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Event memory and misinformation effects in a gorilla (*Gorilla gorilla gorilla*)

Abstract Event memory and misinformation effects were examined in an adult male gorilla (*Gorilla gorilla gorilla*). The gorilla witnessed a series of unique events, involving a familiar person engaging in a novel behavior (experiment 1), a novel person engaging in a novel behavior (experiment 2), or the presentation of a novel object (experiment 3). Following a 5- to 10-min retention interval, a tester gave the gorilla three photographs mounted on wooden cards: a photograph depicting the correct person or object and two distractor photographs drawn from the same class. The gorilla responded by returning a photograph. If correct, he was reinforced with food. Across three experiments, the gorilla performed significantly above chance at recognizing the target photograph. In experiment 4, the gorilla showed at-chance performance when the event was followed by misinformation (a class-consistent, but incorrect photograph), but significantly above-chance performance when no misinformation occurred (either correct photograph or no photograph). Although the familiarity can account for these data, they are also consistent with an episodic-memory interpretation.

Keywords Primates · Gorillas · Memory · Episodic memory · Misinformation effects

Introduction

An event is a unique happening that, by definition, occurs only once. Consider the birth of a child or witnessing a burglary. These events etch themselves in human minds in the form of episodic memories (Tulving 1983, 1993, 2002). Episodic memories are defined as long-term memories of past events based on events witnessed only once. In the animal memory literature, considerable attention has been paid to single-trial learning, such as memory in the delayed match-to-sample task (see Morris 2002), but not to event memory or episodic memory (see Schwartz and Evans 2001). However, recently there has been a surge of interest in the possibility of episodic or episodic-like memory in nonhumans (Clayton and Dickinson 1998; Menzel 1999; Clayton et al. 2001; Zentall et al. 2001; Morris 2002; Schwartz et al. 2002). The term "episodic-like" has become popular because it does not imply the subjective experience of the past implied by the term "episodic" (see Clayton and Dickinson 1998). We will use the term episodic throughout this paper but do not imply that our studies show that gorillas or any other animals have the same subjective experience of the past that humans do.

In human cognitive psychology, eyewitness memory has become major areas of inquiry (Loftus 1993; Roediger 1996). At the heart of this research is the assumption that human beings learn based on unique events and can mentally time travel and remember these past events later. Consider an eyewitness identifying a suspect. This act is based on learning that took place during a single event and involves retrieval of how things occurred in the past, not the whereabouts of objects or people in the present. Tulving and Lepage (2000) refer to this past-focused memory as palinscopic memory (also see Suddendorf and Corballis 1997). They distinguish past-focused or palinscopic, in which knowledge of the past state of the world is relevant (e.g., remembering chatting with a neighbor while out for a walk), from proscopic memory, in which is knowledge of the current state of the world (e.g., remembering where your keys are before you leave your house). Thus, proscopic memory includes semantic memory and spatial memory (Tulving and Lepage 2000) whereas palinscopic means episodic memory.

In this view, single-trial learning at long-term memory retention interval does not define episodic memory. Sev-

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eral conditions must be met in order for a memory to qualify as episodic. First, it cannot be made on the basis of stimulus familiarity, that is, by having the rememberer (whether human or animal) choose on the basis of recency, salience or novelty (Metcalfe 1993). Second, the memory must not refer to the current state of the world. Indeed, studies such as spatial memory studies by MacDonald (1994) and Gibeault and MacDonald (2000) demonstrate that gorillas can remember at long-term memory retention intervals after single-trial learning, but the tasks call for the gorillas to remember the locations of food now, not where food was previously. Third, in order to be episodic, the memory response cannot be made based on retrieval from working memory. Episodic memory is a long-term memory system (see Squire 1992; Baddeley 2002). Thus, sufficiently long retention intervals must be used and effort must be made to avoid rehearsal. Typically, delayed match-to-sample tasks are carried out to test working memory (Morris 2002).

