Journal of Experimental Psychology:
Learning, Memory, and Cognition
1995, Vol. 21, No. 3, 768–776


0278-7393/95/$3.00

OBSERVATIONS

# Bias in the Priming of Object Decisions: Logic, Assumption, and Data

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R. Ratcliff and G. McKoon (1995) describe 7 experiments that led them to conclude that priming of possible but not impossible objects on the object decision task introduced by D. L. Schacter, L. A. Cooper, & S. M. Delaney (1990) is attributable to explicit memory processes that offset a bias to call studied objects "possible." On the basis of this point, Ratcliff and McKoon (1995) claim to have undermined our hypothesis that a structural description system plays an important role in object decision priming. Ratcliff and McKoon (1995) also offer a general critique of multiple memory systems accounts of priming and explicit memory. Ratcliff and McKoon's (1995) arguments are based on an inaccurate characterization of Schacter et al.'s theoretical position; the evidence for Ratcliff and McKoon's (1995) idea that explicit memory offsets bias is weak, and the central assumptions that underlie both Ratcliff and McKoon's (1995) specific experimental manipulations and their general conclusions are questionable.



Ratcliff and McKoon (1995) reported a series of experiments that examined priming of possible and impossible objects on an object decision task that we have developed and explored in a series of recent studies (e.g., Schacter, Cooper, & Delaney, 1990). Ratcliff and McKoon's (1995) article contains a number of valuable contributions. They used methods for manipulating retrieval processes that should prove useful in research on implicit memory; they produce some interesting and important empirical phenomena that add to researchers' knowledge of priming effects on the object decision task, and they clearly highlight the need for more detailed theoretical accounts of priming and implicit memory. At the same time, however, Ratcliff and McKoon (1995) made several claims about our interpretation of object decision priming data and the viability of multiple memory systems hypotheses. In this commentary we question the basis for these claims.

## Background and Central Issues

During the past several years, we have reported numerous experiments in which people study line drawings of structurally possible and impossible novel objects and then make possible versus impossible decisions about studied and nonstudied drawings that are exposed for brief durations (e.g., 100 ms). Priming effects are said to occur on this task when study-list exposure to an object alters the likelihood of the participant's calling it "possible" or "impossible" in relation to nonstudied objects. Priming is typically compared with performance on a yes–no recognition test, wherein participants attempt to remember explicitly whether they have seen an object earlier. A single finding from these experiments constitutes the central focus of Ratcliff and McKoon's (1995) article: Significant priming is consistently observed for possible objects but not for impossible objects (Cooper, Schacter, Ballesteros, & Moore, 1992; Schacter & Cooper, 1993; Schacter, Cooper, & Delaney, 1990; Schacter, Cooper, Delaney, Peterson, & Tharan, 1991). However, we have also produced many other findings about the characteristics of object decision priming (Cooper et al., 1992; Schacter & Cooper, 1993; Schacter et al., 1990; Schacter, Cooper, Delaney, et al., 1991; Schacter, Cooper, Tharan, & Rubens, 1991; Schacter, Cooper, & Treadwell, 1993; for review, see Cooper & Schacter, 1992).

The overall pattern of converging evidence from various kinds of encoding manipulations, study-to-test changes in object properties, and experiments with patients with amnesia has led us to argue that priming on the object decision test depends on an encoded representation of the global three-dimensional structure of an object and the relations among its parts—what others have referred to as a *structural description* of the object (e.g., G. W. Humphreys & Riddoch, 1987; Marr & Nishihara, 1978; Riddoch & Humphreys, 1987; Sutherland, 1973; Winston, 1975). Furthermore, we drew on theoretical perspectives that have been independently developed in neuropsychological research on object processing deficits to characterize the system that supports object decision priming. This independent line of research suggested the existence of a structural description system that computes global, three-dimensional object representations of an object (Riddoch & Humphreys, 1987; Warrington, 1982). We characterized the structural description system as a subsystem of a more general perceptual representation system that can function indepen-

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Preparation of this article was supported by National Institute of Mental Health Grant RO1-MH45398. We thank Tim Curran, Doug Hintzman, Wilma Koutstall, Gail McKoon, Ken Norman, and Roger Ratcliff for useful comments and discussion, Jessica Lange and Allison Newman for research collaboration, and Kimberley Nelson for help with preparation of the manuscript.

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dently of episodic memory (Schacter, 1990, 1994; Tulving & Schacter, 1990).

