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Recognition Memory and Affective Preference for Depth-rotated Solid Objects: Part-based Structural Descriptions May Underlie the Mere Exposure Effect

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Following Biederman and Gerhardstein (1993) and Srinivas (1995), we tested whether different representations are necessary to describe explicit and implicit memory performance for depth-rotated solid objects in the mere exposure paradigm. Subjects were presented with novel three-dimensional objects, followed by an explicit recognition memory or an implicit affective preference test. In Experiment 1, recognition memory but not affective preference was impaired by an 80° depth rotation of the objects between study and test. In Experiment 2, when subjects had to discriminate between 0° and 80° views of previously studied objects, recognition memory was greater than chance but affective performance was not. These findings imply that the representations used for recognition memory coded depth orientation information, whereas those used for affective preference did not. The results are discussed in terms of viewpoint-specific and viewpoint-invariant representations for explicit and implicit memory.

INTRODUCTION

The "mere exposure effect" is the increase in positive affect that results from the repeated presentation of previously unfamiliar stimuli (Zajonc, 1968). This effect has been observed with a variety of stimuli, including Chinese ideographs, Turkish words, irregular polygons, and possible and impossible three-dimensional objects (for reviews, see Bornstein, 1989; Harrison, 1977). This effect has even been observed for visual stimuli presented so briefly at study that they were not recognized on a subsequent memory test (e.g. Bornstein,

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Leone, & Galley, 1987; Kunst-Wilson, & Zajonc, 1980; Seamon, Brody, & Kauff, 1983a, 1983b; Seamon, Marsh, & Brody, 1984). This finding has led a number of theorists to describe the mere exposure effect as a demonstration of implicit memory (e.g. Schacter, 1987; Squire, 1992).

According to Graf and Schacter (1995), implicit memory refers to the unintentional, non-conscious retrieval of previously acquired information, whereas explicit memory refers to the conscious, intentional recollection of past experience. Implicit memory is measured by indirect memory tests that do not ask subjects to recollect specific prior experiences, whereas explicit memory is typically measured by direct tests of memory such as free recall, cued recall and recognition. Implicit memory is inferred in tests such as object identification, word-stem completion and affective preference, when subjects show a facilitation or change in performance that is attributable to information acquired previously during study. This facilitation or change in performance is often referred to as priming.

Research has shown that implicit and explicit memory can be dissociated by a variety of experimental variables, including perceptual transformations of the stimuli involving changes in orientation or size (for implicit memory reviews, see Moscovitch, Goshen-Gottstein, & Vriezen, 1994; Roediger & Srinivas, 1993; Schacter, 1987). For example, Biederman and Cooper (1991) found that reflection of drawings of common objects between their first and second presentations produced no impairment in naming latency or accuracy. The subjects demonstrated equivalent repetition priming to reflected and non-reflected objects by naming them faster and more accurately on their second presentation than their first. L.A. Cooper, Schacter, Ballesteros and Moore (1992) observed that reflection of their possible and impossible object stimuli between study and test had no effect on object decision priming, indicated by more accurate object classification for studied than non-studied possible objects, but it impaired recognition memory for all stimuli. And, in a study of affective preference and recognition memory, Seamon et al. (1997) used the object stimuli of L.A. Cooper et al. (1992) and obtained the same pattern of results: Reflection of the stimuli between study and test had no effect on affective preference for previously viewed stimuli, but it impaired recognition memory for them.

Size transformations between study and test have dissociated implicit and explicit memory in the same manner as a reflection transformation: When stimuli are larger or smaller than originally presented, priming is unaffected but recognition memory is impaired. These results were observed in normal and amnesic populations in studies involving recognition (Jolicoeur, 1987; Kolers, Duchnicky, & Sundstroem, 1985; Milliken & Jolicoeur, 1992), picture naming and recognition (Biederman & Cooper, 1992; Cave & Squire, 1992), object decision priming and recognition (L.A. Cooper et al., 1992; Schacter, Cooper, & Treadwell, 1993), and affective preference and recognition (Seamon et al., 1997). The larger the size ratio between study and test, the greater the recognition impairment (Jolicoeur, 1987).

Researchers have interpreted the recognition impairment following stimulus transformations of reflection or size as evidence that the object representations that support explicit memory performance code distinctive spatial information (e.g. Biederman & Cooper, 1992; L.A. Cooper et al., 1992; Humphrey & Khan, 1992; Jolicoeur, 1987; Zimmer, 1995). However, there remains considerable debate about the nature of the object representations that support implicit memory performance. Structural description models hold that objects are represented by symbolic descriptions of an object's component parts and their spatial arrangement (Humphreys & Bruce, 1989). In assuming part-based representations of objects, these models assume that object representations do not code specific features such as orientation or size (e.g. Hummel & Biederman, 1992; Marr & Nishihara, 1978). For L.A. Cooper et al. (1992), these representations are "abstract" for such features; for Biederman and his colleagues, object representations lack specification regarding object orientation in depth, reflection, size, location and colour (e.g. Biederman & Gerhardstein, 1993; E.E. Cooper, Biederman, & Hummel, 1992).

