2004

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Recommended Citation

Hoffman, Megan L. (2004) "Communication of where an event occurred by a gorilla (gorilla gorilla gorilla)," *Modern Psychological Studies*: Vol. 10 : No. 1 , Article 8.
Available at: <https://scholar.utc.edu/mps/vol10/iss1/8>

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Communication of Where an Event Occurred by a Gorilla (*Gorilla gorilla gorilla*)

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Episodic-like memory for the “where” component of unique events was examined in an adult gorilla (*Gorilla gorilla gorilla*). The gorilla witnessed a unique event, performed by an experimenter (e.g. watching an experimenter blow bubbles) at one of three locations surrounding his enclosure. After a 4 to 17 minute retention interval, a tester presented the gorilla with photographs of the three locations, which were mounted on wooden cards, and asked the gorilla where the event had occurred. The gorilla communicated his choice by handing a card to the tester and was rewarded if correct. The gorilla was significantly above chance at identifying the event location. Results suggest that the gorilla was not responding on the basis of familiarity by choosing the most recently visited location, but choosing the location where the event occurred.

Episodic memory refers to the ability to mentally travel back in time, and consciously re-experience events from one's past (Tulving, 1993; 2002). Schwartz and Evans (2001) have argued that the defining features of episodic memory are: long memory based on unique events from one's past, experiencing feelings of pastness when those memories are retrieved, and feelings of confidence in those memories. Until recently, it was assumed that episodic memory was unique to humans (Tulving, 2002; Schwartz, in press). A large number of memory systems such as working memory, procedural memory (or reference memory), and long semantic memory have been found to operate in non-human animals (Mercado, Uyeyama, Pack, & Herman, 1999). However, only recently has there been increased research concerning if animals have

episodic memory similar to humans (Clayton, Yu, and Dickinson, 2001; Menzel, 1999; Schwartz, Colon, Sanchez, Rodriguez, & Evans, 2002; Schwartz, Meissner, Hoffman, Evans, & Frazier, 2003). Because episodic memory involves a private conscious experience, accompanied by feelings of pastness upon retrieval, it is difficult to demonstrate episodic memory in non-human animals (Schwartz, in press). Unlike humans who can readily report their conscious experiences through the use of language, most animals are unable to communicate their conscious experiences to humans. Therefore, definitions of episodic-like memory have been created to describe the behavioral criteria that must be met by non-human animals, in order to support the hypothesis that they are experiencing episodic memory that is similar to human episodic memory.

Spatial Memory in Great Apes

Several studies have explored memory for the "where" component of unique events in great apes, by using simulated foraging tasks (Gibeault and MacDonald, 2002; MacDonald, 1994, MacDonald and Agnes, 1999; Menzel 1973; Tinklepaugh, 1932). MacDonald (1994) explored the spatial memory of an adult and juvenile gorilla (*Gorilla gorilla gorilla*) using a simulated foraging task. In this study, half of the total number of food sites in an enclosure were baited with food. A gorilla was allowed to enter the enclosure and forage freely. After the foraging process was complete, the gorilla was encouraged to leave the enclosure. After a delay, the same food sites were rebaited with food, and the subject was reintroduced into the enclosure, and allowed to find and consume the food. The adult gorilla was accurate at remembering which locations had previously contained food after retention intervals of 24 hours, and the juvenile gorilla was accurate at remembering which locations had previously contained food after retention intervals of 10 minutes. In a similar study by MacDonald and Agnes (1999) orangutans (*Pongo pygmaeus abelii*) also exhibited above chance accuracy at remembering which locations had previously contained food after retention intervals of 10 minutes.

Tinidepaugh (1932) examined the spatial memory of two chimpanzees (*Pan troglodytes*). A chimpanzee was led into several different rooms, and watched as an experimenter hid food in one member of a pair of containers located in each room. Then, the chimpanzee was removed from the area, and, after a delay interval, was allowed to revisit the rooms and search for the hidden food. The chimpanzees were highly accurate at remembering which pair of containers contained food, even for as many as 10 pairs of containers.

