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*PNAS* 1996;93:7405-7408  
doi:10.1073/pnas.93.14.7405

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## Self-recognition and abstraction abilities in the common chimpanzee studied with distorting mirrors

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Contributed by Derek Denton, March 26, 1996

**ABSTRACT** The reactions of chimpanzees to regular mirrors and the results of the standard Gallup mark test have been well documented. In addition to using the mark test to demonstrate self-recognition in a regular mirror, we exposed six female chimpanzees to mirrors that produced distorted or multiplied self-images. Their reactions to their self-images, in terms of mirror-guided self-referenced behaviors, indicated that correct assessment of the source of the mirror image was made by each subject in each of the mirrors. Recognition of a distorted self-image implies an ability for abstraction in the subjects in that the distortion must be rationalized before self-recognition occurs. The implications of these results in terms of illuminating the relative importance of feature and contingency of movement cues to self-recognition are discussed.

Self-awareness has for many years been assessed solely in terms of presence or absence; however, there is no *a priori* reason to expect self-awareness to be a discrete capacity that an organism either has or does not have or to expect that one self-aware organism possesses the same level of awareness as another. In human children, for instance, the sense of self develops gradually (1, 2), and manifestations of self-identity vary qualitatively with age (3). It is also likely of nonhuman primates that any self-awareness they possess will vary qualitatively. A relevant consideration here lies in the ability for self-recognition in an individual exposed to various cues of self.

These questions constitute the focus of the present study, in which six subjects were exposed serially to a convex and a concave mirror and finally to a triptych mirror (a three-faced mirror designed to produce three images) to test further the extent and quality of the self-concept present in chimpanzees. The great majority of studies in the field have focused on one criterion or cue to evaluate the presence of self-recognition—i.e., visual feature recognition. However, the present study lends insight into the ability of chimpanzees for self-recognition when visual feature cues are distorted. The demonstration of this ability indicates the use of some other cue or cues, most probably contingency of movement cues (i.e., the precise contemporaneity of volitional movement of subject with movement of reflection) to evaluate the source of the mirror image. This could prove valuable in directing further attention toward the investigation of different aspects of self-awareness; possibly aspects that are more relevant to various nonhuman animals than is visual feature recognition.

### MATERIALS AND METHODS

**Subjects and Housing.** The subjects were six female captive-bred chimpanzees (*Pan troglodytes*) between the ages of 7 and 14. The subjects were housed in social groups at the Southwest Foundation for Biomedical Research, San Antonio, TX, and had all had limited prior mirror experience. For the duration

of the study, the subjects were moved in pairs from their regular housing to an experimental building containing two connected home cages and an experimental cage [160 cm (width) × 198 cm (depth) × 250 cm (height)].

**Apparatus and Procedure.** All observations were recorded from two angles using portable video cameras mounted on tripods. To obtain unhindered view and record, one side of the cage was a sheet of 2-cm thick Lexan plastic. Unlike the majority of mirror studies with adult subjects, in which the mirrors are placed outside the cage, our subjects were exposed to mirrors attached to the inside of the experimental cage. This allowed the subjects a clearer view of the mirror image while also allowing the observer a clearer view of the subjects' reactions to the image.

The mirrors were constructed using Plexiglas held in place with wooden frames. The convex, concave, and regular mirrors measured 150 cm × 75 cm. The triptych mirror was constructed of three pieces (150 cm × 30 cm each) of flat Plexiglas in a wooden frame that held the two outer pieces at a 45-degree angle from the middle piece.

Each pair of subjects underwent at least 1 week of habituation to the new environment and to conditions similar to those under which observations were taken (but with no mirrors present) before observations began. The subjects were moved to the experimental cage for observations. Both subjects were observed once a day, in the morning and the afternoon, alternatively. The duration of each observation was 2 hr. Continuous recordings of the subjects' behavior were taken by the observer using a laptop computer (Tandy 102).

Observations were conducted by the first author (A.K.) after reliabilities of 89–96% were obtained between the first author and the third author (L.B.).

