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Observations on the Behavior of Gibbons (*Hylobates leucogenys, H. gabriellae,* and *H. lar*) in the Presence of Mirrors

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Three captive gibbons (*Hylobates leucogenys, H. gabriellae,* and *H. lar*) were videotaped in the course of longitudinal exposure to mirrors introduced into their familiar cage or island housing situation. The gibbons, which differed in age, sex, species, and rearing condition, exhibited great individual differences in their behavioral reactions to mirrors, spanning from a minimal reaction dominated by social responses to a dramatic sequence of progressive behavioral change that featured a variety of contingency testing behaviors and included mirror-mediated, self-directed behavior. Additional information on the mirror competence of gibbons was provided by modified mark tests and a hidden object task. The results are discussed in relation to current criteria for self-recognition in primates and factors involved in individual and species differences in reactions to mirror exposure.

The introduction of a novel testing method, the mark test, for assessment of mirror self-recognition (MSR) in animals and humans (Amsterdam, 1972; Gallup, 1970) stimulated a number of experiments designed to examine MSR in a variety of primates. These included all species of great apes (see, for example, Lethmate & Dücker, 1973; Patterson & Cohn, 1994; Povinelli, Rulf, Landau, & Bierschwale, 1993; Suarez & Gallup, 1981; Swartz & Evans, 1991; Walraven, van Elsacker, & Verheyen, 1995) and a number of primate species other than the great apes, for example, capuchin monkeys (Anderson & Roeder, 1989), marmosets (Eglash & Snowdon, 1983), tamarins (Hauser, Kralik, Botto-Mahan, Garrett, & Oser, 1995), long-tailed macaques (Gallup, 1977a), hamadryas baboons and mandrills (Lethmate & Dücker, 1973), Japanese macaques (Platt & Thompson, 1985), and gibbons (Hyatt, 1998; Inoue-Nakamura, 1997; Lethmate & Dücker, 1973). Incidental mentions of mirror reactions of gibbons are contained in Boutan (1913), Goustard (1983), and Pribram (cited as personal communication in Gallup, 1977b).

On the basis of these studies, it has been suggested that a phylogenetic discontinuity in MSR capacity separates the great apes and humans from other primates (Anderson, 1994; Gallup 1977b; Povinelli & Cant, 1995). In view of the close phylogenetic relationship of gibbons to the great apes and in view of the paucity of descriptive information concerning the behavior of gibbons in mirror situations provided by the studies cited above, more data on the mirror performance of the lesser apes would be desirable. We have therefore studied the behavior of captive gibbons in a variety of mirror situations designed to provide information about their reactions to mirror exposure and the extent to which they might recognize themselves in a mirror.

Method

Observational Study of Behavioral Reactions to Mirror Exposure

Subjects

Dodo. At the time of the experiment, Dodo was a 14-year-old adult, wild-born male gibbon (*Hylobates leucogenys*) housed in an open-air cage at the Budapest Zoo, Budapest, Hungary. He had been living without a mate for 3 months before mirror exposure and was studied in August of 1997.

Todi. At the time of the experiment, Todi was a 7-year-old adolescent, wild-born, male gibbon (*Hylobates gabriellae*) housed on an island at the Nyíregyháza Zoo, Nyíregyháza, Hungary. He was unmated and was studied in August and September of 1998.

Buci. At the time of the experiment, Buci was a 22-year-old adult, captive-born, female gibbon (*Hylobates lar*) housed alone in a cage at the Jászberény Zoo, Jászberény, Hungary. She has lived alone for most of her life and was studied in May and June of 1998.

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Table 1
Conditions and Length of Mirror Exposure

Period	Length of exposure (in days)	Details regarding mirror
		Dodo
1	2	Chrome, 60 × 70 cm, right wall of the cage
2[a]	6	A second mirror, 50 × 70 cm, glass, was added, mounted on the back wall of the cage facing the visitor area
3	1	Single glass mirror, same size and location as in Period 2
		Todi
1[a]	3	Glass, 60 × 70 cm, covered with Plexiglas, affixed to a tree trunk on the island
2[a]	3	Glass, 50 × 60 cm, without cover, glued to a sturdy plywood backing, affixed to the outside wall of a cage
3	1	Glass, 50 × 60 cm, free standing, mounted vertically on a flat horizontal platform standing on the ground
		Buci
1[b]	1	Chrome, 60 × 70 cm, right wall of the cage
2[c]	5	Half-silvered mirror, 100 × 70 cm, replaced a portion of the barred wall of the cage
3	4	Glass, 100 × 70 cm, left wall of the cage

[a] After these periods, there was a 2-week interval with no mirror. [b] After this period, there was a 1-week interval with no mirror. [c] After this period, there was a 4-week interval with no mirror.

Procedure

None of these gibbons had previous mirror experience. We gave them three periods of mirror exposure by mounting mirrors inside their home cages (island in the case of Todi). The time sequence of exposure to different mirrors for each gibbon is presented in Table 1. The gibbons' behavior was recorded on videotape with a Betacam camera, a Panasonic video camera, and a Sony digital video camera in various combinations. The videotaped records served as source for all behavioral data used in the present report.

