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Cotton-Top Tamarins (*Saguinus oedipus*) Fail to Show Mirror-Guided Self-Exploration

MARC DAVID HAUSER[1,2*], CORY THOMAS MILLER[1], KATIE LIU[1], AND RENU GUPTA[1]
[1]*Department of Psychology, Harvard University, Cambridge, Massachusetts*
[2]*Program in Neurosciences, Harvard University, Cambridge, Massachusetts*

To investigate the problem of inter- and intraspecific differences on the mirror test, we conducted two experiments on cotton-top tamarins. Experiment 1 employed a technique similar to one used recently on chimpanzees, and provided no evidence of mirror-mediated touching of the marked area. In a control condition, involving colored dye applied to one arm, two subjects also failed to show self-directed touching, even though they clearly looked at their newly dyed arm. Under these test conditions, cotton-top tamarins fail to show mirror-guided self-exploration. Experiment 2 examined whether this failure was due to insufficient mirror exposure, as well as other details of the testing conditions. In particular, we replicated the design of a previously successful experiment on mirror-mediated recognition in tamarins [Hauser et al., 1995], providing four new animals with a protracted period (three weeks) of mirror exposure prior to dying their hair. In parallel with results from Experiment 1, we observed no evidence of mirror-mediated behavior (recognition) in Experiment 2. Am. J. Primatol. 53:131–137, 2001.

Key words: self-recognition; mirrors; cotton-top tamarins

INTRODUCTION

Three findings provide difficulties for the proclaimed phylogenetic pattern of mirror self-recognition, in which apes pass the mirror-mark test [Gallup, 1970] and monkeys do not. First, not all chimpanzees show either spontaneous mirror self-exploration or mirror self-recognition following the dye-mark test [Povinelli et al., 1993, 1997; Swartz & Evans 1997; de Veer & van den Bos, 1999]. Second, gorillas fail the mirror test [Shillito et al., 1999]. Third, a study [Hauser et al., 1995] of adult cotton-top tamarins suggests that individuals of this species recognize their own mirror image when tested under a slightly modified version of Gallup's original experiment. Specifically, subjects touched their color dyed hair tuft while looking in the mirror, but only if they were exposed to the mirror for several weeks before receiving a hair color change [Hauser et al., 1995; Hauser & Kralik, 1997]. Subjects with prior mirror exposure and dyed hair also stared into the mirror without any sign of aggression, and did so for longer periods of

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*Correspondence to: Marc D. Hauser, Department of Psychology, Harvard University, 33 Kirkland Street, Cambridge, MA 02138. E-mail: hauser@wjh.harvard.edu

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time than they had done before their hair changed colors; they also stared longer into the mirror than did subjects with dyed hair but with either no prior mirror exposure or a brief period of exposure.

The tamarin results have either been criticized, ignored, or used to argue against interspecific differences among the primates in mirror self-recognition [Anderson & Gallup, 1997; Hauser & Kralik, 1997; Heyes, 1998; Swartz & Evans, 1997; de Veer & van den Bos, 1999]. Although Anderson and Gallup [1997] raised several important issues with respect to the original study, Hauser and Kralik [1997] responded to these by providing additional data and methodological clarifications. Nonetheless, because controversy in this area continues, and because one test provides insufficient grounds to reject a hypothesis, we decided to run two additional experiments on mirror self-recognition in cotton-top tamarins. The procedure used in Experiment 1 followed the general design of experiments carried out by Povinelli and colleagues [1993, 1997] on chimpanzees to further test for mirror self-recognition in this species. This procedure, which controls for methodological problems associated with earlier tests, provides a briefer period of exposure to mirrors before testing, colors only one half of the hair on top of the subject's head, and tests individuals alone, away from their social group. In Experiment 2, we used the same procedure as in Hauser et al. [1995] in an attempt to replicate the earlier findings with a new group of subjects.

EXPERIMENT 1

Methods

Experiments were conducted on 12 adult cotton-top tamarins: six males and six females. Ten of these tamarins had no prior exposure to mirrors; two individuals participated as controls in the previous experiment and received 40 min of exposure to the mirror after having their hair dyed [Hauser et al., 1995]. All the tamarins in our colony have seen individuals with color-dyed hair, and were occasionally anesthetized for routine veterinary procedures.

Subjects were tested in an experimental chamber (Fig. 1), and received one of three conditions in each trial: Experimental Chamber Familiarization, Mirror Habituation, or Mirror Test. Each trial lasted 20 min. Each subject received a familiarization every 1–3 d.

