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# Adapting a memory framework (source monitoring) to the study of closure processes

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The present experiments adapt a memory framework (source monitoring) to the study of closure processes. Closure processes are invoked as explanatory mechanisms underlying the ability to identify objects under conditions of incomplete visual information. If closure processes are activated, filling in missing pieces of visual information, intriguing memory predictions follow. When making source judgments about the way in which visual information was experienced initially (e.g., complete or incomplete in form), a particular kind of memory error should be evident. Incomplete visual information should be remembered as complete in form, and indeed, this error is observed. The present experiments test alternative interpretations for the initial reports of this memory error in the context of a search task modeled after the *Where's Waldo?* children's books. The effects of several new factors (e.g., familiarity) are reported, and alternative interpretations for the bias to report *complete* are eliminated. Findings, therefore, have implications for understanding the mechanisms of closure processes, as well as for the source-monitoring framework itself.

Whether navigating in the environment (e.g., driving, jogging), searching for someone in a crowded scene (e.g., a family member at a crowded airport), being occupied by professional responsibilities (e.g., scanning X rays for evidence of tumors, scanning and creating mugshots), or being "lost" in aesthetic experiences (e.g., looking at works of artists such as Bev Doolittle or Arcimboldo), the ability to identify objects figures prominently in our success and enjoyment. Remarkably, these identification feats are often accomplished with only partial information. Although this visual information may be experienced as fragmented, the phenomenal experience derived from that information gives rise to a sense of continuity and completeness (Akins, 1996; Durgin, 1995).

The empirical study of object identification under these conditions of incomplete visual information has a long and fruitful history (Gollin, 1962; Kanizsa & Gerbino, 1982; Leeper, 1935; Sekuler & Palmer, 1992; Sekuler, Palmer, & Flynn, 1994; Snodgrass & Feenan, 1990), yet theoretical debates about the mechanisms mediating this ability are far from resolved (e.g., Akins & Winger, 1996; Churchland & Ramachandran, 1996; Dennett, 1992; Kellman & Shipley, 1991; Kimchi, 1992; Pessoa, Thompson, & Noe, 1998; Sekuler, 1994). One theoretical perspective proposes that *filling-in* processes, often referred to as *closure processes*, are automatically activated by the incomplete visual information and serve to supply the "missing" portions of objects (or pictorial referents) in the mind's eye (Akins, 1996; Churchland & Ramachandran, 1996; Sekuler et al., 1994; Snodgrass & Feenan, 1990; Snodgrass & Kinjo, 1998). An alternative view suggests that the visual system essentially ignores the missing information; object recognition occurs when there is sufficient information in the incomplete form to resolve its identification (e.g., Dennett, 1992, 1996; Hearst, 1991).

Laboratory analogues intended to parallel object identification under conditions of incomplete visual information provide compelling evidence in support of filling-in processes. These analogues include the use of fragmentation (Biederman, 1987; Bregman, 1981; McClelland & Rumelhart, 1981; Snodgrass & Feenan, 1990) and priming tasks (Sekuler & Palmer, 1992; Sekuler et al., 1994). In fragmentation tasks, pictures of objects (e.g., Snodgrass & Feenan, 1990) or words (Snodgrass & Kinjo, 1998) are rendered incomplete by partial deletion (e.g., Snodgrass &

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Feenan, 1990) or partial occlusion (e.g., Bregman, 1981; Brown & Koch, 1993; McClelland & Rumelhart, 1981). During the course of a trial, a series of increasingly complete pictures is presented. Individuals are able to identify objects emerging in the series before the completed versions are shown. Similarly, in priming tasks, partially occluded primes are as effective as those presented completely in view, whether the occluders are real (Nakayama, Shimojo, & Ramachandran, 1990) or illusory (e.g., Sekuler, 1994).

Theories based on filling-in processes explain these robust fragmentation and priming effects by suggesting that deleted or occluded fragments are "added" by closing in the missing contours (Sekuler & Palmer, 1992; Snodgrass & Feenan, 1990). However, it is also plausible that the missing information is simply ignored when performing these identification tasks. To further evaluate the feasibility of explanations emphasizing filling-in or ignoring processes, we focus on the study of memory for the way in which the visual information was experienced. Very different memory predictions follow from each of these explanations.

Explanations based on filling-in processes predict that a particular kind of memory error should be observed. If the processing of incomplete visual information prompts filling-in processes and leads to more complete internal representations of the objects, individuals should be confused about the way in which they have experienced that information, falsely reporting that incomplete information has been experienced as complete. On the other hand, if the expression *closure processes* serves only as a marker for occasions in which individuals ignore missing information, one of two different patterns will be expected. Individuals' memory for the incomplete information should be quite accurate, showing no confusion. Or if people fail to notice and encode information about completeness, they should be equally confused about both complete and incomplete visual forms.

The memory predictions derived from explanations based on filling-in processes are consistent with findings from investigations of implicit imaginal processing within the source-monitoring theoretical framework (SMF; Johnson, Hashtroudi, & Lindsay, 1993; Johnson & Raye, 1981, 2000). Because the logic guiding our study of memory for incomplete visual information is based on the SMF, we provide a brief overview of the framework before describing initial tests of the memory predictions. Judgment about the way in which visual information is experienced is a type of *source-monitoring* judgment, and memory errors about this information are instances of source failures. According to the SMF, decisions about the source of memories may involve the consideration of qualitative characteristics of the memories themselves, as well as more extended reasoning based on knowledge and belief systems. The qualitative characteristics that might be considered include sensory, perceptual, and semantic features of memories. And indeed, many studies confirm the role of these memory characteristics (Henkel, Franklin, & Johnson, 2000; Johnson, Foley, & Leach, 1988; Johnson, Foley, Suengas, & Raye, 1988; Johnson et al., 1993; Johnson, Raye, Foley, & Kim, 1982).