It was in this broader context that we offered an interpretation of the single finding that is central to Ratcliff and McKoon's (1995) article, namely, the relative absence of priming effects for impossible objects. We noted that for impossible objects, no coherent, globally consistent three-dimensional representation of structural relations can be computed; that is what makes an impossible object impossible. Accordingly, if a system that computes a description of global object structure plays an important role in object decision priming, it makes sense that priming of impossible objects is not typically observed.

Ratcliff and McKoon (1995) rejected this view, arguing instead that priming on the object decision test is a consequence of two opposing factors: a general bias to call any familiar object "possible," and explicit memory for "some particular configuration of corners, angles, or twists from an object that is associated with information about whether the object is possible or impossible and so serves, for impossible objects, to counteract the bias to respond possible" (p. 758). According to Ratcliff and McKoon (1995), in the standard object decision paradigm that we have used, explicit memory for features of impossible objects approximately cancels the bias to call familiar impossible objects "possible." In their first experiment, Ratcliff and McKoon (1995) replicated our standard pattern of results. In Experiments 2–5, Ratcliff and McKoon (1995) attempted to eliminate explicit retrieval by imposing on their participants response deadlines and memory loads. Under these conditions, the previously observed standard pattern of results was replaced by a pattern that reflected a general bias to call previously studied possible and impossible objects "possible," compared with nonstudied objects. In Experiments 6 and 7, Ratcliff and McKoon (1995) attempted to render explicit retrieval ineffective by using highly similar possible and impossible objects, and they reported patterns of priming that, they contended, provided support for their views and evidence against our position.

The observation that object decision priming can be affected by bias of the kind documented by Ratcliff and McKoon (1995) is not novel; we have observed bias effects in various experimental conditions and discussed the issue at some length (Schacter et al., 1990; Schacter, Cooper, Delaney, et al., 1991). However, three features of Ratcliff and McKoon's (1995) contribution are novel: (a) their demonstration that bias can be influenced systematically by retrieval manipulations; (b) their claim that once the offsetting influence of explicit retrieval is eliminated, a bias pattern is observed; and (c) their argument that the observation of bias patterns when explicit retrieval is eliminated fatally undermines our structural description system account of object decision priming. The first of these three novel features represents a significant contribution. The second feature is also potentially important, but as we point out below, Ratcliff and McKoon's (1995) claim that bias is normally offset by explicit retrieval lacks direct empirical support.

The third feature of Ratcliff and McKoon's (1995) argument is unwarranted because it is based on a mischaracterization of our position. Specifically, Ratcliff and McKoon (1995) attributed to us the view that an encounter with an impossible object leaves no trace in the structural description system. However, we have never taken this extreme view. On the contrary, we have argued that the possible parts of impossible objects are represented, and we have predicted that priming of impossible objects would be observed on tests other than object decision that do not demand access to global structural descriptions (Schacter, Cooper, Delaney, et al., 1991, p. 16: see also Schacter et al., 1990, p. 19). Seamon et al. (1995) confirmed this prediction by showing priming of impossible objects on a preference test:

> We note that while the demonstration of implicit memory for impossible objects was made first in the present studies, it was anticipated by Schacter and Cooper. Schacter et al. ([Schacter, Cooper, Delaney, Peterson, & Tharan] 1991, p. 16) state that while they failed to find priming for impossible objects in their object decision test, such priming should occur for an implicit test that is based on information about individual (and possible) parts of an impossible object. In terms of their model, the structural description system can compute global structural descriptions of possible objects and structural descriptions of possible parts of impossible objects. In other words, while the structural description system cannot compute single global descriptions of impossible objects, it can compute structural descriptions of their possible parts. (p. 720)

The hypothesis that an encounter with an impossible object leaves behind a representation of its possible parts raises a key question: Why are robust bias patterns not observed consistently under standard object decision test conditions? If possible parts of impossible objects are represented, then they should enhance the tendency to call previously studied impossible objects "possible." Before Ratcliff and McKoon's (1995) experiments, we had assumed that significant bias is not observed consistently under standard conditions because the object decision test requires access to global, three-dimensional object information—information that is not represented in possible part representations. Ratcliff and McKoon (1995), however, provided an alternative answer: Bias attributable to possible part representations is normally offset by explicit memory for configurations of features in impossible objects.

Ratcliff and McKoon's (1995) idea about the role of explicit memory may or may not be correct. Even if we accept their conclusion, however, it need not lead to the wholesale rejection of our position, nor would it support Ratcliff and McKoon's (1995) assertion that "it is noteworthy that it was so simple to use standard retrieval manipulations to produce data inconsistent with predictions from Schacter, Cooper, and colleagues' basic definition of an entire memory system (p. 763)." Rather, their experiments suggest a potentially important solution—a very different one than we had imagined—to the empirical puzzle of why possible part representations of impossible objects do not ordinarily influence object decision priming. Nevertheless, it is still important to consider carefully the empirical basis for their ideas about the role of explicit memory in offsetting bias.