Previous work from our lab on event memory focused on single-trial learning and retrieval at long-term memory retention intervals. Schwartz et al. (2002) looked at the gorilla King's ability to remember past events by asking the gorilla to recognize a particular food or a particular person after a unique "feeding event." The gorilla was trained to associate the food items with cards depicting each item, and the gorilla was also trained to associate cards with names on them to particular people. In each trial, one of the experimenters gave the gorilla a specific food. Retention intervals were either short (5 min) or long (24 h). At the time of test, in order to be reinforced, the gorilla had to respond with a card representing both the correct food and the correct person. The gorilla performed significantly greater than chance following both the short and long retention intervals at identifying both the food and the person. These data suggest that the gorilla was remembering information about the past based on exposure to a single event, supporting the notion of palinscopic memory in nonhuman species.

However, there were certain problematic elements in the study of Schwartz et al. (2002) for examining trial-unique event learning. First, the same set of five foods was used throughout the two studies. The gorilla had to remember events based on single-trial learning, and he was always tested on the most recent event, which could not be predicted by other events. But the repetition of the same food stimuli dampens the claim to unique event learning. Similarly, in experiment 2 of Schwartz et al. (2002), the same three people were the to-be-remembered humans throughout. Second, although testers were kept out of sight of the target foods and persons, we did not test the testers to ensure their blindness to the target. Third, food was the chief stimulus for the gorilla. It is possible that such trial-unique learning might not generalize to other nonfood and truly unique events because food may be the only kind of stimulus for which single-trial learning is important. If so, animals may have evolved alternative ways of learning after a single trial.

In the current study, we examined trial-unique learning and long-term memory of unique events. In the experiments, King, a male western lowland gorilla, was expected to remember familiar people, unfamiliar people, and common objects (food was only used in experiment 4) by selecting the photograph of the person or object he had encountered several minutes earlier. Thus, in each of the experiments, the to-be-remembered target was a unique and mostly nonrepeating element (some familiar people were used more than once, but they performed a different event each time). Our hypothesis was as follows: we expected that King would be able to remember information about people and objects that he had experienced earlier and communicate these memories through the use of photographs. Thus, we expected his recognition of target photographs to be better than what a chance model would predict. At this point, we would like to emphasize that there is no evidence to date that suggest that gorillas (or any other primate) can remember the kind of information presented here based on trial-unique learning at the retention interval used (i.e., not explicable in terms of working memory). Thus, the outcome of these experiments is important regardless of whether one invokes an explanation based on recollection (i.e., episodic memory) or familiarity.

Experiments 1, 2, and 3

Methods

Subject

The subject, King, a male western lowland gorilla (*Gorilla gorilla gorilla*), was 32 years old at the time of the experiment. King was born in the wild in Cameroon, but was raised in a circus in the United States. At the age of 10, he was moved to Monkey Jungle in Miami, Fla., USA, where he has lived for the last 22 years. He has been the subject of an investigation on mirror self-recognition (Swartz and Evans 1994) and previous episodic-memory experiments (Schwartz et al. 2002).

Environment and stimuli

King was housed in an indoor–outdoor facility. He slept in an air-conditioned nighthouse. In the morning, his trainers released him into a cage area for testing (11.4×4.1× 3.67 m). Following testing, usually by 10:00 a.m., King would then be permitted to enter his large outdoor area (0.18 ha). During testing, he had full access to his entire cage area, and if he did not wish to participate, he could move to another area in his cage. Testing was always done in one corner of his cage. King was provided with a daily diet of chow, vegetables, leaves, and fruit. The food provided for him in the experiment was integrated into his normal diet to prevent excess weight gain. He was not food deprived during trials or at any time during these experiments.

The cards were 20.32×13.97×3.81 cm. Photographs measuring 7.62×11.43 cm were slipped into the cards and then screwed shut so that King could not separate the photograph from the card.

Design and analyses

Retention interval was defined as the amount of time that passed after the event was completed until when he returned a card to the tester. Cards containing the photographs were given to him 5 min after the event was completed. In each of the experiments described here, King made responses quickly and the average retention interval was around 7 min. Because King was not constrained and could choose when or if to participate on any given trial, we could not keep the retention interval completely constant from trial to trial. In fact, on some trials, King did not respond immediately, but delayed several minutes before responding. In addition, some of the longer retention intervals resulted when a tester was engaged in other activities and was unable to test immediately at the 5-min mark. Testers were people whom King had spent significant time with, specifically his Monkey Jungle trainers and the first author.