Biederman and Gerhardstein's (1993) finding that object depth rotation did not affect priming has generated controversy in object identification research. These researchers found no difference in latencies in an object naming task for familiar objects shown depth-rotated up to 135° from the first to the second presentation in a repetition priming task. This result suggests depth rotation invariance when the rotation does not result in the occlusion of any component parts of the object. Together with related results showing no effect of changes in reflection, size or location on priming (Biederman & Cooper, 1991, 1992), these findings are consistent with part-based structural description models, such as Biederman and Gerhardstein's (1993) geon structural description model, which assume non-structural feature invariance.

However, Biederman and Gerharstein's (1993) finding that object priming was unaffected by depth rotation is at odds with multiple-view object recognition models that assume viewpoint specificity. According to these models, representations that support priming and recognition are "viewer-centred" regarding object changes in orientation (e.g. Srinivas, 1993, 1995; Tarr, 1995). For example, Srinivas (1995, experiment 2) presented subjects with object and non-object stimuli in an object classification task ("Is this an object or non-object"). Study stimuli were presented in one of four orientations: 0°, 67°, or 135° orientations that preserved most salient parts, or a part-occluded view that occluded some salient parts that were visible in the 0° orientation. A subsequent recognition memory test, with studied and non-studied objects and studied and non-studied non-objects all presented at a 0° orientation, showed highest accuracy for stimuli studied and tested in the 0° orientation, indicating that recognition memory was sensitive to stimulus orientation. However, a repeat of the object classification task (now used as a measure of priming) with the same test stimuli found faster classification latencies for previously studied 0° and 67° oriented stimuli than non-studied stimuli, but no difference in latencies for studied and non-studied stimuli when the studied stimuli were rotated 135° between study and test or shown initially in a part-occluded view. Srinivas (1995) interpreted the lack of priming in the 135° rotated condition as a failure to support Biederman and Gerhardstein's (1993) results.

In a subsequent experiment employing an object orientation task ("Is this object oriented left or right?"), Srinivas (1995, experiment 3) presented subjects with 0° or 80° full views or 40° part-occluded views of novel block figures that were oriented left or right. When she later used this same task as her measure of priming with studied and non-studied objects, all shown at a 0° orientation, Srinivas found faster classification latencies for studied than non-studied objects only for studied objects originally shown at 0° orientation. Recognition memory was close to chance (50%) in each condition. Srinivas concluded that the results of her experiments suggested that priming was not mediated by part-based structural descriptions of objects. Instead, she argued that priming was mediated by viewpoint-specific representations that may generalize (for familiar objects, at least) across small changes in viewpoint (Srinivas, 1995, p. 1033). Essentially, the same conclusion can be drawn from the results of Humphrey and Khan (1992), who reported that recognition memory for previously studied novel objects was impaired when they were tested in a depth-rotated view, and Tarr (1995), who observed priming for novel objects in an object naming task only when they were presented in previously viewed orientations. Biederman and Gerhardstein (1995) have subsequently questioned the research supporting viewpoint-specific representations (but see Tarr & Bulthoff, 1995, for a conflicting interpretation).

At present, controversy remains about whether object representations used in implicit memory tasks are viewpoint-specific or viewpoint-invariant for stimulus orientation information. To date, the only implicit memory measures that have been used to study the effect of a depth rotation on novel, three-dimensional objects have involved latency data in variations of a repetition priming paradigm. Following the suggestion of Roediger and Srinivas (1993) that converging evidence is desirable from a variety of implicit memory measures, it is important to examine the effect of a depth-orientation transformation on a different implicit memory measure to determine whether sensitivity or insensitivity to this transformation is observed. One overlooked implicit memory measure is the affective preference test. As suggested by Seamon et al. (1997), this test is an ideal candidate for studying the effect of stimulus transformations on implicit memory because it can be used with depth-rotated, novel stimuli.

EXPERIMENT 1

The aim of this first experiment was to determine the effect of a depth rotation transformation on recognition memory and affective preference for previously viewed novel objects. Subjects were shown Srinivas's (1995, experiment 3) three-dimensional objects at study and asked to determine the left–right orientation of each object in an object orientation task. Following study, the subjects were shown studied and non-studied object pairs in either the same orientation as at study, or a depth-rotated orientation, and asked to make recognition memory or affective preference judgements. Based on previous research demonstrating that object representations used for recognition memory code spational information (e.g. Biederman & Cooper, 1982; L.A. Cooper et al., 1992; Humphrey & Khan, 1992; Seamon et al., 1997), recognition memory performance should be more accurate for studied objects shown in the same orientation as study than in a depth-rotated orientation. Affective preference performance should show the same effect as recognition memory if the object representations that underlie affective judgements also code depth orientation information. However, if subjects demonstrate comparable affective preference for both same and different orientation studied objects, this would imply that the object representations that underlie affective judgements do not code depth orientation information, at least for the orientations tested in this experiment.