## Experiments and Data

### *Experiments 2–5*

Given that deadline and load manipulations in Experiments 2–5 produced a bias pattern in object decision priming, the critical question concerns the evidence for Ratcliff and McKoon's (1995) idea that these manipulations eliminate the explicit retrieval of information from impossible objects that normally offsets bias.

This account implies that experimental conditions that yield low levels of explicit memory for configurations of lines, edges, and angles in impossible objects should be associated with greater bias than experimental conditions that yield a high level of explicit memory for this kind of information. Indeed, with very high levels of explicit memory we should begin to see positive priming of impossible objects, because the explicit retrieval that offsets bias should recover enough information about configurations of lines, edges, or angles associated with impossibility to produce more accurate decisions about studied than nonstudied impossible objects.

In several of our experiments with college students, we have compared elaborative encoding tasks (e.g., thinking of verbal labels for objects) and structural encoding tasks (e.g., judging whether the object faces left or right). Although the elaborative tasks have produced higher levels of explicit memory for impossible objects than structural tasks, these manipulations have had no systematic effect on the amount of observed bias (Schacter & Cooper, 1993; Schacter et al., 1990; Schacter, Cooper, Delaney, et al., 1991). However, these findings may be of limited relevance to Ratcliff and McKoon's (1995) hypothesis: Elaborative tasks that improve yes–no recognition of impossible objects probably promote verbal or semantic encoding, which may not enhance memory for the configurations of features that they believe offsets bias.

More directly pertinent are experiments in which we have attempted to increase the amount of available perceptual information by providing participants with multiple opportunities to perform a structural (i.e., left vs. right) encoding task. Schacter, Cooper, Delaney, et al. (1991, Experiment 1) found much higher levels of recognition of impossible objects after four left-versus-right judgments during encoding than after a single left-versus-right judgment during encoding. In light of these results, it seems reasonable to expect that participants who performed only a single left-versus-right encoding judgment would have more difficulty remembering configurations of lines, angles, or edges associated with impossibility than participants who performed four left-versus-right encoding judgments and would thus be more susceptible to bias. However, there was little or no bias in either condition, and there was no evidence for positive priming of impossible objects in the four-repetition condition, even though levels of explicit memory were extremely high. A follow-up experiment yielded similar results. Other experiments have shown that explicit memory for impossible objects is reduced by study-to-test changes in object size and reflection, but these experiments, likewise, have not yielded consistent effects on the magnitude of bias (Cooper et al., 1992).

We have also conducted object decision experiments in patients with amnesia who exhibit seriously impaired explicit memory. The logic of Ratcliff and McKoon's (1995) approach dictates one necessary feature of object decision priming in persons with amnesia: to the extent that there are any effects of prior study exposure on object decision performance, these effects should be manifested as a bias pattern. This is because patients with amnesia lack the explicit memory abilities that Ratcliff and McKoon (1995) maintain are usually used by college students to offset bias. Contrary to this expectation, in the two experiments that we have reported concerning object decision priming in persons with amnesia, there was no evidence of bias in patients with amnesia—these patients exhibited priming for possible objects and no priming for impossible objects (Schacter, Cooper, Tharan, et al., 1991; Schacter et al., 1993).

The foregoing considerations led us to confront another problem with Ratcliff and McKoon's (1995) account. If explicit memory for configurations of lines, angles, and edges associated with impossibility usually works against the prevailing bias to call studied impossible objects "possible," then explicit memory for lines, angles, and edges associated with possibility should enhance such a bias for studied possible objects. This implication follows directly from Ratcliff and McKoon's (1995) statement that during the object decision test, subjects explicitly remember "some particular configuration of corners, angles, or twists from an object that is associated with information about whether the object is possible or impossible" (p. 758). Thus, deadline and load manipulations in Experiments 2–5 should significantly decrease the amount of priming that is observed for possible objects. On the contrary, inspection of Ratcliff and McKoon's (1995) data reveals that their deadline and load manipulations had no systematic effect on priming of possible objects.

