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Initial storage of unfamiliar objects: Examining memory stores with signal detection analyses

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Abstract

The memory source(s) underlying performance of the object decision task were examined. Application of signal detection theory with independent indices of sensitivity and bias indicated that greater object decision sensitivity (possible vs. impossible object discrimination) is observed for primed than for unprimed objects and a greater bias to respond “possible” is observed for primed than for unprimed objects. To test whether a single memory store underlies the two effects, we assessed whether the two effects would be influenced in similar ways by a particular experimental manipulation. Sensitivity did not differ between processing of 180°-rotated primed objects vs. un-rotated primed objects, but bias to respond “possible” differed between those conditions in predictable ways depending on the cerebral hemisphere of direct test presentations. Results support a conciliatory resolution to the debate concerning memory in this task and help to clarify properties of memory stores underlying the initial storage of unfamiliar objects.

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1. Introduction

In an age in which new gadgets and icons are encountered frequently, the ability to store information about novel objects and shapes is important. Every familiar object was unfamiliar at first, necessitating some sort of new representation or modification of old representation for the initial storage. What are the representational changes that are used to store novel objects? In the following study, we used signal detection analyses of performance in the object decision task to investigate these representational changes and to address the debate concerning the nature of the memory store(s) underlying performance of this task.

2. Memory in the object decision task and alternative explanations

An important way to examine the storage of novel objects is through the indirect memory task of object decision (Schacter, Cooper, & Delaney, 1990). In this task, participants decide whether line drawings depict objects that are structurally possible (objects that could exist in three dimensions) or structurally impossible (those that could not exist in three dimensions). Some of the objects presented during the test phase have been presented previously in the experiment and others have not been presented previously. Memory is inferred from differential performance with previously presented (primed) objects compared against previously unprimed (unprimed) objects. An initial observation that generated much interest was that accuracy in object decision judgments is higher for primed than for unprimed possible objects, but accuracy does not differ for primed vs. unprimed impossible objects. Unfortunately, this result can be interpreted in different ways. These alternatives were tested in the present study.

The explanation originally put forward by Schacter and Cooper and colleagues (henceforth S&C) is that memory exhibited in the object decision task reflects repetition priming but not explicit memory (Schacter et al., 1990). They hypothesized that a structural description system supports repetition priming for possible objects but not for impossible objects, because it encodes representations of the global three-dimensional structures of objects, which can be formed for possible objects but not for impossible objects. This system is one of the perceptual representation systems that subserve implicit memory but not explicit memory (Schacter, 1990). This theory is supported by several dissociations between priming in the object decision task and explicit memory for the same objects (for a review, see Cooper & Schacter, 1992).

An alternative explanation put forward by Ratcliff and McKoon (henceforth R&M) is that memory in this task reflects a bias to respond “possible” to previously viewed objects combined with explicit memory for the objects (Ratcliff & McKoon, 1995). A “bias priming” effect occurs for both possible and impossible objects, such that primed possible objects are judged “possible” (correctly) with greater frequency than unprimed possible objects and primed impossible objects also are judged “possible” (incorrectly) with greater frequency than unprimed impossible objects. The reason that pattern of results for the impossible objects is not observed in standard

object decision experiments is that explicit memory also contributes to performance during the test task. Explicit memory for previously presented impossible objects increases the frequency of judging them “impossible” (correctly), offsetting the increased frequency of judging them “possible” (incorrectly). This theory is supported by findings that, when explicit memory is restricted by task manipulations (e.g., imposing a response deadline or including a memory load during the test task), only bias priming is observed for both possible and impossible objects (Ratcliff and McKoon; see also Williams & Tarr, 1997).

An interesting debate took place between the proponents of the two views (McKoon & Ratcliff, 1995; Schacter & Cooper, 1995), and despite the addition of an interesting conciliatory perspective (Williams & Tarr, 1997), the debate remains unresolved. An important difficulty in this debate is that the S&C theory can accommodate the findings that originally motivated the R&M theory. S&C argued that the reason why R&M’s experimental manipulations produced a bias priming pattern of results was not that the manipulations restricted explicit memory from contributing to performance. Instead, they had the effect of interfering with normal access to object representations in a structural description system, allowing priming from a separate memory source, familiarity, to contribute to performance. Familiarity was conceptualized as the total similarity between a test object and all objects stored during encoding (similar to global matching models of recognition memory; see Clark & Gronlund, 1996). When familiarity contributes to performance, it should increase the tendency for participants to respond “possible” to both primed possible and primed impossible objects, producing a bias priming pattern. Note that this theory posits that familiarity affects performance under the kind of experimental conditions used by R&M; it does not affect performance in standard object decision conditions.

Thus, when the standard conditions are used, the critical difference between theories is whether one memory source or two independent memory sources contribute to performance in the object decision task. The S&C theory is that one memory source, the structural description system, supports priming for possible objects but not for impossible objects. The R&M theory is that one memory source produces a bias priming effect and another contributes accurate explicit memory for the objects. In the study reported here, we used the standard object decision procedure, and we applied signal detection theory (Macmillan & Creelman, 1991) to calculate two independent measures of performance (sensitivity and bias). In the next two sections, we briefly describe our application of signal detection theory to object decision performance, and then we describe how the two signal detection measures should reflect the properties of different hypothesized memory stores.

3. Signal detection model of object decision performance

Williams and Tarr (1997) demonstrated that, with appropriate models, the application of signal detection theory to the analysis of object decision performance allows measurement of independent indices of sensitivity and bias (Snodgrass & Corwin, 1988). Our application of signal detection theory to the object decision task is

similar to that of Williams and Tarr, but with the following exceptions. We hypothesize that when test objects are presented briefly (as is typical in object decision studies; e.g., Carrasco & Seamon, 1996; Cooper, Schacter, Ballesteros, & Moore, 1992; Ganor-Stern, Seamon, & Carrasco, 1998; Liu & Cooper, 2001; Ratcliff & McKoon, 1995; Schacter et al., 1990; Schacter, Cooper, Delaney, Peterson, & Tharan, 1991; Schacter, Cooper, Tharan, & Rubens, 1991; Schacter, Cooper, & Treadwell, 1993), participants often cannot completely determine their full three-dimensional structure (or lack thereof) with great clarity. Instead, test objects are judged to fall on different points along a dimension of feeling of “possibility” (see Fig. 1; note that this dimension is different from the “structural evidence” dimension proposed by Williams and Tarr). This feeling of “possibility” may be understood as somewhat analogous to the feeling of “familiarity” assumed when signal detection theory is applied to old/new recognition memory experiments (in which participants decide whether test items seem familiar enough to be judged “old;” e.g., see Snodgrass and Corwin). When test objects are presented briefly and participants are encouraged to respond quickly, a continuum of imperfect feeling-of-possibility values may be used in the object decision task.

A feeling-of-possibility value is derived from the degree to which a test object weakly activates various representations in storage (note that neither a novel possible nor a novel impossible object should activate a particular preexisting representation very well, but may weakly activate a number of representations of similar looking objects). These stored representations may include explicit memory representations and representations that underlie visual object recognition and priming. Participants compare the feeling-of-possibility value against a criterion (which is held constant at least for a block of trials; see Norris, 1995) to make their “possible” vs. “impossible” decisions. Because possible objects tend to look more similar to familiar objects encountered in the world and hence to any familiar objects in storage, compared with impossible objects, unprimed possible objects should have a greater likelihood than unprimed impossible objects of activating stored representations. Thus, for unprimed objects, the probability distribution for possible objects should be located to the right of the distribution for impossible objects on the feeling-of-possibility continuum (Fig. 1).

