THE IDENTIFICATION OF NOVEL THREE-DIMENSIONAL OBJECTS: An examination of structurally based fluency

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ABSTRACT

Various dissociations between performance on explicit tasks (those requiring conscious memory) and implicit tasks (those requiring no reference to conscious memory) have been used as support for the existence of multiple systems of memory. Specifically, based on a dissociation between performance on an object decision task and a recognition task, Schacter and Tulving (1990) postulated the existence of a separate system representing possible novel three-dimensional objects as distinct from a system supporting the identification of impossible novel three-dimensional objects. Memory may be better understood in the view of transfer-appropriate processing, however, in which memory relies in part on a fluency heuristic and that subjective processes influence memory. Experiment 1 eliminated the influence of a response bias towards structural "possibility" by involving a decision in which possible and impossible objects were classified together as three-dimensional objects, as distinct from two-dimensional objects. Both possible objects and impossible objects benefited equally from previous exposure. Experiment 2 employed a "go-no/go" task but was unsuccessful in manipulating the response bias in order to create an advantage for identification of studied impossible objects. These results have suggested that by eliminating the bias towards structural possibility, impossible objects benefit from experienced fluency. Further discussion of the process of memory has been provided.

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Introduction

Research on memory suggests that some kinds of learning and retrieval are available to consciousness while other kinds are not. On the basis of the presence of awareness, the existence of an explicit/implicit memory dichotomy has been postulated (Schacter, 1987). Explicit memory is revealed by tasks that require conscious memory of the experience. In contrast, implicit memory is revealed by tasks in which performance is facilitated by previous experience, but for which recollection is not required. That is, previously acquired information is unintentionally retrieved with no reference to any explicit instructions to remember the task.

Various dissociations between performance on explicit and implicit memory tasks have been demonstrated by normal performance on one test despite impaired performance on the other. Evidence from brain damaged patients and intact adults indicates that performance on explicit memory tasks may be selectively impaired (Richardson-Klavehn & Bjork, 1988). These findings have traditionally provided evidence for the existence of separate systems under the assumption that these measures tap different memory systems in the brain (e.g., Tulving and Schacter, 1990, Squire, 1987). Proponents of a *multiple memory systems* approach postulate that performance on implicit memory tasks is mediated by a different underlying system than is performance on explicit memory tasks (Tulving & Schacter, 1990).

The obtained data, however, do not necessitate the postulation of separate underlying memory systems. An alternative approach to explaining the dissociations between explicit and implicit memory, referred to as *transfer-appropriate* procedures, argues that different memory processes operate within a unitary system. That is, performance on an explicit or implicit memory test may be attributed to different functions of the same underlying system. Performance may be related to the degree to which the processing operations in which the item was originally encoded are reinstated at the time of test.

In the spirit of transfer-appropriate processing, the possible existence of independent memory stores will be examine. Specifically, the focus will be on the structural description store, one particular implicit memory system, postulated by Schacter and colleagues (Schacter & Tulving, 1990; Schacter, Cooper, Delaney, Peterson, & Tharan, 1991*a*; Schacter, Cooper, Tharan, & Rubens, 1991*b*). This specific memory system has been described as storing three-dimensional representations of objects that can exist in the real world. This description of the structural description store, however, is theoretically sparse in that it offers little information as to the nature, or process, of memory. Rather, the transfer appropriate processing view may offer insight as to the memory processes occurring during the confrontation of an object.

Priming: Multimodal View

Direct priming, the facilitative effect of prior experience on indirect tests of memory, is an extensively studied type of implicit memory. The effect can be demonstrated by an increase in the accurate identification of previously encountered targets or as a reduction in response latency compared to nonstudied control items. Tulving and Schacter (1990) have advanced a theory in which priming on implicit tasks of memory is mediated by a perceptual representation system (PRS). They hypothesize that priming aids in the identification of previously encountered stimuli by relating the present structural information with the information stored in PRS (Tulving & Schacter, 1990). This process is hypothesized to differ from recognition memory, in which operations consist of a successful matching between the stimulus and its prior semantic and episodic representations. That is, both priming and recognition memory are facilitated by prior study, but priming is due to the representation of the studied objects in the structural description store, whereas recognition memory depends on information stored in explicit/episodic memory.

The PRS model makes many assumptions regarding the structure and function of memory. For instance, it implies that memory consists of a number of systems with different and independently operating characteristics. For example, the visual word form system and the structural description system are hypothesized subsets of the PRS: the former is solely concerned with perceptual identification of words and the latter with objects. Both are conceptualized as being specialized for representing global information about the visual form and structure of words and objects, and may be involved in object decision priming and other implicit tasks. Both, however, exclude handling of any semantic or associative properties. In other words, PRS is thought to represent information at a presemantic level (Tulving & Schacter, 1990).

The object decision task, developed by Schacter, Cooper, & Delaney (1990) and a recognition task are used together extensively to assess the relationship between implicit and explicit memory processes. The two tasks are comparable since the object decision task, like other implicit tasks, is believed not to rely on the direct use of explicit memory for earlier presentations of test items. Line drawings of novel three-dimensional structurally possible and impossible objects were constructed and presented to subjects (see *Appendix 1*). Half of the objects were constructed such that they could exist in a three-dimensional world. The other half depicted structurally impossible objects that could not exist as three dimensional objects due to surface and edge violations. These novel objects are thought to not have preexisting representations in memory and to be independent of the idiosyncratic properties of verbal material (i.e., "semantic baggage"), since the subjects have never seen the objects before the study phase.

In the first phase of the experiment, subjects were encouraged to study the objects and make a decision regarding the direction to which the object faced (i.e., "left-right"), which was thought to encourage the processing of the global object. Following the study phase, subjects were then measured on implicit and explicit tasks. Priming, the facilitative effect of prior experience on indirect tests of memory, was assessed by an object decision task in which the subjects, given a brief exposure to the object, decided whether each drawing was structurally possible or impossible. Priming was indicated by more accurate object decision performance for previously studied possible objects than for nonstudied possible objects. Impossible objects, however, did not show the effect of priming.

This object decision task is considered to be an implicit task, separate from explicit memory, in the sense that it does not make reference to, or require recollection of any specific encounter with a presented object. In fact, results differ when explicit instructions for retrieval are given. For the explicit component of the test, subjects performed a conventional recognition test (i.e., "yes-no"). The identical stimuli were included, but subjects were now required to remember whether they had studied them. Generally, recognition was found to be slightly more accurate for the possible objects than for the impossible objects.

Based on the object decision task, Schacter and his colleagues (Schacter, Cooper, Delaney, & Peterson, 1990; Schacter et al., 1991a) advance several tenets regarding the nature of priming (i.e., the characteristics of PRS). First, priming of *possible* objects is mediated by newly acquired structural descriptions of target drawings. Priming occurs only on an object decision task which is thought to encourage the processing of information regarding global features (i.e., a task regarding the orientation of an object: "is the object facing left or right?"). Facilitation for possible studied items does not occur, however, when attention is directed only to local features (i.e., a task regarding structural detail of an object: more "horizontal lines vs. more vertical lines").

Second, priming is observed only for structurally possible objects. Priming was never found for structurally impossible objects despite various modifications of the instructions emphasizing "impossible" over "possible" responses, minor changes in the nature of the material, and manipulations of the number and duration of exposure of items on the study list (Schacter et al, 1990; Schacter et al., 1991a). Lack of priming of impossible objects is thought to reflect computational constraints in coding a structural description that preserves global, three-dimensional information since there are no consistent internal representations of the impossible object in the three-dimensional world. Therefore, Schacter proposes that the representation of impossible objects is supported by a separate episodic memory system. This system is thought to rely on access to information regarding the distinctive spatial, temporal, contextual and semantic aspects of the impossible objects.