It is conceivable, however, that explicit memory would be more useful for impossible objects than for possible objects in the context of the object decision task because the impossibility of an object can be indicated by a particular local configuration of features, but there is no analogous local configuration that signals the possibility of the object.[1] Although this view may have merit, we make two observations. First, it is well known that configurations of local elements can specify object impossibility only in the context of information about the full object structure. For example, Hochberg (1968) has shown that when impossible objects are viewed section by section (sequentially) through a moving aperture, participants are unable to appreciate the global impossibility of their structure. Thus, useful explicit memory for impossible objects must contain information about relationships among many parts of the object, as well as information specified by local configurations alone. Second, it is plausible that local configurations of lines—forming T and Y junctions that specify corners of three-dimensional objects, parallelisms that specify correspondence of edges, and so forth—provide visual information that is helpful in attempts to compute the global structure of a possible object as well as of an impossible object. Accordingly, explicit memory for configurations of local elements (in relation to the entire object) could, under appropriate circumstances, influence responses to possible as well as to impossible

[1] This point was raised by Douglas Hintzman in a review of an earlier version of our commentary. It is not made by Ratcliff and McKoon (1995), whose statements regarding the use of explicit memory during the object decision test all suggest that explicit memory for features associated with either possibility or impossibility can influence object decision performance.

structures. Thus, although explicit memory processes of the kind to which Ratcliff and McKoon (1995) appeal might be selectively helpful for impossible as opposed to possible objects, we do not think that such selective effects can be automatically presumed.

The idea that configurations of features associated with impossibility are more readily accessible to explicit memory than are configurations of features associated with possibility is critical because it can allow Ratcliff and McKoon (1995) to account for their own finding that deadlines and loads affected priming of impossible but not possible objects. If the idea is correct, then there should be some direct evidence that explicit memory for impossible objects is more accurate than explicit memory for possible objects. Participants should be able to use the set of features associated with the impossibility (but not the possibility) of an object as an aid to remembering the prior presentation of the object. One problem with this suggestion is that in every experiment that we have conducted, explicit memory for impossible objects is less accurate than explicit memory for possible objects (Cooper & Schacter, 1992; Cooper et al., 1992; Schacter & Cooper, 1993; Schacter et al., 1990, 1993; Schacter, Cooper, Delaney, et al., 1991; Schacter, Cooper, Tharan, et al., 1991; Schacter, Cooper, & Valdiserri, 1992).

Ratcliff and McKoon (1995) point out that yes–no recognition may not be the appropriate test of explicit memory for the configurations of features that are central to their argument and that other kinds of explicit tests might reveal a different pattern. We agree that this possibility merits investigation, but we see no compelling reason to treat the results of yes–no recognition tests as irrelevant to the issue at hand. It remains to be determined whether explicit memory is more useful for impossible objects than for possible objects on the object decision test, even though numerous experiments have shown that explicit memory is more useful for possible objects than impossible objects on a yes–no recognition test. The idea that such a crossover interaction exists is certainly counterintuitive and deserves serious investigation.

Aside from general differences in explicit memory for possible and impossible objects, it is also important to consider whether deadlines and loads influence explicit memory for impossible objects more than for possible objects. Ratcliff and McKoon (1995) cite prior evidence that deadlines and loads can impair performance on explicit memory tests. With respect to the present experiments, one possibility is that deadlines and loads would impair explicit memory for both possible and impossible objects. Although this expectation seems reasonable, such an outcome does not explain Ratcliff and McKoon's (1995) results. Given Ratcliff and McKoon's (1995) consistent finding that deadlines and loads have no effect on priming of possible objects and their claim that these manipulations interfere with explicit memory for configurations of features in impossible objects, it follows that deadlines and loads should affect explicit memory for impossible objects more than for possible objects. But Ratcliff and McKoon (1995) present no such data; in fact, they present no data at all concerning tasks that specifically require explicit memory.

In an attempt to explore the matter directly, we have collected preliminary data concerning the effect of a 200-ms response deadline on explicit memory (i.e., yes–no recognition). Results indicate, perhaps not surprisingly, that the deadline has parallel effects on recognition of possible and impossible objects. Further research will be necessary to determine whether other test conditions exist in which deadlines and loads impair explicit memory for impossible objects more than for possible objects, as seems to be logically required by Ratcliff and McKoon's (1995) account.

Although we have focused on the role played by explicit memory in Ratcliff and McKoon's (1995) account, problems also arise with Ratcliff and McKoon's (1995) assertion that a deadline manipulation should not affect the structural description system. We have never made any claims about response deadlines and the structural description system, but Ratcliff and McKoon (1995, p. 759) impose a prediction on us:

> This explanation predicts that a response deadline will not affect the pattern of priming results. The structural description system is a memory system used in perception of objects (cf. Tulving & Schacter, 1990); it is presemantic and its function is to 'improve identification of perceptual objects' (Tulving & Schacter, 1990, p. 301). To achieve this function, information from the system must quickly be retrieved, much more quickly than would be affected by the deadlines imposed in our experiments (or else the system would not be useful in perception).

