Memory source confusions: Effects of character rotation and sensory modality

TRACEY L. KAHAN
Santa Clara University

Eighty subjects viewed and visually imagined upright or rotated alphanumeric characters and later judged whether test characters were previously seen or imagined (*reality monitoring*). Identification and test characters were presented verbally or visually. When characters were identified and tested verbally, source confusions (misjudging a seen character as "imagined" and vice-versa) were infrequent and were comparable for rotated and upright characters. When characters were identified and tested visually, source confusions were more frequent and were influenced by character rotation. Memories for imagined characters were especially susceptible to source confusion. Also source confusions for seen characters increased when characters were rotated. These results are consistent with the proposal that increasing sensory similarity between perceived and imagined items increases source confusion and that perceived rotation generates cognitive operations similar to those generated when the subject imagines a character rotated.

Most of us can describe occasions when we had difficulty discriminating memories for real events and memories for imagined events. For example, during your morning commute, you find yourself wondering whether you locked the front door or simply planned this action in your imagination. Johnson and Raye (1981) term this decision process *reality monitoring*. The Johnson-Raye reality monitoring model (Johnson & Raye, 1981; Johnson, Hashtroudi, & Lindsay, 1993) describes the processes involved in the discrimination and confusion of memories originating with perceptual processes and memories generated through imagination.

Major assumptions of the Johnson-Raye reality monitoring model

A major assumption of the reality monitoring model is that the characteristics of memories for actual and imagined events differ in predictable ways. All memories include sensory, contextual, or semantic details of an event, along with information about the cognitive operations (such as search, decision, or imagery processes) that were engaged when the

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memory was originally established (see also Johnson, 1983, 1985; Johnson & Hirst, 1993). Perception typically produces memory records with more sensory, contextual, and semantic information, whereas imagination typically produces memory records with more information about cognitive operations.

When individuals retrieve a memory, they may decide that the event actually happened because the memory includes sensory detail typical of perception (e.g., "I must have actually eaten the papaya because I recall its rich, smooth taste"). Or, they may attribute the memory to an internal source because the memory includes considerable information about cognitive operations (e.g., "I recall being in a hammock and watching a technicolor sunset. I must have imagined this experience because I recall mentally painting the sky with my favorite colors"). In both cases, the individual makes a judgment about the likely origin of the memory based on the typical characteristics of memories from imagined and perceived sources.[1] Although individuals are typically quite good at discriminating memories for perceived and imagined events (reality monitoring), there are occasions when reality monitoring is difficult such as *memory source confusion*(see Johnson et al., 1993 for a review).

The major intent of the present study was to extend previous research on memory source confusions by testing three hypotheses derived from the following reality monitoring proposition: the greater the overlap between characteristics of memories for imagination and perception, the harder the discrimination between the two will be (Johnson & Raye, 1981; Johnson et al., 1993).

The first two hypotheses concern specific conditions under which memories for imagined events are likely to be misattributed to perception, whereas the third hypothesis concerns conditions under which memories for perceived events are likely to be misattributed to imagination. Although several previous studies have tested these hypotheses individually, the hypotheses were tested jointly in the present study. This permitted us to investigate whether or not memories for imagined events are more susceptible to confusion with perception and whether particular qualitative characteristics of memories are more likely to contribute to memory source confusions (see Johnson et al., 1993).

Producing source confusions for imagined events

Most previous studies of reality monitoring confusions were designed to produce memories for imagined events that were atypical of their class and, hence, likely to be misattributed to perception. For example, Johnson, Foley, and Leach (1988) found that participants could readily discriminate memories for words imagined in their own voice and words heard in a speaker's voice. However, this discrimination was more difficult when participants imagined the words in the speaker's voice. In the latter case, imagined words were especially likely to be misattributed to perception, presumably, because the memories for imagined events were more like typical perceptual events in terms of their (auditory) sensory detail (also see Johnson, Raye, Wang, & Taylor, 1979; Mohsen, Kahan, Tandez, & McDonald, 1996). This led to my first hypothesis: memories for imagined events will tend to be misidentified as perceived events when memories for imagined and perceived events include considerable sensory detail.