The binomial test was used to determine if King's response differed from chance. In all four experiments, chance performance was considered 33% because he had three photograph cards with which to respond.

Procedure

The general procedure is described as follows. King witnessed a live event acted out by a familiar person performing an unusual event (experiment 1), an unfamiliar person performing an unusual event (experiment 2), or was presented an object to view by a familiar experimenter (experiment 3). At least 4 days elapsed between the end of each experiment and the beginning of the next one (and over a month between experiments 3 and 4). The events performed by familiar or unfamiliar individuals generally involved some sort of unusual behavior, such as skipping rope, playing a ukulele, swinging a tennis racket, or bouncing a basketball. The objects shown to King in experiment 3 included such items as hair dryers, rubber frogs, toothbrushes, and tennis rackets. The event itself (experiments 1 and 2) or presentation of an object (experiment 3) lasted about 1 to 2 min.

Events started when the designated target entered into King's visual range (experiments 1 and 2) or when the object was made visible to King (experiment 3). The event ended when the person or object was removed from King's view. We could not guarantee that King attended to every event, but when objects were presented, the experimenter kept the object visible until it appeared that King made visual contact with the object. Objects were usually held within 1 m of his eyes by the experimenter. His responses to people were more obvious to track, usually consisting of approaching (familiar people) or displaying towards unfamiliar people. Events with people usually took place about within 1 m of the bars of his cage, often not more than 1 m from where King was located. Care was taken to ensure that no physical contact took place between King and the target.

A designated person was the tester, and he or she was kept experimentally blind so that King could not be cued during testing. To ensure blind testing, the tester was given the photograph cards and asked to choose the target before entering King's area. This allowed us to correlate the tester's hunch with King's choice to detect any cueing inadvertently passing from the tester to King (i.e., to avoid the Clever Hans phenomenon). Five minutes after the event was completed the tester (which was most often Monkey Jungle trainer T.C. or the first author, B.L.S.) would enter and present King with three photograph cards. The tester would show each card to King and then push it through the bars of his cage.

The photographs used to test King consisted of the correct target and two similar distractors. In experiments 1 and 2, one distractor was a photograph of a person familiar to King and one was a photograph of a person unfamiliar to King. If the target person was a man, all of the distractors were men, and if the target person was a woman, all of the distractors were women. Distractors were roughly equated for age and appearance. The photographs depicted a close-up of the head and shoulders of the person with the face facing the camera. The background was a white wall. In experiment 3, the correct object was shown along with two incorrect objects. The objects were depicted against a white background. When King selected a photograph and passed the photograph card through the bars of the cage, the response was recorded. A correct answer was scored when King passed the correct answer through the bars of his cage. An answer was scored as incorrect if King manipulated the correct answer first, but slipped an incorrect answer through to the tester. The photographs were passed to King in randomized order.

After King had responded, the tester called out King's response. An experimenter, out of view of both King and the tester, replied if King's response was correct. If King was correct on a trial, he was given a food reward (usually a banana, orange, or grapes) and verbal praise from the tester. After he ate the reward, the tester would encourage King to return the remaining unchosen cards. In some instances, food (usually raisins) was required to obtain compliance in returning the unchosen cards. Once all of the cards had been retrieved, the tester would leave the area if another event was planned for that day. One to three trials were run each day, with 2 being the modal number of trials per day.

In experiment 1, 12 familiar people served as targets across 30 trials. Because of the constraints of doing research in a zoo environment, we could not use all familiar people equally often. Some were used only once as a target, some as many as five times. Testers were B.L.S., T.C., J.K., and Y.M. King was familiar and comfortable with all four testers. With the exception of B.L.S., the

other three testers were regular trainers, employed by Monkey Jungle. For experiment 1, 17 days of testing took place in May and June of 2002.