Behavioral inventory of reactions to mirror exposure. Videotaped records of the behavior of the 3 gibbons were collated with observers' notes from the experiments and used to create a time log of behavioral reactions to mirror exposure and experimental manipulations for each gibbon. A chronological tabulation of behaviors of interest served as the basis for computing the behavioral statistics (such as the incidence of a given behavior at different stages of mirror exposure) reported in the Results section below. These behavioral measures include the following:

1. *Mirror visit* is defined as the animal's presence in a position in front of the mirror from which it looked into the mirror at least once.

2. *Vocalization* includes whistles, grunts, murmurs, threat vocalizations, and any other sounds emitted by the animal.

3. *Social behavior* includes baring of teeth in fear at the mirror, sexual presenting and hostile presenting to the mirror, carrying food placed at the mirror away from the mirror, murmuring specifically while looking at the mirror image, and startle reactions elicited by the animal being confronted with the reflection of its own canines in the mirror (e.g., during yawning).

4. *Incidental movements* include a variety of behaviors that did not appear to be used by the animal as a means for exploring the relationship between self-produced movement and the mirror image, but rather were incidental to other activities associated with mirror visits. Examples are elevating and moving the arms for balance while standing upright in front of the mirror or repositioning the arms to get a better view of a reflected object obscured by the arm while hanging on the mirror.

5. *Exploratory movements* include the following behaviors: (a) *Exploration of the mirror as a physical object* includes touching or scratching the mirror or its frame, licking the mirror, and reaching or looking behind the mirror. (b) *Comparison movements* consist of rapid shifting or alternation of gaze between environmental objects and their mirror image, or when two mirrors were accessible to the animal (one of which might be a reflective water surface), a visit to the second mirror immediately after looking at the first. (c) *Contingency testing* is defined as movement(s) performed in front of the mirror that were not normally part of the animal's habitual repertoire of spontaneous movements but that were capable of providing information about the contingency between the animal's own movements and their mirror image. They were classified as such only when there was evidence that the animal was directing its gaze at the image in the mirror and include the following three types of movements: *whole body movements*, such as discrete lateral movements or stepping alternately forwards and backwards in front of the mirror; *isolated movements of body parts*, such as lateral head tilting (often approaching 90°), arm lifting, and leg lifting; *face-related movements*, such as slow, often repetitive, gradually widening mouth opening under silence (not yawning), sometimes baring the canines, without signs of threats directed at the mirror or fear reactions; eating in front of the mirror while observing the reflection; and eye contact with the mirror image. (d) *Expectancy behavior* consists of any spontaneously initiated behavioral sequence that linked behavior away from the mirror with behavior at the mirror and was of three main types: *continuation behavior* consisted of turning to the mirror and looking at the mirror image of an activity (such as eating or yawning) initiated at the mirror before the turn; *carrying behavior* consisted of carrying an object such as food to the mirror and engaging with it (in this case consuming it) while looking into the mirror; and *transfer behavior* consisted of rapid locomotion to the mirror when the gibbon detected an environmental object (such as a familiar keeper) moving in such a way as to become visible in the mirror after the animal's arrival at the mirror, followed by looking at the object's mirror image after arrival. A special case of expectancy is *looking for missing body parts*. It occurred while the gibbon was sitting at a mirror mounted too high for it to see the lower part of its body without leaning forward to the mirror surface and looking down into the mirror.

This would often be followed by a gaze shift to the real body part (legs and feet).

Experiments

Modified Mark Test

All mark tests were carried out without anesthetizing the gibbon. Dodo and Todi were tricked into applying day-glow cosmetic cream to their own face or head. The dye was put to the rim of a deep plastic cup containing whipped cream at the bottom. While the gibbon licked the cream, his face touched the dye. Buci was surreptitiously marked with whipped cream on her forehead by one of the experimenters during grooming. We also include an archival record of a modified mark test performed on Fadoro, a 1.5-year-old captive-born, hand-reared, male siamang (*Hylobates syndactylus*), living with a human foster family at the Zürich Zoo, Zürich, Switzerland, in December of 1980. Fadoro was surreptitiously marked on the forehead by his keeper during a habitual daily session of brushing and tickling play and was observed in the absence and presence of a mirror before and after being marked.

Hidden Object Test

The hidden object test was carried out only with Dodo and Buci. The gibbons had no previous experience with the setup and received no training. Dodo was tested after a 6-month period without mirror exposure that followed his third period of mirror exposure. Buci was tested after completion of her second period of mirror exposure. In both cases a new mirror, measuring 140 × 70 cm and 120 × 80 cm respectively, was mounted outside the bars of the gibbon's cage, that is, in a new position, and at a distance of 130 and 100 cm of the bars, respectively. Two boxes (10 × 10 × 25 cm each) serving as potential hiding places were affixed to the bottom of the cage bars 20 cm apart from each other. They were within easy reach of the gibbon from inside the cage and positioned in such a way that their open side, facing away from the cage and revealing their contents, was visually accessible from inside the cage solely by reflection through the mirror. On the 1st experimental day, both boxes were empty. On the 2nd day while the gibbons were locked away in their holding cage, the left box was baited with a banana resting on a sponge in Dodo's case and an apple in Buci's. In the late stages of Buci's test, the mirror was moved up to a distance of 60 cm and finally 30 cm from the bars. Videotapes were analyzed for orienting and reaching toward the boxes and the mirror, and statistical evaluation of differences and trends of positional behavior before and after baiting of the boxes was carried out.

