Research Article

Mirror Self-Recognition in a Gorilla (*Gorilla gorilla gorilla*)

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ABSTRACT: *Chimpanzees (Pan troglodytes) and orangutans (Pongo pygmaeus) pass the mirror self-recognition test (MSR) with limited mirror training or exposure, but the evidence suggesting that gorillas do so is unclear. This project examined a male gorilla (G. gorilla gorilla) named Otto in a modified mark test. During the test trials, Otto was marked, without anesthesia, with odorless and tasteless dye by his trainer. A video-camera recorded his behavior, which was later scored by observers who did not know whether or not the trials were in front of the mirror. The results showed that Otto touched the marked area more when he was in front of the mirror than in other conditions. These results are interpreted in terms of current theory of MSR.*

Mirror self-recognition (MSR) is used in nonhuman species as an indicator of emerging self-knowledge. Mirror self-recognition means that the animal correlates the image in the mirror with its own body. In the classic mark test, Gallup (1970) put odorless dye on the foreheads of chimpanzees. If the chimpanzee – only on the basis of the mirror image – touched its forehead, it was said to have passed the mark test. Gallup found that when first presented with a mirror, chimpanzees treat the reflected image as a conspecific, that is, an extension of their environment. After the chimpanzees become more familiar with the mirror image, they began testing contingencies. Only after this experience were chimpanzees able to pass the mark test. Of the great apes only chimpanzees, bonobos, and orangutans have shown evidence of passing the mark test (Gallup, 1970, 1979; Lethmate & Dücker, 1973; Suarez & Gallup, 1981; see Gallup & Povinelli, 1993). There is evidence that other animals pass the mark test as well, including capuchin monkeys (Roma, Silberberg, Huntsberry, Christensen, Ruggiero, & Suomi, 2007), dolphins (Loveland, 1995; Mitchell, 1995; Reiss & Marino, 2001; Sarko, Marino, & Reiss, 2002) and elephants (Plotnik, de Waal, & Reiss, 2006; Povinelli, 1989).

The results for gorillas, however, are not conclusive. Most studies find no evidence of MSR (Ledbetter & Basen, 1982; Nicholson & Gould, 1995; Shillito, Gallup, & Beck, 1999), but three gorillas have passed the mark test (Patterson & Cohn, 1994; Posada & Colell, 2007; Swartz & Evans, 1994). Each of these gorillas was living in an enriched environment with extensive human contact. These enriched conditions may have provided the necessary experiences to produce a positive response on a MSR task. With the exception of Posada and Colell (2007), the experiments were performed without experimentally blind experimenters and did not include adequate controls. In addition, the data did not go through peer review. In this paper, we report a double-blind study on a gorilla that had an environmentally enriched experience. If so, the gorilla tested by Posada and Colell (2007) will not be the only gorilla to have passed MSR in a systematic double-blind fashion.

Our experiment sought to determine whether or not a gorilla can pass the mark test in the presence of a mirror without having had specific mirror training. One purpose of this research was to determine if

sufficient exposure to a mirror will facilitate a gorilla's ability to successfully pass a mark test. According to the enculturation hypothesis (Call & Tomasello, 1996) being reared in a species-atypical environment can lead to changes in that species' cognitive abilities (Bjorkland, 2006; Suddendorf & Whiten, 2001; but see Bering, 2004 for a critique of the enculturation hypothesis). Using a modified version of Gallup's mark test and a behavioral checklist derived from Lin et al. (1992), this experiment seeks to find multiple evidence of MSR in a gorilla, first through self-directed and contingent behaviors, and then by a positive mark test result. Given that the gorilla used in this study, Otto (*Gorilla gorilla gorilla*), was raised in an enriched environment, it was predicted that he would show a positive result on the mark test, as did the other three gorillas raised in an enriched environment.