Research conducted by Finke, Johnson, and Shyi (1988) revealed another situation when individuals are likely to misattribute memories for imagined experience to perception. Subjects were presented with half of a symmetrical form, imagined the form completed, and then rated the difficulty of the imagery task (Exp 1). Participants found it easier to imagine forms that were symmetrical about the vertical axis than forms that were symmetrical about the horizontal axis, suggesting that fewer cognitive operations were required for the vertical completion task. In a second experiment, subjects first inspected whole forms and half forms. For whole forms, subjects evaluated the complexity of the pattern. For half forms, subjects imagined the form completed and then rated the complexity. A control group gave only the complexity rating. In a surprise memory test, subjects were asked to identify whole forms as either representing forms seen ("whole"), forms imagined completed ("half"), or as new. Relative to controls, subjects who imagined vertical forms tended to misattribute these memories to perception more frequently than did subjects who imagined horizontal forms. Finke et al.'s (1988) findings indicate that memories for imagined events, generated with relatively little cognitive effort, a feature more typical of perception than of imagination, are especially likely to be misattributed to perception (also see Intraub & Hoffman, 1992; Johnson, Kahan, & Raye, 1984; Johnson, Raye, Foley, & Foley, 1981). Therefore, my second hypothesis was that memories for imagined events will be misidentified as perceived events when memories for imagined and perceived events include relatively little information about cognitive operations.

One general aim was to investigate, in a single study, two conditions expected to result in the misattribution of memories for imagined events to perception. Specifically, memories for simple imagined events should be especially susceptible to confusion with memories for similar perceptual events when memories for the imagined events contain considerable sensory detail and relatively little information about cognitive operations. The other objective was to investigate a condition likely to increase the misattribution of memories for perceptual events to imagination.

Producing source confusions for seen events

A study by Kahan and Johnson (1990) suggested that memories for perceived events that include considerable information about cognitive operations are likely to be misattributed to imagination. Subjects first viewed a letter or number in an upright position (identification). In half of the trials, subjects then viewed the character rotated clockwise to several discrete positions. The remaining trials were identical except that subjects imagined the character rotated. Later, the identification characters and comparable new characters were presented and subjects judged whether each test character was one they had seen, imagined, or was new. Subjects had difficulty discriminating items they had seen rotated (53%) from items they had imagined rotated (58%), in spite of excellent old/new recognition (90%). Further, source identification did not differ from chance performance for either seen or imagined characters. Kahan and Johnson (1990) offered two explanations for these memory confusions. The memories for imagined and seen characters were highly similar in terms of their sensory characteristics because subjects viewed an exemplar character at the onset of both the imagined and seen trials. Memories for imagined events may have been confused with memories for perceived events, based on the high level of sensory information associated with imagined events. Memories for seen events may have been confused with memories for imagined events because memories for perceived events included considerable information about the cognitive operations engaged at the time the memories were generated. Kahan and Johnson (1990) reasoned that imagining *or* seeing characters in a sequence of positions within a circle could engage the cognitive operations involved in mental rotation (e.g., Bethell-Fox & Shepard, 1988; Cooper, 1976; Cooper & Shepard, 1973a, 1973b; Koriat & Norman, 1984; Shepard & Metzler, 1971). Reality monitoring could have been difficult on the basis of relative similarity in cognitive operations information (e.g., Johnson et al., 1981). Unfortunately, the conditions employed by Kahan and Johnson (1990) did not permit an unambiguous interpretation of the likely basis of the observed source confusions.

The present study

The present study replicated and extended the Kahan and Johnson (1990) study in order to test three hypotheses concerning the conditions likely to increase reality monitoring confusions. The similarity between memories for seen and imagined events was varied along two

dimensions identified as important for reality monitoring: information about the sensory characteristics of the event and information about the cognitive operations involved in the formation of the memory.

The basic paradigm developed by Kahan and Johnson (1990) was used; a letter or number was identified and then the character was seen or imagined. Later, the identification characters were re-presented as test items, intermixed with new characters. The subject's task was to decide whether test characters were originally seen, were originally imagined, or were new (reality monitoring).

Manipulating sensory characteristics. In the present study, the acquisition task was always visual: seeing or visually imagining the characters. The first experimental manipulation involved the sensory modality used to identify the characters and to present test stimuli. Identification and test characters were presented visually (*visual mode*) to half of the subjects and verbally (*verbal mode*) to the other half of the subjects. Sensory similarity between seen and visually imagined events should be high in the visual mode and low in the verbal mode. This is because the visual mode involves perceptual input (identification of a character) that is in the same sensory modality as the imagined and seen tasks. However, the verbal mode involves perceptual input (identification of a character) that is in a different sensory modality as the imagined and seen tasks. The first prediction is that memories for imagined characters should be more often misidentified as "seen" in the visual mode than in the verbal mode.