The multimodal approach does not provide an understanding of how objects might be represented in the system or what kinds of processes might operate on those representations. The findings provide evidence as to what conditions produce priming, but offer little formal theory as to why a prior representation would lead to priming. Overall, the structural description store model proposed by Schacter and colleagues suffers from several criticisms. First, explaining the dissociations in terms of multiple systems may be unnecessary. Relevant dissociations can be easily understood in terms of processing operations carried out during study and test without postulating the existence of separate memory systems. Rather, the differences between performance on the recognition task and performance on the object decision task may be viewed as reflections of different processes operating in a single memory processing system. Evidence suggests that dissociations may be produced by different retrieval processes operating on a single memory system (Feustel, Shiffrin, & Salasoo, 1983). Second, as pointed out by Coltheart (1989), each dissociation would lead us to hypothesize the existence of yet another memory system or subsystem. This further fractionation may lead "to an unhealthy proliferation of subsystems" (p. 285). Such a descriptive model would lend little information regarding the nature of memory. Third, priming and other forms of memory are not mutually exclusive. For example, there are similarities between the two, such as benefits from repetitions (Kersteen-Tucker, 1991; Feustel, et al., 1983).

Alternative View: Transfer-Appropriate-Processing

Dissociations between implicit and explicit memory may be attributable to different processes operating within a single memory system (Jacoby & Dallas, 1981; Masson, 1989). Priming may reflect the operations performed during encoding and retrieval tasks. The unimodal model is supported by the principle of transfer-appropriate processing, in which performance on a memory task depends on the match between the processing operations performed during initial encoding and those performed when reinstated at the time of test. Thus, knowledge is represented in terms of the "procedures or operations applied during interaction with symbols and objects" (Masson, 1989, p. 128).

Memory is posited to operate primarily on the basis of the fluent reapplication of the procedures used during original encoding in response to a retrieval cue. Memory is enhanced when there is adequate overlap or similarity between the procedures involved in both the encoding and retrieval phases. Furthermore, Jacoby and Dallas (1981) have suggested that implicit identification depends on data-driven processing derived from perceptual properties of study and test materials (i.e., bottom-up processing), while explicit tasks depend on conceptually driven encoding, such as elaboration of meaning (i.e., top-down processing). Therefore, according to the unimodal view, the dissociation found between the different memory systems may really only be reflecting the different types of processing within the same episodic memory system.

The processing approach offers a dynamic view of memory and attempts to do more than merely identify a task with a particular system. From this perspective, it may be that memory relies in part on a fluency heuristic and that subjective processes influence priming. Although most memory research has focused on objective results on performance tasks, subjective experience involves an attribution, or unconscious inference, that is affected by past and present memories. The subjective experience of remembering involves an "automatic" feeling of familiarity in that judgments are made faster and less effortful (Jacoby, 1992). The feeling of familiarity, independent of awareness of remembering, results from the enhanced perceptual recognition of an item that comes from having studied the item in the experimental situation. That is, prior exposure to an item results in more fluent processing, whereby the material is more easily identified relative to new items.

Perceptual fluency is thought to be a basis for the feeling of familiarity or in other words, the basis for remembering. The ease with which an item "pops into mind" or the relative fluency of a task may serve to be evidence that we are remembering. Mere exposure of a stimulus influences subjects to judge that they have seen the stimulus before because the processing of the item seems relatively fluent. This reliance upon differences in processing may be a heuristic used for recognition memory. People may infer that items must have occurred earlier since they were felt to be processed easily (i.e., was processed more fluently). For instance, subjects report that "old" items seem to "jump out" on a test of recognition memory (Jacoby & Dallas, 1981).

The feeling of familiarity, however, may also be responsible for misattributions in memory due to difficulty in distinguishing between factors of subjective experience and of the past. For instance, words that are more easy to perceive may be judged as being familiar and may be misidentified as having been presented before. Prior experience with items has even influenced subjective experience on cognitive judgments such as preference, in that subjects like the random polygons to which they had already been exposed better than novel ones (Kunst-Wilson & Zajonc, 1980). Also, visual perceptual identification of prior presented words is affected by fluency. Words already read by subjects were reported as staying on the screen longer and being easier to report (Jacoby & Dallas, 1981).

It may be that a misattribution of this feeling of familiarity, based on perceptual fluency, can account for the null results found for priming of impossible objects. The feeling of familiarity may have led to a bias in the attribution process. On first presentation of both the impossible and possible objects during the study phase, there is no contact with an existing prior representation of the item. On the repeated presentation of the item, however, the episodic trace formed during study may be accessed. Prior exposure to both the possible and impossible objects may result in perceptual enhancement which evokes a feeling of familiarity. Subjects may rely upon a familiarity heuristic in which the feeling of familiarity of fluent processing of previously encountered objects (both possible and impossible objects) creates a bias to classify those objects as possible. In other words, the perceptual fluency associated with the object may be misattributed, and the subject's judgment could be as follows: "if I can process this item more easily than other items in the list, it must be a possible object, since possible objects seem easier to process compared to impossible objects". This misattribution may be responsible for the incorrect classification of impossible studied items.

This claim is supported by the existence of reverse priming, the tendency to respond more correctly to nonstudied items than to studied items. In several experiments (Schacter, Cooper, & Delaney, 1990; Schacter, et al., 1991a), performance for studied impossible objects was somewhat lower (although not significantly) than for nonstudied impossible objects, thereby indicating an enhanced tendency to say "possible" to studied impossible objects. It was previously postulated that if the tendency to respond possible is indeed due to a misattribution, then by removing the response bias, priming would be uncovered (i.e., there would be an advantage for the correct identification of old impossible objects relative to new impossible objects). The response bias may work in opposition to the otherwise "normal" effects of priming for impossible objects. It was reasoned that manipulating the instructions on the object decision task may influence the response bias. If subjects are consciously aware of their reliance on this "flawed" strategy, they may purposefully attempt to utilize an alternative approach. That is, if subjects are explicitly made aware that there is a tendency to misattribute fluency on decision tasks, they may avoid any cues from the feeling of familiarity, thereby overriding the use of perceptual fluency. Therefore, the bias towards responding "possible" for old impossible objects may be eliminated and priming for impossible objects may emerge. Earlier pilot experiments (*see Appendix* 2), however, were unsuccessful in demonstrating this effect despite manipulation of the instructions, suggesting the my hypothesis was not sufficient.

A bias was hypothesized by Schacter and colleagues (Schacter, et al., 1990b) to be operating at the time of initial encoding and therefore, the instructions for the object decision test were encouraging subjects to detect possible objects. In one experiment, subjects were instructed to press a response key for the object decision task if it "could be a possible object" and another response key if it "could *not* be a possible object". Since the emphasis is placed on the detection of "possibility", subjects may have equated an impossible response as being a negative response, and may have a preference to use a positive response. Instructions were further altered to examine this bias. Subjects were now required to press one response key if it "could be a possible object" and another response key if it "could be an *impossible* object". The negative connotation associated with the instructions was thought to be removed, yet priming was still not found for impossible objects (Schacter et al., 1990).

Instructions were also manipulated in an attempt to address the possible contribution of a response bias for the negative priming effect found with impossible objects (Schacter, et al., 1991a). Subjects were explicitly informed on the object decision task that half the objects were possible and the other half were impossible. On previous tests, subjects were only informed that some of the objects were possible. This manipulation in the instructions, however, did not produce priming for impossible objects. Despite other attempts, such as further modification of task instructions, inclusion of repetitions in encoding tasks, and different structural encoding tasks, Schacter and colleagues failed to document priming of impossible objects.

Similarly, in an earlier study, instructions were intended to inoculate the subjects against the use of the familiarity heuristic as a basis for an object decision judgment. Subjects were accurately informed following the encoding phase that half of the objects were possible and the other half were impossible. They were further cautioned that any sense of familiarity experienced with an object should not influence their decision as to whether the object is structurally possible or impossible since there is an equal chance of the object being one or the other. Despite these instructions, the data did not support the existence of priming for possible objects. Furthermore, on a second unsuccessful attempt, subjects were informed prior to the encoding phase that they would be viewing structurally possible and impossible objects and would be required to make an "impossible-possible" judgment. Also, prior to the test phase they were cautioned against reliance on familiarity since it is not informative as to the structural nature of the object. No information regarding the probability of the presentation of the possible and impossible objects was offered. Similarly, priming for impossible objects did not occur.