The characteristic of particular interest to us is that related to *cognitive operations* information. The SMF suggests that cognitive operations activated when experiencing events (e.g., search and decision processes, imaginal processes, and inferential processes) are represented in memory and can later affect source judgments. This aspect of the model is also supported by considerable empirical work (Durso & Johnson, 1980; Foley, Durso, Wilder, & Friedman, 1991; Foley, Foley, Durley, & Maitner, 2002; Foley & Ratner, 2001; Johnson, Foley, & Leach, 1988; Johnson, Foley, et al., 1988; Johnson et al., 1993; Johnson, Raye, Foley, & Foley, 1981). For example, after seeing pictures and words referring to familiar objects, if adults and children respond to those objects simply by describing actions they might perform with the objects, subsequently they claim that the words were presented as pictures, reducing source performance on words (Foley et al., 1991). Source confusions between what was perceived (words) and what was experienced only in thought (images for the objects) are interpreted as evidence for the automatic activation of implicit imaginal processes (Foley et al., 1991). More generally, when imaginal processing (one kind of cognitive operation) is relatively automatic and less attention deploying, source-monitoring performance is predictably reduced (e.g., Foley et al., 1991; Johnson et al., 1981).

From our point of view, implicit imaginal processes evoked by words may resemble those evoked by incomplete visual information. As such, implicit imaginal processing should lead to confusions about the way in which visual information is experienced, with individuals claiming that they saw the incomplete information as complete in form. In our initial test of these memory predictions (Foley, Foley, Durso, & Smith, 1997), incomplete visual information was created by explicitly deleting portions of pictures of familiar objects along the midline. Individuals were shown pictures of complete or incomplete familiar objects. After viewing pictures under one of a number of encoding conditions (e.g., naming objects, identifying functions of objects), they were surprised with a source-monitoring task; they were asked to remember the way in which they had experienced those pictures initially. We reasoned that if incomplete pictures evoke implicit imaginal processing (filling in missing portions of pictures), individuals should mistakenly report that incomplete pictures had been seen as complete in form. Individuals were indeed confused about the ways in which they had experienced the visual information, claiming that incomplete pictures had been presented complete in form. This bias was observed for a wide variety of visual information (Foley et al., 1997), whether the visual information was rendered incomplete by explicit deletion (Experiments 1–4) or by occlusion (Experiment 5).

The goal of the present experiments was to consider alternative interpretations for the memory error of reporting that incomplete pictures had been experienced as complete in form. In the preliminary studies, the memory error followed the presentation of familiar objects (e.g., eyeglasses, a pair of scissors, an umbrella). Thus, the presentations of incomplete visual information could have evoked a generic and visually complete conceptual representation of the object without necessitating the activation of filling-in processes. When presented with an incomplete picture of a pair of eyeglasses or a pair of scissors, for example, preexisting visual representations for eyeglasses or scissors could be activated and later remembered as having actually been seen. This kind of generic representation could occur for both incomplete and complete objects, but its consequence for memory confusion would be evident only for incomplete ones. In this case, then, the occurrence of the memory error does not distinguish between explanations based on filling-in processes and those based on ignoring processes. Although conducted for different purposes entirely, the results of an experiment reported by Finke, Johnson, and Shyi (1988) are consistent with this concern. After individuals had been asked to complete incomplete symmetrical abstract forms in their mind's eye, they were later asked to decide which forms had been seen as complete or incomplete. The bias to report incomplete versions as complete was not evident in these experiments. Therefore, one goal of the present experiments was to see whether the memory error of reporting "complete" would still be evident when unfamiliar objects were the focus of attention (Experiments 1 and 3) and whether the error would vary for familiar and unfamiliar ones (Experiment 2). Because judgments about completeness could be inflated by the presence of familiar characters, only unfamiliar ones were included in Experiments 1 and 3. A second purpose was to test more specific predictions about the nature of the decisions underlying these source judgments (Experiment 3).

## OVERVIEW OF EXPERIMENTS 1–3

In the three experiments reported in this series, cartoon characters were presented as part of a search task modeled after that found in the *Where's Waldo?* series of children's books. Each of several cartoon characters was embedded in one complex scene, presented either in full view or partially occluded by another object. This search task was intended to mimic the way in which incomplete information is typically experienced. On a surprise source-memory test, participants were asked to remember the way in which the cartoon characters had appeared in the scenes, in full view or partially occluded. The preparation and selection of the cartoon characters involved a norming study that will be summarized before we proceed to the reports on the experiments.

### Preparation of Scenes and Cartoon Characters

Sixty cartoon characters were selected from a variety of cartoon materials. A group of 20 undergraduates, different from those who participated in the experiments reported in this paper, rated each cartoon character for its familiarity, using a 5-point scale. The 24 characters rated the most familiar and the 24 rated the least familiar were selected. The means were 4.86 and 1.09 for the familiar and unfamiliar characters, respectively. Two versions of each character were created, an occluded and an unoccluded rendering. Figure 1 illustrates both types of renderings for familiar and unfamiliar cartoon characters. Unfamiliar characters were presented in Experiments 1–3, and familiar characters were presented along with the unfamiliar ones in Experiment 2.

