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Age Differences in the Ability of Chimpanzees to Distinguish Mirror-Images of Self From Video Images of Others

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To evaluate Heyes's (1994) claim that chimpanzees are incapable of using mirrored information to obtain otherwise unavailable information about the self, we exposed two different age groups of chimpanzees (3-year-olds and 7- to 10-year-olds) to mirrors and video images of conspecifics. Their reactions to these stimuli were videotaped and were later scored for behavioral indices of self-recognition by a trained observer who was blind to the purpose and conditions of the study. Some types of behavior (contingent facial and body movements) were clearly influenced by the type of stimulus that the chimpanzees were viewing but not by age; however, other behaviors (self-exploration) were affected by age in conjunction with the type of stimulus the animals were viewing. The results suggest that, unlike self-exploratory behavior, contingent facial and body movements may not, by themselves, be reliable indicators of self-recognition.

Chimpanzees exposed to mirrors for the first time typically display social responses to their images (Gallup, 1970). For many chimpanzees who have had as little as 15–30 min of experience with mirrors, however, these responses are supplanted by self-directed responses such as using the mirror to gain visual access to otherwise visually inaccessible areas of the body such as the ano-genital region and inside the mouth (Calhoun & Thompson, 1988; Gallup, 1970; Lethmate & Dücker, 1973; Povinelli, Rulf, Landau, & Bierschwale, 1993; Suarez & Gallup, 1981). Gallup (1970) treated these self-directed behaviors as a conglomerate and interpreted them as evidence that the animals had come to appreciate the dualism implicit in mirrors and that they realized that their behavior was the source of the behavior being depicted in the reflection. An objective test was then administered in which individual animals were surreptitiously marked on areas of the face that were not visible without the aid of a mirror. On subsequent confrontation with a mirror, the chimpanzees' behavior confirmed Gallup's (1970) impressions, as mirror-experienced chimpanzees reached up to touch the marks when the mirror was present but not when it was absent.

In contrast to this interpretation, Heyes (1994) has proposed that the existing data do not conclusively demonstrate that any nonhuman animal is capable of correctly deciphering mirrored information about itself. She argued that other interpretations of the relevant data are possible, and that one need not refer to psychological notions of self (e.g., Epstein, Lanza, & Skinner, 1981).

The contrasting interpretations of the behavior that chimpanzees display toward mirrors can be distilled into two separate issues, the first of which has two parts. First, there is the issue of (a) whether chimpanzees can distinguish mirrored information from other forms of social stimuli; and (b) if they can, there are uncertainties as to whether they can use information gleaned from a mirror to explore themselves. In other words, does mirror-behavior differ from behavior in other contexts? Gallup (1970) concluded that the evidence indicates that it does, and Heyes (1994) suggested that it does not. Second, if one infers that chimpanzees can use mirrored information to explore the self, then

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there are questions as to the cognitive implications of this finding for psychological aspects of the self (Heyes, 1994; Mitchell, 1994). In a manner similar to Gallup et al. (1995), this report is not concerned with the cognitive implications of mirror self-recognition, but rather addresses the claim that "chimpanzees are not capable of using a mirror as a source of information about their own bodies" (Heyes, 1994, p. 913).

One point of contention between the interpretations offered by Gallup (1970) and Heyes (1994) concerns the distinction between self-grooming observed under many circumstances and self-directed behavior that possibly occurs only under conditions of mirror-image stimulation. Heyes argued that when chimpanzees are confronted with a mirror, their normal levels of self-grooming are replaced by social responses. According to Heyes, however, these social responses habituate and self-grooming once again returns to baseline levels. Thus, the self-directed behavior interpreted by Gallup and others as evidence that chimpanzees were using the mirror to explore the self are interpreted by Heyes as a return to normal levels of self-grooming behavior. One clear prediction of this interpretation is that there should be no difference in the levels of self-directed behaviors displayed by chimpanzees when observing a mirror as compared with observing (a) conspecifics or (b) nonsocial stimuli. A forerunner to this interpretation was suggested by Povinelli et al. (1993), who noted that normal levels of self-grooming may have been precluded because of the extensive occurrence of social reactions, thus creating the illusion of self-recognition in some chimpanzees who were not, in fact, using the mirror to explore parts of themselves. However, the results also demonstrated that a more rigorous behavioral ethogram can effectively distinguish baseline self-grooming from behaviors in which chimpanzees use mirrored information to explore aspects of the self.