In a similar study, E. Menzel (1973) investigated spatial memory in 6 chimpanzees (*Pan troglodytes*). One chimpanzee witnessed food being hidden in 18 different locations in an enclosure while the other 5 chimpanzees did not observe the food being hidden, and thus served as controls. After a 2 minute retention interval, all of the chimpanzees

were allowed to search the enclosure. As was predicted, the chimpanzee who had observed the foods being hidden retrieved the majority of the foods compared to the control subjects, suggesting that the observe chimpanzee had extensive knowledge of where the foods had been hidden. In a follow-up study, Menzel (1973) demonstrated that when preferred foods were hidden at some locations and less preferred foods were hidden at other locations, the observer chimpanzee recovered the more preferred foods first, suggesting that the chimpanzee also possessed knowledge of what had been hidden in addition to where it was hidden.

C. Menzel (1999) examined memory for unique events in a language-trained chimpanzee (*Pan troglodytes*), Panzee, for both "what" and "where" components. Panzee watched as an experimenter hid foods and objects in different locations outside of her enclosure. Panzee used a lexigram keyboard to spontaneously communicate information about what had been hidden, and pointed to indicate where the object had been hidden, up to 16 hours after the event had took place. Using the information Panzee provided, experimentally blind testers were able to locate the hidden food and objects outside of her enclosure. Because Panzee was highly accurate when reporting the information, this suggests that she was able to recall "what" and "where" components of unique events.

Episodic-Like Memory in Birds

Clayton and Dickinson (1998) proposed that episodic memory contains information about "what" occurred, "where" it occurred, and "when" it occurred. Furthermore, these components (what, where, and when) are bound together in a memory for that event. With this criteria in mind, Clayton et al. (2001) examined episodic-like memory in food-storing scrub jays (*Aphelocoma coerulescens*) using a caching task that required the scrub jays to form integrated memories of "what", "where", and "when" information. The scrub jays were given perishable and nonperishable foods, which they were allowed to cache in trail-unique locations at different times. Later they were allowed to recover the foods they cached. It was demonstrated that the scrub jays were capable of remembering the location of their cache sites, the content of the cache sites and the relative time since the items were cached. Furthermore, all three components

needed to be remembered correctly in order for the jays to respond correctly, suggesting that the what, where, and when components of caching events were bound together in memory.

Zentall, Clement, Bhatt, and Allen (2001) examined episodic-like memory in pigeons (*Columbia livia*). Pigeons were trained to peck or not peck using a symbolic system. Then, on some trials, after a short retention interval, an unexpected test was given to the pigeons, requiring them to respond as to whether they had just recently pecked or not pecked. The results suggest that pigeons were able to comment on specific action events that they had recently performed. However, the retention interval did not exceed the limits of working memory, and therefore cannot be considered evidence of episodic-like memory.

Memory for Action Events in a Dolphin

A similar study, carried out by Mercado, Uyeyama, Pack, and Herman (1999) measured memory for recently performed events in a bottlenosed dolphin (*Tursiops truncatus*). The dolphin, Elele, was asked through human gestural instruction to perform an action event with a specific object. Then on randomly determined trials, she was given the gestural sign for "repeat" after a short delay interval, instructing her to repeat the action she had recently performed. Although the delay interval did not require retrieval from long memory, the dolphin was able to communicate her memory for multiple components of an event (the action she performed and the object used) on random tests.

Palinscopic Memory in a Gorilla: Reference to the Past

Another definition of episodic-like memory focuses on the palinscopic nature of episodic memory. Tulving and Lepage (2000) have argued that episodic memory involves "palinscopic" memory (memory that concerns the past), rather than "proscopic" memory (memory which concerns the present). Schwartz (in press) has proposed that episodic memory has the following qualities: (1) it must be based on trial-unique learning, (2) it requires retrieval from long-term memory, and most importantly (3) subjects must comment on events that occurred in the past (palinscopic memory), rather than display knowledge of the current state of the world (proscopic memory). With the exception of

the Mercado et al. (1999) study and the Zentall et al. (2001) study, experiments that have investigated episodic-like memory have only concerned proscopic memory. In these studies (e.g. Clayton et al., 2001), animals only have to remember where food is currently located, which could be accomplished by semantic memory, rather than episodic memory (Schwartz, in press).