Several visually complex scenes (e.g., a busy train station, a crowded beach scene) were randomly selected from the *Where's Waldo?* children's books, scanned and modified so that the character Waldo was deleted from all the scenes. The location of the targets within each scene was varied randomly, appearing in each of four possible quadrants with equal frequency. For each experiment, half of the target characters were embedded in their respective scenes in full view. The other half were partially occluded by other objects (e.g., in a busy airport scene, occluding a portion of a traveler with a large suitcase; in a beach scene, occluding a portion of an adult with a large beach ball). The occluding objects for target and distractor characters were similar (e.g., a ball occurring once in each case), so that the occluders were not discriminative cues for the memory test. When reproduced in booklet form, each scene was presented on 8.5 × 11 in. paper. In all cases, materials were counterbalanced so that each cartoon character occurred equally often in full or occluded view and as target or distractor on the source tests. The order in which the target characters were presented was randomized and different for the search and the test sequences. In each case, two different orders were used, each with equal frequency.

## EXPERIMENT 1
## Occlusion Judgments About Unfamiliar Objects

The purpose of Experiment 1 was to see whether the bias observed previously was evident when unfamiliar objects were the focus of study. If the memory error observed in previous studies reflected the activation of preexisting generic representations or impressions of completeness arising from frequent previous exposure to the unoccluded versions of familiar objects, the error should be minimized with unfamiliar objects.

### Method

**Participants.** Twenty undergraduates attending Skidmore College participated in this experiment, each receiving credit toward the completion of an introductory psychology course requirement.

**Materials and Procedure.** Sixteen unfamiliar characters were selected from the set of unfamiliar characters, and they were then embedded, one in each of 16 scenes. Half of the characters were shown in full view, and half were partially occluded. The undergraduates were told that the purpose of the study was to compare the search strategies of adults and children, measuring how long it took to lo-

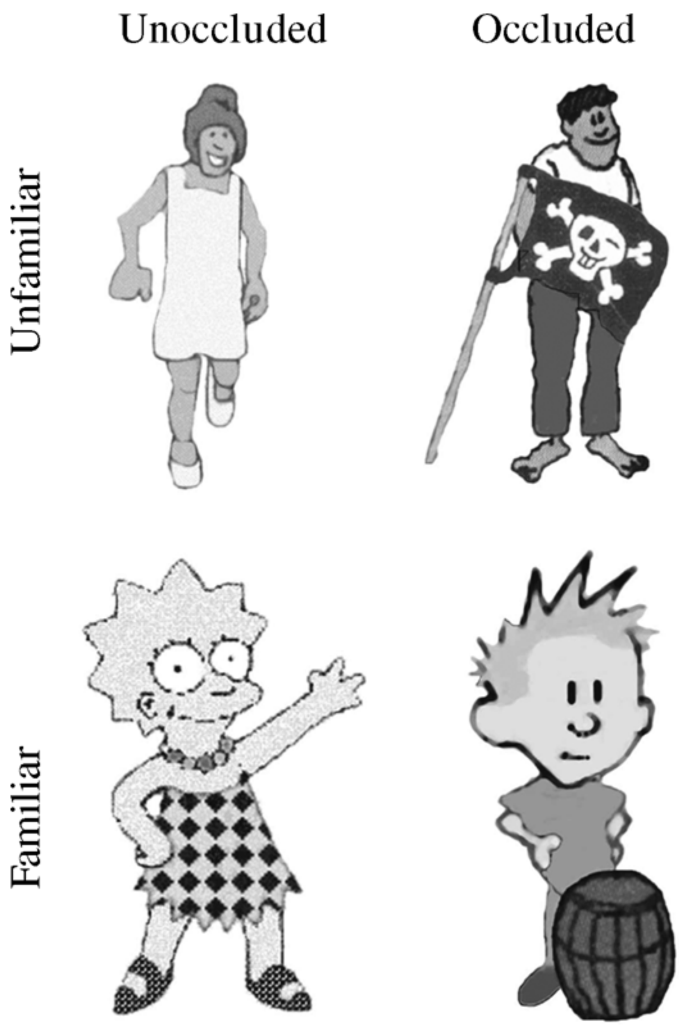


**Figure 1. Sample of familiar and unfamiliar characters.**

cate cartoon characters within complex scenes. We noted that the search task was self-paced, and the undergraduates were forewarned that some of the targets for which they were searching might be partially blocked from view by other objects. However, they were not told which characters were presented in full view and which were partially occluded. Each participant was first shown a target character in full view; the page of the booklet was then turned, and its corresponding scene was presented. Although the sample target was not visible throughout the search, the participants were free to look back at the page illustrating the target character as often as they wanted, and the experimenter recorded the number of times the participants checked back for each target.

A stopwatch was used to record search times for each character. If the participant did not locate a particular target within 2 min, the experimenter asked whether he or she wanted a hint about the target's location. When yes was indicated, the experimenter pointed to the quadrant in which the target was embedded. If an additional 3-min period elapsed, the experimenter again offered to provide a hint. Eventually, each participant found every target. After completing the search task, the participants were given a 3-min distractor task, listening to and selecting tunes from Disney movies that they thought would be appropriate to include in a children's play session. We made reference to children's activities in order to add to the credibility of the cover story and because we intended to adapt this procedure to a search task with young children.

The participants were then surprised with a source-monitoring task. They were shown pictures of 24 cartoon characters, again one at a time, presented in booklet form. Initially, on each test trial, the test character was presented in full view. If the participants responded "yes," indicating that they thought the cartoon character had been included in the search task, they were then shown a pair of pictures (i.e., for each pair, with the character shown in full view or partially occluded). They were asked to select the one they had pointed out in the scene. If they responded "no," this second set of test materials was omitted, and the next test cartoon was presented. The order in which the target characters were presented was different from that used during encoding.