Results

Observational Study of Behavioral Reactions to Mirror Exposure

The three gibbons showed considerable differences in their initial reactions to mirror exposure. Each gibbon then underwent a distinctive sequence of behavioral change during the 1st and subsequent days of exposure. Dodo produced an unexpected cascade of rapid behavioral change, which took him from the most dramatic initial mirror-reaction to a state of apparent familiarity with mirrors, including their use for examining not otherwise visible body parts. Todi underwent a similar but far subtler sequence of change over the course of a number of days, whereas Buci gave little evidence of change except for a gradual lessening of her interest in the mirror.

Dodo

On the first introduction of a mirror, Dodo reacted by a combination of excitement and apprehension, as evidenced by incessant brachiation and vocalization (whistles and grunts both at and away from the mirror) and suspension of habitual cage activities such as begging, playing, eating, and scratching. Frequent but brief mirror visits were precipitously ended by jumping or backing away. His first physical contact with the mirror took place after 40 min. Regarding social reactions, Dodo showed no agonistic responses to the mirror, but in the 1st hr of mirror exposure, he exhibited a startle reaction when seeing the reflection of his bared canines during a yawn, and he carried food placed in front of the mirror away from the mirror. However, his interest in the mirror and the mirror image was high, as evidenced by frequent orienting movements and gaze behavior (fixating on the mirror image). Counts of the frequency and length of his mirror visits during the first 5 consecutive half hours of mirror exposure are given in Figure 1.

From the second 30-min interval onward, a decline in Dodo's initial excitement was apparent because of a decrease and then cessation of vocalization, relaxed approaches to and departures from the mirror (e.g., walking instead of jumping), and longer and longer continuous mirror visits. These changes were accompanied by the emergence of new behaviors seen only at the mirror.

During the first 30-min interval, Dodo's movements in front of the mirror were largely incidental movements, consisting of arm movements serving to balance his upright stance in front of the mirror. In the second 30-min interval, he increasingly started to sit down in front of the mirror and performed a number of unusual movements (such as discrete leg lifting) while looking into the mirror. Some of them were accompanied by alternating gaze between the body part and its mirror image. Illustrations of these contingency testing movements are given in Figure 2. Table 2 shows the types, the frequency, and the distribution of these exploratory movements.

As can be seen in the table, there was a tendency for different exploratory movements to be concentrated to successive, partially overlapping time segments within this exploratory phase. The first of these to appear were whole body movements (e.g., stepping forwards and backwards in front of the mirror), followed by head tilting, mouth opening, and leg lifting, whereas arm lifting, eating in front of the mirror, and eye contact with the mirror image were the last to emerge.

Dodo's exploratory movements were associated with distinctive positional behavior, exhibited neither in the half hour preceding the emergence of exploratory movements nor after they ceased (Day 4). This positional behavior therefore helps define a distinctive stage of his mirror responses. The habitual sitting posture of gibbons includes a support grip (holding onto branches, etc.), a behavior Dodo exhibited consistently when sitting except when he was sitting in front of the mirror performing his exploratory movements, though a rope ladder for such support was available to him (Table 3).

New exploratory behaviors emerged after the introduction of a second mirror (see Table 1) into Dodo's cage. Discrete gestures and postures in front of the mirror were increasingly replaced by longer, more complex behavioral sequences, such as carrying food to the mirror and consuming it while looking into the mirror,

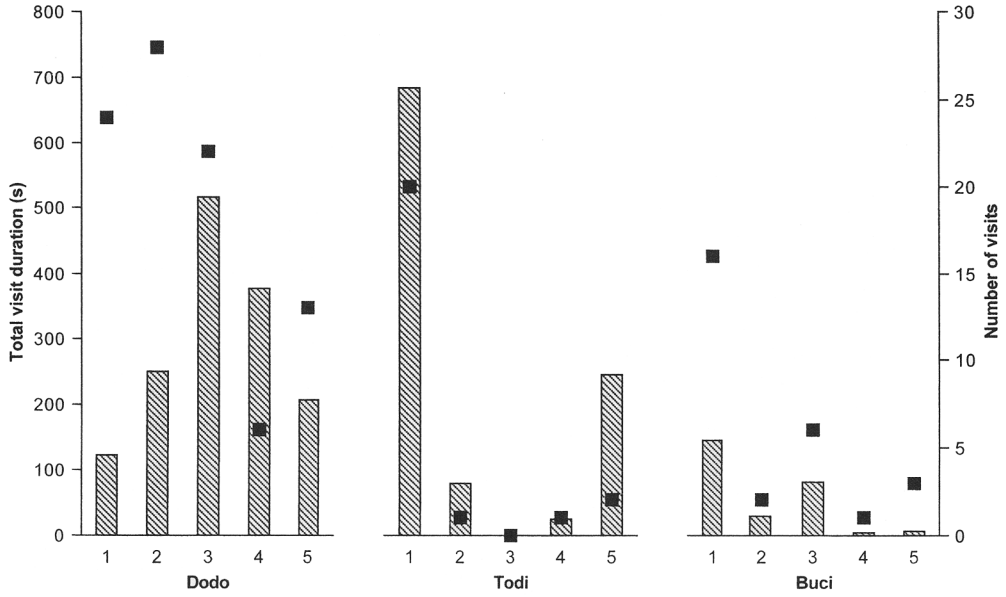

Figure 1. The number of mirror approaches (squares) and the total duration of time (bars) spent in front of the mirror during the first five consecutive 30-min intervals of mirror exposure for each gibbon.

alternating his gaze between environmental objects and their mirror reflection, comparisons between two mirrors (Dodo also treated the reflective surface of a puddle of water on the cage floor in this way), and a number of instances of what we have called *expectancy behavior*. The latter (of which the above-mentioned food carrying is an instance) included examples of each type defined in the Method section (continuation, carrying, and transfer).

