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Memory for Seen and Imagined Rotations of Alphanumeric Characters

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According to Johnson and Raye (1981), similarity between perceived and imagined items should result in poor discrimination between memories originating with perception and imagination ("reality monitoring"), although old/new recognition might be quite high under the same circumstances. In order to produce imagined and perceived events that were similar perceptually and similar in terms of cognitive operations, a variation of Cooper and Shepard's (1973) mental rotation task was used. There were 24 trials of letters and numbers that were either seen or imagined rotated through a sequence of positions. After this acquisition phase and a distractor task, 32 test characters (24 old and 8 new) were presented in upright position and in a randomized order. Half the subjects made old/new recognition judgments and half the subjects identified the source (seen/imagined/new) of each test item. As expected, reality monitoring accuracy, but not recognition, was low under these conditions.

A possible functional correspondence between perceptual and imaginal processes has been creatively investigated in recent years. Notably, perception and imagination appear to use some of the same processing resources, as indicated by studies showing mutual interference when perceiving and imagining involve the same sensory modality (e.g., Brooks, 1967, 1968; Finke, 1980, 1985; Paivio, 1978; Podgorny & Shepard, 1978; Segal, 1971; Segal & Fusella, 1972). Although much of the work comparing imagination with perception has focused on ongoing imagination and ongoing perception, studies of memories for past perceptions and past imaginations also suggest that there is a great deal of similarity between perception and imagination.

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The reality monitoring framework proposed by Johnson and Raye (1981), for example, describes the processes presumed to underlie the discrimination and confusion of memories for events originally imagined or perceived. According to Johnson and Raye (1981), memories for perceptions typically differ from memories for imaginations in the relative amounts of different types of information preserved in memory. These characteristic differences can help to distinguish these two classes of memories. Perceptually-derived memories typically include more sensory information, more information about the spatial and temporal context in which the event occurred, and are more semantically detailed. Imaginally-generated memories, on the other hand, typically include more information about the cognitive operations used to generate the memory. Cognitive operations include such things as search, decision and imagery processes that take place when a memory is originally established (see, especially, Johnson, 1985). Johnson and Raye (1981) proposed that these relative differences between memories derived from perception and self-generated memories may provide discriminative cues to someone attempting to judge the origin of a memory. For example, a memory with a lot of sensory information would tend to be judged as having originated with perception, while a memory that includes a lot of information about cognitive operations would tend to be judged as having been imaginally-generated. This strategy would result in incorrect source identification (or poor "reality monitoring") when the memory being judged was atypical of its class, such as an imaginally-generated memory with very little cognitive operations information associated with it (cf. Johnson, Kahan, & Raye, 1984).

According to the reality monitoring framework, then, if the amount of cognitive operations information stored during the processing of a perceptual event is very similar to the amount of cognitive operations information stored during the processing of a similar, imagined event, reality monitoring should be difficult (e.g., Johnson, Raye, Foley, & Foley, 1981; Finke, Johnson, & Shyi, 1988). Likewise, if the amount of sensory information associated with an imagined event is very similar to that associated with a perceived event, reality monitoring should be difficult (e.g., see Anderson, 1984; Johnson, Raye, Wang, & Taylor, 1979). Thus, if we simultaneously make perceptual events very like imaginal events with respect to cognitive operations and imaginal events very much like perceptual events with respect to sensory information, then reality monitoring accuracy should be very low.

In the present study, a modified version of Cooper and Shepard's (1973) mental rotation task was used. Subjects saw some block letters and numbers and imagined others. There were two types of trials — *Seen* and *Imagined*. Each trial included 5 slides. On *Seen* trials, the first slide presented a letter or number centered inside a circle, such as an "A." On the following four slides, the letter "A" appeared in four different positions. On *Imagined* trials, a similar exemplar slide was presented, such as an "E." However, for the next four slides, the subject was asked to *imagine* the "E" rotated to the position indicated by a small arrow. Following this acquisition phase and a distractor task, subjects were given one of two surprise memory tests. A measure of reality monitoring accuracy was obtained by asking half of the subjects to identify, for each test character, whether it had been Seen rotating, Imagined rotating, or had not occurred (Source Identification Test). The other half of the subjects was asked to differentiate Old from New characters (Recognition Test).