## Results

Three dependent variables are reported: source-monitoring scores (or accuracy about the versions of the

**Table 1**
**Source Monitoring Performance**

| | Version Embedded in Scene | | | |
|---|---|---|---|---|
| | Unoccluded | | Occluded | |
| Stimulus Materials | *M* | *SE* | *M* | *SE* |
| Experiment 1 | | | | |
| Unfamiliar characters | .84 | .02 | .50 | .06 |
| Experiment 2 | | | | |
| Unfamiliar characters | .81 | .04 | .69 | .06 |
| Familiar characters | .83 | .04 | .43 | .05 |
| Experiment 3 | | | | |
| Unfamiliar Characters | | | | |
| Unoccluded-only | .80 | .05 | .35 | .07 |
| Unoccluded/occluded | .74 | .07 | .45 | .07 |
| Unoccluded/occluded predicts | .91 | .06 | .69 | .09 |

characters actually seen), proportion of hits (or accuracy about which characters had been seen), and false positives (or number of distractors misclassified as having been seen "full" or "occluded"). In addition, we report measures based on the search task itself, to eliminate alternative interpretations for the memory effects.

**Source-monitoring performance: Occlusion judgments.** The source-monitoring scores were proportions, equal to the number of cartoon characters correctly classified (as having been seen "in full view" *or* "partially occluded"), divided by the number of targets in each category (unoccluded or occluded) correctly recognized as those that had been part of the search task. Note that the participants located all of the characters included on the search task. Thus, performance on the memory test did not need to be conditionalized according to whether or not the targets had been spotted in their respective scenes. In an analysis of variance including viewing condition (full vs. occluded) as the within-subjects factor, source-monitoring scores were better for cartoon characters appearing in full view than for those appearing partially occluded [$F(1,19) = 24.04$, $MS_e = 0.05$, $p = .0001$]. As is shown in Table 1, this difference in performance was produced by the participants' tendency to mistakenly report that occluded versions had been seen in full view, rather than the reverse.

**Recognition of targets: Proportion of hits.** The source test was rescored to calculate the proportion of hits. An analysis of variance showed that proportion of hits did not differ for characters presented in full ($M = .94$) or occluded ($M = .88$) view [$F(1,19) = 1.12$]. Thus, the memory errors about the way in which characters had been viewed, leading to a reduction in source accuracy for occluded versions, was not a reflection of poor memory for the cartoon characters that had been partially occluded. An alternative technique for assessing source judgments (Batchelder & Riefer, 1990) produced essentially the same pattern of findings as those reported here, largely because recognition performance was quite good and did not differ for occluded and unoccluded targets.

**Misrecognition of distractors: Number of false positives.** Similarly, the number of false positives committed was relatively low, and the tendency to misclassify a distractor incorrectly called "old" as a character presented in "full" ($M = .01$) or "occluded" ($M = .03$) view did not differ.

**Search performance: Hints and time.** As was mentioned earlier, the participants located all of the cartoon characters included on the search task. Although told that they could request hints to help locate the targets, the participants rarely did so. In fact, they rarely flipped back to remind themselves what a particular target looked like while trying to spot the target in its scene. Unlike our previous occlusion study (Foley et al., 1997, Experiment 5), the time spent locating characters embedded in complex scenes was recorded in Experiment 1, and indeed, the time spent searching for target characters depended on the presence of an occluder. In an analysis of time spent searching for cartoon characters presented in full or occluded view, there was a main effect for viewing condition, with more time spent searching for occluded characters ($M = 58$ sec) than for unoccluded [$M = 29$ sec; $F(1,19) = 45.69$, $MS_e = 1.8\text{E-}6$, $p = .0001$]. Although more effort (as measured by time) was expended searching for the occluded characters, neither source-monitoring nor recognition performance was better for these characters.

### Discussion

In earlier studies, each familiar object was from a unique semantic category. Thus, a generic representation (the category label or a generic visual rendering) could have been activated when specific instances were observed. This possibility was precluded in Experiment 1 by including only unfamiliar objects, all of which were from the same or a similar semantic category but did not have corresponding unique labels for the instance within the category. The memory error reported previously for familiar objects was again observed for unfamiliar ones, an outcome suggesting that the error to report "complete" reflected the activation of filling-in processes, rather than simply the activation of preexisting representations for objects. In Experiment 2, familiar and unfamiliar characters were compared in order to test additional predictions about filling-in processes derived from the SMF.

## EXPERIMENT 2
## Occlusion Judgments About Familiar and Unfamiliar Objects

According to the SMF, if the cognitive operations mediating filling-in processes are relatively automatic and less attention deploying, cues associated with this kind of information will be less helpful in distinguishing the way in which objects were presented. Assuming that these cognitive operations are more automatic in the presence of familiar objects, the memory error of reporting "complete" should be greater for familiar objects than for unfamiliar ones. Along similar lines, when scanning a scene for a familiar character, individuals may be more likely to experience a complete visual image of that character (or they may be better able to hold an image of the search character in mind during the search process), again leading to greater confusion about the way in which the character had appeared in the scene.

Previous studies have shown that perceptual detail facilitates accuracy in other kinds of source-monitoring judgments (Foley et al., 1991; Johnson et al., 1982). Thus, the possible influence of this feature on completion judgments was also examined in Experiment 2. The perceptual detail selected here was visual complexity, defined as the intricacy of the line drawings (Snodgrass & Vanderwart, 1980). If visually simple objects are filled-in more readily (or more successfully) than visually complex ones, errors should be greater on visually simple renderings.

### Additional Preparation of Stimulus Materials

A second norming study was required for the preparation of materials for Experiment 2. Two versions of each familiar and unfamiliar character were created for the purpose of varying their visual complexity. Visual complexity was defined in terms of the amount of visual detail present in each cartoon, using a criterion established by Snodgrass and Vanderwart (1980) for simple familiar objects. A second group of 18 undergraduates rated the characters for their visual complexity, with each undergraduate seeing only one version of a particular cartoon character. The mean complexity ratings were 4.51 and 1.89, on a 5-point scale, for the visually complex and the visually simple versions of each character. This factor was also counterbalanced, with each complexity version occurring equally often across conditions (e.g., as targets and distractors).