Method

Subjects. The subjects were 40 male and female Wesleyan University students who were between 17 and 24 years old. All subjects received introductory psychology credit or served as paid volunteers, and none had taken part in any previous research involving affective preference or recognition memory.

Materials and Apparatus. The stimuli were 32 novel objects used by Srinivas (1995, experiment 3). Srinivas (1995, p. 1030) described the solid, symmetrical objects as being composed of distinctive wooden parts that included an elongated vertical axis, two symmetrical parts that signified an "arm" on each side, and two additional parts that signified a "head" and a "tail" to differentiate front and back. Each object had previously been photographed by Srinivas under conditions of even illumination and similar background in an arbitrary 0° orientation and an 80° depth-rotated orientation that preserved all parts that were visible in the 0° orientation. Half of the objects in the 0° and 80° orientations unambiguously faced left, and the other half clearly faced right. In the present experiments, the stimuli were photographed as slides and presented on a 75 × 90 cm screen by a Gerbrands projection tachistoscope under conditions of low room illumination. The study stimuli were shown individually, and they subtended mean visual angles of 6.61° in height and 5.53° in width. The test stimuli were the same size, and they were shown in pairs on the left and right side of the viewing screen with a mean visual angle of 9.82° separating the innermost parts of the objects. Figure 1 shows examples of the objects in the 0° and 80° orientations. A careful inspection of the objects in each pair indicates that the 0° and 80° orientations are not reversed images, although they are near mirror reversals (see Figure 1).

Design. Experiment 1 was a mixed factorial with test type (recognition memory *vs.* affective preference) and stimulus set (A *vs* B) manipulated as between-subject variables, and study object orientation (0° *vs* 80°) and study–test object orientation (same *vs* different) manipulated as within-subject variables. The test type and stimulus set variables yielded four experimental groups consisting of 10 subjects each. Following Seamon et al. (1995, 1997), separate analyses were conducted on the recognition memory and affective preference data.

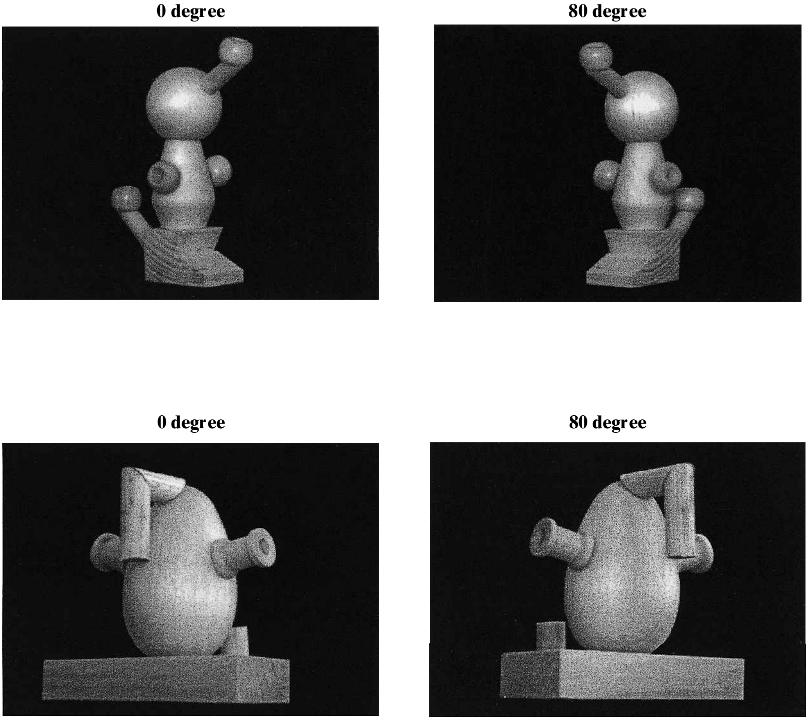
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FIG. 1. Examples of the three-dimensional, solid objects in their 0° and 80° depth-rotated orientations.

Procedure. The subjects were told that the experiment would measure perceptual decision making and how consistently people made perceptual decisions over time. The subjects were asked to focus their attention on the centre of the screen where they would be presented with a sequence of 32 unfamiliar objects. The objects were described as having a head, tail and arms that allowed them to be perceived as facing left or right. After viewing two examples that were not used in the experiment and being shown how the head and tail of each object indicates left–right view, the subjects were asked to decide if each displayed object was facing left or right by circling the appropriate response on their answer sheets. No mention was made of any subsequent test.