During the first 10 min of the Experimental Chamber Familiarization trial, we presented subjects with a screen covering the location of the mirror. During the next 10 min, we raised the screen, revealing a black piece of paper. The first 10 min of the Mirror Habituation session served as a control period, during which we occluded the mirror with a screen. After the initial 10-min period, we raised the screen and provided the subject with 10 min of mirror exposure.

Prior to the Mirror Test session, which occurred 1–3 d after the familiarization condition, we transported subjects to the surgical room, restrained them, and injected them with 0.5–0.75 mg of Ketamine. While the tamarin's eyes were covered, we administered either pink or green Manic Panic® hair dye to one half of their white hair tuft. Once they recovered, we brought the subjects into the experimental room and tested them on the Mirror Habituation condition [see Hauser et al., 1995]. We tested three experimental groups (A, B, and C) in Experiment 1, and exposed subjects in each group to the apparatus during either Mirror Habituation trials and/or Experimental Chamber Familiarization trials prior to Mirror tests. We ran subjects in Group A (two males, three females; half of their hair dyed pink) on 15 Mirror Habituation trials (2.5 hr) followed by a

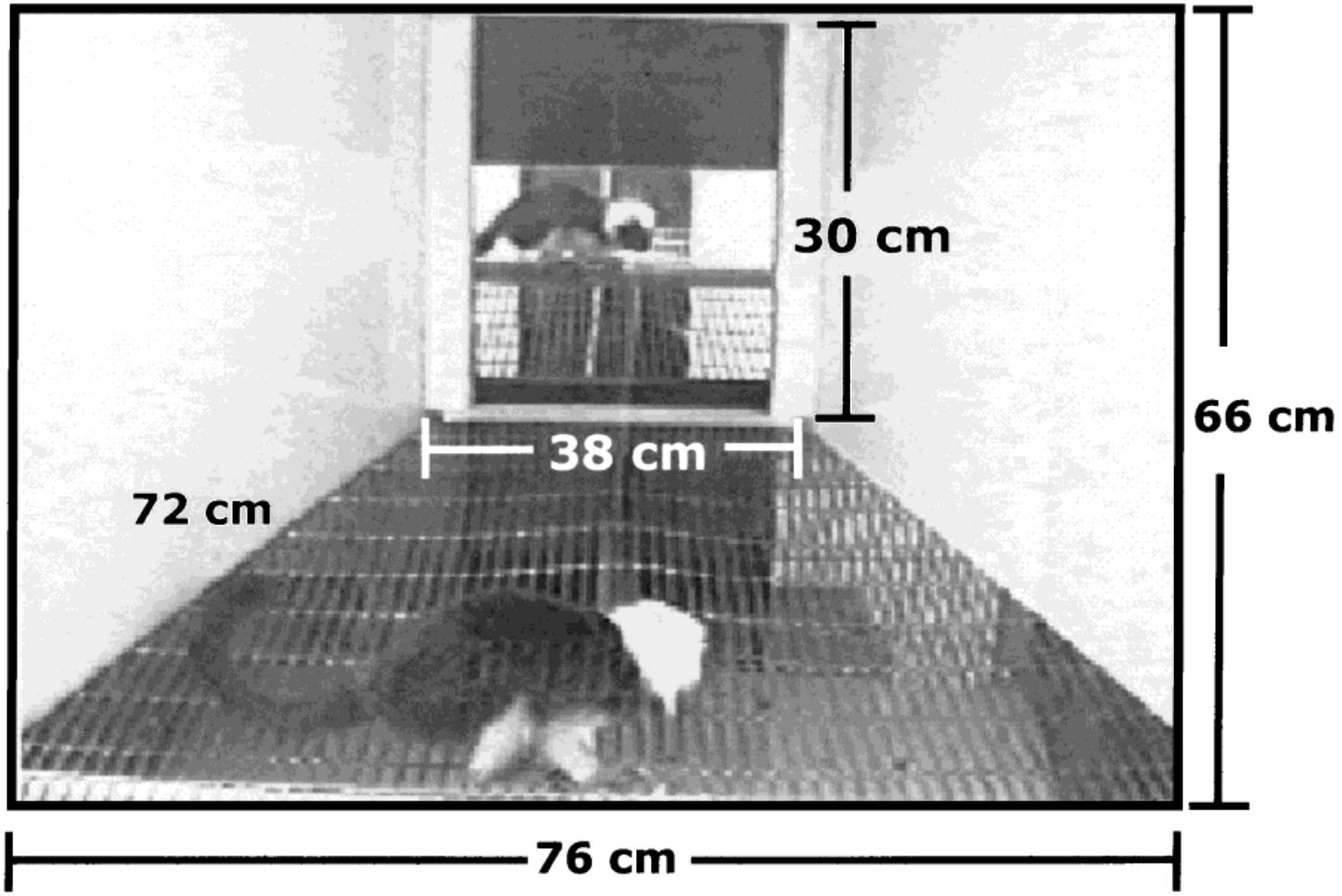

Fig. 1. Experimental apparatus in Experiment 1. Photograph shows subject located to the rear of chamber, with mirror reflection at the front of the chamber.