In the first study examining palinscopic memory at long-term memory retention intervals in non-humans, Schwartz et al. (2002) examined episodic-like memory in King, a male western lowland gorilla (*Gorilla gorilla gorilla*). In a series of experiments, an experimenter presented King with a unique feeding event, and after a delay, King was asked what he had eaten, and who had given him the particular cards, which symbolically represented the fruits and experimenters used in the experiment, and he could use these cards to communicate his response to the tester. Because the food had been consumed, and the experimenter who had presented the food was no longer present, King was required to comment on an event that occurred in the past, rather than communicate his knowledge of the present state of the world.

King was significantly above chance at identifying both the "what" and "who" components of trial-unique feeding events, both at short retention-intervals of 7 minutes and long retention-intervals of 24 hours, both of which exceed the limits of working memory and require retrieval from long-term memory. In another study, Schwartz et al. (2003) demonstrated that King was significantly above chance at identifying familiar, and unfamiliar people (who component) and novel objects (what component) after short retention of 7 minutes, which presumably require retrieval from long-term memory. The present study examined palinscopic memory of where a unique event had occurred, after long-term memory retention intervals. Because King was accurate at remembering both the "what" and "where" components of unique past events, the hypothesis was that King would be able to remember the "where" component of unique events and communicate this memory by handing the tester the photo card of the appropriate location.

Method

Subject

King, a male western lowland gorilla (*Gorilla gorilla gorilla*), served as the subject. At the time of the experiment King was 32 years old, weighed approximately 227 kg (500 lb), and stood approximately 1.5 m (5 ft) tall. King was born in Cameroon, but was brought to the United States at the age of 2, where he was raised in a circus. He was moved to Monkey Jungle in Miami, Florida 22 years ago, at the age of 10. King has been the subject of a study on mirror self recognition (Swartz & Evans, 1994), experiments on episodic memory (Schwartz et al., 2002), and a study on event memory and misinformation effects (Schwartz et al., 2003).

Environment and Stimuli

Environment King's environment at Monkey Jungle consisted of an indoor/outdoor enclosure, connected by a tunnel to an outdoor exhibit. King was tested in the indoor/outdoor enclosure from 9:00 - 10:00 in the morning, before being released into his outdoor exhibit. An event was presented at one of three distinctive stimulus locations surrounding the indoor/outdoor enclosure: the main cage, the nighthouse, or the tunnel gate. Testing for memory of the event location was always done in a separate cage because it was removed from the three locations. During both the presentation and testing phases of the experiment, King had access to the entire indoor/outdoor enclosure (the main cage, test cage, and nighthouse), and could move to another area if he did not want to participate in the experiment.

Stimuli At the time of test King was given photographs of all three locations and could communicate where the event had occurred by handing a photo card back to the tester. The photographs were taken from King's perspective inside the enclosure. The photographs measured 8.89 cm (3 by 12.70 cm (5n)), and were mounted behind acrylic panels, on wooden cards measuring 20.32 cm (8") by 13.97 cm (5 by 3.81 cm (1.5")).

Design and Analysis

The binomial test was used to determine whether King's responses differed from what would be predicted by chance. Because King had three location cards to choose from, chance performance was assumed to be 33%.

Procedure

The experiment was conducted an aver-

age of two days per week during the month of March, April, and May of 2003. An average of three trials were run on each day of testing. A total of 60 trials were completed, with 20 trials at each of the three locations. The trials were randomized, so that neither King, nor the tester could predict the event location on any given trial.

Presentation Phase King witnessed a novel event, performed by a familiar person (M.L.H., C.A.M., SE, or G.T.), at one of three distinct locations: the main cage, the nighthouse, or the tunnel gate. The novel events included such things as watching an experimenter put on a "de Brazza" monkey mask and watching an experimenter blow bubbles. On some trials, King was given a small amount of fruit as an incentive to come over to the event location. The event lasted approximately 1 to 2 minutes. In order to ensure that the tester was experimentally blind and unable to cue King to the correct answer, the tester was kept out of view of the three stimulus locations during the presentation of the event. After the event was completed and King had left the location where the event had occurred, an experimenter timed and recorded any visits King made to the other two distractor locations (the two stimulus locations where the event was not presented) or any subsequent visits he made to the event location.