Manipulating information about cognitive operations. The amount of cognitive operations induced by the experimental task was also manipulated. Half of the subjects viewed and imagined the characters rotated (rotation) and half of the subjects viewed and imagined the characters in a single upright position (no rotation). More cognitive operations should be required to construct an image in several different orientations than to construct and maintain a single image (e.g., Corballis, 1986; Logan, 1978), even if imagining letters is a relatively easy imagery task (e.g., Jolicoeur, 1988). The memories for the characters imagined in a single position should be easily confused with the memories for similar seen characters because both types of memories include relatively little information about cognitive operations, a feature more typical of perception than of imagination. This information about the relatively low level of cognitive operations could later serve as a cue that these memories originated with primarily perceptual processes. The second prediction, then, was that memories for items imagined in a single position (no rotation) should be misattributed to perception more frequently than memories for characters imagined in several orientations (rotation).

Finally, if mental rotation involves the controlled processing that typifies imagining, memories for characters that were imagined rotated, *or* seen rotated, should include considerable information about cognitive operations, a feature more typical of imagination than of perception. Therefore, the third prediction was that the characters that were viewed in several orientations (rotation) should be misattributed to imagination more frequently than the characters that were viewed in a single orientation.

Summary

In general, memories for seen and imagined events should be similar with respect to semantic content (letters and numbers) and contextual information (characters presented or imagined within a circle on a computer screen). Across the four combinations of modality and rotation, memories for seen and imagined items should vary only in information about cognitive operations and in information about the sensory features of the event. Source confusions for *imagined* events were predicted to increase when memories for imagined events are more like typical perceptual events in sensory detail (Hypothesis 1) and/or in information about cognitive operations (Hypothesis 2). Source confusions for *perceived* events were predicted to increase when memories for perceived events are more like typical imagined events with respect to information about cognitive operations (Hypothesis 3).

EXPERIMENT

METHOD

Subjects

Eighty undergraduates (44 females and 36 males; *M* age = 20.4 years) were randomly assigned to one of the four experimental conditions. Subjects received partial credit in an introductory psychology course.

Stimuli and apparatus

The twenty-six letters of the English alphabet and the numerals two through nine defined the initial 34-character set.[2] Twenty-four characters (18 letters and 6 numbers) were selected and then randomly assigned to either seen or imagined trials.[3] Two of the remaining ten characters were randomly selected for use in practice trials and the other eight characters (one number and seven letters) became the set of "new" characters for the test list. "Old" and "new" items were not explicitly matched in terms of orthographic frequency.

Twelve rotation sequences were defined for two of the experimental conditions (visual mode, rotation, verbal mode, rotation). Each sequence involved four positions, unequally spaced so subjects could not readily anticipate a char-

acter's next position (see Figure 1). Rotation sequences differed in how far the character was rotated. Four different character sequences were defined at each of three levels of rotation: "low rotation" sequences terminated between 20 and 80 degrees, "moderate rotation" sequences terminated between 110 and 170 degrees, and "high rotation" sequences terminated between 200 and 260 degrees. The 12 imagined and 12 seen characters were assigned to a rotation sequence so that four imagined and four seen characters thus occurred at each rotation level (low, moderate, high). A second character set was constructed by reversing which items were seen or imagined. The two character sets were counterbalanced across the two rotation conditions.

Design and procedure

A 2 (modality: visual, verbal) × 2 (rotation: yes, no) × 2 (source: seen, imagined) mixed design was used. Modality and rotation were varied between subjects and source was varied within subjects. Subjects' tendency to confuse memories for the source of seen and imagined items was compared across the four combinations of modality and rotation. Old/new recognition and false positive rates were also compared.

Acquisition. Subjects were told that this study compared the qualities of imagination and perception and, in particular, seeing versus imagining letters and numbers. Subjects were seated 1.22 m from a computer screen elevated 25.4 cm and were asked to fixate on a small cross centered inside a circle. The circle remained illuminated throughout the acquisition phase. The computer-presented stimuli were amber capital letters and numbers against a black background (see Figure 1).

Subjects received a verbal overview of the trial sequence, followed by one seen and one imagined practice trial. For two of the experimental conditions (visual modality: rotation, no rotation), trials consisted of five stimuli: a visual identification stimulus and four visual acquisition stimuli (see Figure 1). For