The problem with this argument is that it does not take into account the specific demands of the object decision test that is used to evaluate priming. This task requires participants to make a complex decision about the global structure of each object. The processes involved in making this decision are likely to be slow and therefore susceptible to deadline manipulations. In fact, latency data that we have gathered in the course of numerous experiments indicates that mean reaction times on the object decision task are in the general vicinity of 900–1,200 ms. We infer from the mean split of reaction time data in Experiment 1 that Ratcliff and McKoon's (1995) object decision latencies are quite comparable. Although it could be argued that some of that time is devoted to explicit retrieval, we have observed similar latencies in studies in which there was no study list and in which participants simply made baseline decisions about briefly flashed possible and impossible objects. In short, there is good reason for us to believe that priming supported by the structural description system, as assessed by the object decision task, could be influenced by the deadline manipulations used by Ratcliff and McKoon (1995). Ratcliff and McKoon (1995) provided no evidence to the contrary, and the rationale that they do invoke, as quoted above, is overly abstract and is not tied directly to the object decision task. Moreover, Ratcliff and McKoon (1995) did not even attempt to provide a rationale indicating why a memory load would fail to affect retrieval from the structural description system, even though this assumption is central to their interpretation of Experiment 5.

### *Experiments 6 and 7*

Ratcliff and McKoon (1995) used possible and impossible versions of objects that are highly similar to one another in an attempt to "eliminate the effects of explicit retrieval in a different way, with a design in which explicit information was not indicative of a decision in the object decision task" (p.

761). Experiment 6 shows that presentation of either a possible or impossible version of an object during study produces a comparable bias on a subsequent object decision test to say "possible" to either the possible or impossible version of the object. In Experiment 7, Ratcliff and McKoon (1995) were able to eliminate the effect of prior study by using a two-alternative forced-choice procedure in which the possible and impossible versions of an object were presented, and participants had to indicate which one had just been flashed.

These are interesting and potentially informative outcomes. However, as noted earlier, the conclusions that Ratcliff and McKoon (1995) drew on the basis of both Experiments 6 and 7 rested on an inaccurate characterization of our position (i.e., that impossible objects leave no trace in the structural description system). Moreover, in Experiment 6 Ratcliff and McKoon (1995) provided no evidence to support their claim that the inclusion of similar possible and impossible objects eliminates the effects of explicit retrieval. One problem with this argument is that a significant proportion of the objects on the object decision test are the same as on the study list—that is, in addition to priming a possible object with a similar impossible version and vice versa, Ratcliff and McKoon (1995) also primed possible objects with identical possible objects and primed impossible objects with identical impossible objects. How would participants know before a test exposure whether or not explicit retrieval is useful? In Experiment 7, participants passively viewed a flashed object and then decided which of two highly similar objects was just flashed. Although we have argued that the structural description system plays an important role in priming when participants have the time and resources to make structurally based object decisions, there is no particular reason to assume that the structural description system will be engaged in the same way when participants make no decisions about a flashed object. It is possible that familiarity responses may be elicited more readily under these conditions, and as Ratcliff and McKoon (1995) pointed out, familiarity did not provide a basis for choosing between alternatives on the forced-choice test. Future researchers should examine these possibilities.

### *Alternative Possibilities*

We noted earlier that if Ratcliff and McKoon's (1995) ideas about explicit memory offsetting bias are correct, then they would solve the puzzle of why possible part representations do not ordinarily create bias patterns. However, what if Ratcliff and McKoon's (1995) ideas are not correct, for reasons that we have suggested? Why would deadline and load manipulations produce the observed bias patterns? We cannot provide an unequivocal answer to this question, but we can suggest an alternative possibility. Specifically, we agree with the general proposition that tasks are not process pure and that they may be influenced by different processes under different conditions (Jacoby, 1991; Schacter, Bowers, & Booker, 1989). We suggest that two processes may be particularly relevant to the object decision task: priming that reflects the output of the structural description system and priming that is based on a sense of familiarity that is produced by a prior encounter with an object or a collection of similar objects. We define familiarity as the total similarity (Jones & Heit, 1993) between a test item and all studied items, as formalized in several models of recognition memory (e.g., Gillund & Shiffrin, 1984; Hintzman, 1988; Murdock, 1982).