## Method

**Participants.** Twenty undergraduates attending Skidmore College volunteered to participate, each receiving credit toward the completion of his or her course requirement for an introductory psychology class. These participants were different from those who had participated in Experiment 1.

**Materials and Procedure.** Twenty-four visually complex scenes were selected, each with a target character embedded. In Experiment 2, the search task included 24 target characters, 12 presented in full view and 12 partially occluded in their respective scenes. Of each set of 12, half were familiar and half unfamiliar, and within each of these subsets, half were rendered as visually simple and half as visually complex. The source test included 48 cartoon characters, 24 targets and 24 distractors. The distractors also varied in complexity, familiarity, and completeness. Materials were counterbalanced appropriately, with each target occurring under each condition (e.g., full view vs. occluded, target vs. distractor).

The procedure was identical to that followed for Experiment 1. The participants were told that the purpose of the experiment was to compare the search strategies of adults and children, measuring how long it took to locate cartoon characters within complex scenes. They searched for cartoon characters, each embedded in a complex scene. After the search phase, they were shown a picture of a cartoon character and asked whether this character had been included in the search task. If they responded "yes," they were then shown two test versions (the character presented complete or partially occluded) and they were asked to select the version that they had actually seen while searching. If they responded "no," this second phase was omitted.

## Results

Three memory measures are reported, as in Experiment 1; source-monitoring scores, proportion of hits, and false positives. As in Experiment 1, for each participant, all of the targets had been located on the search task. Information about search time and hints follows the report on the memory measures.

**Source-monitoring scores.** Source-monitoring scores were expressed as proportions and were computed separately for familiar and unfamiliar characters and for their visually simple and visually complex versions. In a 2 (full or occluded version) $\times$ 2 (familiar vs. unfamiliar cartoon character) $\times$ 2 (visually simple or visually complex version) analysis of variance, source-monitoring performance was more accurate for targets presented in full view than for those partially occluded [$F(1,19) = 23.98$, $MS_e = 0.11$, $p = .0001$], and as is shown in Table 1, this difference was exaggerated for familiar targets, producing an interaction between familiarity and visual completeness [$F(1,19) = 12.61$, $MS_e = 0.06$, $p = .002$]. The Tukey–Kramer test was used for post hoc comparisons. Post hoc tests showed no difference for the full versions, but performance was significantly poorer for familiar than for unfamiliar characters, when they had been occluded [$F(1,19) = 24.40$, $F_{critical} = 7.90$]. No other effects were significant. Source judgments did not differ for simple ($M = .71$) and complex ($M = .67$) versions.

**Recognition of targets: Proportion of hits.** The source-monitoring test was also scored for proportion of hits, without regard for correct decisions about the versions seen. In a 2 (full or occluded version) $\times$ 2 (familiar or unfamiliar cartoon character) $\times$ 2 (visually simple or visually complex version) analysis of variance on proportion of hits, only one effect was significant. Proportion of hits was higher for familiar characters ($M = .95$) than for unfamiliar ones [$M = .85$; $F(1,19) = 15.44$, $MS_e = 0.02$, $p = .001$], the reverse of the pattern observed for source scores in the prior analysis. Thus, the confusion we reported above was not a reflection of poor target memory for familiar characters. Although source-monitoring confusions were greater for familiar characters than for unfamiliar ones, this result did not occur because memory for the familiar characters was poorer. No other effects were significant. Mean proportions for occluded ($M = .90$) and unoccluded ($M = .91$) versions did not differ, nor did they differ for simple ($M = .91$) and complex ($M = .89$) versions.

**Misrecognition of distractors: Number of false positives.** A similar analysis on the false positives showed three significant effects. If a new item was misclassified as one included on the search, undergraduates were more likely to say it had been occluded rather than unoccluded, a bias opposite to that reported for target items [$F(1,19) = 18.22$, $MS_e = 0.09$, $p = .004$]. They were also more likely to think that they had seen a new item before if it was a familiar cartoon character, but this was the case only for occluded versions [$F(1,19) = 13.36$, $MS_e = 0.05$, $p = .002$]. Means were .18 and .10 for familiar and unfamiliar occluded distractors, but .09 and .07 for familiar and unfamiliar unoccluded ones.

**Searching for cartoon characters: Requests for hints and search time.** The participants requested hints very rarely (on average, .21 out of a large number of possible requests when searching on each trial), so this measure was not analyzed further. In an analysis of search time, including familiarity, complexity, and completeness as factors, on average, it took longer to spot visually simple characters than visually complex ones, especially for unfamiliar characters, producing an interaction between complexity and familiarity [$F(1,38) = 31.10$, $MS_e = 6.45E8$, $p = .0001$]. For familiar characters, the means were 38 and 19 sec for simple and complex versions, whereas for unfamiliar characters, the means were 63 and 23 sec for simple and complex versions, respectively. It also took longer to spot cartoon characters that were partially occluded, particularly if they were unfamiliar, producing an interaction between completeness and familiarity [$F(1,38) = 9.87$, $p = .003$]. For familiar characters, the means were 36 and 39 sec for those presented in full or occluded view. For unfamiliar characters, the means were 40 and 53 sec, respectively. No other effects were significant.

### Discussion

The memory error of reporting "complete" in response to incomplete pictures was observed again in Experiment 2 and was exaggerated for familiar characters, consistent with the hypothesis that filling-in processes are activated in the presence of incomplete visual information. Establishing the boundary conditions for the memory error associated with incomplete objects is important for informing our understanding of the basis for the effects. Therefore, Experiment 2 was replicated, modifying only the focus of source judgments. A different group of participants ($N = 20$) was asked to remember whether the versions they saw were visually simple or visually complex in their detail. In this case, there were no significant effects in the analysis of source judgments about complexity. Most important, source performance was comparable for occluded ($M = .85$) and unoccluded ($M = .80$) versions. They were comparable as well for familiar ($M = .80$) and unfamiliar ($M = .86$) ones. This further experiment shows that the poorer source-monitoring scores observed for occluded versions is specific to judgments about their completeness.