Confusion between imagined and seen characters in this study, then, should occur for two reasons. First, letters and numbers are very familiar and simple stimuli, and should be easy to vividly imagine, especially when subjects are provided with an "exemplar" just prior to imagining. The memories for these imagined and seen letters should thus be quite similar in terms of their sensory characteristics and subsequently difficult to discriminate on the basis of relative differences in sensory information (Johnson & Raye, 1981). Secondly, seeing letters and numbers presented in different positions around a circle should induce subjects to mentally rotate the seen characters *between* discrete positions, such that considerable cognitive operations should be engaged in the Seen as well as in the Imagined condition (see, especially, Freyd & Finke, 1984). The memories for these imagined and seen letters should thus also be quite similar in terms of the cognitive operations engaged at the time the memories were generated. Again, based on the reality monitoring model of Johnson and Raye (1981), these memories for seen and imagined rotated characters should be difficult to discriminate on the basis of relative amounts of cognitive operations information (see also Finke et al., 1988).

In the current study, the similarity between perceived and imagined events should make discriminating between them difficult; these same conditions would not necessarily make old/new judgments difficult because these would be more likely to be based on a judgment of overall familiarity (see Johnson, 1985). Therefore, under the present conditions, we expected to find relatively good recognition and poor reality monitoring.

Method

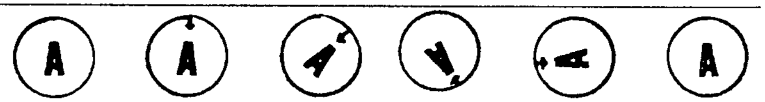
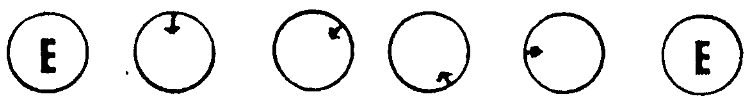
Subjects

Twenty students, 14 females and 6 males, from the State University of New York at Stony Brook, served as subjects. Three subjects were graduate students and the rest were undergraduates. Seventeen subjects received payment for their participation, and three received credit in an introductory psychology course.

Stimulus Construction

Each trial included five slides (see Table 1): an initial, identification slide, followed by four rotation slides. Twenty-four characters were ran-

Table 1
Exemplary Rotational Sequences for Seen and Imagined Trials

Trial	Acquisition Sequence [1] [2] [3] [4] [5]	Test
Seen		
Imagined		

domly assigned to either "Seen" or "Imagined" trials. Within both Seen and Imagined trials, the 12 characters were randomly assigned to a rotational sequence. The rotational sequence terminated between 20 and 80 degrees for four characters (Small); between 110 and 170 degrees for another four characters (Medium); and between 200 and 260 degrees for the remaining four characters (Large). A second stimulus set was then created in which the same rotational sequences occurred but characters that were seen rotating in the first set were imagined rotating in the second set, and vice versa. Subjects were randomly assigned to receive one of the two stimulus sets.

Apparatus

Acquisition and test slides were presented using a slide projector. All subjects were seated 6 feet from the projection screen. During the test phase, a three-choice reaction time device was placed immediately in front of the subject and a two-sided wood screen separated the subject from the electronic mechanism that registered the subject's responses and response latencies. Labels for the three response buttons were counterbalanced across subjects within each test condition: "Old"-"New" and "New"-"Old" for the Recognition test condition and "Seen"-"Imagined"-"New" or "Imagined"-"Seen"-"New" for the Source Identification test condition.

Design and Procedure

A 2 (Type of Processing: Seen or Imagined) x 3 (Degree of Rotation: Small, Medium, or Large) x 2 (Test Condition: Recognition or Source Identification) mixed design was used. Type of Processing and Degree of Rotation were varied within subjects and Test Condition was varied between subjects. The effects of Type of Processing and Degree of Rotation on subjects' accuracy in the Recognition or Source Identification Test were analyzed.