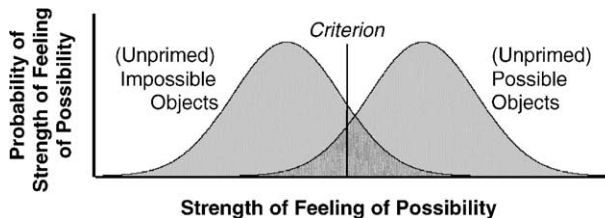


Fig. 1. Schematic depiction of the probability distributions for (unprimed) possible and impossible objects on a dimension of strength of feeling of possibility, according to a signal detection model of object decision performance.

In this model, responding “possible” to a possible object is considered a hit, and responding “possible” to an impossible object is considered a false alarm. Hit and false-alarm rates are used to estimate sensitivity and bias. Sensitivity is the degree to which possible objects are discriminated from impossible objects and is calculated as the distance between the possible and impossible object distributions (d'). Bias is a general tendency to produce predominantly “possible” or “impossible” responses and is calculated as the distance between the criterion and the intersection of the possible and impossible object distributions (C). When this analysis is applied to the accuracy means reported in previous object decision studies, sensitivity in discriminating possible and impossible objects is greater than 0 for unprimed objects, but bias (to respond one way or the other) is near 0 for unprimed objects (as depicted in Fig. 1).

Of greatest interest are the effects of previous processing of objects on signal detection measures of object decision performance. When signal detection analysis is applied to the results from studies using the standard object decision procedure (e.g., Ratcliff & McKoon, 1995, Experiment 1; Schacter et al., 1990, 1991), greater sensitivity is found for primed objects than for unprimed objects and a greater bias to respond “possible” is found for primed objects than for unprimed objects (as depicted in Fig. 2). According to the present model, the increased sensitivity and increased bias for primed objects are due to memory encoding and/or representational changes that occur during the processing of those objects during the encoding phase of the experiment. The probability distributions for primed objects are shifted relative to those for unprimed objects because primed distributions reflect not only the likelihood that the test objects weakly activate various pre-experimentally stored representations (like unprimed distributions do) but also the likelihood that they activate any new representations stored and/or representations modified during the initial encoding of the primed objects during the experiment.

In the following study, we used this model to measure changes in sensitivity and bias in object decision performance that are due to previous processing of objects. Most important, we tested specific hypotheses of the information storage that causes such changes.

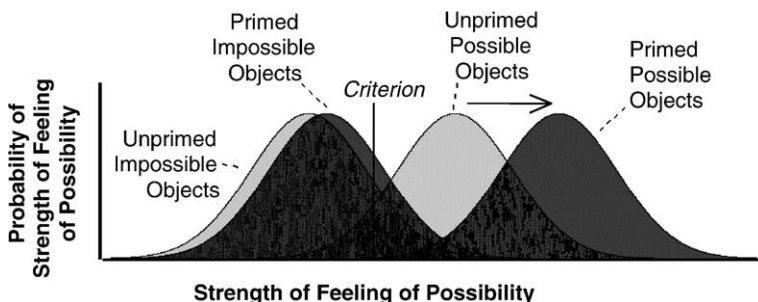


Fig. 2. According to signal detection analyses applied to the results from previous studies using the standard object decision procedure, sensitivity is greater for primed than for unprimed objects and a bias to respond “possible” is greater for primed than for unprimed objects.

4. Potential memory sources and signal detection measures

When the standard procedure is used in this paradigm, three potential memory sources may contribute to performance during the test phase (see Fig. 3). These memory sources have different putative effects on the probability distributions in the signal detection model.

The structural description system posited by S&C is a single store that should underlie priming effects leading to the pattern depicted in Fig. 3A. The probability

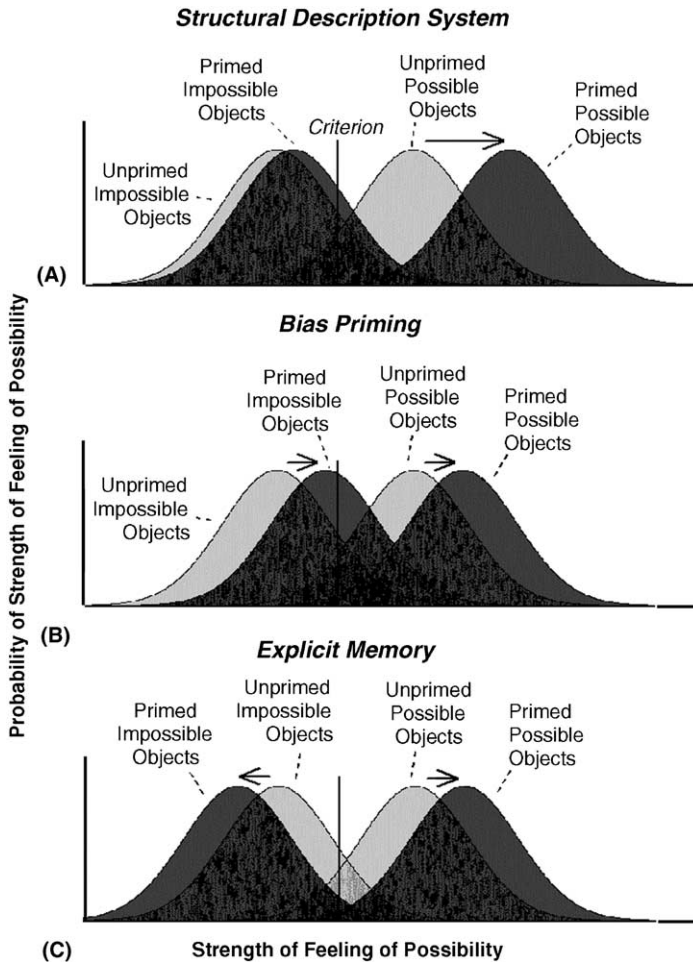


Fig. 3. Effects of three potential memory sources on the probability distributions in a signal detection model of object decision performance: (A) priming (only for possible objects) in a structural description system, (B) “bias priming” of both possible and impossible objects, and (C) explicit memories for the processing events during which primed (possible and impossible) objects were encoded. (Note that the lack of complete overlap between the distributions for unprimed impossible objects and primed impossible objects in panel A is purely for the purpose of enabling views of both distributions.)

distribution for primed possible objects should be shifted to the right compared with the distribution for unprimed possible objects, but this shift should not occur for impossible objects, because the system should support priming only for possible objects. Representations for possible objects that were recently activated should be easier to reactivate than representations for possible objects that were not, causing an increase in the feeling of possibility for primed possible objects.

In contrast, the kind of bias priming mechanism posited by R&M should lead to the pattern depicted in Fig. 3B. The probability distributions for both primed possible and primed impossible objects should be shifted to the right compared with the distributions for unprimed objects. This mechanism should involve structural or decision changes in perceptual processing that occur for both possible and impossible objects, enabling reactivation of both to be easier when primed than when unprimed, and causing an increase in the feeling of possibility for both primed possible objects and primed impossible objects. (It should be noted that priming from the familiarity memory source posited by S&C could also lead to the pattern in Fig. 3B, but putatively not under the standard conditions for the object decision task.)