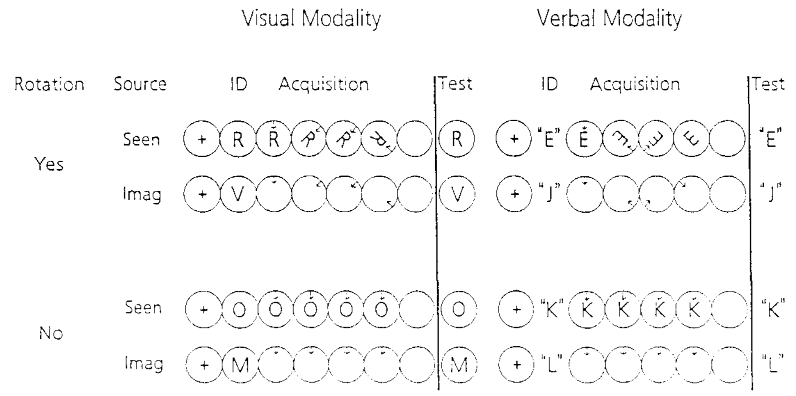

Figure 1. Representative seen and imagined trials for the four experimental conditions; in the verbal modality, characters were verbally identified and verbally tested

the other two conditions (verbal modality: rotation, no rotation), each character was verbally identified prior to presentation of the four visual acquisition stimuli. For example, for a seen character presented in the visual modality and with rotation, subjects first saw a circle on the screen (see Figure 1). A small cross then appeared in the center of the circle; subjects were instructed to focus on the cross. A letter or number replaced the cross (e.g., an "R"). An arrow pointing down through the top of the character was added. Next, the character and arrow were re-presented in several discrete positions representing a clockwise rotation. At the end of the trial, only the circle was displayed. Imagined trials differed from seen trials in that, when the arrow was displayed, the character disappeared (see Figure 1). Subjects were instructed to vividly *imagine* the previous character (e.g., a "V") in the positions indicated by the arrow, with the arrow pointing down through the top of the imagined character.

Subjects assigned to the verbal modality with rotation experienced the procedure just described except that the character was identified verbally while the subject was focused on the cross. Subjects assigned to a condition involving no character rotation experienced the procedure appropriate to their assigned sensory modality (visual or verbal) and all characters were seen or imagined in a single, upright position (see Figure 1). Each trial (character identification followed by four acquisition stimuli) was 15 s with a 2–s interstimulus interval (phi motion did not occur at this presentation rate).

The mirror image judgment was included in a second run through the practice trials. Subjects were asked to verbally rate the difficulty ranging from 1 (*very easy*) to 7 (*very difficult*) of imagining the mirror image of each character in its final position.[1] The mirror image ratings were designed to increase the face validity of the experimental task and to provide an indirect index of whether subjects were following the imagery instructions.[2]

The 24 experimental trials followed, with the subject reporting his or her mirror image rating after each trial. The intertrial interval was about 6 s.

Distractor task. Following acquisition, subjects completed Marks's (1973) Vividness of Visual Imagery Questionnaire (VVIQ). This task averaged 5 min, during which subjects were asked to visualize and rate the vividness of several complex memory images (e.g., a mountain scene; a familiar person). The VVIQ was expected to prevent incidental rehearsal of the acquisition items and to maintain subjects' task involvement

Source monitoring test. All subjects were tested for their ability to identify the source of 32 computer-presented test characters (the 24 identification characters used during acquisition intermixed with 8 new characters). Test characters were randomized in blocks of eight, with each block containing two new, three seen, and three imagined characters. Within each block, the seen and imagined characters also encompassed the three rotation conditions (low, moderate, and high). Items from each third of the acquisition set were included in each third of the test order to reduce possible primacy and recency effects.

Test trials began with the subject focused on the cross inside the circle (see Figure 1). For subjects in the visual mode, test characters were then presented visually, in an upright position and centered inside the circle. For subjects in

the verbal mode, test characters were presented verbally (see Figure 1). The interstimulus interval (ISI) was 3 s.

Participants used the first finger of the writing hand to press one of the three labeled computer keyboard keys ("seen," "imagined," or "new"). The new response key was located between the other two response keys whose order (Seen, Imagined) was counterbalanced across subjects. Subjects were instructed to base their source judgments on what happened with the character after it was introduced (whether visually or verbally) and to be as accurate as possible and still respond quickly. Subjects were debriefed after the source monitoring test.

RESULTS AND DISCUSSION

A significance level of $p < .05$ was adopted, unless otherwise noted.

Source confusions

The variable of interest was source confusions: memories for imagined items misidentified as "seen" and memories for seen items misidentified as "imagined." As the measure of source confusions, two proportions were calculated for each subject; one proportion for seen characters and another for imagined characters. The proportion for seen characters is represented by the formula:

$$\frac{[(\text{total})\ I \mid S]}{[(\text{total})\ I \mid S + S \mid S]}$$

The value to the left of each slash represents the subject's judgment and the value to the right of each slash represents the actual source of an item. Thus, the numerator in the above proportion reads: "the number of characters the subject judged as 'imagined' that were, in fact, seen." The denominator reads: "the number of characters the participant judged as 'imagined' *or* 'seen' that were, in fact, seen." A comparable measure was obtained for imagined characters. In short, source confusions were the proportion of correctly recognized seen characters that were misidentified as having been imagined and the proportion of correctly recognized imagined characters that were misidentified as having been seen. These measures are conceptually consistent with previous reality monitoring studies (e.g., Finke et al., 1988; Johnson et al., 1984; Johnson et al., 1981; Kahan & Johnson, 1990, 1992).