Baseline observations were taken under similar conditions to all other observations except with no mirror in the cage. Five baseline observations were recorded before subjects were exposed to any mirror, and one baseline observation was recorded weekly throughout the study. After the initial baseline observations, the subjects were exposed to the regular mirror for four observations (on four consecutive days).

Following this, the mark test was performed following the procedure of Gallup (4). The mark test was incorporated into the experimental design to confirm the ability of the subjects for self-recognition in a regular mirror. The subjects were anesthetized using ketamine hydrochloride. Two marks (red and yellow) of 2.5-cm diameter were applied to the forehead and ear of the subjects using opaque paint marker pens. Little or none of the marks had worn off by the following day when the subjects were exposed to the regular mirror for 2 hr each to test their reaction to the marks. The subjects were visually separated using a sheet of black plastic throughout the 2 days of the mark testing. Visual separation was deemed necessary in view of reports of human infants touching their own heads when observing a mark on their mothers' foreheads (2, 5). The test was performed on the day following the anesthetization in view of issues raised by some researchers (for example see ref. 6) who attribute the positive mark test results to the effects of

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anesthetic recovery on species with a high baseline frequency of self-directed behavior. This factor was eliminated in the present study by exposing the subjects to the mirror on the second day, at least 22 hr after the anesthetization and marking had taken place. No aftereffects of anesthetization were apparent on this day.

On the basis that it may be more biologically relevant, and thus of more interest to the subject, the procedure of the mark test was followed with four of the subjects in the following week substituting a painted "eye" for the mark.

In the following 3 weeks, the subjects were exposed four times to the convex mirror, four times to the concave mirror, and finally four times to the triptych mirror. This amounted to 32 hr of total mirror exposure per subject; 8 hr per mirror, plus 16 hr of baseline observations.

**Coded Behaviors.** The duration and frequency of all behaviors were recorded during the observations using the laptop computer. The relevant behaviors are listed in Table 1 and were derived from Lin *et al.* (7).

**Data Analysis.** To examine the presence or absence of demonstrated self-recognition in a regular mirror, the duration of time spent touching the mark during the mark test was compared with the time spent touching the same area (center forehead and either ear) in the baseline observations. The significance of differences in this behavior was tested using *t* tests. The critical significance level was taken as  $P < 0.05$ .

Evidence of self-recognition on exposure to the distorting mirrors was assessed by measuring the onset and quantity of manipulations of facial and otherwise visually nonaccessible body areas (i.e., mirror-guided self-referenced behaviors) in baseline and regular mirror observations and comparing them with the measure taken in the distorting mirror observations. A comparison was also made between the observed onset and quantity of facial and body contingent movements (as defined in Table 1) in the various mirrors and similar movements without the mirror in baseline observations (defined as facial and body contortions in Table 1). The levels of visual and tactile interest in the various mirrors provided additional insight on the results.

## RESULTS

**Mark and Eye-Mark Tests.** Overall, the subjects touched the area of the mark significantly more in the mark test [ $t(5) = 2.592$ ;  $P < 0.049$ ] than in the baseline observations (Fig. 1). The results of the eye test were similar. The eye was touched significantly more [ $t(3) = 3.511$ ;  $P < 0.039$ ] when compared with the baseline observations.

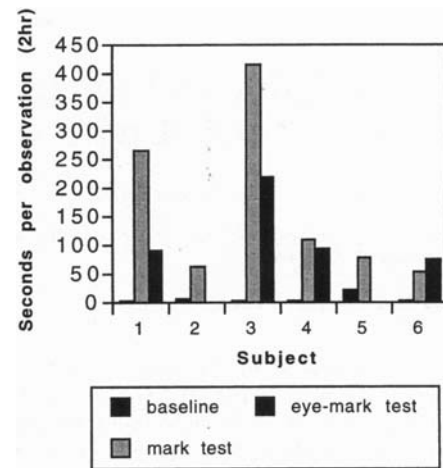


FIG. 1. Time spent touching area of mark and eye mark. Chimpanzees are numbered as follows: 1, Ava; 2, Elke; 3, Heather; 4, Katie; 5, Pamela; and 6, Poppy. The eye mark tests (the right column in each animal) were not performed on Elke or Pamela.