Although we focus on familiarity when interpreting the differences between the two character sets, these sets may differ in other ways as well. Familiar figures could appear more distinct because of visual features or because the ability to name each figure renders them more distinct from one another. Because there may be preconceptions about the way the familiar cartoon characters typically appear, the complexity manipulation could affect judgments about familiar characters more than it affects judgments about unfamiliar ones (or affect them in a different way). However, if the effects were differential, the interaction between complexity and familiarity should have been significant, and it was not. The simple recognition findings are consistent with the possibility that familiar characters are more distinctive and, hence, more memorable, in that hits were higher for familiar objects than for unfamiliar ones. However, the source-monitoring performance is not consistent with this view. The SMF predicts that if objects or events are less distinctive and more similar to each other, they should be less discriminable (Johnson et al., 1993), leading to greater confusion, not the reduced confusion that we observed. Future studies will be required in order to isolate the critical features producing the effects of familiarity, but the crucial point for present purposes is that the bias is indeed observed for objects that do not have corresponding individual names or preexisting representations.

An alternative interpretation for the bias observed for both object sets does warrant further consideration here. The bias may reflect a different kind of memory confusion, one that is far less intriguing theoretically. In Experiments 1 and 2 in the present series, on each encoding trial, the picture prompts or cues guiding the search were always presented in full view. Similarly, although we varied the nature of the picture prompt in our first occlusion study (Foley et al., 1997, Experiment 5), again the prompt on the search task was always presented in full view. Thus, the bias could be due to remembering the prompts themselves, rather than the versions embedded in the scenes. Furthermore, in Experiments 1 and 2, the proportion of complete forms was greater than the proportion of incomplete forms. Not only were all the prompts unoccluded versions, but also, at test, the participants were initially shown unoccluded versions as well. Only if they reported that the test character had been part of the search task did they then see both an occluded and an unoccluded version. Because an unoccluded version was always seen as the initial test prompt, the tendency to pick an unoccluded version from the test pair might have been inflated. More generally, the bias to report "unoccluded" could have been induced by an overall impression that most of the pictures seen during encoding and test seemed to be in full view. If the participants were thinking about the global structure of the series of pictures when making occlusion judgments, they would exhibit a bias to report that objects had been seen in full view. We considered the possible contributions of these contextual features in Experiment 3, modifying both the search task and the form of the source test.

## EXPERIMENT 3
## Occlusion Judgments and Impressions of Completeness

Varying the prompts used during encoding and, therefore, their predictive value for the target versions changed the search task. In the unoccluded-only condition, identical to that used in Experiments 1 and 2, all the prompts were presented as full versions, and the targets were either full (hence, identical to the prompts) or partially occluded. In the unoccluded/occluded condition, both the prompts and the targets were presented in full view or partially occluded, but the completeness of the prompt matched the completeness of the target on only half the search trials. Thus, as in the first condition, the prompt version matched the target version on half of the search trials, but both occluded and unoccluded prompts were used in this second condition. In the third condition, the unoccluded/occluded-predicts condition, the prompts were presented in full view or partially occluded and were completely consistent with the versions of the targets embedded in the scenes. Thus, the unoccluded/occluded conditions represent cases in which the proportion of complete and incomplete prompts is balanced.

To address the potential imbalance resulting from the form of the test, in Experiment 3, the participants were initially shown both the occluded and the unoccluded versions, whereas in Experiments 1 and 2, initially they had seen only the complete versions. If the results of Experiments 1 and 2 reflected confusion about the referent for the source test (i.e., prompt vs. target), source-monitoring performance should vary with the search conditions. Specifically, we should find the bias (or an exaggerated one) only in the original condition (unoccluded-only), suggesting that it led to a global impression of completeness. In Experiment 3, as in Experiment 1, only unfamiliar characters were included, to minimize the overall impression of completeness.

## Method

**Participants.** Thirty-six undergraduates attending Skidmore College participated in this experiment, each receiving credit toward the completion of an introductory psychology course requirement.

**Materials and Procedure.** As in Experiment 1, 16 visually complex scenes were reproduced in booklet form, with each scene presented on 8.5 × 11 in. paper. Thirty-two characters were presented in total, 16 as targets and an additional 16 as distractors on the source test. Across participants, each character occurred equally often in full or occluded view in their respective scenes and as target and distractor.

In Experiments 1 and 2, the prompt character was shown first, and then a page of the booklet was turned to present its corresponding scene. If the participants wanted to view the prompt again, they had to flip the pages back and forth. In Experiment 3, however, the prompt was always in view, shown on one page (e.g., the left side of the booklet), with the scene present on a second page (right side of booklet).

The participants were told that the purpose of the study was to compare search strategies for different kinds of materials. In all three conditions, the search task was self-paced; on each trial, the participants were shown a visual prompt of the target and its corresponding scene. Although search time was not recorded in this experiment, as in the other two experiments in this series, if the participant did not locate a particular target by pointing it out within 2 min, the experimenter asked if he or she wanted a hint about the target's location. When yes was indicated, the experimenter pointed to the quadrant in which the target was embedded. Eventually, each participant found every target before proceeding to the next in the series. In fact, the participants rarely asked for hints about the target locations in the scenes.