In experiment 2, 33 unfamiliar female people were used as targets. We used only women because King does not respond aggressively to unfamiliar women as he does to unfamiliar men. As we wound up scheduling more than 30 targets, we ran them all, which gave us 3 more trials in this experiment than in experiments 1 and 2. Only T.C. and B.L.S. were used as testers. Otherwise, the method used in experiment 2 was identical to experiment 1. One distractor was always an unfamiliar person, matched to look like the target. The second distractor was a familiar person. For experiment 2, 17 days of testing took place in June and July of 2002.

In experiment 3, King witnessed familiar experimenters demonstrate or present 30 different objects (e.g., plastic frog, tennis racket, etc.). The experimenter would remain with King until she was sure that King had looked at the objects. Only T.C. and B.L.S. were used as testers. Testing procedures were identical to the earlier studies. Other objects were used as distractors. In experiment 3, three trials were completed per session. For experiment 3, 10 days of testing took place in July and August of 2002.

Because King has been involved in enrichment programs at Monkey Jungle and previous memory experiments (e.g., Schwartz et al. 2002), no training was conducted prior to the first trial in any of these experiments.

Results

Experiment 1

King responded correctly on 18 of 30 familiar-people trials, for an accuracy of 60%, which was significantly above chance (33%) using the binomial test, $P<0.05$. The mean retention interval was 7.3 min and varied from 5 to 15 min. Retention interval was not correlated with percent correct. The human tester was correct on 11 of 30 trials (37%), which was not significantly above chance, nor was there a significant correlation with the tester's choice and King's choice; they matched on only 13 of 30 trials. Analysis of King's incorrect choices revealed that he did not choose the familiar distractor (50%) more often than the unfamiliar distractor (50%).

Experiment 2

King responded correctly on 18 of 33 unfamiliar-people trials, for an accuracy of 55%, which was significantly above chance (33%) using the binomial test, $P<0.05$. The mean retention interval was 6.7 min and varied from 5 to 11 min. Retention interval was not correlated with percent correct. The human tester was correct on 14 of 33 trials (42%), which was not significantly above chance, nor was there a significant correlation with the tester's choice and

King's choice (they matched on 9 of 33 trials)[1]. When King was incorrect, he did not choose the unfamiliar distractor (60%) more often than the familiar distractor (40%). Interestingly, although this research was not intended to address face recognition per se, these data show that gorillas can easily learn to recognize human faces. In the laboratory, chimpanzees have also been shown to recognize novel human faces after brief exposure (Bauer and Philip 1983).

Experiment 3

King responded correctly on 15 of 30 object trials, for an accuracy of 50%, which was significantly above chance (33%) using the binomial test, $P<0.05$. The mean retention interval was 7.4 min and varied from 5 to 21 min. Retention interval was not correlated with percent correct. The human tester was correct on 10 of 30 trials (33%), which was not significantly above chance, nor was there a significant correlation with the tester's choice and King's choice (they matched on 11 of 30 trials).

Combined analyses of experiments 1 through 3

King responded correctly on 51 of 93 trials, for an accuracy of 55%, which was significantly above chance (33%) via the binomial test, $P<0.05$. The mean retention interval was 7.1 min. Retention interval was significantly correlated (across all three experiments) with percent correct ($\rho=0.31$), $P<0.05$, indicating (curiously) that longer retention intervals resulted in better accuracy.

Each tester was trained to note a particular behavior observed in pilot work with King and informally in other experiments. On some trials, King was observed to place the correct card under his leg and then return an incorrect card. Across experiments 1, 2, and 3, King was observed to place the correct card under his leg 10 times on trials in which he returned an incorrect photograph (out of a total of 42 incorrect responses), but was never seen placing an incorrect card under his leg during any of the trials he answered correctly (51 total). Thus, 24% of those incorrect trials are ones in which he likely knew the correct answer but did not cooperate.

Four people were used as testers across all three experiments. King was 50% accurate when the tester was B.L.S. (42 trials) and 56% when the tester was T.C. (39 trials); these accuracy rates were not significantly different. King was 88% accurate when the tester was J.K. (only 8 trials) and 25% accurate when the tester was Y.M. (only 4 trials). This number of trials did not allow statistical comparisons; J.K. and Y.M. were weekend trainers,

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[1] This was surprising because a familiar target was always present, so the testers could have been above chance by always ruling out the familiar target. Tester B.L.S. used this strategy, but tester T.C. never adopted this particular strategy. Based on his incorrect responses, King did not use this strategy either.

not full time trainers (T.C.). We suspected his varying rates partially reflected his willingness to cooperate with those trainers. Unfortunately, J.K. left Monkey Jungle before we could capitalize on her good relationship with King.