METHOD

Subject

Otto, a male lowland gorilla (*G. gorilla gorilla*), was approximately 45years-old at the time of testing. He was brought to the Suncoast Primate Sanctuary in Palm Harbor, Florida, at approximately age 2, with various health problems including tuberculoses and septic arthritis. After recovering from his illnesses Otto was housed individually at the Sanctuary in an enriched environment, which included activities, such as foraging, watching television, and painting. Otto had not previously participated in research of any kind, nor had he extended exposure to mirrors (as far as the authors know). However, he had extended human interaction and social contact.

Otto's enclosure included two main areas, an indoor area and an outdoor area. The indoor area had a bench near one of the sides. Otto spent much of his time here relaxing, so this site was chosen for placement of the mirror. Otto had full access to both areas of his enclosure during the experiment.

Materials

A Canon ZR100 was used to film all sessions. The sessions were recorded onto DVDs for coding. Observers KN, CB, and JM, (all college undergraduates) were blind to the hypothesis and coded the behaviors. During mirror trials, a mirror (3 ft x 2ft 2.5 inches) was placed approximately 3 ft from the enclosure. Odorless, tasteless, transparent mineral oil (approximately the same consistency of the paint used in the mark test) was used during the sham trials as explained below. A non-toxic, odorless, white paint (Plaid Washable Paint for Kids) was used for marking during the mark test. Otto's trainer, DC, performed the application of the sham and painted marks. The experimenter, MA, trained the coders according to a behavioral checklist, filmed all sessions, and performed all other procedures. After the set up of each trial, the experimenter started the video camera and left the area. The experimenter remained out of Otto's sight for the duration of the trial, insured that no other individuals interacted with Otto, and only returned when the trial was over.

Procedures

A modification of the original Gallup (1970) mark test procedure was used. In our procedure, Otto was not anesthetized, as this represented a health risk for Otto. Otto progressed through four trial types: baseline, mirror exposure, sham, and test (see figure 1). The initial behavioral baseline was recorded by video in ten 1-hr sessions without the presence of the mirror. These taped sessions occurred in the same location as all other trials.

Condition	Description	Number of Trials	Trial Duration (minutes)
1. Baseline	no mirror	10	60
2. Mirror Exposure	mirror, no mark	30	45
3. Sham Trials	no mirror, false mark	5	30
	mirror, false mark	5	30
4. Test Trials	no mirror, paint mark	3	30
	mirror, paint mark	3	30

Fig. 1. A description of the four trial types, including the number and duration of those trials.

After the baseline behavior was recorded, the mirror was introduced in thirty 45-min sessions. At no time was Otto's attention drawn by the experimenter to the mirror. These sessions were uninterrupted time in front of a mirror with no specific training. This is similar to the familiarization procedure used by Shillito, Gallup, and Beck (1999).

After the mirror familiarization trials, the test trials began. The sham trials allowed Otto to habituate to the marking procedure. A familiar trainer, DC, performed the sham marking procedure prior to the start of the

session by rubbing a paintbrush, filled with the colorless and odorless mineral oil, along the left brow ridge. Behaviors were recorded for 30 min without the mirror followed by 30 min in the presence of the mirror, with the order of mirror and no mirror sessions were randomized. Sham trials allowed us to determine if Otto was attending to the mark and not to the novel situation of his trainer painting his brow.

After the sham trials, two paint test trials were conducted. During the application of the paint in Test Trial one, insufficient paint was applied so a third test trial was added. Each test trial included a session with the mirror and without the mirror. The trainer marked the brow ridge as in the sham trials, this time with an odorless paint. Behavior was recorded in thirty-minute sessions, first without the mirror and then followed by the presence of the mirror, with mirror and no mirror sessions being counterbalanced.

The procedures used in this experiment were in compliance of USDA rules, and the experiment conducted was approved by the Florida International University Institutional Animal Use and Care Committee (Approval number 06-003).