The subjects were then presented with 16 stimulus objects shown twice in two random orders of 16. For each of the 32 study trials, a stimulus was presented in the centre of visual field for 2.5 sec, followed by a 3.5-sec-inter-stimulus interval. Half of the 16 objects in each order faced left and half faced right; within each left–right view, half of the objects represented a 0° orientation and half represented an 80° orientation. Left–right view and 0–80° orientation were randomized across study trials, and repeated objects at study were always shown in the same left–right view and 0–80° orientation. Finally, for the purpose of stimulus counterbalancing, two different sets of 16 object stimuli (sets A and B) were constructed for use during study. The 16 unused stimuli for each set constituted the non-studied stimuli for the subsequent test trials. For half of the subjects in each test condition, the stimuli in set A served as the studied stimuli and those in set B served as the non-studied stimuli; for the remaining subjects, these conditions were reversed.

Following the study trials, the subjects were presented with 16 test trials, each shown for 1 sec followed by an inter-trial interval of 3.5 sec. Each test trial consisted of a pair of stimuli—a previously studied object and a novel, but comparable, non-studied object—presented side-by-side on the screen. The location of the studied object was randomized across trials with the constraint that it was the left member of each pair for half of the trials and the right member for the other half. Within the 16 test trials, the study and test orientation of the objects was either the same or different. Specifically, there were four trials each of the following types: study orientation 0° and test orientation 0° (same); study orientation 80° and test orientation 80° (same); study orientation 0° and test orientation 80° (different); and study orientation 80° and test orientation 0° (different). Although the orientation of the study and test objects could differ, the left–right view and 0–80° orientation of both objects in each test trial was always the same.

Two independent groups of subjects made different test judgements. For each test pair, one group of 20 subjects was asked to determine which object they recognized from the study phase of the experiment (recognition memory test), while a second group of 20 subjects was asked to determine which object they liked better (affective preference test). No connection was specified between the study and test trials for the subjects given the affective preference test. They were merely informed that they would have to make a different perceptual decision from that previously made. Within each group, half of the subjects had studied objects from set A and half had studied objects from set B. All subjects, who were tested in groups of up to six in each condition, made their responses by circling the appropriate choices on their answer sheets.

Results and Discussion

Recognition Memory. Table 1 shows that, although subjects were able to recognize the previously shown objects in both study–test orientations, their performance was better when test objects were shown in the same orientation as study than in a different orientation. The results of an analysis of variance showed an effect of study–test orientation on performance, $F(1,18) = 8.53$, $MSe = 0.23$, $p < .01$, but no effect of stimulus set (A *vs* B) or study object orientation (0° *vs* 80°), both $F < 1.0$, and no interaction of any variables on performance, all $p < .25$. Recognition memory for studied objects was greater than chance (50%) when the study and test objects were in the same, $t(19) = 19.87$, one-tailed, $p < .001$, or different, $t(19) = 8.22$, one-tailed, $p < .001$, orientations, or collapsed over both orientation conditions, $t(39) = 17.26$, one-tailed, $p < .001$.

The study–test orientation result is consistent with previous research by Humphreys and Khan (1992), who found that recognition memory was impaired when novel, three-dimensional objects were depth-rotated 80° between study and test, and it is consistent with other research showing that recognition memory is generally sensitive to a stimulus reflection transformation (e.g. Biederman & Cooper, 1992; L.A. Cooper et al., 1992; Seamon et al., 1997). But the present finding differs from that of Srinivas (1995, Experiment 3), who reported that recognition memory was close to chance in all test conditions. Numerous procedural differences exist between the experiment of Srinivas and the present study, making a direct comparison of results difficult. However, the

TABLE 1
Percent Recognition Memory and Affective Preference for Studied Objects in Experiment 1 (Mean ± Standard Error)

Study–Test Object orientation	*Test* *Recognition Memory*	*Affective Preference*
Same	88.1 ± 1.9	63.1 ± 4.2
Different	77.5 ± 3.3	57.5 ± 4.1
Mean	82.8 ± 1.9	60.3 ± 2.9

Note: Chance performance is 50%

higher recognition memory performance in our experiment may be the result of differences in study or test conditions, as Srinivas presented more objects for study for less total study time than the present experiment, and she employed a 5-min distraction period between study and test,

Affective Preference. Table 1 also shows that subjects demonstrated a mere exposure effect by liking previously shown objects greater than chance. In addition, the magnitude of the mere exposure effect (approximately 60%) is typical of mere exposure experiments (e.g. Seamon et al., 1984, 1995, 1997). However, unlike the recognition results, affective preference was largely unaffected by the orientation of the studied objects at test. The results of an analysis of variance showed no effect of study–test orientation, $F(1,18) = 1.57$, $MSe = 0.06$, $p > .20$, stimulus set, $F(1,18) = 2.45$, $MSe = 0.23$, $p > .10$, or study object orientation, $F(1,18) = 1.25$, $MSe = 0.09$, $p < .20$, and no interaction of these variables on performance, all $p > .25$. Based on the estimate of the maximum effect size obtained from the corresponding recognition test, the power of the affective preference test to detect an effect of study–test orientation was .83. Affective preference for studied objects was greater than chance (50%) when the study and test objects were in the same, $t(19) = 3.12$, one-tailed, $p < .005$, or different, $t(19) = 1.83$, one-tailed, $p < .05$, orientations, or collapsed over both orientation conditions, $t(39) = 3.55$, one-tailed, $p < .005$.