single Mirror Test trial. Subjects in Group B (three males, two females; half of their hair dyed pink) were first given two trials of the Experimental Chamber Familiarization condition, and then one Mirror Test trial. We subsequently ran these subjects on 14 Mirror Habituation trials followed by a second Mirror Test trial. Individuals in Group B were therefore exposed to the mirror for 15 trials (2.5 hr) before being run on the second Mirror Test trial; Group A was exposed to the same number of trials. In this second test, the tamarins had the other half of their white hair tuft dyed green. We ran Group C subjects (one male, one female) on one trial of the Experimental Chamber Familiarization condition, and then one trial involving a slight modification to the Mirror Test condition. Rather than dying their white hair tuft, they were anesthetized and the white hair on one forearm was dyed green.

We recorded each trial on videotape and then scored it offline, blind to the conditions tested; all scorers were previously trained on each of the target behaviors until they reached perfect agreement. We recorded all aggressive displays directed at the mirror, number of touches to different parts of the body while looking at the mirror or away from it, and the amount of time spent looking at the mirror. We defined a bout of looking into the mirror as a continuous period of staring while facing the mirror.

Results

We did not observe a single case, in any condition, of a subject touching the dye-marked area while looking in the mirror. Furthermore, subjects failed to touch the dye-marked area (hair or arm) while looking away from the mirror, did not use the mirror to observe previously unseen body parts, and did not display at their mirror image. Furthermore, cage mates failed to touch the dye-marked area of the test animal, and, in general, showed limited interested in them.

On their first exposure to the mirror during trial 1 of the Mirror Habituation, all members of group A looked significantly less (X = 201.9 sec, SE = 21.2) than did individuals in group B (Mirror Test trial 1; X = 378.9 sec, SE = 24.0; $t(4) = 4.94$, $P = 0.008$). Since individuals in these groups were randomly assigned, with no difference in sex ratio, this group difference likely reflects individual differences in response to the mirror. Group A, however, did not have Familiarization trials prior to mirror exposure as did Group B, and this could have had some effect. There was no statistically significant difference between the amount of time spent looking at the mirror in the final habituation trial for group A (X = 135.7 sec, SE = 46.7) and the final habituation trial before the second test for group B (X = 145.6 sec, SE = 17.9; $t(4) = 0.23$, $P = .82$). For Group A, time spent looking at the mirror between the final habituation trial (X = 135.7 sec, SE = 46.7) and the mirror test trial (X = 201.9 sec, SE = 21.1) was not statistically significant ($t(4) = 1.87$, $P = 0.14$). For group B, however, there was a significant increase in looking time between the final habituation trial (X = 145.6 sec, SE = 17.9) and the second mirror test trial (X = 232.9 sec, SE = 36.0; $t(4) = 3.6$, $P = 0.02$). The mean amount of time group B spent looking in the mirror on the first mirror test trial was significantly higher than on the second mirror test trial ($t(4) = 2.91$, $P = 0.04$). There was no significant difference in time spent looking at the mirror between group A's mirror test trial and the second mirror test trial for group B ($t(4) = 1.24$, $P = 0.28$). This shows that on the first hair color change for both groups, there were no differences in time spent looking. For both groups combined, there was a significant increase in time spent looking at the mirror between the

final habituation trial (X = 143.48 sec, SE = 24.93) and the mirror test trial (X = 217.4 sec, SE = 20.4; $t(9) = 3.40$, $P = 0.008$).

Discussion

In contrast to the results presented by Hauser et al. [1995], we failed to record a single case of self-directed touching of the dye-marked area in these experiments. The lack of touching was particularly striking in the two cases in which the dye mark appeared on the tamarins' arm, and thus was directly visible without the use of a mirror. This suggests that for some individuals the dye mark lacks sufficient salience to elicit touching.

Analyses of looking into the mirror revealed evidence that the tamarins noticed something of sufficient significance to increase looking time. Individuals tended to show an increase in time spent looking from the final habituation trial to the first test trial. Further, individuals looked longer at their mirror reflection when the first exposure was associated with a change in color than when there was no change in hair color. This result can not be accounted for by the novelty of the color alone because during the course of these experiments, members of the colony could see other individuals with dyed hair before they were tested. What appeared to be novel, as revealed by their attention to the mirror, was the fact that the reflection included a color change from previous exposures; this change did not, however, cause subjects to display at the mirror—an indication that they did not perceive the image as a threat.