**Initial Exposure to Distorting Mirrors.** All subjects exhibited mirror-guided self-referenced behaviors as observed during regular mirror exposure during their first exposure to all three types of distorting mirrors. The elapsed time before the first observed mirror-guided self-referenced behavior was less during initial exposure to the distorting mirrors than during initial exposure to the regular mirror in 8 out of the 18 initial exposures (see Table 2).

On exposure to the regular and distorting mirrors, the subjects displayed little of the social behaviors (e.g., head bobbing, play invitations, begging gestures, and sexual presentations) commonly reported in chimpanzees on initial exposure to mirrors (for example see refs. 8 and 9). The sole "socially relevant" behavior exhibited was a display in which the subject stood pilo-erect in front of the mirror, moving and occasionally hitting the mirror. This behavior was displayed infrequently in front of all types of mirrors with a mean number of occurrences per 2-hr observation of 0.57; the duration per occurrence ranging from 3 to 9 sec.

**Overall Results of Exposure to Distorting Mirrors.** The overall time spent touching visually inaccessible body areas and engaging in facial and body contingent movements ranged from 40% to 130% higher during exposure to the distorting mirrors than when no mirror was present (Fig. 2). The time spent engaging in these behaviors decreased uniformly as total time of mirror exposure increased—i.e., from the level displayed on exposure of the first mirror (regular mirror) to that

Table 1. Definitions of coded behaviors

Behavior	Definition
<b>Nonmirror behaviors</b>	
Self-exploration	Manipulation of nonvisible body areas (e.g., face, anal/genital areas) with fingers or hands
Facial and body contortion	Unusual facial or body movements (such as those defined as contingent movements while looking in mirror)
Marked area	Touching the area of the forehead and ear where the mark would be placed during mark and eye-mark testing
<b>Mirror-directed behaviors</b>	
Touch mirror/look mirror	Any physical contact with mirror or looking at mirror without engaging in facial or body-contingent movement or self-exploration
Display behavior	Standing pilo-erect in front of mirror, moving, and occasionally hitting mirror
<b>Mirror-guided behaviors</b>	
Self-referenced behavior	Manipulation of nonvisible body areas (e.g., face, anal/genital areas) with fingers or hands while looking at own image
Facial and body-contingent movement	Unusual and repetitive facial or body movements while looking at own image
Touch mark (mark and eye tests)	Using mirror to touch the area of the mark

Table 2. Time (sec) elapsed before first recorded mirror-guided self-referenced behavior

Subject	Regular	Convex	Concave	Triptych
Ava	20	18	38	36
Elke	154	412	985	113
Heather	91	45	32	44
Katie	144	30	511	404
Pamela	40	1237	401	1658
Poppy	383	20	61	1396

displayed on exposure to the fourth mirror (triptych mirror). This decrease corresponds to the uniform decrease in total mirror interaction recorded from the first to the fourth mirror (an overall decrease of  $\approx 11\%$ ).

Although there was considerable variation between subjects in the overall time spent in mirror interaction, as well as the time spent in mirror-guided behaviors, all subjects engaged in inspection and touching of the face and of otherwise visually inaccessible body areas in all mirrors. Contingent body and face movements were also displayed by all of the subjects in all the distorting mirrors (except by one subject, Poppy, in the triptych mirror).