Furthermore, Schacter and his colleagues (Schacter, et al., 1991a) analyzed the combined data for possible and impossible objects in an attempt to measure accuracy on the object decision task, independent of response bias. The gamma correlation (i.e., Yule Q statistic) analyzes the orthogonal combination of subjects' actual responses (possible/impossible) and of object type (possible/impossible). Q's were computed separately for studied and nonstudied items. The larger the Q value, the stronger the association between subject's responses and object types, revealing more accurate object decision performance, independent of response bias. Priming was reflected by an increase in the accuracy of object decision performance for studied objects relative to nonstudied objects as indicated by significantly higher Q values for studied items. Therefore, Schacter and colleagues conclude that priming results from an increase in the accuracy due to prior exposure to the studied items as opposed to a generalized bias to use the possible response more frequently for studied than for nonstudied objects. Although Schacter's application of Yule's Q does address a bias towards a preponderance of either possible or impossible responses, this analysis falls short when addressing the hypothesis under consideration here. That is, Yule's Q does not address the nature of the bias to say "possible" when fluency is experienced and a feeling of familiarity is evoked.

Ratcliff and McKoon (1993) demonstrate an alternative approach which may essentially address the bias arising from the feeling of familiarity. Conscious memory may supplement implicit processing in the object decision task. Subjects do make use of explicitly remembered information even when the task instructions do not require them to do so. The extraction of explicit information regarding some detail of the previously studied object may act as a cue as to whether the object was possible or impossible. Therefore, in conjunction with the response bias, recollection may influence whether the object is reported as being possible or impossible. For example, if the previously studied object is possible, then the bias towards responding possible to more familiar objects and explicit memory for cues about the object work in concert to produce a "possible" response. If confronted with a previously studied impossible object, however, then these two processes work in opposition. The tendency to respond possible is cancelled out by the explicit memory for a particular impossible feature of the object. For example, subjects sometimes explicitly remember a particular corner, angle, or twist from an impossible object, and this information can be used to counteract the bias to respond possible. Therefore, explicit retrieval must be eliminated in order to observe a clear picture of priming.

Ratcliff and McKoon (1993) argued that the response bias and explicit retrieval work against each other to produce the null effect of priming for impossible test items. First, they examined the operation of a bias by eliminating *explicit retrieval*. They suggested that explicit retrieval is likely to be a relatively slow process and may be eliminated by imposing deadlines (i.e., restricted time to respond) and memory loads (i.e., performance on concurrent memory tasks). The response bias was observed for both the possible and impossible objects, in that impossible objects showed reversed priming. In other words, the study phase increased the probability of responding possible (incorrectly) to impossible objects.

Second, Ratcliff and McKoon (1993) attempted to eliminate the *response bias* by combining a similarity and forced choice task. An object was flashed and was immediately followed by the presentation of the identical object as well as another version (i.e., either possible or impossible). Subjects had to decide which of the two displayed objects was the one that had been previously flashed. When the subject is faced with two similar objects, they both may appear equally familiar, even though only one had been previously studied. Therefore, familiarity would offer no basis on which to chose one object over the other. The authors concluded that since the bias for the two objects was sufficiently equated, subjects were left with neither the bias nor the explicit information to influence their decisions. By eliminating the response bias towards possible, a symmetrical null effect of prior exposure was found for both possible and impossible objects.

Ratcliff and McKoon (1993) successfully demonstrated the existence of a response bias and the contribution of explicit retrieval. It appears that prior exposure has an influence on the subject's tendency to respond possible. Ratcliff and McKoon, however, did not demonstrate general improved accuracy in the classification of objects due to prior exposure. Rather, their argument precludes the possibility of past experience leading to subsequent accuracy on a task. It can be argued, however, that the associated fluency, as a result of prior experience, leads to improved accuracy with items.

To reiterate the view derived from transfer-appropriate processing, pure fluency serves to enhance the identification of both possible and impossible objects, but is differentially obscured by the operation of a response bias. When studied objects are identified, a feeling of familiarity is experienced because the object has been fluently processed. A response bias then arises to attribute the experienced fluency, or feeling of familiarity, to some factor. How this experienced fluency is attributed ultimately influences the classification decision.

The response bias, will artificially pull the responses in different directions. For example, subjects may rely on the bias that "easily processed items are possible". Therefore, an advantage is created for possible objects (i.e., accuracy for possible old objects will be enhanced), whereas, a disadvantage is created for impossible objects (i.e., accuracy for impossible old objects will be reduced).

The purpose of Experiment 1 is to test the hypothesis that fluency associated with prior experience aids in the correct identification of studied objects. In order to circumvent the response bias, subjects will perform a judgment in which a discrimination between two and three-dimensional objects is made. Both possible and impossible objects are classified together as three-dimensional objects in an attempt to discourage any fluency ascribed towards structural *possibility*. Subjects reinstate the already processed structural three-dimensional information of each object. Similar processes may occur for both the structurally possible objects and the impossible objects: both or neither objects should demonstrate priming. Therefore, by removing the bias by placing the possible and impossible objects in the same category, the contribution of fluency on the subsequently correct identification of objects will be examined.

In summary, the demonstration of priming for both possible and impossible objects will provide evidence for the important role of fluency. Indeed, if impossible objects do benefit from prior exposure (although conceivably masked by the operation of a response bias) priming will occur when the response bias associated with structural "possibility" is eliminated.

Experiment 1

To address the proposed biased response to fluency (particularly noticeable for the impossible objects), the retrieval task was manipulated. Similar effects of priming may occur for both possible and impossible objects if the basis of responding is restricted. By choosing a task in which possible and impossible objects are classified together, (i.e., both as three-dimensional objects) the bias to classify fluently processed items as possible is eliminated. During the test phase, subjects were asked to discriminate between two-dimensional and three-dimensional objects. Therefore, the bias towards using the possible response for studied items may be eliminated since there is no longer an emphasis towards structural possibility. If the bias towards possibility is eliminated, the priming effect for the possible objects and the misattribution for the impossible objects will be removed and the resulting level of priming should be similar. In other words, information regarding structural possibility is now deemed useless and may not provide a differential basis for judgment. Rather, subjects are left with the experienced fluency of the items. Since both possible and impossible objects receive similar direct enhancement from prior exposure, the effect of priming will be similar. In other words, if the bias is no longer operative, both the possible and impossible objects will either experience a null effect of priming or a similar effect of priming.

Thus, it may be a response bias, aided by prior experience with the object, that influences accuracy on the object decision task. By removing the bias, the result is a difference in the level of discriminability between the objects, or in signal detection theory terminology, a difference in "sensitivity". An examination of the influence of prior experience with an object can be made, since signal detection theory will allow an independent assessment of sensitivity and bias. When left with only a measure of sensitivity, prior experience with the object would not be expected to differentially influence accuracy for the identification of impossible and possible objects.

Priming has been reported by Schacter and colleagues (Schacter et al., 1990b) to occur on object decision tasks only when global three-dimensional features of the object are encoded (i.e., "Left-Right" encoding task), but not when attention is directed only to local features (i.e., "Horizontal-Vertical" encoding task). Thus, the "Left-Right" encoding task has been taken as a marker of three-dimensional processing that contributes to subsequent priming on an object decision task. Both local and global encoding phases are incorporated into the design of this experiment as a basis for dissociating performance on an object decision task from a recognition task. It is imperative to set up a dissociation between the object decision task and the recognition task in order to rule out the contribution of explicit memory on the object decision task. Unlike the object decision task, the recognition task is thought to not depend on the nature of the encoding task: both the "Left-Right" encoding task and the "Horizontal-Vertical" encoding task produce equal priming. A dissociation in performance on these two tasks would suggest that the object decision task is not being powerfully affected by recollection.