Finally, explicit memories for the processing events during which primed objects are encoded should lead to the pattern depicted in Fig. 3C. Such representations should have the effect of shifting the distribution for primed possible objects to the right and shifting the distribution for primed impossible objects to the left. Explicit memory can include contextual information such as the action performed with a certain stimulus during a processing episode. Especially if object possibility decisions are made during the encoding phase (as in the following experiments), explicit memory representations may include the decisions that were given to the primed objects. If so, primed possible objects should activate memories that the objects were encoded earlier and given “possible” judgments, which should increase the feeling of possibility, and primed impossible objects should activate memories that the objects were encoded earlier and given “impossible” judgments, which should decrease the feeling of possibility. Indeed, this kind of effect has been observed in the analogous task of lexical decision. Memory traces that contain previous decisions made to nonword strings have been evidenced when nonwords are repeated between encoding and test; when the lexical decision task is used during both encoding and test (but not otherwise), repeated nonwords are given “nonword” judgments more quickly than new nonwords at test (Zeelenberg, Wagenmakers, & Shiffrin, 2004). For an apparently similar finding in a neuroimaging study of repeated size judgments for familiar objects, see Dobbins, Schnyer, Verfaellie, and Schacter (2004).

It is important to note that multiple memory sources may influence shifts of probability distributions (even Schacter & Cooper (1995) noted that tasks rarely are process pure (e.g., Jacoby, 1991)). Thus, the pattern of results from past studies using the standard procedure—greater sensitivity for primed than for unprimed objects and a greater bias to respond “possible” for primed than for unprimed objects (see Fig. 2)—could reflect different situations. It may reflect priming in a structural description system alone (Fig. 3A), as hypothesized by S&C, or it may reflect a combination of bias priming (Fig. 3B) and explicit memory (Fig. 3C), as hypothesized by

Table 1
Theoretical perspectives and empirical predictions

Experiment	Predicted object decision sensitivity	Predicted bias to respond “possible”	Theoretical memory source(s)
<i>Schacter and Cooper</i>			
Experiment 1	Primed > unprimed	Primed > unprimed	Structural description system
Experiment 2	Un-rotated primed > 180°-rotated primed	Un-rotated primed > 180°-rotated primed	Structural description system
<i>Ratcliff and McKoon</i>			
Experiment 1	Primed > unprimed	Primed > unprimed	Explicit memory (sensitivity) Bias priming (bias)
Experiment 2	Un-rotated primed = 180°-rotated primed	Un-rotated primed > 180°-rotated primed	No explicit memory for olds Bias priming (bias)
<i>Marsolek and Burgund</i>			
Experiment 1	Primed > unprimed	Primed > unprimed	Explicit memory (sensitivity) Perceptual priming (bias)
Experiment 2	Un-rotated primed = 180°-rotated primed	LH: Un-rotated primed > 180°-rotated primed RH: Un-rotated primed = 180°-rotated primed	No explicit memory for olds LH: Parts-based priming (bias) RH: Whole-based priming (bias)

R&M (for summary, see Table 1). A goal of the following study was to test these alternative explanations using signal detection measures.

Certain signal detection measures are particularly appropriate for addressing this question. Snodgrass and Corwin (1988) demonstrated mathematically and empirically that signal detection theory using logistic distributions and the measures d_L and C_L produces an index of sensitivity that is independent of bias. Other models and indices exhibit non-independence in that a decrease in sensitivity decreases the range of values that can be attained in the bias measure. Because one of the present theories is that different memory sources underlie only a change in bias due to previous encoding (Fig. 3B) vs. only a change in sensitivity due to previous encoding (Fig. 3C), independent measures of sensitivity and bias are needed to test the theory. Using the recommended measures, we first attempted to replicate the previous sensitivity and bias results in object decision priming. Then, we tested whether a particular experimental manipulation would have qualitatively different effects on sensitivity and bias, to test whether different memory sources contribute to performance in different ways.

5. Experiment 1

During the initial encoding phase, participants performed the object decision task with a series of possible and impossible objects presented for five seconds each in the central visual field. These presentations allowed relatively robust inspection of the

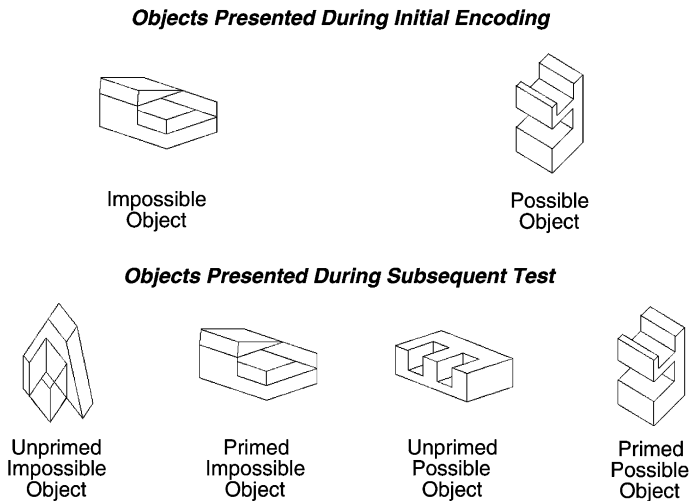


Fig. 4. Examples of impossible and possible objects and the priming status conditions (unprimed vs. primed) used in Experiment 1.

primed objects, and this task allowed the judged possibility statuses of the objects to be part of the encoding events. During the subsequent test phase, participants performed the object decision task with primed and unprimed objects presented briefly in the left visual field (directly to the right hemisphere; RH) or briefly in the right visual field (directly to the left hemisphere; LH). These presentations did not allow robust inspection of the objects, presumably encouraging participants to access feelings of possibility to perform the task. (The manipulation of hemisphere of direct test presentation was important for the purposes of Experiment 2 and will be discussed later.) It is important to note that the unprimed objects were new objects that were structurally unrelated to the primed objects in this experiment (see Fig. 4).

The main goal for this experiment was to replicate the pattern of results obtained when signal detection measures are calculated from the accuracy means reported in previous object decision studies using the standard object decision procedure (e.g., Ratcliff & McKoon, 1995, Experiment 1; Schacter et al., 1990, 1991). In particular, we tested whether sensitivity is greater for primed than for unprimed objects and whether a bias to respond “possible” is greater for primed than for unprimed objects.

5.1. Method

Participants: Sixty-four male undergraduate students from the University of Arizona or the University of Minnesota volunteered to participate for payment or for course credit. All were restricted to be fairly strongly right-handed as assessed through the Edinburgh Handedness Inventory (range of laterality quotients = .50–1.0; mean = .82; Oldfield, 1971) and had normal or corrected-to-normal vision.

Exclusively right-handed males were tested in the experiments reported in this article because they generally exhibit more reliable hemispheric asymmetries than do females and left-handed males (see, e.g., Hellige, 1993), and we were interested in any potential hemispheric asymmetries (see Experiment 2). No participant was tested in more than one experiment reported here.

Design: Test object type (possible vs. impossible), priming status (primed vs. unprimed), and hemisphere of direct test presentations (LH vs. RH) were within-participants independent variables, in a $2 \times 2 \times 2$ factorial design.

Materials: Stimuli were line drawings of 40 possible and 40 impossible objects (collected from various sources including Cooper et al., 1992; Cowan, 1977; Draper, 1978; Huffman, 1971; Penrose & Penrose, 1958; Schacter & Cooper, 1993; Schacter et al., 1990, 1991; Sugihara, 1982). Agreement about the possible or impossible nature of the objects was assessed by presenting an original set of objects to 40 additional participants and asking them to judge each object as possible or impossible (and to provide confidence judgments) when given unlimited viewing time. Each participant classified 80 of the original set of 160 objects, and these classifications were used to select the set of 80 objects that were used in the experiment. On average, the 40 possible objects selected for use were classified as possible by 98% of the participants and the 40 impossible objects selected for use were classified as impossible by 94% of the participants. The raters also indicated which, if any, of the objects seemed familiar to them. Few were judged as familiar, but those that tended to be judged as such were excluded from the set of 80 objects selected for use in this study. Examples of the objects used are presented in Fig. 4.