The exploratory phase came to a close in Dodo's 4th day of exposure with the reemergence of the support grip while he was sitting at the mirror. A qualitatively new way of using the mirror appeared, which may be described as *instrumental*. He spent long periods of time quietly sitting at the mirror, gazing at his reflection, including episodes of sustained eye contact with his mirror image, examining his surroundings through the mirror, and playing at close quarters to the mirror (e.g., by using his mouth and hands to play with a string while silently looking into the mirror at his own activity and into his own eyes or juggling a plastic syringe). This final phase of behavioral change also featured instances of Dodo's use of the mirror for viewing otherwise nonvisible body parts, such as walking away from the mirror in such a way as to reveal his back in the mirror and looking back over his shoulder at the mirror while doing so, and culminated in quiet manual exploration of his lips and cheek with his thumb through the mirror (within centimeters of its surface, see Figure 2). No instance of face touching by Dodo was observed in any other situation, at or away from the mirror. This event occurred on Day 1 of Period 3 (see Table 1), following a total of 9 days of mirror exposure. We note that no social behavior reemerged after reintroduction of the mirror after a 2-week break. After the instance of mirror-mediated manual exploration of his face, no qualitatively new behaviors were observed, and Dodo made only sporadic mirror visits. Table 4 shows the behaviors that occurred on the 1st day of the second period and on the 1st day of the third period.

Todi

Todi—unlike Dodo—showed no signs of apprehension on encountering the mirror installed on his island but unhesitatingly approached it, calmly touching it and exploring it within minutes of his first encounter (this included exploring the back of the mirror, which was accessible to Todi but not to Dodo). Frequent and long mirror visits became a part of his usual daily activities of brachiating, playing, and eating. As can be seen in Figure 1, Todi's interest in the mirror, as measured by length and frequency of mirror visits, was maximal in the first 30 min of exposure, then declined (the third 30-min interval coincided with his midday rest and was without mirror visits). Todi also did not show agonistic responses to the mirror but murmured softly in front of the mirror and carried food away from the mirror (he did this consistently in the first exposure period, but ceased doing so in the course of the second period).

The stages of Todi's behavioral change coincided largely with his three periods of mirror exposure and can be defined by the successive addition of new behaviors to those of a previous stage, while earlier behaviors persisted. As shown in Table 2, Todi's mirror visits during his first hours of exposure featured two primary activities: scrutiny of the mirror image of objects and persons in his familiar surroundings combined with head turns to observe the actual object or person directly and quiet eye contact with his own mirror image. Active exploratory movements were rare and were confined to whole body movements while hanging in front of the mirror. This pattern persisted through subsequent days of exposure.

With Todi's second period of mirror exposure, new, more complex behaviors were added: an unusual body posture (climbing upwards by his legs while hanging with his back toward the mirror until he hung upside down in front of the mirror while looking into it), mirror–mirror comparisons, and expectancy behavior (see the