Analysis of variance (ANOVA) was used to investigate source confusions in relation to the three manipulated variables: the sensory modality of identification and test characters (verbal, visual), character rotation (no, yes), and character source (seen, imagined). Overall, source confusions were higher for imagined characters ($M = .37$) than for seen characters

($M = .25$), $F(1, 76) = 8.33$, $MSE = .50$, and for the visual modality ($M = .43$) than for the verbal modality ($M = .20$), $F(1, 76) = 53.50$, $MSE = 2.12$. Source confusions did not differ for characters that were rotated ($M = .32$) and characters that were not rotated ($M = .31$), $F(1, 76) = .16$, $MSE = .01$. However, a significant Source × Rotation × Modality interaction, $F(1, 76) = 3.86$, $MSE = .23$, revealed that the influence of character source on subjects' tendency to misjudge the source of memories depended on the sensory modality of identification and test characters and on whether characters were rotated. Figure 2 illustrates this pattern.

Differences across sensory modalities. The three-way interaction was explored by conducting separate ANOVAS for the verbal and visual modalities. When identification and test characters were presented *verbally* (Figure 2, left panels), source confusions were generally low ($M = .19$) and comparable for seen ($M = .20$) and imagined ($M = .20$) characters, $p > .10$. Source confusions were also comparable for rotated ($M = .24$) and upright ($M = .16$) characters, $p > .10$. There was no interaction between source and rotation.

When identification and test characters were presented *visually* (Figure 2, right panels), the difference in source confusions for seen and imagined characters was greater when characters were not rotated than when characters were rotated, $F(1, 38) = 4.27$, $MSE = .40$. Also, imagined

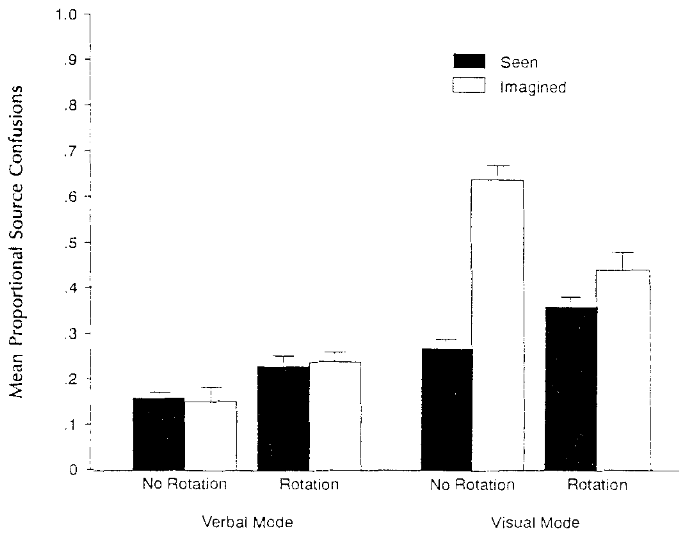

Figure 2. Mean proportional source confusions of seen and imagined characters as a function of sensory modality and character rotation. Vertical lines indicate the 95% confidence interval for the mean

characters were more often misidentified as "seen" ($M = .54$) than were seen characters misidentified as "imagined" ($M = .32$), $F(1, 38) = 10.57$, $MSE = 1.00$. Subjects who were instructed to imagine the characters in a single upright position ($M = .64$) were much more likely to later judge these characters as having been "seen" than were subjects instructed to imagine the characters rotated to various positions ($M = .44$), $F(1, 38) = 2.22$. Contrary to expectation, the tendency to misattribute seen characters to imagination did not differ for subjects who viewed the characters rotated through a sequence of positions ($M = .36$) and for subjects who viewed the characters in a single, upright position ($M = .28$), $F(1, 38) = 1.29$, $p > .10$.