The participants were randomly assigned to one of three search conditions. In the unoccluded-only condition (replicating Experiments 1 and 2), the prompts were all shown in full view, but the undergraduates were forewarned that some of the targets for which they were searching might look different from the prompts, partially blocked from view by other objects. In fact, half of the prompts matched the targets (i.e., when both versions were in full view). In the unoccluded/occluded condition, the prompts were presented in full view or partially occluded, but the target version matched the prompt on only half the trials (e.g., occluded-prompt/occluded-target). Thus, as in the first condition, the prompts predicted the target versions on half the trials. The participants in this condition were forewarned that the target character embedded in the scene might look the same as or somewhat different from the target character. In the unoccluded/occluded-predict condition, the prompt and the target versions were identical, with half presented in full view and half presented partially occluded. In this condition, the undergraduates were told that the versions in the scenes were identical to the prompt versions. In the two conditions that included some occluded prompts, the occluding objects were always the same as those shown with the target versions. And as in Experiments 1 and 2, occluding objects (e.g., suitcases, large rocks, and barrels) were not unique to the targets or the distractors.

After completing the search task, the participants were given a 7-min distractor task, in which they searched for number sequences embedded in a complex array of numbers. The time spent on the distractor task was increased in Experiment 3, relative to the other experiments reported thus far, to address a concern about recognition levels. As we reported for Experiments 1 and 2, recognition was comparable for occluded and unoccluded characters, indicating that the confusion on occluded pictures was not due to poor recognition memory for the targets. However, in Experiments 1 and 2, recognition performance was quite good (over 90%). A ceiling effect on recognition could therefore have masked potential differences. By increasing the distractor duration, although still relatively brief (now 7 min), we attempted to address this concern. As the results for this experiment will show, this goal was accomplished. Recognition rates were lower (approximately 80%) but still comparable for occluded and unoccluded characters.

Finally, the participants were surprised with the source-monitoring task. They were shown pictures of several cartoon characters, again presented in booklet form, and were asked if the characters had been included in the search task. On each test trial, however, they were shown the two versions of the character simultaneously, without first looking at an unoccluded version. They were asked if the character had been part of the search task, and if they responded "yes," they were asked to identify the version they had spotted in the scene. The order in which the target characters were presented was different from that used during encoding.

## Results

The same three memory measures used in the earlier studies are reported here: source-monitoring scores, proportion of hits, and number of false positives. In addition, information about the search task is provided.

**Source-monitoring performance: Occlusion judgments.** In an analysis of variance including search condition and picture version (full vs. occluded) as factors, a main effect for picture version was observed [$F(1,33) = 62.79$, $MS_e = 0.03$, $p = .0001$]. Source-monitoring scores were better for cartoon characters appearing in full view ($M = .82$) than for those appearing partially occluded ($M = .51$). This lower performance on occluded objects reflected the error of reporting that occluded versions had been seen in full view, an outcome consistent with our previous work (Foley et al., 1997, Experiment 5), as well as with the results of Experiments 1 and 2. Source-monitoring performance also varied for the three search conditions [$F(2,33) = 4.52$, $MS_e = 0.08$, $p = .02$]. Post hoc tests showed that overall, source-monitoring performance was higher when the prompt and the target versions matched ($M = .80$) than in either of the other two search conditions ($M$ = .58 and .62, respectively). Most important, however, the bias was evident in all three cases, as is summarized in Table 1. The interaction between completeness version and search condition was not significant ($F$ = 1.22).

**Recognition of targets: Proportion of hits.** The source test was also scored for proportion of hits, without regard for correct decisions about which versions had been seen. A 2 (full vs. occluded) × 3 (search condition) analysis of variance showed that recognition memory for the characters that were part of the search task did not differ for characters presented in full or occluded view [$M$ = .83 and .81, respectively; $F(1,33)$ = 0.70]. Proportion of hits was also equivalent for the three search conditions [$M$ = .78, .80, .87; $F(2,33)$ = 1.55]. Although the proportion of hits tended to be higher in the one condition in which the prompts and the targets matched, the differences were not significant. Again, as in Experiments 1 and 2, the difference in source accuracy for full and occluded versions is, therefore, not attributable to differences in trace strength for these two kinds of cartoon characters. Equally important, in Experiment 3, the absence of a difference in proportion of hits for the two versions is not attributable to a ceiling effect, a matter of concern for the recognition data for previous experiments reported in this series.

**Misrecognition of distractors: Number of false positives.** An analysis of variance on the number of false positives showed a response bias; the participants were more likely to report that the figure had been partially occluded ($M$ = 3.44) than that it had been seen in full view [$M$ = 2.17; $F(1,33)$ = 11.93, $MS_e$ = 0.60, $p$ = .001]. No other effects were significant. The presence of this bias is important because it indicates that the bias to claim that incomplete pictures had been seen in full view is not a general response bias to report "unoccluded." Although this is consistent with the false positive findings for the other two experiments in this series, these findings from Experiments 1 and 2 are less convincing as refutations of a general response bias, because of potential floor effects. The level of false positives was much lower in the previous experiments than in the present one. Because the number of distractors varied across the three experiments, this relative comparison is based on percentages (less than 1% in previous studies and 3.5% in Experiment 3).

**Search Task: Hints.** Each participant located all of the characters included in the search task. Although they were told that they could request hints to narrow the search in the scenes, they rarely did so in any of the three conditions. Therefore, this measure was not analyzed.

### Discussion

The memory error of reporting "complete" was evident across the three versions of the search task and the source test, even when half of the prompts were occluded, indicating that the previous results were not due simply to confusion between the prompts and the versions embedded in the search scenes. More generally, our previous effects, as well as those reported in Experiments 1 and 2 in the present series, are not artifacts of the way in which memory was assessed.