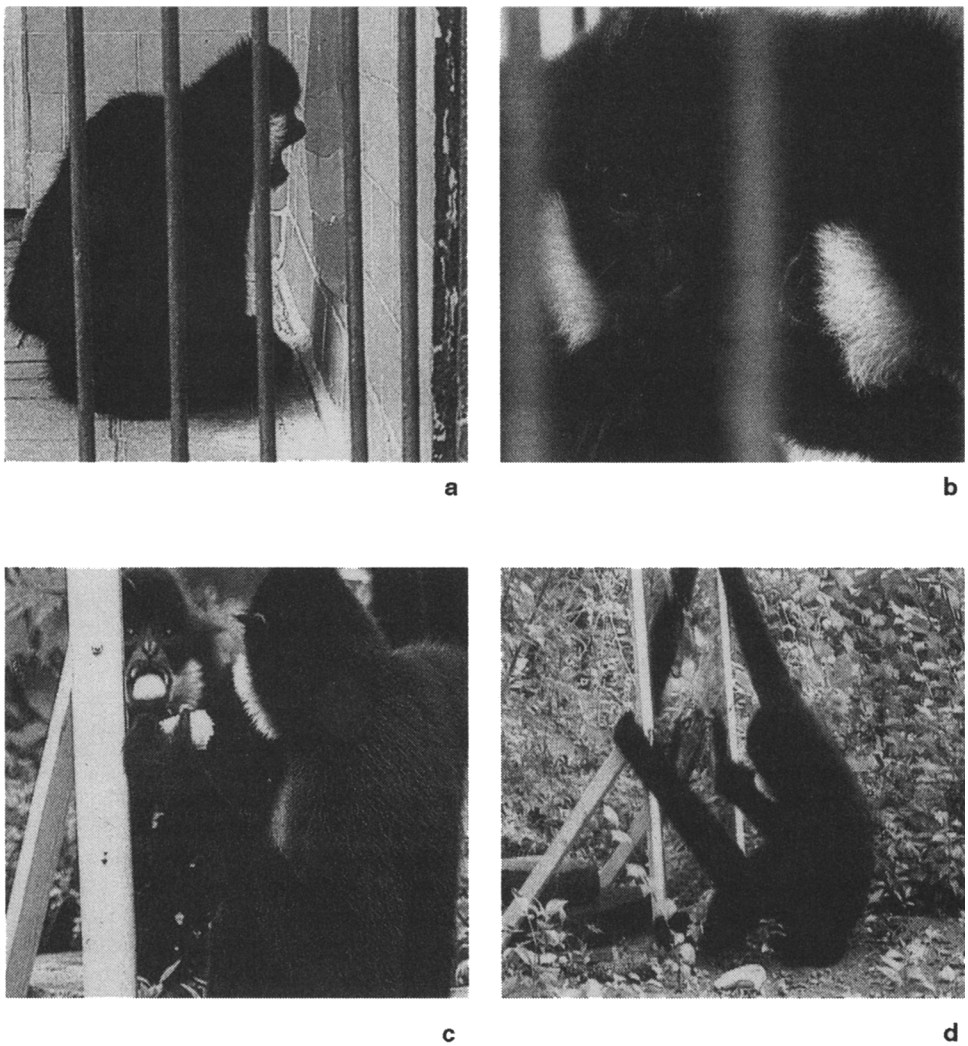

Figure 2. Exploratory movements produced by Dodo and Todi during mirror exposure. a: Dodo, mouth opening in front of the chrome mirror (Period 1, Day 1); b: Dodo, manual self-inspection of his lips with his thumb (Period 3, Day 1); c: Todi, eating a banana in front of the mirror (Period 3, Day 1); d: Todi, leg lifting in front of the mirror (Period 3, Day 1).

Method section for definition). Below are descriptions of these behaviors.

Mirror–mirror comparisons. Todi used the water surface of the moat as a mirror and ambulated between it and the real mirror. On the 1st day of the second exposure period, this action occurred three times. The first such occasion spanned 7 min: He remained in front of the mirror (106 s), moved to the side of the mirror and looked toward it (84 s), then went to the moat and looked into its reflective surface without drinking or touching the water with his face (212 s). He occasionally glanced back at the mirror from the water's edge and finally went back to the mirror and looked into it (16 s).

Expectancy behavior. This type of behavior included continuations (eating, scratching, yawning) and looking for missing body parts. The latter behavior occurred repeatedly during the 1st day of the second exposure period when the mirror was mounted 40 cm above ground level but ceased after the mirror was lowered to 10 cm above ground level (Table 4).

On the 1st day of his third period of mirror exposure (after a 2-week break; 7th day of total mirror exposure), Todi performed contingency testing exploratory movements involving isolated body parts (leg lifting) while examining them in the mirror (illustrated in Figure 2c and 2d), behaviors very similar to those performed by Dodo on the 1st day. He also scratched himself, ate, and touched his face at close quarters to the mirror. He glanced or looked at his reflection in the course of doing so but generally without the sustained scrutiny expected during active self-inspection as seen in Dodo. He also removed a speck of banana (which had adhered to his lower lip for 96 s before removal) immediately after having looked at himself in the mirror. In this third exposure period, Todi consistently carried food to the mirror rather than away from it as in the first period (Table 4).

Table 2
Inventory of Behaviors on the 1st Day of Mirror Exposure

	Dodo					Todi					Buci				
Behavioral variable	1	2	3	4	5	1	2	3[a]	4	5	1	2	3	4	5
Nonexploratory behaviors															
Incidental movement	21	27	20	—	—	18	2	—	1	4	—	—	—	—	—
Social behavior	2	—	—	—	—	1	1	—	—	—	1	—	2	1	—
Exploratory behaviors															
Mirror as an object															
Touching	—	1	4	—	2	—	—	—	—	—	3	—	—	—	—
Licking	—	—	—	—	1	2	—	—	—	1	1	—	—	—	—
Reaching behind it	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—
Whole body movement	12	14	8	—	—	9	—	—	1	1	—	—	—	—	—
Body part movement															
Head tilting	—	7	6	—	—	—	—	—	—	—	—	—	—	—	—
Leg lifting	—	—	2	2	4	1	—	—	—	—	—	—	—	—	—
Arm lifting	—	—	—	1	3	—	—	—	—	—	—	—	—	—	—
Face-related movement															
Mouth opening	—	—	19	4	4	—	—	—	—	—	—	—	—	—	—
Eating	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
Eye contact	—	—	—	4	3	5	2	—	1	3	—	—	—	—	—
Comparison															
Mirror to environment	—	—	1	2	—	14	3	—	1	3	11	2	2	—	1

Note. The numbers 1 through 5 under the subjects' names represent sequential 30-min intervals of mirror exposure. Dashes represent the nonoccurrence of that behavior.
[a] The third half hour coincided with Todi's midday rest period and was devoid of mirror visits.

As with Dodo, there was an association between Todi's positional behavior with respect to the mirror and the stages of his progress outlined above. Todi's dominant mode of support during mirror visits in the first and second exposure periods was to hang by his arms in front of the mirror, a behavior that virtually disappeared in the third period, in which it was replaced by sitting. The length of sitting events increased steadily over time (Spearman rank order correlation = .542, $p < .001$).