Each of the groups of 40 possible objects and 40 impossible objects were divided into four lists of 10 objects. Lists were equated so that they did not differ significantly from each other in terms of mean proportion agreement or mean level of confidence in object judgments. Within-participants conditions were created by crossing prime type (primed vs. unprimed) with hemisphere of direct test presentations (LH vs. RH), and each of the possible-object and impossible-object stimulus lists was rotated through those four conditions across participants for counterbalancing purposes. Thus, each cell in the design was represented by 10 possible-object and 10 impossible-object trials per participant. Counterbalancing assured that each possible and impossible object (including left/right reflections of each object, which was held constant for each participant) represented each experimental condition equally often across all participants.

Stimuli were presented on an Apple RGB Monitor with a Polaroid CP-50 filter placed over it to reduce glare, and presentations were controlled by a Macintosh II or IIsi computer. The objects were presented in black lines against a white background, and each object subtended 7.5 – 6.7° of widest (horizontal or vertical) visual angle. A 2 mm dot (subtending 0.23° of visual angle) served as the central fixation point that indicated the beginning of a trial. Objects appeared in the center of the monitor during the encoding phase of the experiment. During the test phase, objects were presented in the left or right visual field such that the center of each object was 7.7° from the center of the monitor, and the inner edge of an object never appeared closer than 4.0° from the center, virtually assuring that objects were presented di-

rectly to only one hemisphere. Finally, a chin rest was employed to keep participants' eyes approximately 50 cm from the monitor.

Procedure: Participants were tested in individually conducted sessions. Each experimental session had an encoding phase and a test phase.

During the initial encoding phase, participants viewed 20 possible and 20 impossible objects (40 objects total; plus 5 filler objects—three at the beginning and two at the end—to attenuate primacy and recency effects) and decided whether each object was possible (could exist in three dimensions) or impossible (could not exist in three dimensions). Before the encoding phase began, the experimenter made sure that each participant understood this distinction and answered any questions about it.

Each encoding trial began with the presentation of a fixation point, which appeared at the center of the display for 500 ms. Participants were instructed to focus on this fixation point. Then, an object was presented in the center of the display for 5 s, and participants pressed one of two keys on the keyboard after the disappearance of the object to indicate their judgment. The assignment of keys to responses was counterbalanced across participants. In addition, half of the participants used their right hand to respond, and half used their left hand to respond.

The list of encoding objects was presented twice in succession, to encourage substantial priming for each item, and participants were told to follow the same instructions in the second iteration as they had followed in the first. For each of the two successive list presentations, a different pseudorandom order was used for the experimental trials. These orders were random with the constraints that no more than three objects appeared consecutively that were possible or impossible or that would be presented in the right or left visual field at test.

During the subsequent test phase, participants were presented with the same possible and impossible objects that they viewed during the encoding phase (40 primed objects) intermixed with a set of 40 objects that were previously unseen (unprimed objects). Participants were instructed to decide as quickly and accurately as possible whether each object was possible or impossible. Therefore, the test phase contained 80 trials. Two of the possible-object lists (20 objects) and two of the impossible-object lists (20 objects) were primed, and the other two possible-object lists (20 objects) and the other two impossible-object lists (20 objects) were unprimed. Within each of the primed and unprimed possible and impossible object conditions, one list was presented directly to the LH (in the right visual field; 10 objects) and the other list was presented directly to the RH (in the left visual field; 10 objects).

Each test trial began with the presentation of the fixation point at the center of the display for 500 ms. Participants were encouraged to focus on the fixation point when it appeared and not to anticipate which side of the point the next object would appear. Immediately after the fixation point disappeared, an object appeared in the left or right visual field for 183 ms. A blank screen followed and remained until the participant pressed a response key to indicate whether the object was possible or impossible. Participants used the same keys to indicate possible and impossible responses as they had during the encoding phase, and they used the same hand to respond as they had during the encoding phase. Ten additional trials appeared at the beginning of the test phase for practice and warm-up. Trials were presented in orders that were

random but with the constraints that no more than three objects appeared consecutively that were possible or impossible, were presented in the right or left visual field, or were primed or unprimed.

5.2. Results

Two repeated-measures analyses of variance (ANOVAs) were conducted to examine object decision performance during the test phase, one with sensitivity (d_L) as the dependent measure and the other with bias (C_L) as the dependent measure. To calculate these measures, “possible” responses to possible objects were considered hits, “possible” responses to impossible objects were considered false alarms, and the signal detection model was based on logistic distributions (Snodgrass & Corwin, 1988). Because estimates of d_L and C_L are undefined when hit or false alarm proportions are 0 or 1, proportions of 0 were converted to $1/(2N)$ and proportions of 1 were converted to $1-1/(2N)$, with N referring to the number of trials contributing to the proportion, as recommended by Macmillan and Creelman (1991). This experiment was designed to allow signal detection measures to be calculated for each subject, but for archival purposes the mean probabilities to respond “possible” are reported for all conditions in Table 2. In both ANOVAs, priming status (primed vs. unprimed) and hemisphere of direct test presentations (LH vs. RH) were within-participants independent variables.

Sensitivity: Fig. 5 displays the important results from the analysis of sensitivity (d_L) in Experiment 1. As predicted, object decision sensitivity was greater for primed objects (2.35) than for unprimed objects (1.77), resulting in a main effect of priming status, $F(1, 63) = 16.3$, $p < .001$, $MSe = 1.29993$. This effect did not interact with hemisphere of direct test presentations, $F < 1$. Indeed, simple effect contrasts revealed that, when objects were presented directly to the LH, sensitivity was greater for primed (2.28) than for unprimed objects (1.64), $F(1, 126) = 9.18$, $p < .01$, $MSe = 1.41228$, and when objects were presented directly to the RH, sensitivity was greater for primed (2.42) than for unprimed objects (1.90), $F(1, 126) = 6.02$, $p < .05$, $MSe = 1.41228$. The main effect of hemisphere of direct test presentations was not significant, $F(1, 63) = 2.57$, $p > .11$, $MSe = 0.99587$.

Bias: Fig. 6 displays the important results from the analysis of bias (C_L) in Experiment 1. As predicted, the bias to respond “possible” was greater for primed objects

Table 2
Proportions of “possible” responses in Experiment 1

Test object type	Priming status			
	Unprimed		Primed	
	LH	RH	LH	RH
Possible	.69	.69	.77	.79
Impossible	.35	.32	.33	.32

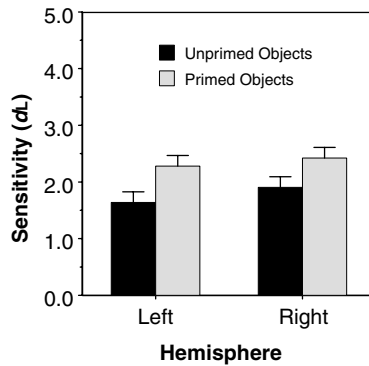


Fig. 5. Results from Experiment 1, in which object decision performance was measured for primed and unprimed objects (and unprimed objects were new objects that were structurally unrelated to the primed objects). Object decision sensitivity (d_L) is displayed as a function of priming status (unprimed vs. primed) and hemisphere of direct test presentations (left vs. right). Error bars indicate standard errors of the mean.