In summary, the present experiment will help to identify memory processes. From a multimodal perspective, bias would be due to the representation of the object in memory. It is thought that only the privileged intrinsic properties of possible objects achieve a level of representation and result in subsequent facilitated identification (Tulving & Schacter, 1990). Since impossible objects do not have a prior representation, identification should be no better than if the object had not been studied. On the other hand, prior experience with both possible and impossible items may enhance accuracy in the classification task and the operation of a response bias may influence the actual expression of "priming".

Method

Subjects. Ninety-six undergraduates were recruited from an Introductory Psychology course in exchange for course credit. Subjects were randomly assigned to the experimental conditions. All had normal or corrected-to-normal vision and were naive regarding the purpose of the experiment.

Stimuli. The experimental materials consisted of 48 two-dimensional line drawings depicting unfamiliar three-dimensional objects and 48 two-dimensional line drawings of unfamiliar two-dimensional objects (*see Appendix 3*). All 48 of the three-dimensional objects were taken from the materials used by Schacter (Schacter, et al., 1991a). Half of the objects were impossible, in that they contained edge and surface violations and, therefore, could not exist in the real three-dimensional world. The practice materials consisted of 8 items. Half of the eight practice items consisted of structurally possible objects, and the other half were structurally impossible objects.

The two-dimensional objects were constructed by varying the original three-dimensional objects. The outlines of the three-dimensional objects were maintained but mirror reversed. The internal features of each object were redrawn to remove any properties reflecting three-dimensionality. work indicated that at an unlimited exposure duration, subject's accuracy in discriminating between the two and three-dimensional objects ranged between 96-100% suggesting that the objects were discriminable on the basis of dimensionality. Furthermore, the two and three-dimensional objects were equated in terms of complexity. The original three-dimensional objects were comparable with their corresponding newly created two-dimensional objects on the basis of the number of lines and vertices for each object.

Design. The experiment was a 2 ("left-right" vs. "horizontal-vertical" encoding task) X 2 (object decision vs. recognition tasks) X 2 (possible vs.

impossible objects) X 2 (studied vs. nonstudied) repeated measures design. The encoding phase (i.e., "left-right" vs. "horizontal-vertical") and test phase (i.e., object decision vs. recognition tasks) were between-subject variables, whereas possible vs. impossible and studied vs. nonstudied were within-subject variables.

In the study phase, two of the groups were instructed to compare the number of horizontal and vertical lines in each of the two and three-dimensional objects. The other two groups were instructed to compare vertical and horizontal lines in each of the two dimensional objects but to decide for each of the three-dimensional objects whether it was facing right or left. In the test phase, one group from each encoding task condition was given a recognition memory test and the other group was given an object decision test. Twenty-four subjects participated in each of the four conditions. Twenty-four two-dimensional objects and their corresponding 24 three-dimensional objects were shown in separate blocks in the study phase. The two-dimensional objects were shown first, followed by all the three-dimensional objects; or vice-versa. Of the three-dimensional objects, half were possible and the other half were impossible. In the test phase, all of the two and three dimensional objects were be randomly presented in a single block.

Procedure. (see Appendix 4 for a summary of the procedure). Subjects were individually seated 50 cm. from a Macintosh computer screen. Subjects were initially informed that the experiment was concerned with object perception and were provided with instructions pertaining only to the current phase of the experiment. In the study phase, two relevant practice items appeared at the beginning of each block of 24 critical items (one block of two-dimensional items and one block of three-dimensional items).

For the block in which three-dimensional objects were presented, half the subjects performed a task involving the encoding of the global features of the object. Subjects in this "left-right" encoding condition were instructed to make a decision as to whether the object primarily faces left or right. The other half of the subjects were involved in an encoding task directed to local features of the object. In this "horizontal-vertical" encoding condition, subjects were instructed to indicate whether the object had more horizontal or vertical lines. All subjects performed this task with the two-dimensional objects. Each object was presented for 5 seconds. Once the object disappeared from the screen, subjects in both encoding tasks were required to press either the rightmost or leftmost key on a response pad to indicate their binary decision. Subjects were encouraged to use the entire 5 second exposure duration to examine the objects since the objects are more complex than they may initially appear. Once a response was made, the next trial followed automatically.

Subjects proceeded to the test phase immediately after completion of the encoding phase. Half the subjects in the "left-right" judgment and in the "horizontal-vertical" judgment encoding condition participated in an object decision task. First, the experimenter presented the subjects with instructions explaining the difference between two-dimensional and three-dimensional objects.

Subjects were informed that some of the three-dimensional objects were structurally possible and some were structurally impossible. They were instructed to press the leftmost button if the object is two-dimensional and to press the rightmost button if the object three-dimensional. Each trial was initiated by a fixation point, to which the subjects were to direct their attention. The objects were presented for a 50 ms duration and were immediately followed by a mask. In addition, trials were self-paced; each trial began when the subject pressed the middle key on the response pad.

Ninety-six objects were presented, of which 48 were two-dimensional and 48 were three-dimensional. Half of the three-dimensional objects were possible objects and the other half were impossible objects. Within each object type (possible, impossible, or two-dimensional) half the objects were viewed during the encoding phase and half were not seen before. The object decision task was preceded by eight practice trials, half consisting of previously displayed practice items and 4 showing new items.

The other half of the subjects participated in the recognition task. Subjects were informed that they will be presented with a series of line-drawings, some of which will have been presented in the study phase and some of which are new. Subjects were further instructed to press the rightmost button if they had seen the object before and to press the leftmost button if they had not seen the object before. The stimuli were identical to those presented for the object decision task. The objects appeared on the screen until the subject responded, or until a maximum duration of 5 seconds. The task began with the presentation of 8 practice trials.

At the completion of testing, all subjects were debriefed and provided with a written explanation of the purpose and background of the research.

Results

The results of performance on the object decision task and the recognition task were analyzed and are described separately.

Object Decision. A signal detection analysis was applied to the effects observed in the object decision task. Signal detection analysis takes into account both successes (hits) and failures (false alarms) and allows for an independent assessment of the influence of prior exposure on enhanced perceptual sensitivity and the contribution of biased operations applied to the perceptual stimuli. The purpose of Experiment 1 was to establish that in the absence of a response bias, priming effects in the object decision task may occur for both possible and impossible objects, based on operations responsible for "low-level vision" (e.g., feature extraction and identification). If no difference in sensitivity occurs between possible and impossible objects, then the results imply that both classes of objects invoke similar perceptual processing operations. If, however, a difference in sensitivity does arise between the possible and impossible objects, then the results would suggest that there may be indeed certain constraints that operate on the processing of certain objects.

Table 1 presents the central results for performance on the object decision task, expressed as hits and false alarms on the two-dimensional vs. three-dimensional judgment, as a function of the experimental variables: type of encoding task (horizontal-vertical vs. left-right), the structure of the object (possible vs. impossible), and the item status (studied vs. nonstudied). Hits were defined as correctly identifying a three dimensional object as such (i.e., responding "three-dimensional" to a three-dimensional object), and false alarms were defined as incorrectly claiming that a two dimensional object was three dimensional (i.e., responding "three-dimensional" to a two-dimensional object).

Table 1
Object Decision Performance: Experiment 1

	Possible		Impossible		Mean	
	Studied	Nonstudied	Studied	Nonstudied	Studied	Nonstudied
Horizontal-Vertical						
HR	.88	.86	.86	.83	.86	.85
FA	.28	.33	.28	.33	.28	.33
A′	.88	.85	.86	.84	.87	.85
B_D''	-.41	-.43	-.33	-.34	-.37	-.39
Left-Right						
HR	.84	.81	.81	.76	.83	.79
FA	.45	.44	.45	.44	.45	.44
A′	.78	.75	.77	.75	.78	.75
B_D''	-.54	-.50	-.44	-.34	-.49	-.42

HR=Hit Rate; FA=False Alarm; A′=Sensitivity; B''_D=Response Bias
Note: FAs for both possible and impossible objects are the same due to the nature of the classification decision.

Several important features of these data should be noted. Performance on the horizontal-vertical encoding task appears to be more accurate than performance on the left-right encoding task as indicated by higher hit rates and lower false alarm rates. Also, for both possible and impossible objects, there appears to be facilitation of object decision performance on studied items compared with nonstudied items. This priming effect is contrary to the usual priming effect (Schacter et al., 1991a; Schacter et al., 1991b) thought to be attributed to structural encoding.