The findings that recognition memory and affective preference for studied objects were both greater than chance and recognition memory was strongly influenced by the orientation of the studied objects at test, whereas affective preference showed little influence of orientation change, indicates that the lack of a significant effect of study–test orientation on affect cannot be attributed to insensitivity of design (see Biederman & Gerhardstein, 1993, p. 1170, for a similar argument with a different data set). These results extend those of Seamon et al. (1997), which showed that the recognition memory test was sensitive to changes in reflection or size for previously studied possible or impossible objects, whereas the affective preference test was insensitive to these transformations. The present results indicated that the recognition memory test was sensitive to 80° depth rotations of previously studied objects, whereas the affective preference test was not. A comparable mere exposure effect was observed for studied objects tested in both their studied and depth-rotated orientations.

EXPERIMENT 2

If the object representations that underlie recognition memory code depth orientation information and those that underlie affective preference do not, it follows that if subjects were presented with test trials pairing a studied and depth-rotated version of the same object, performance on the recognition and affect tests should differ. Specifically, subjects should be able to recognize a previously studied object from a non-studied version of the same object that differs only in depth orientation, but they should be unable to select a previously studied object by affective preference. If implicit memory performance in the affective preference test can be guided by structural description representations, the part-based structural descriptions would be identical for the studied and depth-rotated version of each object. As Biederman and Gerhardstein (1993, p. 1164) noted, if two views of an object have the same structural description, they should be treated as equivalent. Therefore, unlike previous mere exposure research that demonstrated affective preference for studied stimuli in the presence (e.g. Seamon et al., 1995, 1997) or absence (e.g. Bornstein et al., 1987; Kunst-Wilson & Zajonc, 1980; Seamon et al., 1983a, 1983b, 1984) of recognition memory for those stimuli, the present experiment made the novel prediction of an absence of affective preference in the presence of recognition memory. To our knowledge, no previous research has ever predicted the absence of a mere exposure effect following the repeated presentation of previously unfamiliar stimuli.

Methods

Subjects. The subjects, 80 male and female Wesleyan University students, received introductory psychology credit or served as paid volunteers. None had taken part in any previous research involving affective preference or recognition memory.

Materials and Apparatus. The study stimuli consisted of two sets of 24 of the 32 object stimuli used in Experiment 1. One set of 24 objects represented a 0° orientation (set A) and the other set consisted of the same objects represented by an 80° orientation (set B). Within each set, half of the objects faced left and half faced right, and left–right view was randomized across study trials. The test trials were constructed by pairing the same object stimuli from the two study stimulus sets (A and B). Thus, each test trial contained a 0° and an 80° representation of the same object. The 0° orientation objects were the studied stimuli and the 80° orientation objects were the non-studied stimuli for half of the subjects in each condition, whereas this relationship was reversed for the remaining subjects, thereby counterbalancing the studied and non-studied stimuli across object orientations in each condition. Finally, the location of the studied object was randomized across trials with the constraint that it was the left member of each pair for half of the trials and the right member for the other half.

Design. Experiment 2 was a completely randomized multi-factorial design. Study object orientation (0° *vs* 80°), test type (recognition memory *vs* affective preference) and test instructions (orientation-non-specific *vs* orientation-specific) were manipulated as between-subject variables that yielded eight experimental groups, each consisting of 10 subjects. As in Experiment 1, separate analyses were conducted on the recognition memory and affective preference data.

Procedure. During study, the subjects were presented with 24 stimulus objects shown three times in the same left–right view and 0–80° orientation in three random orders of 24. We increased the number of exposures to each object from two to three in this experiment because, compared to the first experiment, there were more stimuli shown during study (24 *vs* 16 objects) and the test trials required a more difficult discrimination because the studied and non-studied objects differed only in orientation (0° *vs* 80°). Half of the subjects in each condition made left–right judgements for the 0° orientation objects from set A (half of these objects faced left and half faced right), and the remaining subjects made these judgements for the 80° orientation objects from set B (again, half of these objects faced left and half right). All other viewing conditions were the same as the first experiment.

Following the study trials, the subjects were presented with 24 test trials, each consisting of a pair of stimuli—a previously shown object in its studied orientation (either a 0° or 80° orientation) and the same object in its non-studied orientation—presented in the same manner as Experiment 1. The location of the object in the studied orientation was randomized across trials with the constraint that it was the left member of each pair for half of the trials and the right member for the other half.