Table 3
Use of a Support Grip by Dodo During Activity at and Away From the Mirror[a]

	Day 1/1					
Support grip	1	2	3	4	5	Day 1/2
	In front of mirror					
Yes	0	6	6	1	0	0
No	0	1	21	7	16	5
	Away from mirror					
Yes	0	1	9	16	10	12
No	0	0	0	0	1	0

Note. "Days 1/1 and 1/2" is notation for Period 1, Day 1 and Period 1, Day 2. The numbers 1 through 5 under Day 1/1 represent sequential 30-min intervals of mirror exposure.
[a] The tendency to sit without a support grip in front of the mirror during activity increased significantly during the first period of mirror exposure (Kendall's tau − b = .473, $p < .001$) but not in away-from-the-mirror situations (Kendall's tau − b = .067, $p = .343$).

Buci

The third gibbon, Buci, also approached and touched the mirror soon after first encountering it in her cage, but in contrast to Todi, she showed signs of apprehension and fear while doing so, but these, in contrast to Dodo, were primarily of a social nature. They included brief whimpering, an instance of baring of teeth at the mirror image in apparent fear, and occasional sexual and hostile presenting to the mirror. During her brief and infrequent mirror visits (see Figure 1) she investigated the physical surface and frame of the mirror and looked at her environment through the mirror, sometimes with gaze shifts between objects and their mirror image (Table 2). While looking into the mirror, she preferentially directed her gaze away from the mirror image of her own face, and on those rare occasions when she did meet her own gaze in the mirror, the encounter was immediately aborted by gaze aversion. None of the contingency testing movements observed in Dodo or Todi were performed by Buci.

During mirror visits, she generally hung by her arms in front of the mirror, and when not doing so, she tended to sit sideways in front of the mirror or even with her back turned toward it, particularly during her third exposure period. In all these respects, her behavior differed from that of Dodo and Todi. Between mirror visits, she engaged in habitual cage activities such as recurrent song bouts (great calls, which attracted visitors to her cage), begging, and eating.

The patterns of behavior summarized above persisted with minor variations throughout Buci's three exposure periods, the major change being a gradual decline in her interest in the mirror (see Figure 3).

Table 4
Inventory of Behaviors on Days 2/1 and 3/1

	Dodo						Todi					
		Day 3/1						Day 3/1				
Behavioral variable	Day 2/1	1	2	3	4	5	Day 2/1	1	2	3	4	5
					Exploratory behavior							
Mirror as object												
Touching, licking	3	—	3	3	—	—	13	—	1	—	—	—
Reaching behind	—	—	—	—	—	—	4	4	2	3	3	2
Whole body movement	1	3	25	14	—	—	25	5	5	—	—	—
Body part movement												
Head tilting	1	—	6	3	—	—	3	—	—	—	—	—
Leg lifting	1	—	3	8	—	—	3	—	3	—	1	—
Arm lifting	1	—	7	1	—	—	4	—	—	—	—	—
Face-related movement												
Mouth opening	1	—	6	4	—	1	1	—	1	—	1	—
Eating	1	—	—	2	—	2	8	1	—	2	1	2
Eye contact	10	—	8	7	—	1	26	5	3	4	5	1
Manual face inspection	—	—	—	1	—	—	—	—	—	1	1	—
Comparison												
Mirror to environment	13	—	13	4	—	—	48	7	7	5	1	1
Mirror to mirror	3	—	1[a]	—	—	—	3[a]	—	—	—	—	—
Expectation												
Continuation	1	—	—	—	3	1	7	—	1	1	1	—
Carrying food	—	—	—	2	—	—	—	1	1	1	—	—
Transfer	1	—	—	—	—	—	—	—	—	—	—	1
					Other activities							
Playing	—	—	—	—	3	2	—	—	—	—	—	—
Cleaning	—	—	—	—	—	—	—	1	—	—	1	—

Note. "Days 2/1 and 3/1" is notation for Period 2, Day 1 and Period 3, Day 1. The numbers 1 through 5 under Day 3/1 represent sequential 30-min intervals of mirror exposure. Dashes represent the nonoccurrence of that behavior.
[a] The second mirror in this case is the surface of water.

Experiments

Modified Mark Test

Dodo, Todi, and Buci showed no clear reaction to the marks when they subsequently visited the mirror, nor did they touch or try to remove the marks after having looked into the mirror. We note that the same pigment also adhered to their hands, easily visible by direct inspection, but none of the gibbons made any effort to touch or remove it at or away from the mirror.

Fadoro, during two consecutive 15-min observation periods before mark application, the first without and the second with a 50 × 70 cm mirror present, never touched his head at any point but behaved as usual. Nor did he touch his head during a 10-min observation period in the absence of the mirror after having been surreptitiously marked on his forehead. After reintroduction of the mirror, Fadoro approached it, glanced into the mirror, arrested his movements for a few seconds, then wiped his hand over his marked forehead removing the greater part of the mark, looked at his hand and then into the mirror, and resumed habitual behavior.

Hidden Object Test

The hidden object test was carried out with Dodo and Buci. Dodo removed the object hidden in one of the pairs of boxes with a single, well-aimed arm and hand movement on his first attempt at reaching into the boxes, which occurred 700 s into the test situation. During this interval, he made a total of 29 spontaneous visits to the box area and looked into the mirror a total of 94 s without making any attempt to reach into either box, though he momentarily touched the upper surface of the empty box once. He never reached toward the mirror. The corresponding 700-s interval on the previous control day (with empty boxes) contained 45 mirror visits.