Statistical analysis confirm this description of the results. A nonparametric signal detection analysis (Donaldson, 1992; Grier, 1971) was applied to these data in order to gather an independent assessment of the influence of prior exposure on discriminability (i.e., sensitivity) and response bias. The measure of sensitivity, A′, takes a value of .5 when responding is at chance and 1.0 when performance is perfect. The decision criterion measure, B_D'', is larger when a higher criterion is in effect and ranges from -1.0 (maximum liberal bias) to 1.0 (maximum conservative bias). The mean values of the obtained A′ and B_D'' in the object decision task are presented in Table 1.

Separate repeated measures analysis of variance (ANOVA) were applied to the sensitivity (i.e., A′) and the decision criterion (i.e., B_D'') scores. In this and all other analyses reported here, type I error rate was set at .05. The between-subjects factor was encoding; the within-subjects factors were prior exposure and structure. For the sensitivity data, the main effect of (left-right vs. horizontal-vertical) encoding was significant, $\underline{F}(1, 46) = 13.69$, $\underline{MS}_e = .04$, indicating that object decision performance was more accurate following local encoding (i.e., horizontal-vertical encoding) than involving global encoding (i.e., left-right encoding). The main effect of (studied vs. nonstudied) prior exposure was significant, $F(1, 46) = 6.08$, $MS_e = .01$, in which object decision performance was more accurate for studied than nonstudied drawings. The main effect of (possible vs. impossible) structure failed to reach significance, $F(1, 46) = 1.121$, $MS_e = .01$, as did any interactions. For the response bias data, the main effect of (possible vs. impossible) structure was significant, $F(1, 46) = 4.61$, $MS_e = .11$, indicating a more liberal bias to respond to possible objects (e.g., a propensity to classify any possible object as three-dimensional). The main effects of prior exposure and encoding and their interaction did not reach significance. Furthermore, an examination of gender as a factor produced null results. The sample group retained a preponderance of female subjects, however, thereby making the results difficult to interpret.

Recognition. Table 2 presents the central results for performance on the recognition task for the three-dimensional objects, expressed as hits and false alarms on the yes-no judgment, and A′ (sensitivity) and B_D'' (response bias), as a function of the experimental variables: structure (possible vs. impossible) and type of encoding task (horizontal-vertical vs. left-right). Hits were defined as correctly identifying an object as having been seen before (i.e., a "yes" response to an old item), and false alarms were defined as incorrectly claiming to have seen the object before (i.e., a "yes" response to a new item). Our results indicate that performance is above chance (i.e., hit rates are higher than false alarm rates). Overall, accuracy in the recognition task is lower than in the object decision task. Performance appears to be more accurate in the left-right encoding task compared to performance on the horizontal-vertical encoding task as indicated by slightly higher hit rates.

Table 2
Recognition Performance: Experiment 1

	Possible	Impossible	2D
Horizontal-Vertical			
HR	.50	.45	.55
FA	.19	.29	.49
A′	.72	.62	.56
B_D''	.55	.42	-.03
Left-Right			
HR	.65	.62	.52
FA	.28	.34	.43
A′	.77	.71	.57
B_D''	.09	.06	.09

HR=Hit Rate; FA=False Alarm; A′=Sensitivity; B''_D=Response Bias

Statistical analysis, as described in the object decision section, was applied to these data. ANOVA's were performed separately for the three-dimensional objects for the measures of sensitivity (i.e., A′) and response bias (i.e., B_D''). A dissociation between explicit and implicit memory was demonstrated by the pattern of data. For A′, the main effects of (possible vs. impossible) structure, $F(1, 46) = 4.40$, $MS_e = .03$ was significant indicating an advantage for the identification of possible objects. The main effect of encoding approached significance, $\underline{F}(1, 46) = 3.10$, $\underline{MS}_e = .04$, although there was a trend towards the identification of global objects (left-right). The ANOVA performed on the response bias data (i.e., B_D'') yielded a significant main effect of encoding, $\underline{F}(1, 46) = 10.28$, $\underline{MS}_e = .40$, indicating that a more conservative bias exists towards the identification of objects in the local encoding (i.e., horizontal-vertical) condition compared to the global encoding condition. The main effect of structure and the interaction between structure and encoding did not reach significance. Furthermore, two-dimensional objects were not included in the analysis as they do not have a "possible-impossible" distinction and were exposed to only the "horizontal-vertical" encoding task. Statistical analysis, however, confirmed that there were no significant effects of hit rate, false alarm, sensitivity, or response bias for the two-dimensional objects ($\underline{F} < 1$).

Discussion

The results of Experiment 1 indicate that performance on the object decision task was facilitated by prior encoding of the global and local features of both familiar possible and impossible objects. This pattern of results for the object decision task differs from that presented by Schacter and colleagues (Cooper, Schacter, Ballesteros, and Moore, 1992; Schacter, et al., 1990a; Schacter, et al., 1991a; Schacter, et al., 1991b) who reported that only possible objects benefited from prior exposure following exclusive encoding of global features. The present results demonstrate, however, that impossible objects benefited from prior exposure and achieved a level of representation for both encoding tasks, although there was an advantage for accuracy in the local encoding condition. Generally, these data raise problems for the interpretation of object decision priming as the product of a perceptual representation system, which is not considered to accommodate impossible objects.

On the other hand, the recognition results mirror those reported by Schacter and colleagues (Schacter, et al., 1990a; Schacter et al., 1990b). First, perceptual sensitivity in the global encoding condition was found to be slightly more accurate than in the local encoding condition (although this trend did not reach significance in the present experiment). Second, recognition of possible objects was higher than compared to recognition of impossible objects.

Had explicit information contributed to performance on the object decision task, the pattern of results would have resembled those found for the recognition task. Clearly, features of these results suggest that different processes involved in the object decision and recognition performance tasks have been tapped. This dissociation between the implicit and explicit tasks provides convincing evidence that recollection does not completely determine the pattern of data found for the implicit task. The first distinction between the two tasks was that for the recognition task, possible objects were more easily recognized compared to impossible objects, whereas prior exposure created no advantage for the possible objects on the object decision task. Second, local (i.e., "horizontal-vertical") encoding produced better performance than global (i.e., "left-right") encoding on the object decision task, but there was a tendency for the reverse pattern for the recognition task. The results approached significance for the encoding condition on the recognition task, demonstrating an advantage for global encoding over local encoding. Thus, it appears that conscious recollection produces a different pattern of results for the recognition task, suggesting that priming is not consciously mediated.

The finding that accuracy for object decision was higher in the local encoding condition is inconsistent with Schacter and colleagues' (Cooper, et al., 1992; Schacter, et al., 1990a; Schacter, et al., 1991a; Schacter, et al., 1991b) reports in which object decision performance was facilitated by prior encoding of only global object structure. It has been demonstrated, however, that object decision performance is not merely facilitated by access to structural descriptions, but that priming may occur following a local encoding task. Given the requirements of the test phase (i.e., the test instructions differ from previous experiments), these results are not surprising when interpreted within the context of transfer-appropriate processing theory. The inclusion of a "two-dimensional vs. three-dimensional" discrimination task may encourage the reinstatement of information specifying features specific to the arrangement of horizontal and vertical lines. Therefore, the local encoding condition may create an advantage since memory for information regarding individual features may be crucial in the decision as to whether the object contains depth or not. In Schacter's previous experiments, the test phase was concerned with whether the object was "possible vs. impossible", a judgment possibly more relevant to information regarding more global features.