## DISCUSSION

**Mark and Eye-Mark Tests.** Due to the positive mark test results obtained, we feel confident in concluding that the ability for self-recognition in a regular mirror was evident in each subject. We inferred from this that the behaviors exhibited on exposure to the regular mirror were ones exhibited by an individual possessing self-awareness. In this way, it was possible to compare the subjects' reactions to, and use of, the distorting mirrors to those of the regular mirror to make an inference about the level of self-recognition obtained by the subjects on exposure to the distorting mirrors. This methodology was developed due to the impracticalities and risks of frequent anesthetization to carry out mark tests in each of the distorting mirrors. Recent studies on common and pygmy chimpanzees have also used criteria other than a positive mark test result, such as the display of mirror-guided self-referenced behaviors to test for self-recognition (7, 10, 11)

Positive results from the eye-mark test due to its biological relevancy could have been cogent for researchers attempting to obtain positive mark-test results on individuals or species (especially those with a low baseline frequency of self-directed behavior) that have previously failed such tests. However, the eye-mark test did not result in a markedly higher level of

interest in the mark compared with the standard mark test in our subjects (Fig. 1). This may be due to the standard mark test being performed before the eye-mark test in each subject, leading to habituation and a resulting decrease in interest in the marks; further investigation will be needed for conclusive results.

**Distorting Mirrors.** Mirror-directed social behavior has been commonly reported in self-awareness studies and is considered to indicate a lack of self-recognition. There was an absence of any marked exhibition of social behaviors by the subjects in the present study on exposure to all mirrors. The sole socially relevant behavior observed in the present study was a display that was performed infrequently. As there was no correlation between this behavior and the amount of mirror exposure the subjects had had, and as this behavior always occurred after the subjects had engaged in numerous bouts of mirror-guided self-referenced behaviors, we concluded that this behavior was not conclusive evidence of "other-directed" behavior—i.e., behavior exhibited in the presence of a conspecific. The absence of any marked exhibition of social behaviors on exposure to the regular mirror may be explained by the subjects having had some, although limited, prior mirror exposure. However, on exposure to the distorting and multiplying mirrors, the subjects were exposed to unfamiliar and novel images—i.e., a markedly shorter and fatter image, a taller and thinner image, and three images simultaneously. Thus, the absence of social behaviors in these mirrors is a clear indication that the subjects never attributed the images to those of a conspecific. When exposed to both distorting and multiplying mirrors, all subjects displayed mirror-guided self-referenced behaviors as well as facial and body contingent movements similar to those exhibited in the regular mirror. These observations, together with the fact that these behaviors were exhibited at elevated levels in all mirrors as compared with the level exhibited in baseline observations (Fig. 2) can be interpreted as an indication of self-recognition in all subjects on exposure to all distorting mirrors.

An overall decrease in mirror interaction (and the accompanied decrease in mirror-guided inspection) similar to that recorded from the first to the last stages of this study (see Fig. 2) has been noted by other researchers. This has been interpreted as further indication of presence of self-recognition in subjects (for example see refs. 12 and 13). Gallup (13) reported that chimpanzees would quickly lose interest in the mirrors after they recognized themselves. Conversely, an animal that continues to interpret the mirrored self-image as the image of a conspecific is likely to interact with that image over an extended period, as it would with an actual conspecific. Thus, the steady decrease recorded in mirror interaction from the level exhibited on exposure to the first mirror (regular) to that exhibited on exposure to the fourth mirror can be interpreted as further evidence of self-recognition. This decrease in mirror interaction from the first to the fourth mirrors may be responsible for the decrease in mirror-guided self-referenced behaviors also recorded from the first to the fourth mirrors.

The demonstrated ability of chimpanzees to recognize a distorted image of themselves leads us to question the way in which this recognition occurs. Mitchell (14) described self-aware beings as those with an "implicitly present mental representation of the organism itself." It follows that such an animal on exposure to a mirror, will compare the image it is confronted with to its mental self-representation to correctly assess the source of the mirrored image. The present study tested the ability of the subjects to recognize a distorted self-image—that is, an image that is significantly different from any mental representation of itself, or a conspecific for that matter, that it might have possessed. Whereas a regular mirror provides both complete feature and contingency of movement information to the subject (see ref. 15), this distorted image provides only contingency information. The demonstration of self-recognition in a distorting mirror thus implies a level of