Both processes have the potential to contribute to object decision performance, but their relative importance may vary according to specific task conditions. Under standard conditions, when participants have adequate time and resources to make structurally based decisions about possible and impossible objects, the output of the structural description system is the primary determinant of object decision performance. Accordingly, priming is observed for possible objects and not for impossible objects for the reasons that we have outlined previously. Familiarity may sometimes influence object decision performance, perhaps indicated by the occasional observations of bias patterns under standard conditions. Under conditions of deadline and load, which we assume interfere with access to object representations from the structural description system, familiarity may be a more potent determinant of performance, and participants will tend to call familiar objects "possible." It thus follows that a bias pattern of the kind documented by Ratcliff and McKoon (1995) will be observed. Future researchers will need to compare and contrast this hypothesis with Ratcliff and McKoon's (1995) ideas about the role of explicit retrieval in offsetting bias.

## Broader Implications

Even though Ratcliff and McKoon's (1995) empirical work focuses on bias and the status of impossible objects, their theoretical critique is much broader. Ratcliff and McKoon (1995) call into question the viability of the multiple memory systems approach and contend that research on implicit memory is insufficiently informed by theory.

One confusing aspect of Ratcliff and McKoon's (1995) discussion turns on their use of the phrase "implicit memory system" when characterizing our position. In their opening paragraph they note that "This priming effect on possible but not impossible objects is taken as evidence for an implicit memory system (p. 754)," and in their discussion they assert that "we see no compelling reason to suppose that priming in the object decision task is mediated by an implicit memory system" (p. 765). The problem here is that we do not use the phrase "implicit memory system," nor do we think that it makes much sense. "Implicit memory" is a descriptive concept that refers to the manner in which a memory is expressed, whereas "memory system" is a theoretical concept that refers to a hypothetical collection of underlying processes. It is an open question as to whether implicit memory depends on a different underlying system than explicit memory. Thus, for example, Schacter (1987, p. 501) noted that the implicit versus explicit distinction "does not refer to, or imply the existence of, different underlying memory systems," and Schacter et al. (1989, p. 65) commented that "The concept of implicit memory was not intended to implicate the existence of, and should not be thought of as referring to, a discrete underlying memory system."

What we have suggested is that the implicit memory effects observed on the object decision task are primarily supported by the structural description system and that explicit memory effects on the yes–no recognition task rely primarily on an episodic system. However, these relationships are not rigid or exclusive. For example, we have argued specifically that the structural description system probably does contribute to explicit memory performance (Cooper et al., 1992, p. 54), and we have also argued that the availability of global structural descriptions for possible but not impossible objects can explain the previously noted finding that recognition of possible objects is consistently higher than is recognition of impossible objects (e.g., Cooper & Schacter, 1992; Schacter et al., 1990).

The fact that Ratcliff and McKoon (1995) did not distinguish between the notions of "implicit memory" and "memory system" also lends a certain incoherence to their claims about exactly what it is that their experiments refute—the "memory systems" account or the "implicit memory" account. As indicated above, these should not be treated interchangeably. For example, Ratcliff and McKoon (1995) claimed that various problems "undermine the use of a structural description system to explain priming on the object decision task with normal participants (p. 763)," but several pages later they proposed an alternative to the "implicit memory explanation" and contend that "The original motivations for implicit memory as an explanatory device for object decision can all be discounted" (p. 765). The problem here is that it is logically possible that implicit memory could underlie the patterns of data that Ratcliff and McKoon (1995) have observed even if a separate structural description system is not involved. More generally, researchers who do not embrace the notion that different underlying systems are involved in implicit and explicit memory nevertheless acknowledge the existence of implicit memory and design experiments to test hypotheses about the mechanisms that underlie it (e.g., Jacoby, 1991; Masson & MacLeod, 1992; Roediger, 1990). Most researchers have accepted that there is a question worth addressing: Does implicit memory depend on a different underlying system than explicit memory? But Ratcliff and McKoon (1995) erroneously treated the notions of "implicit memory" and "memory system" interchangeably, so it would not even make sense from their perspective to pose the question that many researchers have been attempting to answer.