An alternative account for the advantage for local encoding may be due to the different task demands involved in encoding. In the global encoding condition, subjects are required to make two different decisions (i.e., "left-right" for the three-dimensional objects and "horizontal-vertical" for the two-dimensional objects), whereas in the local condition the instructions remain constant (i.e., "horizontal-vertical" for both two-dimensional and three-dimensional objects). For those in the dual instructions condition (i.e., global encoding) the inconsistency in encoding instructions may have resulted in generally less efficient processing of information. In the global encoding condition, a post hoc analysis revealed that there was indeed a main effect of order, $\underline{F}(1, 22) = 4.51$, $\underline{MS}_e = .05$. Encoding left-right information following a horizontal-vertical task results in more efficient processing of the three-dimensional objects. Accuracy is poorer when presented first with the left-right instructions without the prior aid of performing a horizontal-vertical encoding task. It appears that the strategy to encode local features may carry over and create an advantage in the processing of global features (which are less efficiently processed in the two-dimensional/three-dimensional discrimination task).

Also of interest is that fact that the hit rates on the object decision task are substantially higher than those previously reported (Schacter, et al., 1990a; Schacter, et al., 1991a; Schacter, et al., 1991). This was expected, given the different and possibly less difficult task demands involved in the current experiment. The level of accuracy, however, is not at ceiling level, lending confidence to these results.

Generally, in the recognition task, it appeared that the two-dimensional objects were more difficult to differentiate from one another as there were fewer variations in the arrangement of horizontal and vertical lines, compared to constructing objects using depth. Thus, as expected, it was difficult to discriminate between old and new two-dimensional objects given the similarity between these shapes and subjects performed at chance levels.

A systems theorist, who relies on dissociations to define different systems, may interpret these results as evidence for another type of representational system that includes impossible objects and may be appropriate for two-dimensional and three-dimensional discrimination. Rather than accounting for these data by merely postulating the existence of yet another system, the transfer-appropriate processing framework may be adopted. These data provide considerable support for the proposal that priming in object decision involves the experience of fluency accompanying both the possible and impossible items. The normal operation of fluency for the impossible objects is masked by the presence of a bias towards classifying fluently processed objects as possible and by the contribution of explicit retrieval of information about these objects. By minimizing the operation of a response bias and the contribution of explicit factors, impossible objects are indeed processed similarly to possible objects. That is, the pure effect of priming on object decision tasks occurred for possible and impossible studied objects.

In summary, this experiment demonstrated that both impossible and possible objects receive a similar advantage derived from prior processing. This finding supported the hypothesis that previously exposed objects receive an advantage for priming due to a misattribution of perceptual fluency towards some factor. In certain situations in which there was a bias towards "possibility", subjects are more likely to attribute perceptual fluency to structural "possibility". In theory then, if the bias is shifted towards "impossibility" subjects are more likely to attribute perceptual fluency to structural "impossibility". Experiment 2 addresses this issue. Since Experiment 1 revealed an advantage of prior exposure for impossible objects, it may be able to take this process one step further. That is, the strategies used to create an advantage for "possible" objects may be manipulated towards creating an advantage for "impossible" objects.

Experiment 2

By removing the bias to ascribe fluency to structural possibility, the results reflect an advantage in processing for both possible and impossible objects in both encoding conditions. This finding suggests that priming may be influenced by the operation of a response bias. Thus, it may be possible to shift the response bias from a drive to classify a familiar object as "possible" to classify a familiar object as "impossible". As a result, we may demonstrate priming for impossible objects at the expense of priming for possible objects. Thus, perceptual fluency may now be associated with structurally "impossible" objects, and subsequent encounters with familiar objects may result in the tendency for subjects to respond "impossible".

The bias to respond "possible" may be difficult to overcome since we have more experience with structurally possible 3-D objects. This second experiment employed experimental manipulations to demonstrate that the bias may be reversed and that improvement of processing may be shown to include impossible objects. Subjects were involved in the discussion of structural impossibility in order to create a conceptual framework from which to work. In an attempt to create a bias towards impossibility, subjects were exposed only to structurally impossible objects during the study phase. In the test phase, subjects were presented with old impossible, new impossible, and new possible objects. A "go/no-go" task was employed, in which subjects were required to make a response only when the object was impossible. This was used to influence subjects to seek impossibility within the object and hopefully shift the bias towards responding impossible.

Furthermore, it was necessary to ensure that the bias in the typical object decision procedure was not contaminated by a retrieval process that makes explicit information available. Subjects may use extraneous features to act as perceptual cues for discriminating or detracting from the encoding of the global features of the objects. For example, subjects may only direct their attention to a possible subsection of an impossible object and may rely on their memory for possibility. Therefore, to obstruct the retrieval of conscious cues regarding structural possibility, a memory load task was implemented. Subjects were given a list of 4 digits to keep in mind while responding on the object decision test. Thus, these manipulations attempted to "stack the deck" towards more fluent processing of impossible objects.

Method

Subjects. Sixteen undergraduates were recruited from an Introductory Psychology course in exchange for course credit or for five dollars. All had normal or corrected-to-normal vision and were naive regarding the purpose of the experiment.

Stimuli. The experimental materials consisted of 8 practice items and 48 critical items. All items were identical to those used in Experiment 1. There were 24 two-dimensional line drawings depicting unfamiliar three-dimensional structurally possible objects and 24 depicting structurally impossible three-dimensional objects. Half of the eight practice items consisted of structurally possible objects, and the other half were structurally impossible objects.

Design. The experiment was a single repeated measures design. Studied vs. nonstudied was the variable, in which only impossible objects were analyzed. Accuracy was the measure of performance.

All subjects received identical encoding instructions, and exposure to half of the impossible objects. As a counterbalance, one group saw half of the objects and the other group saw the other half. For each of the 12 impossible three-dimensional objects in the study phase, subjects were to decide whether the object was facing right or left. Given that there were so few items, the sample size may have needed to be increased to ensure sufficient power. In the test phase, the 48 possible and impossible objects were randomly presented in a single block. Of the 24 impossible objects, 12 were considered to be studied objects and the other twelve were nonstudied objects.

Procedure *(see Appendix 5 for a summary of the procedure).* Subjects were individually seated 50 cm. from a Macintosh computer screen. Subjects were provided with instructions pertaining only to the current phase of the experiment. Initially, they were informed that the experiment was concerned with the perception of impossible structures. Several examples of impossible drawings, including some Escher sketches, were presented. Subjects were further instructed to make a decision as to whether the impossible object primarily faced left or right. Each of the 12 impossible objects was presented for 5 seconds. Once the object had disappeared from the screen, subjects were required to press either the rightmost or leftmost key on a response pad to indicate their binary decision.

Subjects proceeded to the test phase immediately after completion of the encoding phase. They were informed that the experiment was concerned with their ability to remember numbers as well as their ability to identify impossible objects; therefore, accuracy for both tasks was equally important. Subjects were encouraged to make the judgment regarding structural impossibility as quickly as they could. Furthermore, subjects were told that any familiar objects were impossible objects since they only had prior experience with impossible objects. Each trial was initiated by a fixation point, to which the subjects were to direct their attention. A 4 digit number was presented on the screen for 3 seconds. Subjects were encouraged to keep the number in mind during the present trial. An object was then presented for 50 ms and was immediately followed by the prompt "IMPOSSIBLE?". Subjects were instructed to press a key if they identified the object as being impossible; otherwise, they were to make no response. If the subject indicated no response following 3 seconds, the experimenter pressed a key for the experiment to continue. A "NUMBER?" prompt was then displayed and at this time, subjects were required to report the string of numbers and accuracy was recorded by the experimenter. Each trial began when the experimenter pressed a key. The object decision task began with the presentation of 8 practice trials.

At the completion of testing, all subjects were debriefed and provided with a written explanation of the purpose and background of the research.

Results

Table 3 presents the accuracy results for performance on the "go-no/go" object decision task. All trials were included in the analysis regardless of whether subjects correctly remembered the 4 digit sequence. On the memory performance task, subjects were correct 97% of the time. Clearly, there is an advantage for the selection of impossible objects at the expense of possible objects as indicated by superior accuracy in the impossible condition. A single repeated measures ANOVA, with study as a factor, demonstrated that the difference between studied and nonstudied impossible objects was not significant, ($F < 1$). Therefore, facilitation of studied impossible objects did not occur despite the shift in the decision criterion towards the identification of impossible objects.