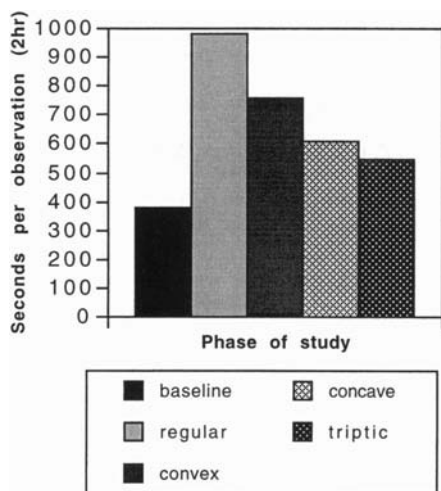


FIG. 2. Time spent engaging in mirror self-referenced behaviors and facial and body-contingent movements.

abstractional ability on the part of the subject. That is, for self-recognition to occur on exposure to a distorting mirror, the subject must not only be using some other cue or cues, but it must also be able to rationalize the distortion of the features of the image.

The ability of chimpanzees for self-recognition in distorting mirrors, as demonstrated in this study, indicates that more than one type of mirrored information can be used by the subject to make a correct assessment of the source of the image. The fact that the initial mirror-guided inspection of otherwise inaccessible areas was observed earlier in the distorting mirrors than in the regular mirror for some of the subjects (Table 2) indicates that, at least for some subjects, an accurate assessment of the source of the distorted or multiplied image occurs equally as rapidly as that of the normal image. These results indicate not only that chimpanzees have the ability of recognition of self using contingency of movement cues without clear feature cues, but also that these cues may be at least as important in self-recognition as feature cues for chimpanzees.

Self-awareness has been defined as the capacity to become the object of one's own attention. It involves being aware of being aware. To be able to anticipate and use one's own experience as a means of development of a variety of introspectively based social strategies to relate to others, either cooperatively or to compete for resources, may carry high survival advantage (16, 17). Being the highest level of consciousness, there is the phylogenetic question as to when it emerged. Using mirror self-recognition as a paramount operational criterion (you cannot examine visually otherwise inaccessible parts of your body with the aid of a mirror reflection unless you know who you are), the capacity is established in chimpanzees and orangutans but with some debate in gorillas (17). A recent paper in which a highly visible typical feature of the species, the cotton top tamarin, was altered by colored hair dye under anesthesia, which resulted in self-directed mirror behavior, suggests on this criteria that possibly some elements of this capacity are present in primates lower than the great apes (18), though G. G. Gallup and D. J. Povinelli (personal communication) are presently unable to replicate the finding in marmosets.

In considering self-awareness, the matter of intention would seem a paramount issue. Longuet-Higgins (19) propose that the idea of a goal or intention is an integral part of the concept of mind, and that an organism that can have intentions is one that could be said to possess a mind, because the idea of forming a plan in turn requires the idea of forming an internal model of the world. Edelman (20) notes that intention has an inexorable component of subjectivity.

A question that can be posed is that if a monkey with its hand, or another animal such as a cat or dog with forelimb, strikes an object in the course of an intentional act, and the result is severe pain, perhaps associated with sound of striking, all within a field of vision and with the contemporaneity or contingency of these events incident with its intention, would it be aware that its own limb was the source of pain, and, at this

level, be aware of itself? Or is the situation with the animal similar to that in the human with a brain lesion, where the patient may be unaware that an arm paralyzed is his or her own (20)? With awareness, it is a common though by no means universal view, that it is biologically an emergent, and primal awareness may be present in lower animals and reptiles (21–23). With self-awareness, whereas a salutation of great import is reflected by mirror self-recognition, it may be that gradations have occurred in its emergence, with animals having some rudimentary appreciation of self (22), even if they are unable to reach the level of awareness in a mirror. G. G. Gallup (personal communication), based on considerations including blind sight, doubts existence of verifiable rudiments of self-awareness below the great ape.

We gratefully acknowledge the help of Amy Kessel, Tony Gutierrez, Bert Barrera, and the staff at The Southwest Foundation. We thank Gordon Gallup for reviewing the paper and Kim Bard for comments on an earlier version of the paper. This work was generously supported by the Howard Florey Biomedical Foundation and the Robert J., Jr., and Helen C. Kleberg Foundation.

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