Because a test trial consisted of the same object in two different orientations (unlike Experiment 1, where a test trial consisted of two different objects in the same orientation), we were concerned that the standard recognition memory or affective preference instructions might prove confusing to the subjects and lead to low performance for recognition memory and the absence of affective preference for studied objects. To test this possibility and maximize studied object selection, we manipulated test instructions in this experiment by changing the wording of the instructions. Half of the subjects received the standard recognition memory or affective preference instructions. the other half received modified instructions for each test that took object orientation into account. As a result of our manipulation of test instructions, four independent groups of subjects made different test judgements. Two groups received the same orientation-non-specific test instructions that were used in our first experiment. One of these groups of 20 subjects was asked to determine which stimulus they recognized from the study phase of the experiment (“Which object did you see in the first part of the experiment?”), and a second group of 20 subjects was asked to determine which stimulus they liked better (“Which object do you like better?”). Two further groups of 20 subjects were given test instructions that were orientation-specific. One of these groups received modified recognition memory instructions (“Which orientation of the object did you see in the first part of the experiment?”) and the other group received modified affective preference instructions (“Which orientation of the object do you like better?”). As in the first experiment, no connection was specified between the study and test trials for the subject given either version of the affective preference test. Finally, within each of the four test groups, half of the subjects had studied objects from set A (0° orientation at study) and half had studied objects from set B (80° orientation at study). All other test conditions were the same as in Experiment 1.

Results and Discussion

Recognition Memory. Table 2 shows that the subjects were able to recognize the previously shown objects greater than chance, and their performance was largely unaffected by whether the test instructions were non-specific or specific regarding orientation. The results of an analysis of variance showed no effect of study object orientation or test instructions, and no interaction of these variables, all $F < 1$. Recognition memory for studied objects was greater than chance (50%) for the orientation-non-specific, $t(19) = 6.38$, one-tailed, $p < .001$, orientation-specific, $t(19) = 4.40$, one-tailed, $p < .001$, and combined instruction conditions, $t(39) = 7.53$, one-tailed, $p < .001$. These results indicate that subjects were not confused by the orientation-non-specific instructions. More important, recognition memory for object orientations (Experiment 2) was not as strong as recognition memory for objects (Experiment 1), $t(58) = 5.96$, one-tailed, $p < .001$, but recognition performance was greater than chance in both experiments, indicating that the representations that underlie explicit recognition memory contain information about an object’s orientation at study. This observation is consistent with the results of Experiment 1, which showed that a change in orientation between study and test impaired object recognition. A change in a stimulus feature, such as its orientation, cannot influence performance unless that feature is part of the object’s representation in memory.

TABLE 2
Percent Recognition Memory and Affective Preference for Studied Objects in Experiment 2 (Mean ± Standard Error)

Test Instructions	*Test* *Recognition Memory*	 *Affective Preference*
Orientation-non-specific	66.0 ± 2.5	51.1 ± 1.9
Orientation-specific	62.3 ± 2.8	51.9 ± 1.8
Mean	64.2 ± 1.9	51.6 ± 1.3

Note: Chance performance is 50%

Affective Preference. Unlike the results of Experiment 1, where subjects demonstrated a typical mere exposure effect, the subjects in Experiment 2 failed to demonstrate any affective preference for previously studied objects. Regardless of whether the affective preference instructions were orientation-non-specific or orientation-specific, Table 2 shows that the subjects did not like previously studied objects at a greater than chance level. The results of an analysis of variance showed no effect of study object orientation, $F(1,36) = 1.45$, MSe = 0.01, $p < .20$, or test instructions, $F < 1.0$, and no interaction of these variables, $F < 1.0$. Affective preference for studied objects was not greater than chance (50%) for the orientation-non-specific, $t(19) = 0.67$, one tailed, $p < .20$, orientation-specific, $t(19) = 1.06$, one-tailed, $p < .10$, or the combined instruction conditions, $t(19) = 0.44$, one-tailed, $p < .30$. Across experiments, affective preference for object orientations (Experiment 2) was less than affective preference for objects (Experiment 1), $t(58) = 3.06$, one-tailed, $p < .005$. Based on the estimates of the maximum effect size obtained from the corresponding conditions of the recognition test in the previous experiment, the power of the affective preference test was greater than .99 for each condition in Table 2. Regardless of the wording of the instructions, the subjects did not select previously studied objects over non-studied objects by affective preference when those objects differed only by depth orientation.

The finding of stimulus recognition without affective preference represents a novel outcome in mere exposure research. To understand the implication of this finding, we need to consider the findings of Seamon et al. (1995, 1997). In those studies that used possible and impossible objects as stimuli, subjects were presented with test trials that consisted of studied objects paired with non-studied objects that were 90° picture-plane rotated versions of the studied objects. In both studies, subjects could distinguish between the studied and non-studied objects by recognition memory and affective preference. However, subjects in the present experiment could distinguish between studied and non-studied objects that differed only by a depth rotation by recognition memory, but not affective preference. Moreover, the subjects in our first experiment demonstrated that recognition memory and affective preference were possible for the stimuli used in the present studied when different studied and non-studied objects were present at test.