Table 3
Proportion Correct on "Go-No/Go" Task

Old Impossible	New Impossible	New Possible
.83	.82	.53

A power analysis (Cohen, 1987) was further conducted to examine whether the sample size was sufficient to support an effect of priming. Taking Schacter's (1990b) effect size of .10 as a benchmark for the expected amount of priming this experiment should produce, a power estimate of .97 was produced. This suggests that the design had enough power to find an effect of that magnitude if it were present. It is apparent that this priming effect was not as big as the effect Schacter and colleagues typically find for their studied and nonstudied possible objects. This condition was unable to support priming.

Discussion

The constraints under which the second experiment was conducted were insufficient to produce priming for impossible objects. Clearly, there was a response bias towards the identification of impossible objects. Accuracy for the impossible objects was high at the expense of the possible objects; which was near chance level. Despite the shift in response bias, we were unable to demonstrate that exposure to impossible objects produces facilitation for subsequent identification. In other words, we were unable to create a situation in which experienced fluency may be misattributed to structural impossibility.

These results may be explained by a number of factors. One possibility is that the conscious decision to call an object "impossible" may have overpowered the less subtle operation of experienced fluency for the object. That is, given the difficulty of the demands of this task, the emphasis on impossibility may have just created a general tendency to call all of the objects "impossible". This bias is reflected by the accuracy for the impossible objects approaching ceiling level, and the accuracy for the "possible" objects remaining at a level of chance. Thus, the effect of prior exposure was once again obscured by the effect of the response bias. An alternative experiment would be needed, however, in order to address the validity of this claim.

The experiment, however, was not without methodological difficulties. A major shortcoming of the design was that the interval following the three-dimensional object and the onset of the presentation of the numbers was not consistent. That is, following the object, if the subject pressed the key (i.e., to indicate an impossible response), then the onset of the number prompt immediately appeared, whereby the subject would report the numbers. If however, the subject did not press a key (to indicate a possible response), then there was a 3 second delay before the number prompt was presented. Because there was an emphasis on the recall of the number string, there was some "pressure" to get on to the number recall phase of the experiment. Thus, it was not surprising that the subjects quickly learned that if they pressed the key (i.e., for impossibility) then they could produce the number string sooner.

Overall, priming is revealed only under certain constraints, as indicated by priming for impossible objects occurring in the two-dimensional/three-dimensional discrimination task, but not either the "go/no-go" task or on earlier work. In these latter experiments the influence of a response bias and possibly of explicit memory was not eliminated.

General Discussion

This research suggests that impossible objects benefit from prior presentation in the same fashion as possible objects. Priming in object decision appears to be influenced by the operation of a bias arising from experienced fluency with the objects. Experiment 1 revealed that both possible and impossible objects benefited from prior exposure when the tendency to misattribute fluency towards structural possibility was eliminated. This finding suggests that the fluency associated with previously exposed objects may be sufficient to support object decision priming.

Furthermore, a dissociation was established between the object decision task and the recognition task, thereby providing convincing evidence in favour of the object decision not being strongly influenced by conscious recollection. Experiment 2, however, was an unsuccessful attempt to create a bias towards structural "impossibility" in order to find an advantage for the processing of studied impossible objects. The methodology was not without flaws, however, and did not provide sufficient evidence to discount the original hypothesis.

Experiment 1 was the first report of an advantage found for the identification of previously exposed impossible objects. A similar approach was cleverly demonstrated by Ratcliff and McKoon (1993) who reported the existence of the bias to respond possible for both possible and impossible objects that had previously been exposed and were further able to eliminate completely the effect of prior study by suppressing the influence of explicit remembering. They did not, however, demonstrate priming for impossible or possible objects.

The results of Experiment 1 raise a number of problems for the interpretation of object decision priming from a multi-store systems viewpoint. First, these data cannot be attributed to a structural description store that encodes possible but not impossible objects (Tulving & Schacter, 1990). Clearly, it has been demonstrated that impossible objects achieve a level of representation. By restricting the basis of responding "two-dimensional vs three-dimensional" in the test phase, it was demonstrated that prior study of impossible objects can affect later object decisions. Second, the results demonstrate that priming of object decision performance is observed not only when encoding tasks involve an encoding task analysis of the global three-dimensional structure of the objects (Schacter, Cooper, & Delaney, 1990), but when subjects were induced to encode local two-dimension features of target items. Indeed, facilitation has been found on the object decision task to be superior after encoding of the horizontal-vertical task. This discrepancy is not easily accounted for by the hypothesized existence of the perceptual representational system.

This theoretical stance may be able to offer some explanation of the processes operating on these representations, unlike that offered by the multi-store hypothesis. Previous interpretation of results from the object decision task assumed a one to one correspondence between the task and the implicit memory system. For example, the object decision showed priming for possible but not impossible objects, and this result was used as evidence that the system could only process possible items. Based on such observations, the representations mediating priming were assumed to be presemantic and hyper-specific abstract structural descriptions that differ from those mediating performance on explicit measures of memory (Tulving & Schacter, 1990). Certainly this description does not offer any explanation of how the system is able to compute the possible items.

Transfer appropriate processing suggests that nonverbal priming is specific to the perceptual operations performed on the studied object. For example, experience with fragmented pictures at study produces greater priming on a task requiring the identification of fragmented pictures than does exposure to intact pictures (Jacoby, Baker, & Brooks, 1989). When study and test items share little in common, very little priming is observed. This suggests that recapitulating the same perceptual operations at study and test produces greater priming than when the perceptual operations required at study are different from the ones required at test.

Furthermore, from the transfer-appropriate processing perspective, implicit tasks are assumed to tap the perceptual aspects of the representation, whereas explicit memory tasks are assumed to tap the meaning-based aspects of the representation (Roediger et al., 1989). Thus, dissociations found between explicit and implicit memory tasks do not require the assumption of two different memory systems; rather they are responses specific to the task demands. Similar, it is not necessary to propose that priming for impossible objects in the object decision task is mediated by a separate system. It has been contended that the possible benefit of previous exposure, whether it be conscious or otherwise, is being counteracted by a tendency to classify an impossible object as possible due to this fluency bias. Indeed, it has been demonstrated that there is no dissociation of performance for possible and impossible objects. Accuracy increased for both previously exposed possible and impossible objects when the bias towards structural possibility was removed. Thus, impossible and possible objects may be represented by a unitary system although the current research has not ruled out the possibility that two separate systems are simultaneously activated.

The multiple systems account has drawn upon convincing data from patients with spared and impaired functions to support their position of different underlying memory systems. Links between implicit memory research and neuropsychological studies of agnosia, dyslexia, and other syndromes in which perceptual representation systems are selectively impaired or preserved, have been formulated (Bowers & Schacter, 1993; Schacter, McGlynn, Milberg, & Church, 1993) to distinguish between an explicit system (usually affected) and an implicit system (usually intact). For example, severely amnesic patients, who perform poorly on explicit tasks that tap episodic memory, seem to profit from tasks that tap various perceptual representations. Moscovitch, Winocur, and McLachlan (1986) found that comparable to normal subjects, amnesic patients could read unrelated word pairs presented in a degraded, but identifiable, format faster on second presentation than on the first. Thus, this evidence has led to the suggestion that priming represents a form of implicit memory that is spared in some patients.

Consistent with the view put forward here, the reported dissociation between implicit and explicit memory in the neuropsychological literature, however, may not be this straightforward. Cermak (1993) states that amnesic patient's implicit memory does not function normally. For example, presenting pseudo-words to amnesic in an implicit task did not produce "normal" priming (Cermak, 1985). Specifically, for repeated items, amnesic patients identify pseudo-words less rapidly as compared to controls. Cermak draws on Jacoby's (1991) unaware and aware distinction in order to offer an alternative explanation for priming. It is possible that amnesic retain that aspect of information about which they are unaware (i.e., automatic and probably perceptually based processing). Conversely, aware processing is more strategic and conceptual, producing a level of awareness that includes knowledge of the existence of the episode (i.e., controlled processing). Cermak maintains that amnesic patients appear to be capable of perceptual processing because it is automatic but are not capable of conceptual processing because it involves processes beyond those at the automatic level.