The positions Dodo occupied with respect to the boxes during the control and test sessions show an even distribution of positions on the control day (17 left, 13 middle, and 15 right), whereas on the test day, he showed a tendency to occupy positions behind the left (baited) box (18 left, 8 middle, and 3 right; see Figure 4). This difference is statistically significant: $\chi^2(2, N = 74) = 6{,}042$, $p < .05$. Moreover, the left positions are concentrated in the latter part of the time interval. In other words, before reaching into the left box and removing its contents, Dodo tended to position himself increasingly behind the left box, a temporal trend that also is statistically significant (Kendall's tau − b = −0.376, $p < .013$). No such trend was observed on the previous (control) day (Kendall's tau − b = 0.000, $p = 1$), nor in the behavior of Buci (who was unsuccessful in the baited box situation and therefore may be regarded as a control subject for Dodo).

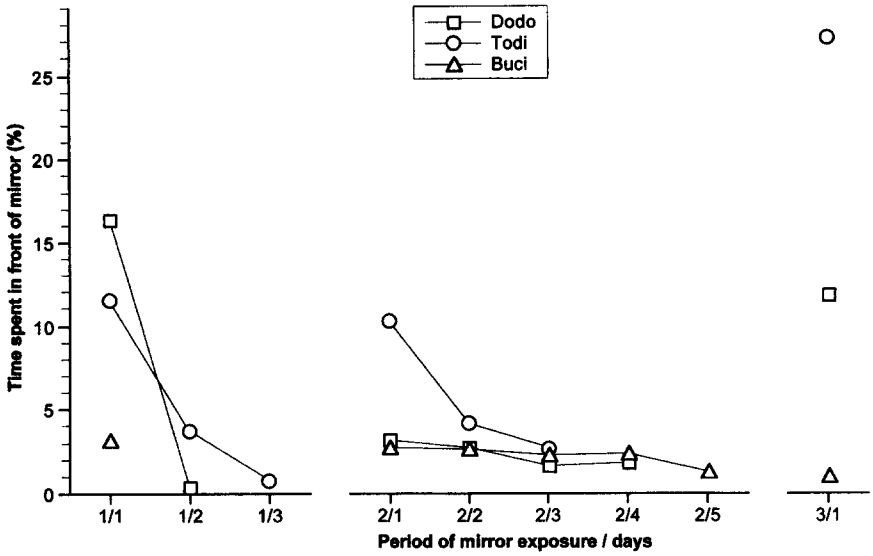

Figure 3. Development of the gibbons' interest in the mirror during three periods of mirror exposure. The interest was estimated by the amount of time spent in front of the mirror as a percentage of total observation time on the given day. Numbers on the horizontal axis represent period and day; for example, 1/1 represents Period 1, Day 1.

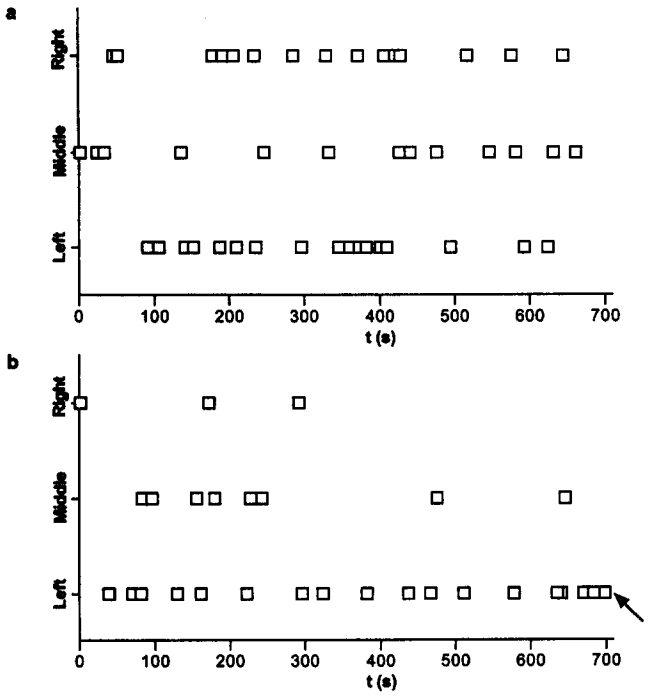

Figure 4. The spatial distribution of the positions Dodo occupied with respect to the two boxes over successive visits to the box area. a: Both boxes were empty. b: The left box was baited. Individual positional markers do not correspond to trials but to Dodo's position on each of a sequence of unreinforced spontaneous visits to the mirror area, which preceded his single, well-aimed, successful reaching movement, marked by an arrow at the last visit.

Buci showed little interest in the empty boxes. In the test situation, she did not try to reach into either box. She did look into the mirror and made reaching movements toward it but not toward the open side of the boxes, even when the mirror was moved to a distance of only 30 cm of the cage bars.

Discussion

Three of our gibbons were studied during mirror exposure totaling at least 8 days. Each of the gibbons showed an individual pattern of reactions to mirror exposure. At one extreme, the *H. leucogenys* male (Dodo) underwent a dramatic sequence of progressive behavioral change that featured a variety of contingency testing behaviors and included mirror-mediated, self-directed behavior. Additional evidence of the mirror competence of this gibbon was provided by the hidden object test, in which Dodo retrieved the bait in a single trial without prior training, reinforcement, or familiarity with the setup,[1] a performance to be compared with the hundreds of reinforced trials required by macaques (Anderson, 1986; Itakura, 1987). The *H. gabriellae* male (Todi) exhibited a stage-wise progression that included some of these behaviors but was more subtle and protracted, whereas the *H. lar* female's (Buci) minimal reaction consisted largely of social responses and did not change much in the course of exposure.