Therefore, the lack of a mere exposure effect for the studied stimuli in the present experiment cannot be attributed to the particular class of stimuli used or insufficient study conditions, such as insufficient study time or number of stimulus exposures. Fewer of the same stimuli and fewer exposures per stimulus at study were used in Experiment 1, which demonstrated a mere exposure effect, than in Experiment 2, which did not. In addition, a mere exposure effect has been demonstrated in previous experiments that presented visual stimuli so briefly at study that recognition performance did not differ from chance (e.g. Bornstein et al., 1987; Seamon et al., 1983a, 1983b, 1984), so study conditions are not likely to be the source of the absent mere exposure effect.

Rather, the lack of a mere exposure effect in the present experiment can be attributed to the unique testing procedure employed. Subjects can distinguish between studied and non-studied versions of the same test stimuli that differ only in orientation by recognition memory and not affective preference if the representations used for recognition memory code three-dimensional depth orientation information, whereas the representations used for affective preference do not. In terms of structural description representations, when no component parts of an object are occluded, a depth-rotated version of a studied object has the same part-based structural description as the studied object, whereas a picture-plane rotated version of that object can have a different structural description if the structural description is axis-based (Cooper & Schacter, 1992; see also Humphreys & Quinlan, 1988). This interpretation can explain why Seamon et al. (1995, 1997) observed a mere exposure effect with picture-plane-rotated objects as non-studied stimuli and the present study did not with depth-rotated objects as non-studied stimuli. When the structural descriptions of objects are the same, discrimination by affective preference may not be possible. Thus, Experiment 2 showed that, under conditions that demonstrated recognition memory, the mere exposure effect was absent. Subjects were unable to distinguish between objects by affect that differed only in depth orientation.

GENERAL DISCUSSION

This research has demonstrated that, when the studied and non-studied test objects are different three-dimensional objects (Experiment 1), subjects recognize and like previously studied objects regardless of whether they were shown in the same orientation as study or in an 80° depth-rotated orientation. However, the effect of a study–test change in orientation was different for both measures. Recognition memory was significantly impaired by an 80° depth rotation, whereas affective preference was not. When the studied and non-studied test objects were the same objects in different orientations (Experiment 2), subjects recognized the previously studied object orientations, but they did not select them on the affective preference test. These results indicate that recognition memory performance was sensitive to an 80° study–test change in object depth orientation, whereas affective preference performance was not.

A Comparison of Implicit Memory Measures. The present results are consistent with the findings of Biederman and Gerhardstein (1993), who observed that object depth rotation did not affect priming in an object naming task, but they are inconstant with the results of Srinivas (1995, experiment 3), who found no evidence of priming for depth-rotated objects in an object orientation task. In addition, we found strong explicit recognition memory performance in the same condition that demonstrated implicit affective preference for depth-rotated objects (Experiment 1), whereas Srinivas (1995, experiment 3) observed poor recognition memory in the same condition that failed to demonstrate priming for depth-rotated objects. Biederman and Gerhardstein's study was similar to that of Srinivas, in that both used a repetition priming procedure, although the specific tasks used in those studies (object naming *vs* object orientation) differed. The present research used the same novel object stimuli, the same 80° study–test change in object depth orientation, and the same encoding rule at study (object orientation decisions) that Srinivas (1995, experiment 3) used, but the implicit memory tasks and dependent variables differed. Srinivas measured latencies in repetition priming; we measured the percentage of studied objects selected in an affective preference task. In light of the many differences between these studies, direct comparisons of results are difficult.

We noted previously that Roediger and Srinivas (1993) suggested that it is important to study the effect of different transformations on a variety of implicit memory tasks to determine whether sensitivity or insensitivity to a transformation is more generally observed. The present research has provided a new task and additional findings relevant to the issue of a depth-orientation transformation. Two studies (Biederman & Gerhardstein, 1993; the present study), employing different stimuli and procedures, have now observed that depth-rotated objects do not affect implicit memory performance. However, the present findings must be tempered by the results of Srinivas (1995, experiment 2), who observed priming for objects depth-rotated 67° but not 135°. She concluded that priming mediated by viewpoint-specific representations may generalize across small changes in viewpoint, possibly on the basis of local features that remain in view. It is possible that the same conclusion may apply to the present results if we assume that affective preference judgements can be based on local features rather than the entire object (Seamon et al., 1995, raised this possibility). However, two problems with this suggestion remain. First, all local features of the objects, as component parts of the objects, were depth-rotated 80° in the present research, thereby implying viewpoint invariance for either an entire object or its component parts. Second, the possibility of generalization of viewpoint-specific representations does not explain why Srinivas (1995, experiment 3) did not observe priming for 80° depth-rotated stimuli and we found a comparable mere exposure effect for 0° and 80° depth-rotated objects.