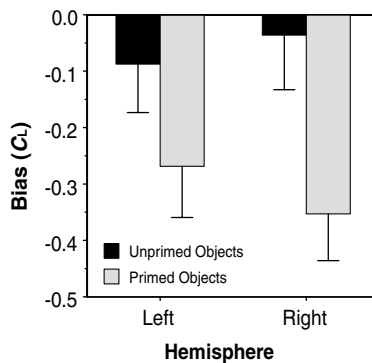


Fig. 6. Results from Experiment 1, in which object decision performance was measured for primed and unprimed objects (and unprimed objects were new objects that were structurally unrelated to the primed objects). Bias (C_L) in object decision performance is displayed as a function of priming status (unprimed vs. primed) and hemisphere of direct test presentations (left vs. right). Error bars indicate standard errors of the mean.

(-0.31) than for unprimed objects (-0.06), in a main effect of priming status, $F(1, 63) = 14.5$, $p < .001$, $MSE = 0.27448$. This effect did not interact with hemisphere of direct test presentations, $F(1, 63) = 1.01$, $p > .30$, $MSE = 0.28718$. Indeed, simple effect contrasts revealed that, when objects were presented directly to the LH, the bias to respond “possible” was marginally greater for primed (-0.27) than for unprimed objects (-0.09), $F(1, 126) = 3.78$, $p < .06$, $MSE = 0.28083$, and when objects were presented directly to the RH, the bias to respond “possible” was significantly greater for primed (-0.35) than for unprimed objects (-0.04), $F(1, 126) = 11.4$,

$p < .001$, $MSe = 0.28083$. The main effect of hemisphere of direct test presentations did not approach significance, $F < 1$.

5.3. Discussion

As expected, greater sensitivity in discriminating possible and impossible objects was observed for primed objects than for unprimed objects, and a greater bias to respond “possible” was observed for primed objects than for unprimed objects. This pattern of results replicates the pattern of results obtained when signal detection analyses are applied to the accuracy means reported in previous experiments using the standard object decision procedure (e.g., Ratcliff & McKoon, 1995, Experiment 1; Schacter et al., 1990, 1991). More important, the replication indicates that our stimuli and procedure are capable of producing the (typical) pattern of results reflecting the model in Fig. 2. In addition, these results were not influenced by hemisphere of direct test presentations, suggesting no hemispheric asymmetries in the operations of the memory source(s) contributing to performance in Experiment 1 (but see also Experiment 2).

Taken alone, the results from Experiment 1 do not unambiguously support one of the relevant theories. The results may reflect priming in a structural description system alone (Fig. 3A), as hypothesized by S&C, or a combination of bias priming (Fig. 3B) and explicit memory (Fig. 3C), as hypothesized by R&M. An interesting and novel way to test these alternatives is to assess whether a particular experimental manipulation will influence the sensitivity and bias effects in qualitatively different manners. One theory is that a single memory store underlies both the sensitivity and bias effects, and if so, a manipulation that influences one effect should similarly influence the other. The other theory is that different memory stores underlie the sensitivity and bias effects, and if so, a manipulation may influence the two effects in qualitatively different manners.

The manipulation examined in Experiment 2 was to replace the unprimed condition of Experiment 1 with a condition in which primed objects were presented in an orientation that was 180°-rotated (in the picture plane) compared with their presentations during initial encoding. In this way, all test objects were presented previously in some way, but half of the test objects were presented in the same orientation as during encoding and half were presented in the 180°-rotated orientation compared with encoding. This manipulation should have different effects on sensitivity and bias in object decisions, according to the following multiple-store analysis.

First, consider the contribution of explicit memory to the object possibility judgments made during the test phase. In Experiment 1, all of the previously presented test objects were presented in the same way that they had been during encoding; they looked just like they did during encoding. In that case, because no modifications were discernible, explicit memories for the encoding experiences with those objects could be trusted as providing valid information about the possibility statuses of those objects. However, in Experiment 2, half of the previously presented objects were modified from how they were presented during encoding (they were rotated); they looked at least somewhat differently from how they did during encoding. In this

case, because modifications should be discernible, explicit memories for the encoding experiences with those objects may not be trusted as providing valid information about the possibility statuses of those objects (at least not as much in Experiment 1). Note that the claim here is that explicit memories for objects stored pre-experimentally still should contribute to performance, thus sensitivity still should be significantly greater than 0 for all conditions in Experiment 2. However, explicit memories for the encoding experiences during the experiment may not be utilized to a high degree.

It is important to note that this kind of prediction is not without precedent in the literature. In Ratcliff and McKoon (1995, Experiment 6) and Williams and Tarr (1997), including test objects that were possibility-modified compared with how they were presented during encoding created a situation in which explicit memory for the previously encoded objects was not evidenced during test. Perhaps more important, there is no theoretical or empirical reason to expect explicit memory to yield a hemispheric asymmetry in Experiment 2. By these considerations, in Experiment 2 little or no sensitivity difference should be observed between the un-rotated primed objects and the 180°-rotated primed objects, and the hemisphere of direct test presentation should not affect the sensitivity results.

Second, consider the contribution of priming in object shape representations to the object possibility judgments made during the test phase. We have hypothesized that dissociable, parallel subsystems underlie object priming (see Marsolek, 1999, 2003; Marsolek & Burgund, 1997). An abstract-category subsystem relies on a features-based processing strategy to store categories of visual objects (e.g., cat), and it operates more effectively than a specific-exemplar subsystem in the LH. In contrast, a specific-exemplar subsystem relies on a relatively image-based processing strategy to store specific exemplars of objects (e.g., an individual cat), and it operates more effectively than an abstract-category subsystem in the RH. In several studies, priming for abstract categories of familiar objects has been observed following presentations of test stimuli directly to the LH and priming for specific exemplars of familiar objects has been observed following presentations of test stimuli directly to the RH (Burgund & Marsolek, 2000; Marsolek, 1999; Marsolek & Burgund, 2003). This hemispheric asymmetry also has been observed for the initial storage of novel two-dimensional forms (Marsolek, 1995), thus the two subsystems could underlie storage of both possible and impossible novel objects as well as familiar objects.

The different processing strategies used by these subsystems should lead to differences in the processing of 180°-rotated primed objects. An abstract-category subsystem is hypothesized to represent two-dimensional category-diagnostic features and their (viewer-centered) spatial relations (see Marsolek, 1995, 2003). Because a 180° rotation of an object changes the spatial relations between features (e.g., above becomes below), this manipulation should detrimentally affect priming in an abstract-category subsystem. In contrast, a specific-exemplar subsystem is hypothesized to rely on more image-based representations of undifferentiated wholes of objects (see Marsolek). Interestingly, a 180° rotation of the kind of straight-edged novel objects used in this paradigm does not dramatically affect an image-based representation. (Note the visual overlap of the two images in Fig. 7; they are located very near