Jacoby and Kelley (1992) set up a situation in which the effect of automatic processing was separated from controlled processing. Familiarity (considered to be an automatic perceptual process) and conscious recollection (a controlled conceptual process) are directly opposed to one another (Cermak, Verfaellie, Sweeney, & Jacoby, 1992). An exclusion task was used in which patients participated in a word-stem completion task in which they were told not to use the words that had just been presented to them on a study. Thus, patients were to exclude stimuli on the basis of conscious recollection of the study list. Amnesic completed more word stems with list items than did alcoholic controls. Cermak argued that the amnesic patients were unable to attribute the source of the fluency that caused them to think first of a particular word to complete a stem to its recent presentation.

Furthermore, Cermak and colleagues (Cermak, Verfaellie, Butler, & Jacoby, 1993), designed an experiment to place fluency and recollection in opposition. Names were randomly selected from a phone book and presented to patients who were asked to pronounce each name. A "fame judgement" followed in which previously presented nonfamous names were intermixed with new nonfamous names and with new famous names. Again, patients were to exclude stimuli on the basis of conscious recollection of the study list. Unlike control subjects, amnesic patients were more likely to endorse old, compared to a new, nonfamous names as being famous. The authors concluded that the amnesiacs are not able to use conscious processes to oppose the automatic effects of memory. The fluency generated by the initial processing of a name and reflected during its subsequent processing was apparently misattributed to the supposed fame of the name rather than to its true source. Controls could attribute this feeling to the correct source because they could consciously remember its prior presentation.

In summary, these findings suggest that implicit priming for amnesic patients may be a product of the familiarity produced by fluency being automatically generated by the repetition of the items. The neuropsychological evidence, which suggest that amnesic rely almost exclusively on fluency to achieve normal performance on implicit tasks, lends support to my view on object decision priming. Although these experiments involved the presentation of verbal information, the underlying theory driving this research was similar to the theoretical approach adopted in the present research. In the view advocated here, the fluency associated with prior experience aids in the correct identification of possible and impossible studied objects and gives rise to a response bias leading subjects to attribute the experienced fluency to some factor depending on the classification decision.

The focus of these experiments on the process of memory has provided an alterative approach to the conceptualization of a multimodal memory system. Little may be added to the understanding of memory function by merely labelling each newly discovered dissociation as a separate memory system, without reference to the process by which the system operates. Further experiments and theorizing are needed to tease apart the influences of fluency, response bias, and conscious contributions to memory in order to provide insight into the operation of memory.

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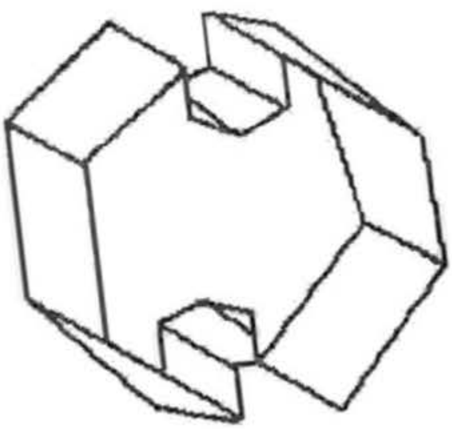
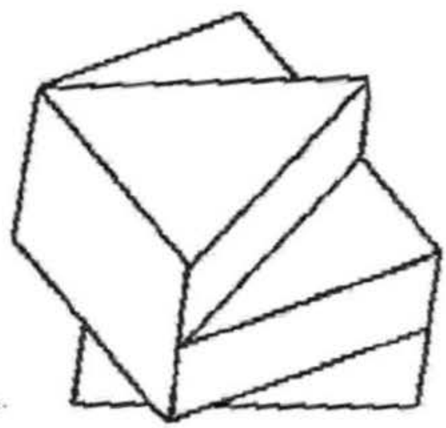
Appendix 1

Three-Dimensional Objects





Possible

Impossible

Appendix 2

Pilot Experiment 1:

Encoding phase:

"Left-Right" decision task

Following the encoding phase:

1) Subjects were informed that half the objects were possible and half were impossible.
2) Subjects were cautioned that any sense of familiarity experienced with an object should not influence their "possible-impossible" decision as there is an equal chance of the object being one or the other.

Test phase:

"Possible-Impossible" decision task.

Pilot Experiment 2:

Prior to the encoding phase:

Subjects were informed that they would be viewing structurally "possible" and structurally "impossible" objects.

Encoding phase:

"Possible-Impossible" decision task

Following the encoding phase:

1) Subjects were informed that half the objects were possible and half were impossible.
2) Subjects were cautioned that any sense of familiarity experienced with an object should not influence their "possible-impossible" decision as there is an equal chance of the object being one or the other.

Test phase:

"Possible-Impossible" decision task.

Pilot Experiment 3:

Prior to the encoding phase:

1) Subjects were informed that they would be viewing structurally possible and impossible objects

2) Subjects were informed that they would be required to make an "impossible-possible" decision.

Encoding phase:

"Possible-Impossible" decision task

Prior to the test phase:

1) Subjects were cautioned against reliance on the experience of "familiarity", which would not aid in their decision as to the structural nature of the object.

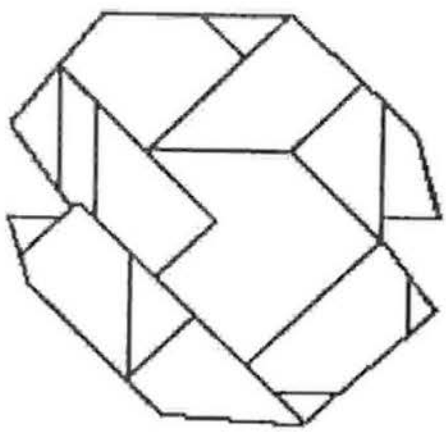
Note: no information regarding the probability of the presentation of the possible and impossible objects was offered.

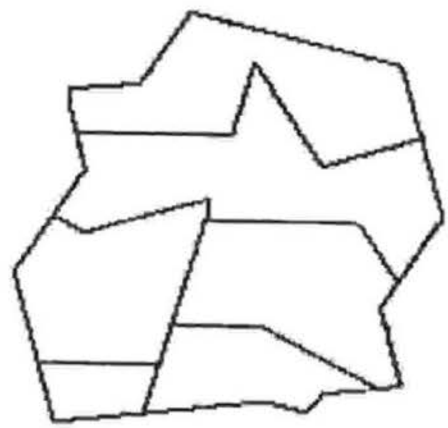
Test phase:

"Possible-Impossible" decision task.

Appendix 3

Two-Dimensional Objects





Appendix 4

Experiment 1

Purpose: To examine whether fluency associated with prior experience with an object aids in the correct identification of both possible and impossible objects.

Experimental Design

1) Study: Encoding Phase
  - a) Global Features: "LEFT or RIGHT?"
  - b) Local Features: "HORIZONTAL of VERTICAL?"

2) Test:
  - a) Object Decision Task: "2-d or 3-d?"
  - b) Recognition Task: "Old or New?"

Results

1) Priming for Structurally POSSIBLE objects and Structurally **IMPOSSIBLE** objects
2) Priming following GLOBAL encoding and LOCAL encoding

Conclusion

Priming was revealed by eliminating the bias towards structural "POSSIBILITY"
- impossible objects benefit from fluency
- priming occurred regardless of encoding condition

Appendix 5

Experiment 2

Purpose: To examine whether fluency may be attributed to Structural "Impossibility"

Experimental Design

1) Study: Encoding Phase
   - Impossible Objects presented only

2) Test:
   a) Fixation Point
   b) Number String; e.g.,"4739"
   c) Object (both Possible and Impossible)
   d) "IMPOSSIBLE" prompt
   e) "NUMBER" prompt

Results

1) Bias towards the identification of Structurally IMPOSSIBLE objects
2) No advantage of prior exposure for the Impossible objects

Conclusion

- Results may be due to the difficulty of the task
- Methodological shortcomings of the experiment

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