Testers responded correctly on 35 of 93 trials (38%), which was not different from chance. The correlation between tester's guess and King's choices was not significantly different from zero (they matched on 33 of 93 trials, or 35%). Thus, we are confident that testers were blind to the correct choice (especially important as one of the main testers was the first author). Therefore, the conclusion is that the testers did not cue King towards any particular answer, right or wrong. However, the retention interval was significantly shorter (5.7 min) when the tester was B.L.S. than when it was T.C. (8.8 min), $F(3, 89)=9.8$, $P<0.05$. However, as noted previously, this does not appear to have influenced the accuracy rates obtained by the two testers.

Experiment 4

One of the mainstays of the human eyewitness memory literature is the misinformation effect (see Loftus 1979; 1993; Loftus and Hoffman 1989). In the basic paradigm, a human witnesses an accident, a crime, or an ordinary scene. People are expected to remember the event based on one exposure to the event, consistent with the general eyewitness paradigm. Later, however, through a variety of means, people receive misinformation about what they witnessed. In one version of the task, people read a police report description about the witnessed event, whereas in another version they are provided with another witnesses' version of the report. Embedded in an otherwise accurate description of the event are subtle errors. Thus, the report might describe a blue car as "green," a Coke can as a "Pepsi" can, or a hammer as a "wrench" (Loftus 1979; Chambers and Zaragoza 2001). Later, people are given a recognition test for what they witnessed in the original event. Relative to people in control conditions, misinformed people are more likely to make errors in their recognition choice, most often in the direction of the misinformation. This lowered memory accuracy is referred to as the misinformation effect.

Harper and Garry (2000) adapted the misinformation task to pigeons (*Columbia livia*), albeit at working-memory retention intervals (up to 20 s). After witnessing an event (a colored light), the pigeons were either given consistent or inconsistent post-event cues. Performance declined following inconsistent information, thus demonstrating a misinformation effect for pigeons. In the current paper, we explore the possibility of a misinformation effect in gorillas. In experiment 4, we will test to see if a gorilla is susceptible to misinformation in a manner similar to human witnesses. In the study, we presented the gorilla with an event, sometimes followed by misinformation, sometimes followed by correct information and sometimes not followed by any post-event information. A long-term memory retention interval then ensued. This procedure permitted us to test his event memory and assess if his performance was worse in the misinformation conditions at long-term memory retention intervals. The term misinformation is not meant to imply that the experiment sets up a deception scenario. The misinformation may simply serve as interference. Regardless of the term, the hypothesis would remain the same.

Our chief hypothesis here was that King would show a misinformation effect, that is, lower performance in a misinformation condition than in suitable control conditions. More specifically, we expected King to show lower memory performance after receiving misinformation than after receiving accurate post-event information or receiving no post-event information at all. We expected that this effect would be seen across a variety of stimulus materials and as such, we used several classes of stimuli.

Methods

The procedure was identical to the procedure used in experiments 1, 2, and 3, with the following exceptions. First, in the correct information and misinformation condition, King was shown a photograph immediately after witnessing the event. Under these two conditions, the retention interval was not considered to have started until the post-event photograph was no longer visible to King. The misinformation photograph was always from the same category (person, object, food) as the correct item. Second, we used three classes of stimuli (people, objects, food). These items were mixed randomly with respect to presentation order. Third, the distractors were randomly chosen from the set of items. Thus, in most cases, King was familiar (in the sense, that he had seen the object or picture before) with both distractors. In the case of the fruits, trainers reported that King, at one point or another, had tried them all before. But, the fruits were novel treats, which had never been given to him before during the experimental context.