To determine whether the failure to replicate was due to the limited amount of mirror exposure, solitary vs. group testing, partial vs. complete hair dyeing, or some other factor(s), we ran Experiment 2 using the same design as in Hauser et al. [1995].

EXPERIMENT 2

Methods

We conducted experiments on four (two adult males, two adult females) cotton-top tamarins with no prior mirror exposure, but with experience in seeing other individuals with dyed hair and dyed arms. We replicated the precise design of Hauser et al. [1995], with the following exceptions: on day 1, a 20-min video recording of the subjects' reaction to the mirror was made, and then 5-min video records were obtained every subsequent day for the remainder of the familiarization period; the mirror was left in place all day for three weeks. Following familiarization, we conducted the dye-mark test on one animal per day. This testing procedure was identical to the one used in Hauser et al. [1995], except that more reliable video records were obtained.

Results

During familiarization to the mirror, we scored no head touching and no aggressive displays toward the mirror. Two subjects, however, looked one or more times behind the mirror. All looks into the mirror were brief. During the test session, two subjects failed to look in the mirror even once during the entire 40-min sampling period; they never touched their hair during this period. The other subjects looked only briefly in the mirror, but failed to show mirror-mediated head touching; one subject touched its hair three times while looking away from the mirror. There was no evidence of prolonged looking into the mirror, nor were

there any aggressive displays. Cage mates failed to touch the dye-marked hair of the test subjects, and generally showed little interest in them.

Discussion

In contrast to our failure to find evidence of mirror-mediated self-exploration in Experiment 1, it is more difficult to account for the failure in Experiment 2 given that we used the same design as in Hauser et al. [1995]. We briefly discuss several possible explanations.

First, some researchers have suggested that our earlier report was methodologically flawed [Anderson & Gallup, 1997] because the data were based on direct observation as opposed to blind videotape scoring; if correct, then there is no evidence of mirror-guided self-exploration in tamarins, and thus, no conflict with the current results. As pointed out by Hauser and Kralik [1997], we don't find this argument compelling; numerous studies in animal behavior are based on direct observations, and include interobserver reliabilities to assure consistency in reporting behaviors. This is precisely the method used in the original study. On the other hand, it is of course possible that what we reported as self-exploration would not have been labeled as such by others currently working on this problem. This possibility can not be ruled out.

A second possibility concerns intraspecific variation in mirror-mediated self-exploration. As pointed out by others [reviewed in de Veer & van den Bos, 1999], some chimpanzees fail to show mirror-mediated, self-directed touching; this variation has yet to be satisfactorily explained. Although we did not observe a single case of mirror-mediated self-exploration, it is possible that differences between individuals can at least partially account for the results reported here and in Hauser et al. [1995]. If there are individual differences, they can not be accounted for by developmental factors or rearing conditions since all of our subjects were adults, all were reared in a social group, and all had experience in experimental tests of visual perception. Some evidence for individual differences comes from the looking-time data reported in Experiment 1, in which subjects in Group B responded differently from those in Group A, even though individuals were randomly assigned to these groups. If there is significant individual variation between tamarins, then we would expect tests of a larger sample of subjects to reveal evidence for this capacity. It should be noted, however, that the observed variation between Groups A and B might have occurred because the two groups received somewhat different familiarization procedures prior to testing. Whether these slight methodological differences can account for the observed behavioral differences can not be ascertained with our small sample size, but suggest that even slight experiential differences may lead tamarins to respond differently to mirrors.

Third, it is possible that our failure to reveal mirror-mediated self-exploration is due to the fact that changes in hair color are no longer novel or sufficiently salient to elicit explicit touching of the marked area. All subjects tested in Experiments 1 and 2 have seen tamarins undergo changes in hair color. Although the mirror mark test itself explores whether animals detect a difference in internal representation pre- and post-test, if tamarins have a generally lower threshold than do chimpanzees to touch or remove things from their body, then the exposure to other hair-dyed individuals may have reduced the novelty of the change. Some support for this explanation comes from Experiment 1, in which subjects could see the color change on their arm, but failed to touch the dye marked area. Studies of tamarins that have never seen dye-marked individuals would help resolve this possibility.

Overall, results suggest that cotton-top tamarins fail to exhibit any evidence of mirror-guided behavior. Although these results contrast with previous studies of this species [Hauser et al., 1995], they are consistent with other studies of monkeys. Taken together, the results from Experiments 1 and 2 tilt the scale back in favor of a phylogenetic gap between monkeys and at least some apes.

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