Practice trials. There were two practice trials, one Seen and one Imagined. For the practice Seen trial, subjects were told that the first slide in each Seen trial would show a letter or a number in an upright position centered inside a circle. An example "identification slide" was then shown (see Table 1). The subject was told that the next few slides would show the same letter or number rotated to different positions in the circle, and the subject was to watch the sequence as closely as possible. The remaining four slides for the Seen practice trial were then presented with a 3-sec inter-stimulus interval (ISI). The Imagined practice trial was then introduced, again with the first slide showing a letter or number centered inside a circle. The next slide, however, showed only a circle with an arrow inside. The subject was instructed to imagine the previous character (e.g., an "E") as vividly as possible inside the circle with the arrow pointing at the top of the character. The subject was told that on the remaining three slides he or she would again see only a circle with an arrow inside and s/he was to imagine rotating the character so that the arrow again pointed at the top of the "E." The remaining slides for this imagined sequence were presented, again with a 3-sec ISI. Following presentation of the practice trials, subjects were told that in the actual experiment they would be presented with several sequences of Seen letters or numbers and several sequences of Imagined letters or numbers, and that before each trial the experimenter would indicate whether the next trial would be Seen or Imagined.

Practice trials were then presented a second time in order to familiarize the subject with the rating he or she would be asked to make after each trial. The subject was told that after each trial s/he would be asked to verbally assign a number from 1 to 7 to indicate his or her evaluation of how much the visual appearance of the letter or number changed over the course of the rotation. The subject was given a written rating scale to refer to, with the end points of the scale indicated as follows: "1" indicated the subject felt the visual appearance of the character did not change at all over the course of the rotation, while "7" indicated that the subject felt the visual appearance of the letter or number changed a lot in appearance. Subjects used the numbers in between to indicate less extreme judgments. Subjects were asked to evaluate the change in visual appearance of the letters or numbers as they were rotated through the sequence, taking the entire rotational sequence into account. That is, this rating of "change" in visual appearance was to be made on the basis of the visual qualities of the particular letter or number, rather than on how far the character had been rotated. This orienting task was designed: (1) to maximize the likelihood that the subjects would process all of the slides in a particular sequence equally, and not merely focus on the first and/or the last slides; (2) to induce subjects to engage in "rotating" the letters and numbers both imaginally and perceptually; and (3) to increase the face validity of the acquisition phase.

Before presenting the practice trials once again, the experimenter summarized the entire procedure. The subject was told that the experimenter would first announce whether the upcoming trial would be Seen or Imagined. The trial would then be presented, followed by a blank slide. At that point, the subject would verbally give the experimenter his or her rating of "change in visual appearance" for the letter or number, taking the entire sequence into account. If the subject had no further questions, both practice trials were presented again, including the "change ratings."

Acquisition. Prior to presenting the 24 experimental trials, the subject was reminded to carefully observe the characters in the specific orientations presented to them on the Seen trials, and to likewise imagine the symbols as vividly as possible in the specific orientations indicated by the arrows on the Imagined trials. The subject was also asked to keep his or her back straight up against the chair and to always look at the screen during each trial. The purpose of this last instruction was to insure that, as much as possible, stimuli for all subjects would subtend a visual angle of 2½ degrees.

All trials were presented with a 3-sec ISI. At the end of each trial, subjects were asked to make a subjective assessment of how much they felt the visual appearance of the character changed over the course of the rotation sequence, using the rating sale provided.

Test. Following acquisition, subjects were engaged in conversation for about 3 minutes before receiving one of two incidental memory tests: Recognition or Source Identification. Assignment was made such that each test condition included 6 subjects who had received stimulus set 1 and 6 subjects who had received stimulus set 2.

In both test conditions, subjects were presented with the 24 identification slides (in which letters or numbers were upright) used during acquisition, along with comparable slides of 8 upright distractor characters, randomly intermixed. Distractors were letters and numbers which had not been presented during the acquisition phase. Care was taken to assign items from each third of the acquisition order to each third of the test order, to control as much as possible for primacy and recency effects. Subjects in the Recognition Test condition made Old/New judgments. Subjects were instructed to press the button labeled "Old" if the letter or number presented was one they had seen or imagined rotating during the first part of the experiment, and to press "New" if the letter or number on the slide was one they had not seen or imagined rotating. Subjects were encouraged to be as accurate as possible and still respond quickly.