Behavioral Measurements

The percentage of time spent in front of a mirror was recorded. To be considered in front of the mirror, Otto had to have one body part on the bench located in his indoor araea. This area was directly in front of where the mirror was located. When Otto left the bench to go to the outdoor area or the back part of his indoor area his behaviors were no longer recorded and he was considered out of the area. The number of touches to the marked area in both the sham and paint trials was recorded. Mirror self-recognition was operationalized as significantly more touches during the test trials to the marked area in the presence of the mirror than in the absence of the mirror.

A modification of Lin et al.'s (1992) behavioral checklist was used to code behaviors (see figure 2). The behaviors were divided into five categories: non-mirror behaviors, mirror-directed behaviors, contingent movements, mirror-guided behaviors, and self-recognition. Non-mirror behaviors included face-directed behaviors, which were acts towards the face excluding the marked area without looking in the mirror, and mark-directed behaviors, which were acts towards the marked area without looking in the mirror. Mirror-directed behaviors included: reaching, attempts to make physical contact with the mirror or supporting apparatus; searching, attempts to look around or behind the mirror from an oblique angle; playing, attempts to interact with the

Behavioral Categories		Examples
non-mirror	body directed	acts towards the body without looking in the mirror
	object directed	acts towards an object without looking in the mirror
	face directed	acts towards the face excluding the marked area without looking in the mirror
	mark directed	acts towards the marked area without looking in the mirror
mirror-directed	reaching	attempts to make physical contact with mirror or supporting apparatus
	searching	attempts to look around or behind the mirror from oblique angle
	playing	attempts to interact with the mirror in a sociable manner
	affect display	any signs of fear or aggression towards the mirror
	looking	gazing at the mirror without moving contingently or acting in a self-directed manner
contingent movements	body movements	movement of head or body while gorilla visually follows movements in the mirror
	facial movements	following the movements of the face in the mirror
mirror-guided	object reach	use of images in the mirror to manipulate an object
	face directed	use of the mirror to direct action to own face exclusive of the mark
mark-directed	mark directed	use of the mirror to direct action to the marked spot

Fig. 2. Modified behavioral checklist, originally in Lin et al (1992).

mirror in a sociable manner; affect display, any signs of fear or aggression towards the mirror; and looking at the mirror without moving contingently or acting in a self-directed manner. Contingent movements comprised of body movements, movement of the head or body while the gorilla visually following movements in the mirror, and facial movements, following the movements of the face in the mirror. Mirror-guided behaviors included: object reach, use of images in the mirror to manipulate an object; body-directed, use of mirror images to direct action to the gorilla's own body; and face-directed, use of the mirror to direct action to his own face exclusive of the mark. MSR was measured by mark-directed behaviors, that is, the use of the mirror to direct action to the marked spot.

Observers were first trained to code behaviors using a video of four randomly selected segments of baseline trials. The observers then coded the remaining segments by watching the videotaped sessions and recording the number and duration of the behaviors on a behavioral checklist. Each trial was broken into 15-minute segments for coding purposes. Observers were randomly assigned to the segments that they coded, with the stipulation that they code at least one segment for each trial, and all observers coded all segments for the sham and test trials. Twenty-four percent of the segments had two observers, and 21% of the segments had three observers. In segments that had two or more observers, only those behaviors that were recorded by at least two observers were included in the data analysis. A total of 1037 (515 of which were 'looking') behaviors were excluded from data analysis. Only one mark-directed behavior and one mirror-mark-directed behavior were excluded. The overall correlation between observers' responses across all trials was r = .60. For mark-directed and mirror-mark-directed behaviors the correlation was higher than the overall correlation, with r = .77.

RESULTS

Statistical reliability was measured at $p < .05$ in this experiment. When the data were parametric, we employed student's t-tests. If the data did not meet the standards for parametric analysis, we used chi-square tests.

Mirror-Directed Behaviors

There were no mirror-directed behaviors recorded during the baseline trials. The percentage of the total time spent in mirror-directed behaviors during the mirror exposure trials was distributed as follows: reaching (0%), searching (5%), playing (.1%), affect display (.1%), and looking (95%). Because reaching, searching, playing, and affect display were a low percentage of the total behaviors they were excluded from further analyses. There were 19.2 looking behaviors per trial, with an average duration of 6.17 seconds per trial.