King witnessed familiar or unfamiliar people on 13 trials, was given a unique food (e.g., passionfruit, cactusfruit) on 30 trials, and was shown novel objects on 47 trials. On misinformation trials, 6 targets were people, 16 were objects, and 8 were food items. These trials were randomly mixed. Immediately following presentation of the actual stimulus, King was placed under one of three conditions in which a photograph of the correct target (correct condition), a photograph of an incorrect target (misinformation condition), or, no photograph at all (control condition) was presented to King. The experimenter made sure that the photograph had been presented in King's visual field for at least 1 min and then took the photograph away. The retention interval was then considered to have begun. After 5 min, the tester entered with the three cards. The tester was not aware of either the target stimulus or the experimental condition. He or she then began the testing phase by passing the cards to King through the bars of his cage. Testing was identical to procedure for the first

three experiments. For this experiment, 46 days of testing took place between September 2002 and January 2003.

In experiment 4, the design was one within-subject variable (accuracy of post-event information) with three levels (correct, misinformation, and control). Thirty trials were run in each condition mixed randomly.

Results

Overall, King was correct on 44 of 90 trials (49%). Under both the control and correct-information conditions, King responded correctly on 16 of 30 trials each for an accuracy of 53%, which was significantly above chance (33%) using the binomial test, $P<0.05$. However, under the misinformation condition, King responded correctly on 12 of 30 trials for an accuracy of 40%, which was not significantly above chance. However, because of a lack of statistical power, we could not directly compare the misinformation condition to the other conditions. King was incorrect on 18 trials under the misinformation condition. Of these trials, King chose the misinformation item 9 times (50%); he was not more likely to choose the misinformation item than the additional distractor.

The mean retention interval was 7.4 min and varied from 5 to 15 min. Experimental condition affected mean retention interval (note that the cards were presented to him 5 min after he was presented with information, but he could not be forced to respond immediately), $F(2, 87)=8.17$, $P=0.0006$. Under the control condition, King only took 6.3 min to respond. Under the correct information condition, King took 7.4 min to respond, whereas under the misinformation condition, King took 8.5 min to respond. Overall, however, the retention interval was not correlated with percent correct.

King showed poor performance when food (40% correct) and when people (39%) were used as stimuli. Indeed, he was only significantly above chance when objects were used as stimuli (57%). This did not appear to interact with the misinformation effect, however. Two main testers were used in this experiment (B.L.S. and T.C.). B.L.S. tested on 42 trials, and King was correct 52% of the time. T.C. tested on 37 trials, and King was correct 46% of the time. King was correct on 45% (5 of 11) of the trials tested by other testers (M.H., J.B., Y.M., J.K., and C.M.). King's responses were not correlated with tester's guesses: on only 33 of 90 trials did the tester and King choose the same target (37%).

Discussion

With three separate classes of stimuli (familiar people, unfamiliar people, and objects), King demonstrated above-chance accuracy at recognizing photos of the witnessed targets at delays on the order of 5–10 min. We assert that these data may support the hypothesis that at least one gorilla can remember unique events in a palinscopic (past-driven) manner. We maintain that these data replicate and confirm our earlier findings of single-trial learning and palinscopic memory with food and familiar people as stimuli (Schwartz et al. 2002).

In experiment 4, King demonstrated a misinformation effect (or an interference effect). His memory performance was worse in the condition in which he had been shown a misleading or incorrect photograph relative to conditions in which he had not. As far as we know, this is the first demonstration of a misinformation effect in a nonhuman primate. Harper and Garry (2000) showed a misinformation effect in pigeons, but at retention intervals that did not exceed 20 s and therefore are measures of working or short-term memory, not long-term memory (Washburn and Astur 1998). In experiment 4, the minimum retention interval was 5 min (300 s), a long-term memory retention interval. Thus, as in humans, King's memory performance was impaired by the presence of misinformation or interfering material.