Subjects in the Source Identification Test condition made source judgments. For each test character, subjects decided whether it was one they had seen rotating ("Seen"), was one they had imagined rotating ("Imagined"), or was not included in the acquisition phase ("New"). Subjects' decisions and response latencies were recorded for both test conditions. [Response latencies were not influenced by Type of Processing or Degree of Rotation and, therefore, will not be included in the presentation of the results.]

Results and Discussion

Change Ratings Made During Acquisition

Change ratings increased with degree of rotation, $F(2,70) = 67.85$, $MS_e = .88$, $p < .001$ (see Table 2). In addition, items that were imagined rotating were judged as having changed more ($M = 3.79$) than items that were seen rotating ($M = 3.46$), $F(1,35) = 7.72$, $MS_e = .73$, $p < .009$.

Table 2
Mean Change Ratings as a Function of Type of Processing and Amount of Rotation

Type of Processing	Amount of Rotation		
	Sm (20-80)	Md (110-170)	Lg (200-260)
Seen	2.44	3.86	4.09
Imagined	2.76	3.99	4.50

Note. Change ratings ranged from 1 to 7, where "1" indicated the subject felt the visual appearance of the character did not change during the rotational sequence and "7" indicated the subject felt the visual appearance of the character changed a great deal over the rotational sequence.

Recognition Test Condition

Correct recognition of Old items included all characters subjects judged as "Old" which had been either seen or imagined rotating during the acquisition phase. Correct recognition of New items included all characters subjects judged as "New" which had not been included in the acquisition phase.

The proportion correct recognition of Imagined items was determined for each subject by dividing the number of Imagined items correctly recognized by the number of Imagined items at each level of rotation (4). Similarly, the proportion correct recognition of Seen items was determined for each subject by dividing the number of Seen items correctly judged "Old" by the total number of Seen items at each level of rotation (4). The proportion correct recognition of New items was determined by dividing the number of New items the subject correctly judged "New" by the total number of New items (8). The question of whether mean proportion correct recognition differed as a function of type of processing or amount of rotation was addressed using a 2 (Type of Processing) x 3 (Amount of Rotation) repeated measures analysis of variance.

Table 3
Mean Proportion Correct Recognition as a Function of Test Condition and Type of Processing

Test	Type of Processing		
	Seen	Imagined	New
Recognition	.87	.93	.94
Source Identification	.83	.94	.89

Subjects' correct Old/New judgments were not affected by the amount that characters had been rotated, $F(2,18) = .08$, $MS_e = .01$, $p > .05$, and thus the data presented in Table 3 are collapsed across rotation. Subjects were very good at discriminating Old (M = .90) from New characters (M = .94), $F(1,9) = 7.36$, $MS_e = .005$, $p < .02$, and subjects recognized significantly more of the characters they had *imagined* rotating (M = .93) than characters they had *seen* rotating (M = .87), $F(1,9) = 10.26$, $MS_e = .002$, $p < .01$. This finding is consistent with previous work showing an advantage for imagined or "generated" over perceived events in recognition memory (e.g., Johnson et al., 1981; Johnson et al., 1984; Slamecka & Graf, 1978).

Source Identification Test Condition

A measure of Old/New recognition was first computed in order to compare recognition accuracy across the two test conditions. In this case, correct recognition included all items the subject judged as having been seen or imagined rotating which had, indeed, either been seen or imagined rotating, without regard for the accuracy of source identification. The mean proportion correct recognition was then determined for each subject in a manner analogous to that used for the Recognition Test condition (see Table 3). Again, the mean proportion correct Old responses was analyzed using a 2 (Type of Processing) x 3 (Amount of Rotation) repeated measures ANOVA.