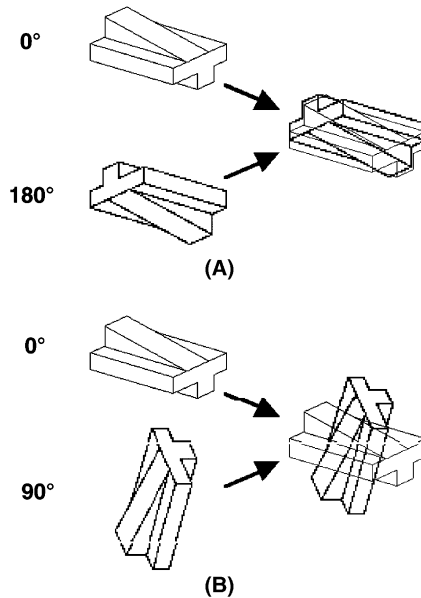


Fig. 7. An example illustrating that un-rotated and 180°-rotated versions of an object typically used in the object decision paradigm are very similar in image space and perceptually (A). As a comparison, un-rotated and 90°-rotated versions are not visually similar in image space or perceptually (B). (These perceptual intuitions were verified psychologically with similarity ratings reported in Experiment 2.)

each other in image space or in any representational space isomorphic with image space, which we verified psychologically with similarity ratings in Experiment 2). Thus, a 180° rotation may not detrimentally affect priming in a specific-exemplar subsystem (at least for the kinds of objects used in object decision studies). By these considerations, significantly greater bias to respond “possible” should be observed for the un-rotated primed objects than for the 180°-rotated primed objects following LH test presentations, but little difference in bias to respond “possible” should be observed between the un-rotated and 180°-rotated primed objects following RH test presentations.

Alternatively, the structural description system hypothesized in the single-store theory leads to different predictions. The structural representations in this system are hypothesized to be reference-frame based and include information about the orientation of the principle axis of an object (Cooper, Schacter, & Moore, 1991). (These are not necessary properties for structural descriptions generally, but they have been hypothesized by those authors.) For this reason, 180° rotations of primed objects should significantly reduce priming, as 90° rotations of primed objects have been shown to do in a previous study (Cooper et al.). Because priming in this system (for possible objects only) should underlie both sensitivity and bias effects (see Fig. 3A), a 180° rotation manipulation should influence both effects in similar ways. Both sensitivity and bias to respond “possible” should be greater for un-rotated primed objects than for 180°-rotated primed objects (for summary, see Table 1).

6. Experiment 2

Experiment 2 was conducted in the same manner as Experiment 1, except that an unprimed condition was not used and a new primed condition was used instead: Half of the test objects were presented in the 180°-rotated (in the picture plane) orientation compared with how they were presented during initial encoding. In this way, all test objects were presented previously in some way, but half of the test objects were presented in the same orientation as during encoding (like the primed objects in Experiment 1) and half were presented in the 180°-rotated orientation compared with encoding (see Fig. 8). Ratings were collected to verify that the 180°-rotated versions of the objects look very similar to their un-rotated versions (see Fig. 7), which was important for the main predictions.

By the multiple-store reasoning presented above, no sensitivity difference should be observed between the un-rotated primed objects and the 180°-rotated primed objects, and the hemisphere of direct test presentation should not affect the sensitivity results. In addition, when test objects are presented directly to the LH, a greater bias to respond “possible” should be observed for the un-rotated primed objects than for the 180°-rotated primed objects, but when test objects are presented directly to the RH, no difference in bias should be observed between those conditions. Such a qualitatively different pattern of results between sensitivity and bias would support the theory that different memory stores contribute to the initial storage of novel objects in this paradigm. In contrast, a similar pattern of results between sensitivity and bias would be in line with the theory that a single memory store underlies the initial storage of novel objects in this paradigm.

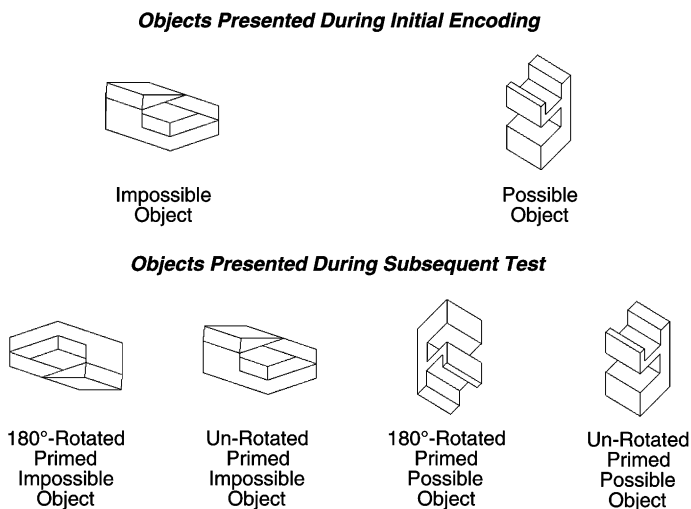


Fig. 8. Examples of impossible and possible objects and the type of primed object conditions (180°-rotated vs. un-rotated) used in Experiment 2.

6.1. Method

Participants: Sixty-four male undergraduate students at the University of Minnesota volunteered to participate for payment or for course credit. All were restricted to be fairly strongly right-handed as assessed through the Edinburgh Handedness Inventory (mean laterality quotient = .86; range = .50–1.0; Oldfield, 1971) and had normal or corrected-to-normal vision. None participated in Experiment 1.

Materials: The objects and counterbalancing lists were the same as those used in Experiment 1. Each object was rotated 180° in the picture plane to produce both an original version and a 180°-rotated version of each object. 320 ratings from each of 10 additional participants confirmed that the 180°-rotated and un-rotated versions of the same objects look very similar visually (4.4 on a 1–7 scale). (As a comparison, random pairings of two different objects elicited 2.1 [$p < .00001$] and 90°-rotated and un-rotated versions of the same objects elicited 2.2 [$p < .0001$] on this scale in the same participants.) Within-participants conditions were created by crossing type of primed object (un-rotated vs. 180°-rotated) with hemisphere of direct test presentations (LH vs. RH), and counterbalancing assured that each object (including left/right reflections of each object, which was held constant for each participant) and each version of each object (original or 180°-rotated) represented each condition equally often across participants. Stimuli were presented on an AppleVision 1710AV Display connected to a Power Macintosh 7600-132, otherwise stimulus presentations were the same as in Experiment 1.

Procedure: The procedure was the same as in Experiment 1, except that during the initial encoding phase, participants viewed 80 experimental objects (as opposed to 40 in Experiment 1). Half of these 80 objects were presented during the test phase as un-rotated primed objects (similar to the 40 primed test objects in Experiment 1), and the other half were presented during the test phase as 180°-rotated primed objects. As in Experiment 1, 10 possible and 10 impossible objects were used in each of the four conditions defined by crossing type of primed object (un-rotated vs. 180°-rotated) and hemisphere of direct test presentations (LH vs. RH).

6.2. Results

As in Experiment 1, two repeated-measures ANOVAs were conducted, one using sensitivity (d_L) and the other using bias (C_L) as the dependent variable. These signal detection measures were calculated in the same manner as in Experiment 1. This experiment was designed to allow signal detection measures to be calculated for each subject, but for archival purposes mean probabilities to respond “possible” are reported for all conditions in Table 3. In both ANOVAs, type of primed object (un-rotated vs. 180°-rotated) and hemisphere of direct test presentations (LH vs. RH) were within-participants independent variables.