Ratcliff and McKoon (1995) also argued that evidence for functional independence and stochastic independence does not necessarily imply the existence of different memory systems. We have considered these points in previous articles and agree that no single kind of data provides conclusive support for dissociable memory systems (Schacter, 1990, 1992; Sherry & Schacter, 1987). To provide external motivation for our ideas about memory systems, we have turned to various sectors of cognitive and neuropsychological research for guidance concerning the nature of the memory systems that are likely involved in various kinds of priming effects. Researchers in these areas have provided independent evidence for the existence of various representational systems and subsystems, such as visual word form, auditory word form, and structural object description subsystems, and we have attempted to draw on converging evidence from various domains to delineate the role of these systems and subsystems in priming (Cooper et al., 1992; Schacter, 1990, 1992, 1994; Schacter et al., 1990; Schacter & Tulving, 1994). More generally, we view the systems approach as complementary to, rather than in conflict with, theoretical approaches that have focused on the relation between encoding and retrieval processes (e.g., Roediger, 1990; Roediger, Weldon, & Challis, 1989). Indeed, Roediger and his colleagues have recently embraced the kind of memory systems approach that we have advocated as a useful complement to a processing approach (Roediger & McDermott, 1993).

At an even more general level, Ratcliff and McKoon (1995) are critical of implicit memory researchers because they did not develop detailed quantitative models and theories. We agree with Ratcliff and McKoon (1995) that the time is now ripe for developing such models. However, considering that the study of priming did not begin in earnest until the 1980s, we think that encouraging progress has been made. Moreover, we believe that Ratcliff and McKoon's (1995) implication that implicit memory research is entirely devoid of theoretical content and that "there seems to be only the priming effect" (p. 755) is an unnecessary exaggeration. Although the theorizing has been largely qualitative, various approaches and ideas have been developed (cf., Hayman & Tulving, 1989; M. S. Humphreys, Bain, & Pike, 1989; Jacoby, 1991; Kirsner, Dunn, & Standen, 1989; Lewandowsky, Kirsner, & Bainbridge, 1989; Marsolek, Kosslyn, & Squire, 1992; Masson & MacLeod, 1992; Moscovitch, 1994; Roediger et al., 1989; Squire, 1992, 1994).

We also must admit that we find it somewhat perplexing, and perhaps ironic, that after castigating others for their reliance on verbal or qualitative theorizing, Ratcliff and McKoon's (1995) own major theoretical contribution is the rather fuzzy notion of "bias." Ratcliff and McKoon (1995) did speculate about how bias might be realized in various models. However, from Ratcliff and McKoon's (1995) discussion of the radically different ways in which bias can be manifested in different situations, bias appears to be little more than a theoretical wild-card that requires at least as much development as do the ideas of the researchers whom they criticize. For example, in Ratcliff and McKoon's (1995) very different application of the bias notion to priming of perceptual identification and stem completion tasks (Ratcliff & McKoon, 1994; Ratcliff, McKoon, & Verwoerd, 1989), where they favor the hypothesis that bias alters early perceptual processing of target information, the idea seems quite promising and is entirely compatible with a multiple memory systems orientation.

Finally, we must also point out that the adoption of a formal modelling approach need not be inconsistent with the sort of multiple memory systems orientation that we have advocated. For instance, McClelland, McNaughton, and O'Reilly (1994) have developed a formal computational model that includes separate yet interacting memory systems, and their model is quite consistent with our general views. Metcalfe, Mencl, and Cottrell (1994) have likewise offered a computational model that incorporates the notion of multiple memory systems. We welcome these kinds of formal models as important extensions of the largely descriptive and qualitative theorizing about memory systems that has developed during the past decade (for a review, see Schacter & Tulving, 1994). Thus, we do not think that it is necessary to discredit the memory systems enterprise and the largely qualitative theorizing on which it has been based to advocate the development of formal models. The early qualitative efforts have provided a foundation to support formal instantiations of the multiple memory systems hypothesis, which in turn will lead to more refined ideas about properties of hypothesized systems and the nature of their interrelations. Qualitative and formal approaches can thus enrich and enhance each other, and we are hopeful that Ratcliff and McKoon's (1995) article and our commentary on it can help to stimulate new developments that will be beneficial to memory researchers working from various perspectives.

In their reply to our commentary, McKoon and Ratcliff (1995) made a number of points that merit response. First, in reference to our idea that deadline and load manipulations could lead participants to rely on familiarity information rather than structural information, McKoon and Ratcliff asserted that "it must be that something about the representation or use of one of the sets of information blocks or inhibits the effects of the other" (p. 779). Elsewhere they stated that "Some aspect of the representation or processing of these structural descriptions prevents stored perceptual information about the parts of previously studied objects from affecting performance" (p. 778). In contrast to these assertions, we have consistently stated that information from any system or subsystem that is useful for a given perceptual task will be retrieved if that system represents it, and if the task conditions are appropriate to its expression. This is a far cry from stating or implying that the system supporting performance on an object decision task blocks the retrieval of information from other systems. Such information is simply not the most useful or relevant under the particular task conditions.