A two-way Rotation × Modality interaction effect was observed in subjects' tendency to misjudge imagined characters as "seen," $F(1, 79) = 7.06$, $MSE = .45$. When identification and test characters were presented verbally, subjects were no more likely to misidentify memories for imagined characters as having been seen when characters were rotated ($M = .24$) than when characters were not rotated ($M = .15$), $F < 1.0$. When identification and test characters were presented visually, subjects were more likely to misidentify memories for imagined characters as having been seen when the characters were not rotated ($M = .64$) than when the characters were rotated ($M = .44$), $F(1, 38) = 2.22$. In general, memories for imagined characters were misidentified as "seen" more often when the same sensory modality was used for the identification of test characters relative to the acquisition task, visual mode, ($M = .54$) than when different sensory modalities were used, verbal mode, ($M = .20$), $F(1, 79) = 35.74$, $MSE = 2.28$.

Source confusions were generally more frequent in the visual mode than in the verbal mode. This finding is consistent with the initial hypothesis that memories for imagined events will tend to be misidentified as originating with perception (judged "seen") when memories for imagined and perceived events are similar with respect to sensory detail. In the visual mode, each character was visually identified before the acquisition trial, so imagined and seen characters were highly similar in sensory detail. In the verbal mode, each character was verbally identified, so imagined and seen characters were less similar in sensory detail. Consistent with the Johnson-Raye reality monitoring model (1981), memories for seen and imagined characters were confused in the visual mode because of the relative similarity in sensory qualities. Memories for seen and imagined characters were not confused in the verbal mode because of the relative differences in sensory qualities. In short, source confusions were increased when the sensory input preceding an imaginal task involved the same sensory modality as the imaginal task (see also Brooks, 1968).

Results from the visual mode are consistent with the hypothesized role of cognitive operations in source monitoring judgments. The second prediction was that memories for imagined characters would tend to be misidentified as having been seen when memories for imagined events include little information about cognitive operations. Source confusions occurred more often when characters were imagined in an upright position than when characters were imagined rotated to several positions. Presumably, more cognitive operations were required to generate images of the rotated characters and this information about cognitive operations was preserved in memory. In spite of the sensory similarity between imagined and seen characters, subjects were able to later correctly identify the source of imagined items that were rotated on the basis of information about cognitive operations (Johnson & Raye, 1981; Johnson et al., 1993). Items that were imagined in a single position were readily confused with seen items because the memories for these items were similar to memories for seen items in high sensory detail *and* little information about cognitive operations.

Differences for seen and imagined characters. An alternative view of the three-way interaction effect for source confusions was evaluated by considering the effects of sensory mode and character rotation separately for seen and imagined characters.

Participants in the visual mode misidentified seen characters as "imagined" more frequently ($M = .32$) than did subjects in the verbal mode ($M = .20$), $F(1, 79) = 11.20$, $MSE = .39$. Also, subjects tended to misidentify seen characters as "imagined" more frequently when characters were rotated ($M = .29$) than when characters were not rotated ($M = .22$), $F(1, 79) = 3.43$, $MSE = .12$, $p = .07$.

These findings lend qualified support for the third prediction that memories for seen characters will tend to be misidentified as having been imagined when memories for seen events include considerable information about cognitive operations, particularly when memories for seen and imagined events are qualitatively similar in other respects (e.g., contextual information or sensory detail).

Recognition

The measure of source confusions takes into account the subjects' overall level of item recognition, so extreme variation in recognition could potentially skew source confusions. It is therefore important to know whether recognition varied across the four experimental conditions.

First, a corrected measure of overall recognition was analyzed (hits-false alarms divided by the total number of items). For each subject, the number of seen and imagined items judged "seen" *or* "imagined" and

the number of new items judged "new" was added ("hits"). The number of new items judged "seen" or "imagined" was then subtracted ("false alarms"). The resulting number was divided by the total number of items (32), yielding the percentage of items correctly recognized. An ANOVA was used to analyze these percentages as a function of sensory modality (verbal, visual) and character rotation (no, yes).

Recognition was better in the verbal mode ($M = .91$) than in the visual mode ($M = .86$), $F(1, 79) = 7.05$, $MSE = .05$, but it did not differ for rotated characters ($M = .89$) and upright characters ($M = .88$). There was no interaction between sensory modality and character rotation. The overall level of recognition ($M = .89$) was comparable to that observed by Kahan and Johnson (1990).