In studies of human eyewitness memory, the assumption is that performance in eyewitness tasks reflects episodic memory, that is, the memory refers to a specific past event. Misinformation is thought to impair or interfere with the retrieval of that specific event (Loftus 1993). Thus, misinformation effects are fundamentally seen as a variable that influences episodic memory (Schwartz 2003). Therefore, evidence for misinformation effects at long-term retention intervals in a nonhuman species can be seen as evidence for episodic memory in that species. However, in these experiments, we cannot rule out the role of familiarity (i.e., choosing the most salient stimulus rather than one recollected from the past, see Jacoby 1991) in guiding King's responses. Therefore, it is premature to call these data episodic memory data; evidence for a more recall-like response or associative recognition of past events would add greatly towards this end. However, because King's response does refer to the past, we think we are justified in calling it palinscopic (Tulving and Lepage 2000). Unfortunately, current dietary concerns for King prevent us from continuing with this line of research.

King's low overall performance

In all of the experiments discussed here, King's above-chance performance was not particularly good. Although we did not test humans in the identical paradigm, we suspect that adult humans would be close to 100% in all of the conditions (including misinformation) tested in the previous discussion. Instead, King's performance hovered around 55%. Several points are in order concerning this level of performance with King. First, we tested only one gorilla. Thus, we do not know if King is doing better or worse than other gorillas might. As a consequence, we do not know if this task represents a fundamentally difficult task for gorillas. Second, King did not always cooperate. Indeed, we observed, in experiments 1 through 3, that in 24% of the trials, he "hid" the correct answer. If these were counted as correct, his performance would have risen to near 80%, presumably respectable. Third, many of the dis-

criminations among photographs were difficult to make (e.g., telling honeydew melon from cantaloupe melon), especially given that his trainers also report that King is likely far-sighted. Therefore, for these reasons, we thought it more important and impressive that King could do the tasks at all than that he did the tasks poorly relative to a hypothetical level of "good performance."

Episodic memory

Do the present data support the contention that gorillas show episodic memory (see Schwartz 2003)? Although the current data are consistent with episodic memory, there are a number of nonepisodic explanations of the current data, which we will review shortly. Consider, however, the following criteria for episodic memory in nonhuman animals. Schwartz (2003) emphasized (1) trial-unique or single trial learning, (2) long-term memory retention intervals between study and test phases, and (3) that retrieval must take place in a task that directs the animal towards the past. Our design and the current data do conform to these characteristics. Thus, these data add to a growing consensus on the existence of episodic memory in a variety of species (Menzel 1999; Clayton et al. 2001; Zentall et al. 2001; Morris 2002). Indeed, although their goals were different, Premack and Woodruff (1978) showed that chimpanzees were also able to recognize a human target (from a videotape), although the retention interval was much shorter and repeated trials were used.

However, there are several possible interpretations of the data that do not rely on King's use of an episodic-memory system. First, human cognition research distinguishes between recollection and familiarity (Jacoby 1991; Kelley and Jacoby 2000). Recollection involves true episodic memory, but familiarity responses may be based simply on enhanced memory strength of a particular stimulus, without necessarily distinguishing the source of the familiarity as being in the past. King's memory responses may come from priming of particular responses. King may have made his responses based on an implicit representation of memory "strength," with the most recent target incurring the strongest value. However, in both experiments 1 and 2, he was no more likely to choose the familiar distractor than the unfamiliar distractor, suggesting that familiarity may not have been a factor in King's mnemonic decisions. Of course, the interaction between pre-experimental and experimental familiarity is a complex one (e.g., Metcalfe 1993), so this argument is only suggestive. Similarly, in experiment 4, he was no more likely to choose the misinformation distractor (which should have been more familiar) than the novel, not suggested, distractor. Here, too, the level of familiarity induced by a real object and a photograph may differ.

Second, we also cannot rule out the rehearsal of information within working memory. It is possible that King maintained a representation of the target stimulus throughout the retention interval through some kind of rehearsal process. Thus, the response potentially is mediated through

working memory and not an episodic long-term memory system. When circumstances can be arranged adequately, a replication the current study at a 24-h or longer retention interval could be used to assess any effects of familiarity-based responding or rehearsal.

Regardless of the system being used by King to make the recognition responses observed in these studies, his responses have to be classified as palinscopic (Tulving and Lepage 2000). His responses refer to past events not the current state of the world. Thus, he is demonstrating event memory. Like human eyewitness memory research, King's responses refer to unique past events, albeit events that only happened a few minutes earlier. And like human memory, King's performance was impaired by incorrect but related post-event information.

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