## GENERAL DISCUSSION

### Judgments About Occlusion: Implications for Explanations of Closure Processes

The present experiments contribute several new findings to the study of memory for incomplete visual information and, in the process, test predictions about mechanisms of closure. The memory error of reporting that incomplete objects had been seen as complete is evident for both familiar (Experiment 2) and unfamiliar (Experiments 1–3) objects. In all of our previous studies, words were used at test (Foley et al., 1997) or, at least initially, complete versions were presented at test (Experiments 1 and 2 in this series). Experiment 3 is the first instance in which the source test initially included both the full and the occluded versions. The bias to report that occluded versions had been seen in full view was observed again, a robust effect clearly evident in the three search conditions of Experiment 3.

The outcomes of all three experiments are consistent with the proposition that implicit imaginal processes are activated by incomplete visual information and that their activation results in an internal representation more complete in form than the version actually seen. The findings for unfamiliar objects suggest that these representations resemble aspects of the specific versions actually seen during encoding, rather than generic versions based on preexisting internal representations for the objects. When incomplete visual information is less familiar, it is highly unlikely that preexisting representations could be evoked by either filling-in or ignoring processes, weakening the persuasiveness of the latter explanation. Thus, the bias to report that occluded versions of unfamiliar objects were seen in their complete form (Experiments 1–3) is particularly intriguing and important in the present context.

The greater confusion for familiar characters does suggest that extraexperimental experiences may contribute to impressions of completeness. The likelihood of previous encounters with the objects is relatively greater for familiar objects than for unfamiliar ones. These previous encounters could elicit implicit imaginal processing more quickly or could simply lead to stronger impressions of completing. In either case, prior experience might contribute to the sense that occluded objects had been seen as unoccluded.

Although the type of cue guiding the search cannot fully explain the bias reported previously or in Experiments 1 and 2 in this series, there is some suggestion that the cue may affect the magnitude of the bias. In Experiment 3, the interaction between search condition and completeness version was not significant, but the pattern of findings is suggestive. The bias was somewhat reduced (although clearly not eliminated) when the prompts guiding the search predicted the form of the version embedded in the scene. Furthermore, the overall level of source monitoring was better in this condition even though the magnitude of the bias was comparable. Thus, in our previous experiments involving occlusion, we may have overestimated the size of the memory error. Future research will be needed to determine whether the absence of the effect for type of prompt, observed in Experiment 3, is due to a lack of power or minimal effects owing to variations in the cues. Future studies might more fully explore contextual factors that may contribute to impressions of completeness (e.g., the proportion of objects experienced as complete in form during search or the nature of the source test itself), affecting the presence (or magnitude) of the memory error.

### Implications for the Source-Monitoring Framework

The asymmetries for occluded and unoccluded judgments, with greater accuracy on the latter, led us to conclude that implicit imaginal processing is activated during the processing of occluded objects. From our perspective, these errors are based on a consideration of source-specific information tied to particular representations for objects. However, alternative explanations have been offered to account for asymmetries in source failures in other contexts, and therefore, these should be considered here. These source failures could have arisen from more global features of the structure of the experimental context, as well as from extraexperimental ones.

Source errors could reflect impressions of completeness emerging from the experience of viewing many unoccluded objects. The proportion of unoccluded objects was greater than the proportion of occluded ones because of the nature of the prompts or the source test used in Experiments 1 and 2. In these two experiments, the overall number of times people saw unoccluded targets was much greater than the number of times they saw occluded ones, because the initial prompts for both the search task and the source test were unoccluded versions. However, the bias was evident even when the proportion of occluded objects more closely resembled the proportion of unoccluded ones (Experiment 3). One could argue that impressions of completeness should be quite strong within the context of a search task involving complex scenes, because many of the objects in those scenes are, in fact, unoccluded. However, the results of a new study suggest that even when occluded objects are not embedded in complex scenes, the proportion of incomplete objects in a series does not affect the bias (Foley, Foley, Scheye, Manning, & Smith, 2002).

Of course, global evaluations used in source-monitoring judgments could also involve the consideration of general knowledge independent of the experimental context (Johnson et al., 1993; Johnson & Raye, 1981). When occluded objects are experienced in everyday life, the objects are expected to continue beyond the occluder. This knowledge about principles of occlusion could also lead to the bias we observed. But if this kind of reasoning was the basis for occlusion source decisions, source accuracy should have been equivalent for familiar and unfamiliar objects, but it was not (Experiment 2). Global evaluations based on knowledge, belief systems, or overall impressions about an experimental context do indeed affect source decisions in other contexts (Henkel et al., 2000; Johnson et al., 1993), but these kinds of global evaluations cannot be the sole basis for the bias observed in the present experiments.

A different alternative explanation for asymmetries in source judgments focuses on the relative strength of the memories for the two classes of objects. From this perspective, asymmetries in source judgments reflect differences in memory strength; the class of memories with the stronger traces (here, unoccluded objects) provides the basis for the asymmetry in errors. This alternative explanation, based on impressions of memory trace strength (Hoffman, 1997), is not a persuasive one for the present findings. Recognition memory for occluded objects is not worse than that for unoccluded ones.

### Future Directions: Integrating Memory-Based and Perceptually Based Approaches

Although the filling-in processes thought to mediate object identification are characterized as relatively automatic ones, the nature of the processes subserving completion have only recently been the focus of study (Behrmann, Zemel & Mozer, 1998; Sekuler & Palmer, 1992; Sekuler et al., 1994). Our experiments suggest that source-monitoring judgments may help to identify these mechanisms more precisely. A fruitful direction for research is the integration of the perceptual and memorial approaches to the study of mechanisms of closure. Perceptual approaches involving fragmentation and priming tasks, among others, focus on representations that are relatively instantaneous, whereas our memorial approach focuses on representations more extended in time. The further study of source judgments may help identify the nature of these underlying representations, as well as the time course of recoding processes.

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