As was found for the Recognition Test condition, overall recognition (M = .94) was high in the Source Identification Test condition, and the mean proportion of items correctly recognized as Old was higher for characters subjects had imagined rotating (M = .94) than for characters subjects had seen rotating (M = .83). Unlike the Recognition Test condition, however, the mean proportion of items correctly recognized as Old on the Source Identification test was influenced by the amount the characters had been rotated, $F(2,18) = 3.62$, $MS_e = .01$, $p < .05$ with greater recognition accuracy associated with items rotated a medium (M = .92) or large amount (M = .90) than items rotated a small amount (M = .83). This latter finding is particularly interesting because it suggests that the amount of cognitive operations involved in the generation of a memory can influence recognition accuracy in the context of a Source Identification task (which is presumed to be more likely to induce subjects to access information about cognitive operations than is a simple recognition test).

In both test conditions, then, subjects' recognition performance was consistently high and recognition accuracy was greater for characters that had been imagined rotating than for characters that had been seen rotating.

A measure of Source Identification was also computed in order to answer the following question: Given that subjects correctly identified a character as "Old," how accurate were they in identifying the processing source of the item (seen or imagined)? The mean proportion of items correctly identified for source, *given* the items had been correctly recognized, was then analyzed as a function of type of processing and amount of rotation. Subjects' ability to identify how the characters were originally processed (seen or imagined) was not influenced by how far the items were rotated, $F(2,18) = 1.12$, $MS_e = .46$, $p > .05$. The important finding was that in spite of their excellent recognition performance, subjects had difficulty discriminating characters they had seen rotating (M = .53), from characters they had imagined rotating (M = .58), $F(1,9) = .27$, $MS_e = 3.00$, $p > .05$. Further, source identification did not differ from chance performance (M = .50) for either Seen or Imagined characters, [$t(9) = .325, 1.33$, $p > .05$, respectively]. This confusion in source identification cannot be attributed to a general response bias to say items had been, for example, imagined. Subjects did not identify characters they had seen rotating as "Imagined" any more often than they identified characters they had imagined rotating as "Seen," $F(1,9) = .22$, $MS_e = .17$, $p > .05$.

General Discussion

Overall, subjects were very good at distinguishing Old from New items, yet were unsuccessful at identifying whether particular characters had been seen or imagined rotating. This profoundly poor Source Identification (56%), given the high level of Recognition (90%) was consistent with predictions derived from Johnson and Raye's (1981) reality monitoring framework regarding the conditions that should produce confusion between memories for seen and imagined events. Confusion between Imagined and Seen characters in this study presumably occurred for two reasons. The simple block letters and numbers used as stimuli should have been easy to vividly imagine, especially since subjects received an exemplar character at the onset of the imagined trials. The memories for these imagined and seen letters should thus be quite similar in terms of their sensory characteristics and subsequently difficult to discriminate on the basis of relative differences in sensory information (Johnson & Raye, 1981). Second, the memories for these imagined and seen letters should also have been similar in terms of the cognitive operations engaged at the time the memories were generated. Imagining the characters in different positions presumably requires cognitive operations involved in mental rotation. Seeing letters and numbers presented in different positions around a circle likewise should induce subjects to mentally rotate the seen characters *between* discrete positions, so that similar cognitive operations would be associated with the Seen and the Imagined characters (see, especially, Freyd & Finke, 1984). So, the observed reality monitoring confusions were likely the result of the similarity between memories for seen and imagined items in terms of their sensory qualities and operations information.

The findings regarding degree of rotation suggest that which aspects of memories subjects use in making decisions vary with the task (e.g., Lindsay & Johnson, 1988). For example, in order to judge whether an item was Old in the Recognition Test condition, subjects needed to determine only whether the character had been one of the characters presented on the identification slides or whether the item had a high level of familiarity or frequency (e.g., Atkinson & Juola, 1973; Mandler, 1980; Underwood, 1983). How far the character had been rotated was evidently irrelevant to judging an item's familiarity.

In the Source Identification test, subjects' recognition performance was influenced by how far characters had been rotated, while subjects' source judgments were not infuenced by amount of rotation. This pattern of results indicates that subjects retrieved information about the degree of rotation in the Source Identification condition. Rotation information, once retrieved, affected Old/New discrimination because Old and New items differed with respect to this information. In contrast, amount of rotation was not an effective discriminative cue for source identification because, in the present case, perceived and imagined events did not differ from each other, on the average, in amount of rotation.

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