Recognition was also considered separately for seen and imagined items. Correct recognition of seen items was defined as the percentage of seen characters ($n = 12$) judged "seen" or "imagined" and correct recognition of imagined items was defined as the percentage of imagined characters ($n = 12$) judged "seen" or "imagined." An ANOVA based on a mixed model was used to analyze the resulting percentages as a function of sensory modality (verbal, visual), character rotation (no, yes), and character source (seen, imagined). Subjects evidenced a comparably high level of recognition across the verbal and visual modes ($Ms = .89, .90$, respectively). Recognition of seen and imagined items was not generally influenced by source, rotation, or modality (all $Fs < 1$). However, a reliable rotation × modality interaction was observed, $F(1, 76) = 6.71$, $MSE = .10$. When identification and test characters were presented verbally (verbal mode), recognition was higher for characters presented or imagined in an upright position ($M = .92$), relative to characters rotated to different positions ($M = .87$). When identification and test characters were presented visually (visual mode), recognition was higher for characters rotated to different positions ($M = .91$) than for characters not rotated ($M = .86$). The fact that recognition was not influenced by item source indicates that the pattern of source confusions described above cannot be explained in terms of differences in the recognition of seen and imagined characters.

False positive responses

The possibility of a general bias to respond "seen" or "imagined" was explored by comparing the proportion of new items judged "seen" and the proportion of new items judged "imagined." The overall false positive rate (new items judged "seen" or "imagined") was very low overall (M proportion $= .06$) and did not vary with modality ($F < 1$). In other words, subjects could readily discriminate "new" and "old" items, and there was no greater tendency to respond, for example, "seen" to new items when the characters were identified and tested visually rather than verbally. The latter finding is especially important because it indicates that the source monitoring confusions of imagined items in the visual modality cannot be explained by a generalized response bias to say "seen."

An ANOVA was conducted to evaluate whether subjects evidenced a response bias to judge new items as imagined or seen. A significant Rotation × Source interaction revealed that subjects' tendency to call new items "seen" or "imagined" was related to whether or not target items had been rotated, $F(1, 76) = 4.04$, $MSE = .03$. When subjects imagined and saw characters in a single, upright position (no rotation), subjects were more inclined to misidentify new items as "seen" ($M = .06$) than as "imagined" ($M = .03$). When subjects imagined and saw characters rotated, they were more inclined to misidentify new items as "imagined" ($M = .07$) than as "seen" ($M = .05$).

Memories for seen and imagined characters in the no rotation conditions should include relatively little information about cognitive operations, a feature more typical of perception than of imagination. And if the memories for these items are also similar in terms of other qualitative characteristics important for reality monitoring, then subjects who are uncertain of the source of a test character would likely apply the judgment heuristic "when in doubt, judge the item as 'seen.'" The present false positive results suggest that when subjects in the no rotation conditions were uncertain of the source of a new item, they applied this same heuristic. Similarly, memories for seen and imagined rotated characters should include more information about cognitive operations, a feature more typical of imagination than of perception. The false positive results suggest that when subjects are uncertain of the source of a new item, they apply the heuristic "when in doubt, judge the item as 'imagined.'" These results are consistent with the reality monitoring model and the predicted basis for source confusions in the present study. That is, subjects were expected to base their source judgments on implicit heuristics concerning the average differences typical of memories for perceived and imagined events. The present results are also congruent with the reality monitoring proposition that the judgment heuristics applied in a source monitoring task are influenced by the relative differences between memories for seen and imagined events in a *particular* task.

Ratings on the VVIQ. For each person, a mean VVIQ rating was computed from the ratings given for the 16 questionnaire scenes. The mean VVIQ rating across all subjects was 3.84 on a scale of (1) (*no image at all*) to (5) (*perfectly clear and as vivid as normal vision*). An ANOVA based on a mixed model was used to analyze the mean VVIQ ratings as a function of sensory modality (verbal, visual), and character rotation (no, yes). Mean VVIQ ratings did not vary with any of the manipulated variables (all $Fs < 1$, $ps > .5$), indicating that subjects were equally able to construct the complex scenes described in the VVIQ. Therefore, subjects' ratings on the VVIQ were not confounded with the level of source confusions observed across experimental conditions.

GENERAL DISCUSSION

In the present study, source confusions of memories for seen and imagined characters were asymmetrical and depended on whether or not characters were rotated, as well as on the sensory modality used to present identification and test characters. Source confusions were generally low in the verbal mode. This finding is consistent with the reality monitoring and source monitoring models (Johnson & Raye, 1981; Johnson et al., 1993) because memories for seen and imagined characters could be readily discriminated on the basis of information about the *visual* characteristics of the event. Memories for seen items would include more visual detail than memories for imagined items. In other words, memories for seen and imagined characters should differ in class characteristic ways in terms of sensory information. This relative difference would provide a reliable basis for differentiating memories for the two types of items. An individual would not need to consider relative differences between memories for seen and imagined characters in terms of other types of information preserved in memory (e.g., cognitive operations). On the other hand, more source confusions occurred in the visual mode because memories for seen and imagined characters were qualitatively more similar and, in certain cases, "atypical" of their class. For example, memories for imagined characters should include vivid sensory detail and, thus, be easily confused with memories for seen characters. In addition, the visual test cue should reinstate the visual identification cue, further reducing the relative differences between memories for seen and imagined items with respect to sensory information. An individual would need to activate other qualities of these memories in order to make a source judgment (i.e., one cannot simply apply the heuristics "if my memory for the character is very vivid perceptually, it was seen; if my memory for the character is not very vivid perceptually, it was imagined"). Instead, subjects needed to consider relative differences between memories for seen and imagined characters in terms of other types of information preserved in memory (see Kahan & Johnson, 1992). Again, the only major qualitative difference predicted between memories for seen and imagined characters in the visual mode was information about the cognitive operations engaged when the memory was established.