Other predictions can also be derived from Heyes's (1994) interpretation of chimpanzee mirror-behavior. For example, if she is correct, then the differentiation of some types of self-directed behavior from others is useless. In other words, she argued that some behaviors that chimpanzees display while they observe themselves in mirrors (such as making unusual facial contortions) have no relation to the presence or absence of mirrors per se and thus are identical to other normally occurring behaviors (such as picking the teeth). This is because, according to her, "chimpanzees happily engage in all forms of [self-directed behavior] in the absence of mirrors" (Heyes, 1994, p. 911). If true, then there is no reason to suspect that some types of self-directed behavior should be systematically related to organismic variables (such as the age of an animal) or to only one form of social stimulus (a mirror as opposed to a videotape of conspecifics). In contrast to the notion that all forms of self-directed behavior belong to the same functionally defined class, Povinelli et al. (1993) have argued for the utility of using different categories for classifying self-directed behaviors because of the predictive leverage offered by such classifications. They found that chimpanzees who engaged in some types of self-directed behavior were more likely to pass a mark test than others. For example, the fact that an animal engaged in five or more bouts of self-exploratory (SE) behavior ("animal uses its fingers or hands to manipulate parts of the body otherwise not visible while looking at its image," Povinelli et al., 1993, p. 352) was a better predictor of whether it would reach up to touch surreptitiously placed marks on the head than if it engaged in the same or even higher frequencies of other forms of self-directed (i.e., contingent facial and contingent body movements [CF and CB, respectively]).

Heyes (1994) also suggested that observations of mirror-behavior may be tainted by the subjective biases of the observer. For example, she argued that "it is difficult to know how a human observer could have been sure that . . . [the self-directed behaviors] were provoked and/or guided by the reflection" (Heyes, 1994, p. 911). We agree with this assessment and one of us has argued elsewhere that every effort should be made to eliminate the possibility that subjective impressions or intuitions enter into experimental investigations of mirror self-recognition (Gallup, 1994). However, if the judgments concerning the functional use of mirrors arise solely from impressions of observers and not from the chimpanzees' behavior itself, then observers should not detect any difference in the frequency of self-directed behaviors when they are unaware of the type of stimulus that chimpanzees are viewing.

A final prediction that can be derived from Heyes's (1994) position is that previous reports investigating the development of self-recognition in chimpanzees have been misguided given that no such phenomenon exists in this species. Indeed, Heyes (in press) has made this point explicitly. As a result, her framework would not predict a developmental dissociation of certain forms of mirror-related behavior from others. In contrast, Povinelli et al. (1993) have argued that CB and CF behaviors should be expected to emerge at a younger age than SE behaviors because the former are merely indicative of a sensitivity to contingency, whereas the latter indicate that the subjects have formed a conceptual identity relation between themselves and what they see in a mirror (see Povinelli, 1995, for details). Thus, Heyes's framework does not predict a developmental decoupling of CB and CF behaviors from SE behaviors (with CB and CF occurring earlier), whereas the self-recognition framework clearly does.

In this report, we describe three tests of Heyes's (1994) argument. The first is that chimpanzees exhibit equal amounts of self-directed behavior when presented with a mirror as when presented with other forms of social stimulation. The second is that behaviors that have been claimed to provide the most compelling evidence of self-recognition (self-exploratory behavior) are independent of stimulus conditions and organismic or maturational variables. Finally, we test the idea that there is no developmental decoupling of certain behaviors that chimpanzees direct toward mirrors (CB and CF) from others (SE).

Method

Subjects

Two age groups (3-year-olds and 7- to 10-year-olds) of captive chimpanzees (*Pan troglodytes*) served as subjects. All animals were born and nursery-peer reared at the University of Southwestern Louisiana's New Iberia Research Center as part of the Center's breeding colony. When not being tested, each of these groups had continuous access to large indoor–outdoor living areas (indoor area: 4.25 × 5.5 × 2.13 m; outside area: 3.7 × 5.5 × 8.5 m). For the purposes of testing, the animals from each group were confined to the indoor portion of their housing unit, except where noted.