A second point concerns the preliminary recognition data that we referred to in our commentary. On the basis of our statement that deadlines and loads could interfere with the slow decision process that is a feature of participants' performance on the object decision task, McKoon and Ratcliff (1995) contended that, by Schacter and Cooper's (1995) view, imposing a response deadline on a recognition test should eliminate the normal advantage of possible over impossible objects. Our pilot data provide no evidence of such an effect. However, according to our previous arguments, possible objects may be recognized more accurately than impossible objects because at the time of study, the episodic system encodes information about global structure for possible objects but not for impossible objects. This would be just as true when a deadline is used at test as when no deadline is used. Our claim that a deadline affects object decision performance because the task involves slow decision processes, leading participants to rely on fast-acting familiarity when it is available, need not imply that no structural information can be extracted from an object when a deadline is used.

A third point concerns McKoon and Ratcliff's (1995) statement that they need not assume that explicit memory is more useful for impossible than for possible objects on the object decision test, and that they in fact assume that deadlines and loads affect memory for possible and impossible objects similarly. The reason, they stated, is that we ignored their finding of greater bias effects in conditions that used a short deadline (200 ms) than in conditions that did not use a short deadline (800 ms and memory load). Note that they provided no justification for grouping the memory load condition with the 800-ms deadline condition; the grouping appears to be based entirely on the finding that the memory load condition yielded a small amount of bias. McKoon and Ratcliff also provided little justification for their assumption that some independent estimate of the contribution of episodic information can be made. They claimed that they can "add back in" the effects of episodic information, and to support their claim they used the 800-ms deadline and memory load conditions. They noted that for the .06 bias effect to be canceled by episodic information for impossible objects there would also have to be a .06 "episodic effect." If a similar .06 effect for possible objects is added to the bias effect of .06, then there is a .12 advantage for previously studied possible objects—close to the value observed experimentally. However, if the same logic is applied to the short deadline conditions, in which more bias was observed, the effect of prior study on possible objects is overestimated substantially. This observation highlights that whether the estimation procedure yields an accurate estimate of the effect of prior study is a function of the amount of bias that happens to be observed in a particular condition. McKoon and Ratcliff's stated reason for focusing on the 800-ms deadline and memory load conditions was that they "eliminate episodic retrieval while otherwise being close to the standard task" (p. 783). However, McKoon and Ratcliff have not provided any independent evidence that these or other conditions "eliminate episodic retrieval." To the extent that there is even some episodic retrieval in these conditions, bias could be estimated inaccurately. Moreover, participants in all conditions exhibited a shift toward bias and we see no principled reason independent of the data to assume that the 800-ms deadline and memory load conditions constitute a valid basis for the estimation procedure. Without a more detailed justification of how, when, and why this estimation procedure should be used, we question the utility of the resulting conclusions.

Finally, McKoon and Ratcliff (1995) stated that "it is difficult to think of any strong prediction that implicit memory theorists have made about object decisions for which disconfirmation would result in the theory being rejected or radically modified" (p. 783). In fact, we have made a number of such predictions. For example, Schacter, Cooper, Tharan, et al. (1991) used the structural description system account to predict preservation of object decision priming in patients with amnesia. If we had observed impaired priming in patients with amnesia, then we would have been forced to modify radically or reject altogether the idea that a system independent of episodic memory supports object decision priming. Schacter, Cooper, Delaney, et al. (1991) predicted priming of impossible objects on tests other than object decision that do not demand access to representations of global object structure; as pointed out earlier, this prediction was confirmed recently by Seamon et al. (1995). If this prediction had not been confirmed, we would have had to rethink our ideas about why we failed to observe priming of impossible objects on the object decision test. Schacter and Cooper (1993) predicted differential effects of structural and functional encoding tasks on object decision priming and explicit memory; a failure to confirm this prediction would have led us to modify or abandon our claim that priming operates at a presemantic level. Cooper et al. (1992)

drew on various kinds of converging neuropsychological evidence to predict invariance of object decision priming across study-to-test changes in size and left–right reflection of studied objects. If we had failed to observe such invariance, it would have been necessary to radically alter our ideas about the nature of structural descriptions. We also used this same converging evidence to generate the testable prediction that the structural description system that supports object decision priming depends heavily on inferior temporal cortex. Although we agree with McKoon and Ratcliff's (1995) cautions concerning the limited value of converging evidence that is used in only a loose or analogical manner, we have attempted to go beyond loose analogies to offer specific predictions that can be tested experimentally.

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Received July 19, 1994
Revision received October 11, 1994
Accepted October 14, 1994 ■