The pattern of results in the visual mode also indicated a tendency for source confusions to increase for seen items and decrease for imagined items when characters were rotated, relative to the no rotation condition. The most parsimonious explanation for this trend is that viewing or imagining characters rotated to various positions induces mental rotation and that the cognitive operations associated with mental rotation are actually of a more deliberate, controlled nature than has been previously assumed (e.g., Corballis, 1986; Logan, 1978). Information about cognitive operations is preserved in memory and, when activated in the context of a source identification task, provides a cue that the memory was likely generated through primarily imaginal processes.

Conclusions

The present results are consistent with the assumption that specific information concerning the conditions under which a memory was established is preserved in memory and later serves as the basis for decisions about the likely source of the memory (Johnson & Raye, 1981; Johnson et al., 1993; Lindsay & Johnson, 1989). Source confusions increase with increased overlap in the characteristics of memories for imagined and seen events. However, source confusions do appear to be asymmetrical, with memories for imagined events more likely to be misattributed to perception. The present data suggest that it is also possible to increase source confusions for seen events although this type of memory confusion is more difficult to produce and may occur only when there is already an unusually high degree of similarity between imagined and perceived events.

Notes

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Correspondence concerning this article should be addressed to Tracey L. Kahan, Department of Psychology, Santa Clara University, 500 El Camino Real, Santa Clara, CA 95053. E-mail: tkahan@scuacc.scu.edu. Received for publication December 14, 1994; revision received May 3, 1995.

1. Johnson et al. (1993) use the term "heuristic" to refer to reality monitoring judgments "based on qualitative characteristics of activated information" and the term "systematic" to refer to judgments "based on more extended reasoning" (p. 5). While both systematic and heuristic processes may be used to determine whether an event was perceived or imagined, the present experimental task likely involves heuristic processes (see Johnson et al., 1993, pp. 4–5 for an extended discussion of the systematic-heuristic distinction).

2. The numerals "0" and "1" were eliminated because of their similarity to the letters "O" and "I," respectively.

3. The resulting character assignment was inspected to insure that similar characters did not consistently occur across seen and imagined conditions (e.g., R seen and B imagined, E seen and F imagined).

4. In the Kahan and Johnson (1990) study, subjects rated the perceived change in visual appearance over the course of the seen and imagined rotation sequences. This task was replaced because it was not appropriate for the conditions in which characters were not rotated.

5. Subjects' mirror image ratings were analyzed as an index of whether the instructional manipulations were successful. For example, subjects who were instructed to actively imagine a character during the acquisition task should find the mirror image task relatively difficult because of the increased processing demands associated with completing two simultaneous imagery tasks (e.g., Brooks, 1968). For each person, an average mirror image rating was calculated for seen items and for imagined items. A 2 (modality: visual, verbal) × 2 (rotation: no, yes) × 2 (source: seen, imagined) ANOVA based on a mixed model was used to analyze the mean mirror imagery ratings. Mirror image ratings were influenced by all three manipulated variables. Participants rated the mirror image task as more difficult when they were instructed to vividly imagine alphanumeric characters ($M = 2.56$) than when they were instructed to simply view characters ($M = 2.20$), $F(1, 76) = 14.53$, $MSE = 4.99$. Participants also considered the mirror image task more difficult when characters were rotated ($M = 2.60$) than when characters were not rotated ($M = 2.16$), $F(1, 76)$ 7.62, $MSE = 1.21$. Finally, subjects found it more difficult to imagine the mirror image of a character when characters were identified visually ($M = 2.67$) than when characters were identified verbally ($M = 2.09$), $F(1, 76) = 10.94$, $MSE = 1.21$). No interaction effects were observed. The mirror image findings are consistent with the assertion that subjects followed instructions when they were asked to vividly imagine a character. These findings also suggest that the demands on cognitive processing are greater under rotated versus static conditions and under conditions when the identification and acquisition stimuli are in the same sensory modality.

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