Testing Phase Five minutes after the event had been completed at the event location, the tester was asked to test King. However, because one of the testers was King's primary trainer, she was not always available to test exactly after the 5 minute retention interval. The retention interval ranged from 4 to 17 minutes, with 6 minutes being the average. Before testing King, the tester was asked to select the location where he/she believed the event had occurred. This was done to investigate whether there was a correlation between the tester's choice and King's response (i.e. whether the tester was inadvertently cueing King to the correct answer).

The tester then entered King's testing area and asked King to come over. Then the tester asked King, in English, where he had seen the familiar person perform the unique event. The tester showed King each of the three photo location cards, and placed the cards between the bars of the cage. King was asked to take the

cards and make a response. Handing a card back to the tester was scored as a response only if King had taken all three cards into his cage, so could see all of the cards before making a decision. If King made a response before doing this, the cards were replaced between the bars and he was asked to make a selection again.

After King made a response, the tester called out King's response to an out of view experimenter, who then indicated to the tester whether King was correct or incorrect. When King was correct he was given a food reward (an orange, banana, apple, or grapes) which was part of his daily diet, as well as verbal praise from the tester. King was asked to return the location cards to the tester. If another trial was scheduled for the day, the tester would leave the testing area and another event would be presented. The average interval between the time when an event was tested for, and the time when the next event was presented was an average of 6 minutes.

Results

King chose the correct location on 27 of 60 trials, for an overall accuracy of 45%, which was significantly above chance using the binomial test, $p < .05$. Although King's overall rate of accuracy was significantly above chance, King exhibited a decline in performance throughout the experiment, showing significantly above chance performance (60%) during the first 20 trials of the experiment, but declining to chance performance (38%) during the last 40 trials of the experiment.

Performance as a Function of Tester

B.L.S. did the majority of the testing. B.L.S. tested on 39 trials and T.C. tested on 21 trials. The testers appeared to be blind to the correct location. The tester chose the correct location on 20 of 60 trials (33%) which was not different from chance guessing using the binomial test, $p < .05$. Although neither tester was above chance in predicting the correct location, T.C. was more accurate than B.L.S. T.C. chose the correct location on 48% of the trials, whereas B.L.S. chose the correct location on 26% of the trials. Therefore, it appears that one tester, although not significantly above chance, was more accurate than the other tester at predicting the correct location.

The testers did not appear to be inadvertently cueing King to the correct response.

King's responses were not correlated with the tester's choices. King chose the same location as T.C. on 53% of the trials, and King chose the same location as B.L.S. on 36% of the trials, both of which were not significantly above chance. However, on the trials in which tester T.C. did choose the correct location, King also chose the correct location 80% of the time, which was significantly above chance. On trials in which B.L.S. chose the correct location, King chose the correct location only 20% of the time. However, on the trials in which T.C. did not select the correct location, King still chose the correct location 67% of the time. King's performance was significantly above chance when tested by T.C. (67%), but not different from chance when tested by B.L.S. (33%).

Performance as a Function of Event Location King was correct on 11 of 20 trials (55%) when the tunnel was the event location, which was significantly above chance using the binomial test, $p .05$. However, King was not significantly above chance when the event location was the nighthouse (45%) or the main cage (35%). King chose the tunnel location more frequently (40%) than he chose the nighthouse (35%) and the main cage (25%) even though the frequency of an event occurring at any of the locations was the same (33%).

Analysis of Retroactive Interference

Trials in which King visited distractor locations after leaving the event location were analyzed, in order to determine whether visiting a distractor location interfered with King's ability to remember the location where the event occurred; that is whether King experienced retroactive interference. On 20 of 60 trials King visited distractor locations after leaving the event location. On 17 of these trials King visited just one distractor after leaving the event location. On 2 of the trials King visited a distractor location and then revisited the event location. And on 1 trial King visited two distractor locations after leaving the event location. On the trials in which King visited one or more distractor locations, King chose the event location 45% of the time, the recently visited distractor location 25% of the time, and an unvisited distractor location 25% of the time. On the only trial in which King visited two distractor locations, he chose the event location, despite the fact that he had visited all three locations.

It appears that King's performance was not affected by retroactive interference, defined as memory of subsequent visits after visiting the event location.