Sensitivity. Fig. 9 displays the results from the analysis of sensitivity (d_L) in Experiment 2. Critically, the main effect of type of primed object did not approach significance, $F(1, 63) = 2.28$, $p > .13$, $MSe = 1.41976$, indicating that sensitivity did not differ significantly for un-rotated primed objects (2.12) and 180°-rotated primed ob-

Table 3
Proportions of “possible” responses in Experiment 2

Test object type	Type of primed object			
	180°-rotated primed		Un-rotated primed	
	LH	RH	LH	RH
Possible	.71	.71	.77	.74
Impossible	.31	.36	.35	.33

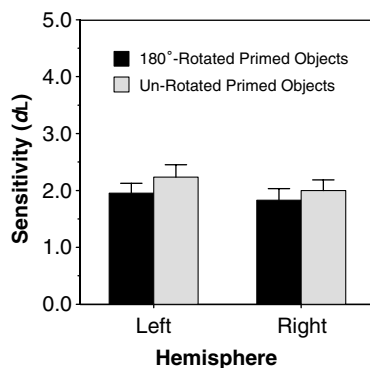


Fig. 9. Results from Experiment 2, in which object decision performance was measured for un-rotated primed and 180°-rotated primed objects. Object decision sensitivity (d_L) is displayed as a function of type of primed object (180°-rotated vs. un-rotated) and hemisphere of direct test presentations (left vs. right). Error bars indicate standard errors of the mean.

jects (1.89). Type of primed object did not interact with hemisphere of direct test presentations, $F < 1$. Thus, simple effect contrasts revealed that, when test objects were presented directly to the LH, sensitivity did not differ between un-rotated primed objects (2.24) and 180°-rotated primed objects (1.95), $F(1, 126) = 1.72$, $p > .19$, $MSe = 1.48679$, and when test objects were presented directly to the RH, sensitivity did not differ between un-rotated primed objects (2.00) and 180°-rotated primed objects (1.83), $F < 1$. This pattern of results differs from the analogous pattern in Experiment 1, as tested below. The main effect of hemisphere of direct test presentations was not significant, $F(1, 63) = 1.61$, $p > .20$, $MSe = 1.31314$.

Bias. Fig. 10 displays the results from the analysis of bias (C_L) in Experiment 2. Most importantly, the interaction between type of primed object and hemisphere of direct test presentations was significant, $F(1, 63) = 9.12$, $p < .01$, $MSe = 0.17067$. When test objects were presented directly to the LH, the bias to respond “possible” was significantly greater for un-rotated primed objects (−0.31) than for 180°-rotated primed objects (−0.04), $F(1, 126) = 12.5$, $p < .001$, $MSe = 0.18615$, for the simple effect contrast. However, when test objects were presented directly to the RH, the bias to respond “possible” did not differ for un-rotated primed objects (−0.15) and 180°-rotated primed objects (−0.19), $F < 1$, for the simple effect contrast. This pattern of

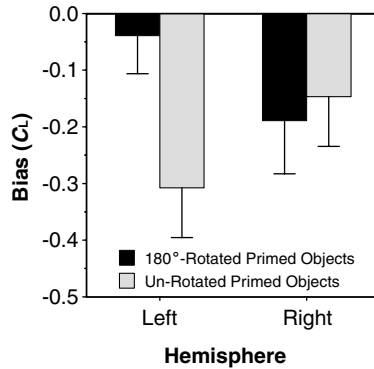


Fig. 10. Results from Experiment 2, in which object decision performance was measured for un-rotated primed and 180°-rotated primed objects. Bias (C_L) in object decision performance is displayed as a function of type of primed object (180°-rotated vs. un-rotated) and hemisphere of direct test presentations (left vs. right). Error bars indicate standard errors of the mean.

results differs from the analogous pattern in Experiment 1, as tested below. Also, the main effect of type of primed object was significant, $F(1, 63) = 4.10$, $p < .05$, $MSe = 0.20163$, but the main effect of hemisphere of direct test presentations did not approach significance, $F < 1$.

Combined results from Experiments 1 and 2. In order to test directly the differences in results between Experiments 1 and 2, we conducted two additional sensitivity (d_L) and bias (C_L) ANOVAs. Each analysis was the same as the ANOVAs reported above but also included Experiment (Experiment 1 vs. Experiment 2) as a between-participants variable.

In the analysis of sensitivity, an a priori interaction contrast was calculated to test whether sensitivity was greater for primed (2.35) than for unprimed objects (1.77) in Experiment 1, but sensitivity did not differ for un-rotated (2.12) and 180°-rotated primed objects (1.89) in Experiment 2. This contrast was significant, $F(1, 126) = 12.4$, $p < .001$, $MSe = 1.35984$.

In the analysis of bias, an a priori interaction contrast was calculated to test whether bias to respond “possible” was found for primed but not unprimed test objects both when test objects were presented directly to the LH (−0.27 vs. −0.09) and when test objects were presented directly to the RH (−0.35 vs. −0.04) in Experiment 1, but bias to respond “possible” was found for un-rotated primed objects and not for 180°-rotated primed objects when test objects were presented directly to the LH (−0.31 vs. −0.04) and such bias was found for both of those conditions when test objects were presented directly to the RH (−0.15 vs. −0.19) in Experiment 2. This contrast was significant, $F(1, 378) = 14.5$, $p < .001$, $MSe = 0.32748$.

6.3. Discussion

Two qualitatively different patterns of results were observed in the sensitivity and bias measures. First, sensitivity did not differ for un-rotated primed objects and 180°-

rotated primed objects following either direct LH or direct RH test presentations. In contrast, bias to respond “possible” was greater for un-rotated primed objects than for 180°-rotated primed objects when they were presented directly to the LH, but bias to respond “possible” did not differ for un-rotated primed objects and 180°-rotated primed objects when they were presented directly to the RH. In addition, these results differed significantly from the results in Experiment 1 in predictable ways. The different pattern of results between sensitivity and bias supports the theory that different memory stores contribute to the initial storage of novel objects in this paradigm, one that affects sensitivity (explicit memory for previous object encoding experiences) and one that affects bias (repetition priming in dissociable object recognition subsystems). A similar pattern of results between sensitivity and bias was needed to support the theory that a single memory store underlies the initial storage of novel objects in this paradigm.

7. General discussion

When signal detection analyses are applied to the results from previous object decision studies using the standard object decision procedure (e.g., Ratcliff & McKoon, 1995, Experiment 1; Schacter et al., 1990, 1991), sensitivity is greater for primed than for unprimed objects and a bias to respond “possible” is greater for primed than for unprimed objects. This pattern of results was replicated in Experiment 1, in both direct LH test presentations and direct RH test presentations. Such a pattern of results may reflect priming in a structural description system alone (Fig. 3A), as hypothesized by S&C, or a combination of bias priming (Fig. 3B) and explicit memory (Fig. 3C), as hypothesized by R&M.

However, in Experiment 2, a particular experimental manipulation influenced the sensitivity and bias effects in qualitatively different ways. Sensitivity did not differ for un-rotated and 180°-rotated primed objects, in both direct LH test presentations and direct RH test presentations. In contrast, bias to respond “possible” was greater for un-rotated than for 180°-rotated primed objects when test objects were presented directly to the LH and not when test objects were presented directly to the RH. The sensitivity and bias measures used in this study are independent (Snodgrass & Corwin, 1988), thus the finding of a manipulation that influences the two measures in qualitatively different ways is important. It suggests that different memory stores contribute to the initial storage of novel objects in this paradigm, one that affects sensitivity and another that affects bias.

These results support a multiple-store perspective. However, it is important for us to emphasize that our theory has both interesting differences and interesting similarities when compared against the R&M and S&C perspectives.

