at least you can try to push the dichotomy and make it break down, so I wouldn't rule out that possibility.

A. SHIMAMURA (*University of California, Berkeley, CA*): I think that your framework is very nice. You have said explicitly what Larry [Squire] and I have felt implicitly. What is nice is that you have now pinned brain systems to some of these implicit memory systems, perhaps in neocortical areas, where the damage is not located in the areas where amnesic patients show damage. But in some sense, and correct me if I'm wrong, aren't you basically saying you can cross out "declarative" and put "semantic" there; cross out "nondeclarative" and put "nonsemantic" there; and underneath put the word form system, the structural description system, and...?

SCHACTER: Yes, more or less. My view is consistent with your general point that in the implicit domain probably more than just one system exists. We're not talking about only two memory systems, one for explicit memory and one for implicit memory. What may make Roddy [Roediger] and others uncomfortable is that I'm talking about *several* memory systems. I think the saving grace, and the reason I am willing to entertain this possibility, is that there is the convergent and initially suggestive evidence from independent domains. If we simply postulate separate systems every time we have a dissociation, however, we are lost.

SHIMAMURA: Larry Squire, I, and our co-workers never really thought that all the abilities within the umbrella of procedural memory would be controlled by one brain system.

SCHACTER: No, I agree completely with Larry in that respect. I think his point has been for a number of years that within the procedural or implicit domain you are dealing with a lot of different systems. Here, I am trying to say let's get more specific about what the systems are and what functions they perform.

J. COHEN (*Carnegie-Mellon University, Pittsburgh, PA*): You used the priming effects on novel stimuli such as non-words as evidence against an activation-based approach or model. But I wonder why? It seems to me in that case it could just be priming of the orthographic phonological subunits, which would still be an activation-based explanation.

SCHACTER: Right. That is a good point, and I think it is something that comes up with any novel stimulus. That is, in what sense is it novel? There is perhaps, always a lower level at which the information is previously represented and you are just assembling it in a new way. However, at the level of words, the non-words obviously are novel—at the word level, but not at the letter level.

COHEN: I asked that question because I was wondering what a model or a mechanism underlying this implicit system would be, if it is not an activation-based model?

SCHACTER: Well, here we have another terminology issue. All of this could invoke activation in the very general sense that it is used in numerous models. But the activation explanation in this particular context refers specifically to the idea that you are not adding anything new to the system, you are just temporarily lighting up

something that was already there, which dies down quickly. So it is not the activation concept that is at issue. I suppose it's the question of "old" versus "new" representations that is at issue. Is implicit memory based on the activation of old representations or the creation of new ones?

COHEN: It is still something old that you are lighting up, it's just at a lower level, that's all.

S. KEELE (*University of Oregon, Eugene, OR*): It seems to me that a failure we have had as psychologists is to define "semantics" in a way that we can make contact with neural systems. I don't know how to specify semantics. Where is it in the neural system, and what role does the hippocampus have in fixating a semantic memory? Do you have any ideas about what semantic memory might mean in a kind of pseudo-neurological sense?

SCHACTER: Well, I think the first thing I would say is that to me the difference between semantic and nonsemantic involves going beyond the structure of the stimulus as given; when you do that, you are passing into the semantic domain. Everything I have talked about as nonsemantic could be construed as dealing with the structure of the stimulus as given. As to the representation of semantics, again one can appeal to some of the data. Some of the Posner, Peterson, and Raichle work shows a more anterior focus of cerebral blood flow activation when you are doing semantic tasks. There is a massive literature showing that there seems to be a left hemisphere locus for these things; the literature goes back a long time. For example, I talked about the associative agnosias. You generally don't get that without some sort of a left hemisphere lesion. So, one can hand-wave a little bit about that, but as for the hippocampus and semantics, that becomes a very difficult issue.

L. NADEL (*University of Arizona, Tucson, AZ*): Let me add something to that. The word "semantic" is another one of those unfortunate words that has been used by psychologists in a way that is somewhat similar to, but actually quite different from, the way in which it has been used in psycholinguistics. The notion of "semantics" that arises in the distinction between syntax and semantics is very different from the notion of semantics entailed by the distinction between episodic and semantic. Consequently, there has been confusion about this notion of semantic with respect to the sense in which we are using it. Mostly we are talking about it in a way that is quite different from the way that language people talk about it. That has led to confusion.

SCHACTER: In the object domain I think you can make somewhat of a sensible distinction if you talk about a semantic domain composed of functional, associative, and perhaps contextual properties of an object. These go beyond the physical form and structure of an object; the presemantic system that I have discussed is restricted to that physical form.

J. FAGAN (*Case Western Reserve University, Cleveland, OH*): What is the matter with the word "meaning"?

SCHACTER: Nothing. Nothing at all.

FAGAN: Is that what you mean by "semantic"? Does "semantic" mean "something that has meaning"?

SCHACTER: Yes, it means that in a certain sense.