There were no significant differences in the number of looking behaviors across all trial types.

Contingent and Mirror-Guided Behaviors

We did not observe much contingent or mirror-guided behavior. Only 14 contingent face movements, 2 contingent body movements, and 1 incident of mirror-guided face directed behavior were observed during 30 mirror exposure trials.

Mark-Directed Behaviors

During the mirror-present sessions of the test trials Otto engaged in 16 mirror-mark-directed behaviors (touching the marked area of his brow), with an average of 1.3 sec/touch. In both the mirror-present and mirror-absent sessions of the sham trials there were no mirror-mark-directed behaviors recorded. There were 10 mark-directed behaviors during the mirror-absent sessions of the test trials, averaging 2.6 seconds per touch. Inspection by the experimenter indicated that Otto found the mark accidentally when he touched a water bottle to his face and transferred the paint from his brow to the bottle. All 10 touches occurred following this incident. A chi-square comparing the mirror and no mirror session of the test and sham trials with 16 touches in the mirror-present test trial, 10 touches in the mirror-absent test trial, 0 touches in the mirror-present sham trial, and 0 touches in the mirror-absent sham trial resulted in significant differences, $\chi 2$ (3, N=16) = 28.05. Comparing the number of touches during the mirror-present sessions of the test trials (16) and the number of touches during the mirror-absent sessions of the test trials (10) yielded a chi square of $\chi 2$ (2, N=16)= 1.38, which did not reach significance.

It is likely that some of Otto's responses in the mirror-absent test condition were mediated by an accidental rubbing of the paint with his water bottle. Inspection of the videotape indicated far less precise touching of the marked area in the mirror-absent condition than in the mirror-present condition. There were also differences in the latency to the first mark-directed touch. In the mirror condition the mark-

directed touching occurred on average 12 seconds from the start of the trial. In the no-mirror condition the mark-directed behaviors did not begin until 107 seconds after the start of the trial. Otto also spent twice as much time (2.6 sec.) in the no-mirror condition touching the area near the mark than in the mirror-present condition (1.3 sec.), which may indicate that there was uncertainty from where the paint on the bottle had come. Test trials can be seen via these links Mirror Mark and Mirror No Mark .

DISCUSSION

Otto showed evidence of touching the marked area during the mirror-present test condition and not during the sham test trials. The number of touches to the marked area has been accepted as an indication of MSR (Asendorpf, Warkentin, & Baudonniere, 1996; Gallup, 1970, 1979; Lethmate & Dücker, 1973; Rochat, 2003; Suarez & Gallup, 1981). We had hypothesized that contingent movements and mirror-guided behaviors would occur. Lin et al. (1992) found evidence that self-directed and contingent behaviors precede self-recognition in chimpanzees and we predicted that the same would be true in Otto's case. Our data indicate that mirror-guided and contingent behaviors may not be good indices of self-recognition in gorillas. Otto failed to show significant evidence of mirror-guided behaviors but still passed the mark test. It is unclear why Otto failed to show contingent and mirror-guided behaviors.

Gorillas' performance on MSR has not been consistent. Several previous studies have concluded that gorillas do not show MSR (Gallup, Wallnau, & Suarez, 1980; Lethmate & Ducker, 1973; Suarez & Gallup, 1981). However, there is evidence that gorillas with extensive experience in an enriched environment show evidence of self-recognition (Koko and King, Patterson & Cohn, 1994; Swartz & Evans, 1994). It may be that these gorillas were given experiences that enhanced their social cognition, enabling self-recognition to be expressed (Bjorkland, 2006; Tomasello, 2000). Indeed, the gorilla Xebo (Posada & Colell, 2007) also appears to be well-habituated to human presence. The results of our study (and that of Posada & Colell, 2007) suggest that latent social cognitive abilities exist in gorillas, although enriched upbringings may be necessary for these abilities to be exhibited.

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