Analysis of Proactive Interference Trials which were preceded by a previous trial on the same day were analyzed, in order to determine whether the previous trial location interfered with King's memory for the current event location; that is whether King experienced proactive interference. King's accuracy was not significantly above chance for the first trial on any given day (35%), or the second trial (40%) using the binomial test, $p < .05$. However, King's performance was significantly above chance on the third trial; he chose the correct location 60% of the time. King's low rate of accuracy for the first trials (35%) did not appear to be due to proactive interference from the last trial of the previous day. On the first trials of a day when King was incorrect, he chose the event location from the last trial of the previous day on only 23% of the trials. It appears that King's performance was not affected by proactive interference.

Discussion

King demonstrated above chance accuracy for communicating palinoscopic memory of where a unique event had occurred, after a retention interval which presumably requires retrieval from long memory. King's responses were not affected by visiting subsequent locations after leaving the event location. When King visited distractor locations after leaving the event location, King still chose the event location the majority of the time. On trials in which King chose an incorrect location after visiting a distractor location, he was no more likely to choose the recently visited distractor than an unvisited distractor. Both of these findings suggest that King was not simply choosing the most recently visited location, but communicating his memory for where the event had occurred.

King's Accuracy for Different Locations

King demonstrated the highest accuracy for tunnel trials, lower accuracy for nighthouse trials, and the lowest accuracy for main cage trials. This may be a result of the relative saliency of the three locations. Before the experiment, King had never seen anyone except his trainers at the tunnel location, making it a truly memorable location. King had spent some time with experimenters in his nighthouse, making it a less novel loca-

tion, and had frequently spent time with experimenters at the main cage location, making it the least salient of all of the locations. It appears that King's less than optimal level of performance throughout the study may have been due to the fact that the locations (excluding the tunnel) were not novel to King.

Possibility of Cueing by Testers Both testers appeared to be blind to the correct answer, and King's responses were not correlated with either of the tester's choices, suggesting that King was not being cued by the testers. However, when one tester (T.C.) did choose the correct location, King chose the correct location 80% of the time. Although this appears suspect at first glance, it cannot be concluded that King was being cued by her because if King was picking up on cues given by the tester, King's responses and the tester's choices should be highly correlated. However, the correlation between King's response and T.C.'s choices was not significantly above chance. Even on trials in which T.C. chose an incorrect location, King was correct 67% of the time. It appears that King was not being cued by T.C. because King was highly accurate when being tested by T.C. regardless of if she had chosen the correct location or an incorrect location.

King's Overall Low Rate of Accuracy Data from previous research with King suggests that he exhibits higher levels of accuracy and attention during the beginning of the experiment, and declines in accuracy and attention throughout the study (Schwartz, personal communication). In the current experiment, King's accuracy was quite high during the first 20 trials (60%), but his performance during the last 40 trials was not significantly above chance. In addition, the three stimulus locations (excluding the tunnel) were not particularly novel to King, and this may have affected his performance. Due to excess weight gain, King was put on a diet during the experiment, thus reducing the amount of fruit that could be given as reinforcement, which is certainly a factor that could have influenced King's motivation to perform well.

Another factor that could have influenced King's accuracy is the nature of the task itself. King has been a captive gorilla all of his life, being a former circus performer and currently a zoo resident at Monkey Jungle. He acquired an outdoor habitat only 2 years before this study

began. Compared to gorillas in the wild and captive gorillas who have been engaged in enrichment activities that promote their natural foraging in a complex environment. However, King has had many experiences with objects and people during his time at Monkey Jungle. This might explain why King was more accurate at remembering "what" and "who" components of trial-unique events in the Schwartz et al. study (2003), than remembering "where" information in the current study.

Episodic-Like Memory The present study replicates the Schwartz et al. (2003) finding of palimpsestic memory at long-term memory retention intervals in the gorilla, King. However, unlike the Schwartz et al. (2003) study, King's responses in the current study were not based on trial-unique stimuli; in the present study the same three locations were used throughout the experiment. Although the current study does not fulfill the trial-unique requirement for episodic-like memory, the results do suggest that in addition to remembering "what" and "who" information, King is also capable of remembering "where" information after long-term memory retention intervals. The fact that King was more likely to choose the event location than a distractor location, even after visiting up to two distractor locations, supports the claim that King's responses are not based on familiarity, but that King is communicating information about a past event.

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