The variety and nature of mirror-mediated behavior in 2 of our gibbons goes beyond what has previously been reported for gibbons exposed to mirrors (Hyatt, 1998; Inoue-Nakamura, 1997; Lethmate & Dücker, 1973), raising the question of what might account for this difference. Both procedural factors and subject

[1] We note that an animal's capacity to generalize across different types and arrangements of mirrors is an important aspect of mirror competence as discussed by Thompson and Boatright-Horowitz (1994).

variables may be involved. Specifically, in the three earlier studies, the mirror was mounted outside the cage bars, out of reach of the gibbon, whereas in our study, it was mounted inside the cage or on the island and was directly accessible to the animals, a factor of potential importance both in terms of the exploratory access provided to the animal and in view of the territorial nature of gibbons.

The length of mirror exposure is a second potentially significant procedural difference because Hyatt's (1998) scored data are based on a total of 2 hr of mirror exposure and Inoue-Nakamure (1997) provided a total of 30 min of exposure, time periods within which many of the behaviors we report failed to occur. Lethmate and Dücker (1973) gave the exposure time (17 days) for only one of their animals, the one for which there is evidence of psychological trauma, as noted by the authors, a potentially significant subject variable. Regarding subject variables, our 2 best performers belong to previously untested species (subgenus *nomascus;* see Geissmann, 1995). Both were wild-born, also a potentially significant variable, and the best performer, Dodo, had long-term social experience that both Todi and Buci lacked (the latter being, moreover, captive-born and aged). For the potential importance of such subject variables in mirror performance, see Povinelli et al. (1993), Swartz and Evans (1994), Custance and Bard (1994), Boccia (1994), and de Veer and van den Bos (1999). We also note that the 1.5-year-old siamang male who passed a modified mark test was reared in a human foster family, and such an enriched environment has been suggested to facilitate mirror performance in gorillas (Patterson & Cohn, 1994). Finally, the individual variability displayed in the performance of our 3 intensively studied animals suggests that the sample size of gibbons, both in total numbers and species variety, needs to be increased relative to other apes, as pointed out by de Veer and van den Bos (1999, p. 464).

Given that 3 of our 4 gibbons provided evidence of mirror competence beyond what has so far been reported for gibbons, what does their performance indicate about the extent to which they recognized that the image in the mirror was that of their own body, that is, their capacity for MSR? The behavioral evidence indicative of MSR has been defined in a number of statements by Gallup and Anderson over recent years (Anderson, 1993, p. 339; Anderson, 1994, pp. 315–316; Anderson & Gallup, 1997, p. 1564; Gallup, 1994, pp. 36–37 and p. 42). According to these authors, an animal that is exposed to a mirror and subsequently gives up social reactions and engages in contingency testing and mirror-mediated, self-directed behaviors is providing evidence for MSR.

One of our gibbons (Dodo) completely gave up social responses to the mirror and engaged in extensive contingency testing,[2] followed by some instances of mirror-mediated, self-directed behavior. According to the MSR criteria reviewed above, this amounts to evidence for MSR in this gibbon. The same may be true of Todi, though the evidence in his case was not as dramatic as in Dodo's. He engaged in clear instances of contingency testing and provided suggestive evidence of mirror-mediated, self-directed acts (such as removing a speck of banana from his lip after looking in the mirror). Fadoro, finally, provided a clear instance of mark touching in a modified mark test that, though not equivalent to Gallup's (1970) test in that the mark was applied during play rather than anesthesia, suggests that further mark tests in gibbons might be informative, perhaps after enhancing the salience of the mark (see Hauser et al., 1995, and below).

Concerning Dodo's and Todi's failure to provide evidence of mark touching in the modified mark tests attempted with them, it should be noted that these same gibbons showed no touching of or other concern with dye marks clearly visible on their limbs, and thus may not be motivated to manipulate marks on their face as suggested previously by Boccia (1994, p. 357). This possibility is strengthened by the paucity of self-grooming or touching of the face in our gibbons (as in marmosets described by Eglash & Snowdon, 1983), a behavior never observed in Dodo (except at the mirror) during 2 years of work with him. Similar factors may be involved in the lesser extent to which our gibbons used the mirror for elaborate bouts of self-inspection and self-manipulation compared with chimpanzees and orangutans (Povinelli et al., 1993; White Miles, 1994). The precise influence of factors such as these on individual and species differences in mirror performance needs to be clarified to assess their bearing on the issue of MSR (see also Anderson & Gallup, 1997; Boccia, 1994; Eglash & Snowdon, 1983; Hauser et al., 1995).

In view of all of the various factors and circumstances considered above, the performance of 3 of our 4 gibbons taken together suggests that gibbons may need to be included among species capable of providing evidence for recognizing the image in the mirror as that of their own body. Further studies of gibbons exposed to mirrors are needed to define in greater detail their capacities in this respect and to clarify factors involved in individual differences among animals.

[2] It has been emphasized by Mitchell (for a recent statement, see Mitchell, 1997) that contingency testing provides an animal with essential information about the correspondence between the mirror image and its own body as a means for attaining self-recognition. It is not without interest in this connection that the instances of mirror-mediated, self-directed behavior observed in Dodo followed his phase of active contingency testing.

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