It is possible that our affective preference results for the 0° and 80° depth-rotated conditions are due to the use of "near mirror-reflection" object pairs. For example, Tarr and Bulthoff (1995) argued that near mirror-reflection images might mask an effect of viewpoint in studies that would otherwise demonstrate viewpoint specificity. Thus, our finding of affective preference for 80° depth-rotated objects may reflect the use of near mirror-reflection stimuli.

However, if the present 0° and 80° depth-rotated objects are near mirror-reflected objects, as they clearly appear to be (see Figure 1), it is surprising that Srinivas (1995, experiment 3) did not obtain priming with these same stimuli in her study. The lack of priming for these depth-rotated objects led her to conclude that recognition memory and priming were mediated by viewpoint-specific representations. Although the present results are more consistent with an interpretation involving viewpoint-specific representations for recognition memory and viewpoint-invariant representations for affective preference, we must temper the interpretation of our results as they are limited to 0° and 80° orientations only of the stimuli. In addition, the use of very different measures of implicit memory by Srinivas and in the present research could suggest that the effect of a depth orientation transformation may not have the same effect on all measures.

In showing insensitivity to 80° depth-orientation, mirror-reflection, size and colour transformations, the research on affective preference (Seamon et al., 1995, 1997; the present experiments) is consistent with the research of Biederman and his colleagues (e.g. Biederman & Cooper, 1991, 1992; Biederman & Gerhardstein, 1993; E.E. Cooper et al., 1992), who found no effect of these different transformations in their repetition priming tasks. The present results may be viewed within the context of structural description models, such as Biederman and Gerhardstein's (1993) geon structural description model, which assume that implicit memory is mediated by part-based representations of objects that lack specification of non-structural features. This interpretation is necessarily tentative because the present results are based on an object depth rotation that involved a near mirror-image reversal that maintained the parts of each object in the same spatial relation, except for left–right view. Whether the same affective preference results would be observed for three-dimensional objects depth-rotated less than or more than 80° (with no occlusion of any salient parts) is unknown. We note also that some theorists have suggested that object identification processes are not exclusively viewpoint-specific or viewpoint-in variant, but instead may be influenced by a variety of factors, including type of task, context and stimulus familiarity (e.g. Farah 1992; Tarr & Bulthoff, 1995). Therefore, it remains to be determined whether other implicit memory tasks, or even the same tasks in different contexts, are mediated by viewpoint-specific or viewpoint-invariant representations.

Understanding the Mere Exposure Effect. We have suggested that the dissociation of our explicit and implicit memory measures by a depth-orientation transformation may be attributed to differences in the type of information coded in the representations used by the recognition memory and affective preference tasks. In fact, this explicit–implicit dissociation may reflect the operation of different underlying memory systems that utilize different types of information. For example, Seamon et al. (1997) applied Schacter and Cooper multiple memory systems interpretation of recognition and priming differences (e.g. L.A. Cooper et al., 1992; Schacter, Cooper, & Delaney, 1990; Schacter et al., 1991) to the mere exposure effect. Recognition memory performance may be based on an episodic memory system, whereas affective preference judgements may be mediated by a perceptual representational system that processes structural descriptions of objects. According to L.A. Cooper et al. (1992), the episodic system codes distinctive spatial, temporal, contextual and semantic information about objects. Thus, study–test changes in any of these dimensions is likely to impair recognition memory for objects. The perceptual representational system does not code their features. Instead, it analyses the structural relations among the component parts of an object to compute a part-based, three-dimensional, structural description representation. Object transformations involving features such as depth orientation, reflection or size do not change these representations because they code only structurally invariant information. Thus, recognition memory, not affective preference, should be impaired by feature changes that maintain object structure.

In terms of the mere exposure effect, subjects may "like" previously studied objects more than non-studied objects because previously studied objects already have structural description representations available to facilitate the subsequent processing of those objects. This interpretation of the mere exposure effect is consistent with Seamon and co-workers (1995, 1997) interpretation of the mere exposure effect as an expression of implicit memory, and it is also consistent with an earlier cognitive interpretation of affective preference as reflecting liking based on perceptual fluency. Seamon et al. (1983a) argued that exposure to previously unfamiliar stimuli can lead to familiarity with processing those stimuli, and stimulus processing familiarity can serve as the basis for affective preference. For the present results, this interpretation holds in that previously studied objects are more easily processed than novel objects because prior stimulus exposures have resulted in structural description representations of those objects. The availability of a structural description for an object can serve as the basis for perceptual fluency and, in a task requiring a forced-choice affective decision, for affective preference as well. According to this interpretation, it is the presence of structural description representations, rather than emotional responses, that determines affective preference for visual stimuli in the mere exposure paradigm (see Seamon, McKenna, & Binder, 1998, for a discussion of different theories of the mere exposure effect). The present research views the mere exposure effect as the result of pattern recognition processes that are fundamentally implicit rather than explicit in nature, thereby linking the mere exposure effect to other studies of object recognition and priming.

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