J. WERKER (*University of British Columbia, Vancouver, B.C.*): I can't help but be reminded of some more ancients in developmental psychology. Bruner and Werner come to mind, with their sensorimotor, perceptual, and conceptual sorts of represen-

tations. I like the distinction between something like “perceptual” and something like a “semantic representational system.” I think that distinction might be very useful. I like your use of the word “meaning” rather than “semantic,” because I always worry that what we are left with is that the only thing that qualifies as semantic memory is something we can talk about. I think of the split brain studies. Would it be that anything that is in the right hemisphere in a split brain patient can’t possibly qualify as semantic memory?

SCHACTER: No, I don’t think that, in principle, would be true. No, I think you can express semantic or meaningful knowledge without language, using other response systems.

WERKER: Right.

NADEL: With respect to this whole idea, I would like to add a historical note. There’s a chapter called “Limited Amnesias” in a book called *Amnesia*; agnosias, apraxias, and a variety of such syndromes are discussed as limited forms of amnesia.<sup>b</sup> That was the first statement that I have seen of the idea that one can think about these early processing systems as modular, representational, or memory systems. Psychologists at that time were restricting the use of the term “memory” to what Miller called “grade A certified learning,” which is now called episodic memory. We are now using the word “memory” in a much broader sense, to include anything that reflects some impact from prior experience. So, the field has moved, but these ideas have been around for some time. They just haven’t been talked about in the same way.

SCHACTER: Certain aspects of the ideas, yes.

R. CASE (*Stanford University, Stanford, CA*): At the beginning of your talk you said a problem with Roddy [Roediger’s] transfer-appropriate processing view was that it had trouble dealing with certain kinds of things that amnesics can do, which you might expect they couldn’t do, which are of a conceptual nature. I have forgotten your example, but could you come back to it and show how your view *does* allow you to account for that?

SCHACTER: Well, for example, category instance production, or some work Art [Shimamura] has done with priming of semantic associates. Art can describe the paradigm better than I.

SHIMAMURA: Well, you give a paired associate like “table” and “chair.” Later on you give the word, “table,” and ask subjects to free associate to it.

SCHACTER: Or the one where you don’t present the actual associate. These are what would be thought of as conceptually driven tasks. Now, what I would say is that is not in the domain of the perceptual systems I have discussed. That is, using implicit tests to tap into a semantic system we find that, at least with respect to old knowledge in the semantic system, amnesics are OK; they show substantial priming of pre-existing semantic knowledge. It’s another issue as to whether amnesics can add anything new to the semantic system. Harking back to the discussion we had before about the kind of mixed findings that have been found with the priming of novel paired associates, which involve some semantic processing. From my point of view, one might think of that as now getting out of the domain of these perceptual systems,

<sup>b</sup>LISMAN, W. A. 1966. Limited amnesias. In C. W. M. Whitty & O. L. Zangwill, Eds. *Amnesia*. Butterworths. London.

into perhaps some cross-talk between perceptual and semantic systems, because these novel associate priming effects are both modality-specific and semantically dependent. Perhaps when you get into the cross-talk of these systems you don't get the purely preserved effect in amnesics that you do when you stay safely within one of these systems. That is just a speculation.

H. L. ROEDIGER (*Rice University, Houston, TX*): I take it from your presentation that the two new systems you have proposed would account for the data that I have collected, but they don't really solve the same problem I was facing. That is, the story would have been quite neat if amnesics only showed preserved priming on perceptual (or data-driven) implicit tests, but they don't. They are preserved on semantic (or conceptually driven) tests, too. Your perceptual representation systems handle perceptual priming, but you still have to face conceptual priming. So we must need another priming system for conceptual priming.

SCHACTER: Well, I think then you get squarely into the semantic-episodic kind of issue, and if you allow amnesics to have a reasonably well-preserved semantic knowledge base—it's then a question of whether they can add anything new to it—but then some of these priming effects could be working off of that.

ROEDIGER: How many systems do you think we will wind up with with this logic? When I read the neuropsychology literature it seems like every time you get a specific knowledge deficit in a patient a new neural system is proposed. If some brain lesion produces an inability to identify yellow Volkswagens but not green Volkswagens, then right away someone proposes that we have a system for green Volkswagens and a different system for yellow ones.

SCHACTER: Yes, obviously one wants to stay away from that. I think the appeal that you and others have made to converging evidence is the best way. I think with the perceptual representation system idea, we can make a reasonably coherent story by bringing together three separate domains: cognitive and neuropsychological studies of implicit memory, neuropsychological studies of reading and object-processing deficits, and neuroimaging studies.

ROEDIGER: Right. With converging operations the systems business makes good sense. I agree.

SCHACTER: With the structural description hypothesis, you can bring together the object agnosia data and the priming results. I think this makes some rather nice predictions about what should happen in PET studies that we will hopefully actually be able to look at. So, I would say we have to rely on the converging evidence and some sensible, principled idea about the function of systems, so we don't have a million of them. I would say that if you took a fast reading of the current cognitive neuropsychological literature, with the way a number of people are thinking about it, you would find evidence for at least four of these perceptual representation systems. I have talked about two of them (the word form system and the structural description system). Others have found some preliminary evidence in the auditory domain for a couple of others—again, one would want to see more evidence of different kinds before accepting these systems, but at least the hypothesis suggesting these other systems is worth investigating. It is probably best to refer to these four as subsystems of a more general perceptual representation system, because they may all function in fundamentally similar ways, albeit with respect to different types of perceptual information.