An important similarity between our theory and R&M’s theory is that separate memory stores contribute to object decision performance, one affecting sensitivity (explicit memory for the previous encoding experiences) and the other affecting bias. An important difference, however, is in the location and cause of the bias effect. Most

recently, R&M concluded that bias effects take place in a decision node that operates after object processing in a neural network model, rather than within the perceptual processing of objects in the model (Rouder, Ratcliff, & McKoon, 2000). Our theory (Marsolek, 2003) is that changes in bias reflect interesting aspects of perceptual information storage (cf. Williams & Tarr, 1997); in particular, they reflect small (presumably synaptic) changes in the weights of the neural networks underlying visual object recognition (cf. McKoon & Ratcliff, 1995), rather than a form of response or decision bias. Also, such priming effects occur within both abstract-category and specific-exemplar subsystems of visual-form recognition, which operate with different relative efficiencies in the two cerebral hemispheres. Small weight changes can occur during encoding of both possible and impossible objects, causing re-representations of both to be stronger during test. This is why a “bias priming” pattern was observed in both hemisphere conditions of Experiment 1. However, the weight changes that occur in an abstract-category subsystem in the LH should not support priming for 180°-rotated primed objects, even though the weight changes that occur in specific-exemplar subsystem in the RH should support priming for them. This is why a “bias priming” pattern was not observed for 180°-rotated primed objects following direct LH test presentations, but was observed following direct RH test presentations.

An important similarity between our theory and S&C’s theory is that dissociable neural systems are critically important for a full understanding of memory. Perceptual priming is supported by small changes in a number of perceptual systems that can operate independently from explicit memory. Different encoding tasks can affect the levels of priming in these systems without influencing explicit memory (Cooper & Schacter, 1992; Marsolek & Burgund, 1997). Also, dissociable visual-form subsystems may exist within the larger “perceptual representation system” and operate with different relative efficiencies across the cerebral hemispheres (Marsolek, Schacter, & Nicholas, 1996). An important difference between theories, however, is that neither of our hypothesized visual-form subsystems operates in the manner hypothesized for S&C’s structural description system. Neither the abstract-category subsystem nor the specific-exemplar subsystem stores three-dimensional structures or models of shape per se (as in Biederman, 1987; Hummel & Biederman, 1992; Hummel & Stankiewicz, 1996; Marr, 1982; Winston, 1975), but instead operate like neural network models with distributed representations that store even three-dimensional objects as two-dimensional representations (see Marsolek, 2003; Marsolek & Burgund, 1997, and for other biologically plausible two-dimensional models, see Edelman, 1998; Edelman & Bülthoff, 1992; Ullman, 1996). This is why priming for impossible objects as well as priming for possible objects can occur in these subsystems (as evidenced in Experiments 1 and 2). Also, our theory is that explicit memory for the previous encoding experiences with objects does contribute to performance in the object decision task. This is why sensitivity was greater for primed than for unprimed objects in Experiment 1.

If so, however, an important question for our theory is why do amnesic patients (with impaired explicit memory) exhibit apparently normal effects in the object decision task? Schacter, Cooper, Tharan, et al. (1991) tested amnesic patients, matched control subjects, and (unmatched) college students, and concluded that priming did

not differ between groups (despite impaired recognition memory for the objects in the amnesic patients). Applying signal detection analyses to their results, we found that all three groups, including the students, exhibited very low sensitivity overall (no greater than 0.57 for combined primed and unprimed objects in any group, compared with 2.06 for combined primed and unprimed objects in the present Experiment 1; see Fig. 5). In fact, the age/education-matched control group and the student group both exhibited below-0 sensitivity for unprimed objects (−0.40 and −0.16, respectively); they exhibited a greater likelihood to respond “possible” to unprimed impossible objects than to unprimed possible objects. Relatively high variance from small samples may have caused spuriously low sensitivity levels in the study with patients (Schacter et al. tested six subjects per group, using 20 possible and 20 impossible objects per subject, which contrasts with the 64 subjects per experiment and 40 possible and 40 impossible objects per subject in the present study).

In line with this possibility, Schacter et al. (1993) compared amnesic patients with age/education-matched control subjects using 12 subjects per group, and sensitivity for the unprimed objects improved. Sensitivity for unprimed objects in the control group (1.82) was similar to sensitivity for unprimed objects in the present Experiment 1 (1.77), but sensitivity for unprimed objects in the amnesic patients was relatively low (1.47). According to our theory, sensitivity for unprimed objects should reflect activation of both explicit memories of pre-experimentally stored experiences with objects and activation of pre-experimentally stored representations in object recognition subsystems. Thus, the lowered sensitivity for unprimed objects in the amnesic patients may reflect an impaired contribution from explicit memory. In addition, the increased sensitivity for primed compared with unprimed objects in the control subjects ($0.54 = 2.36 - 1.82$) was similar to the increased sensitivity in the present Experiment 1 ($0.58 = 2.35 - 1.77$), and both of these increases were greater than that found in the amnesic patients ($0.40 = 1.87 - 1.47$). According to our theory, increased sensitivity for primed compared with unprimed objects should reflect activation of explicit memories for the encoding experiences with the primed objects. Thus, the smaller increase in sensitivity for primed objects in the amnesic patients also may reflect impaired explicit memory. Admittedly, however, amnesic patients did exhibit some increase in sensitivity for primed objects (0.40), which may reflect the fact that none of the patients were densely amnesic (their scores on standard neuropsychological memory tests were significantly lower than the normal population, but not near floor levels).

Another conciliatory theory in this literature is from Williams and Tarr (1997). An important difference between their signal detection model and ours is that they hypothesize a dimension of “amount of structural evidence” instead of feeling-of-possibility. Points on their dimension essentially reflect the number of possible parts that can be discerned in a test object (either possible or impossible) from an analysis of its three-dimensional structure (see also Seamon et al., 1995). Both possible and impossible objects have some possible parts, but possible objects generally have a greater number of possible parts, which is why object decision sensitivity typically is greater than 0 for unprimed objects. In contrast, our feeling-of-possibility dimension reflects weak and imperfect activations of various representations in

storage and does not reflect a full three-dimensional structural analysis of test objects. A full structural analysis likely requires working memory and visual imagery mechanisms, which cannot be put to full use when test objects are presented very briefly. For example, with unlimited viewing times and hence opportunity for full structural analysis, unprimed possible objects are classified as possible at a rate of .98 and unprimed impossible objects are classified as impossible at a rate of .94, yet with brief presentations and hence little opportunity for full structural analysis, unprimed performance is .69 for possible objects and .67 for impossible objects in Experiment 1. In addition, patterns of activation in a neuroimaging study of object decision processing indicate little to no activation in traditional working memory areas of frontal cortex (Schacter et al., 1995). By the Williams and Tarr theory, possible objects always should exhibit a greater shift to the right (on their dimension) than impossible objects, due to priming, because possible objects have a greater number of possible parts to be primed compared with impossible objects. Thus, any greater bias to respond “possible” for primed objects than for unprimed objects always should be accompanied by greater sensitivity for primed than for unprimed objects. The results from the present Experiment 2 do not support this theory. The greater bias to respond “possible” for un-rotated primed objects than for 180°-rotated primed objects presented directly to the LH was not accompanied by greater sensitivity.

The importance of the present research is twofold. Using signal detection theory to distinguish memory stores, the present study helps to resolve the previous debate concerning memory in the object decision task, providing a conciliatory perspective. This research also helps to clarify important properties of the relevant memory stores. For example, storage of impossible objects can be evidenced in this paradigm (as anticipated originally by Schacter et al., 1990), but in qualitatively different ways in more than one memory store. These are fresh contributions to our understanding of the initial storage of novel objects.

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