The younger group consisted of a sample of 5 male and 7 female chimpanzees whose age range was 2 years, 4 months (2;4) to 3 years, 4 months (3;4) at the time of testing. The older group consisted of 7 male and 4 female adolescents ranging in age from 7;10 to 10;0 at the time of testing. All of the subjects had participated in a study of mirror self-recognition approximately 1.5 years before our study (see Povinelli et al., 1993) and had received no more than 6 additional hr of mirror exposure widely distributed across the intervening time period.

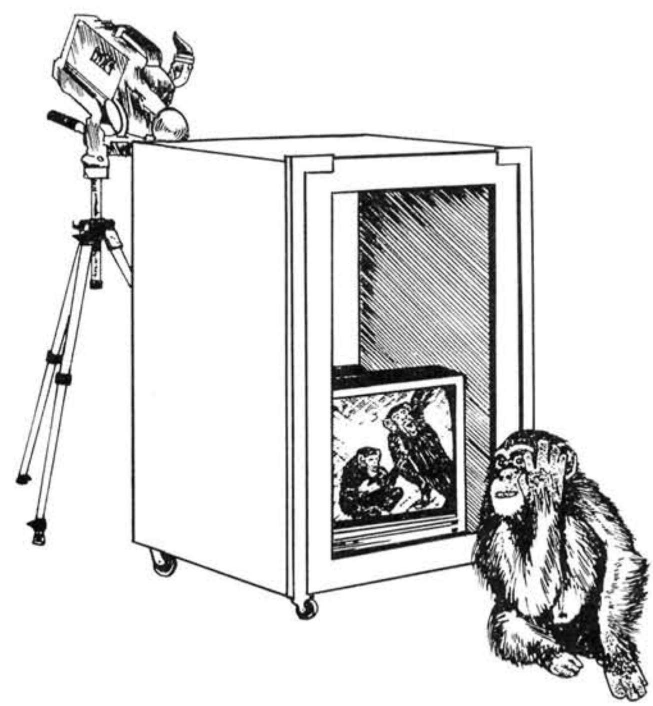

Figure 1. Apparatus used to present stimuli to chimpanzees while simultaneously recording their reactions. Note that the camera that recorded the chimpanzees' reactions does not capture the type of stimulus the animals were viewing (see text for details). A wire mesh partition (not shown) separated the subjects from the apparatus.

Materials and Apparatus

A large open plywood box (approximately .75 × .6 × 1.0 m) was constructed so that either a .42 × .55 mirror or a television monitor of identical dimensions could be placed in the bottom portion of the box while reactions to these stimuli could be recorded with a video camera through the top portion. This arrangement allowed stimuli to be placed in view of the chimpanzees and their reactions to these stimuli could be recorded on videotape, but neither of the stimuli would be recorded by the camera (see Figure 1). The inside of the box was painted matte black to eliminate the possibility of reflective glare. To eliminate further reflective problems when presenting the videotape stimulus to the animals, a 150W flood lamp was positioned so that it faced toward the stimuli in both of the stimulus conditions.[1]

The videotape stimulus that was presented to the subjects consisted of a 25-min sequence depicting a group of twelve 4- to 5-year-old captive chimpanzees interacting with their environment and each other. The stimulus animals had limited previous visual exposure to both groups of subjects. The videographer for the stimulus tape recorded individual animals or small groups of animals most of the time, but the videotape occasionally portrayed a wide angle of a large portion of the cage environment while also including chimpanzees in the frame. The stimulus videotape was presented via a Panasonic camcorder and an RCA Colortrak television monitor, each of which were placed in the lower portion of the apparatus described earlier (see Figure 1). The chimpanzees' reactions to both the mirror and the videotaped stimuli were recorded on a Panasonic S-VHS camcorder.

Procedure

The chimpanzees' reactions to the two stimuli (mirror and videotape) were recorded during four testing sessions that began in the early afternoon. Each test session consisted of an experimenter placing the apparatus just out of reach of the animals (approximately 0.4 m from the front of the subjects' cage) and connecting electrical equipment (various combinations of video monitor, camcorder, and flood lamp) as required. For sessions involving videotape presentation, the experimenter switched on the equipment, muted the sound from the television monitor, began to play the stimulus tape, activated the camera that recorded the chimpanzees' reactions, and then promptly left the room. For the mirror stimulus condition, the experimenter placed the mirror in position, activated the camera, and left the room. For both types of sessions, the experimenter returned after 20 min had elapsed, turned off the equipment, and removed the apparatus. For both groups of animals the mirror stimulus was presented first and alternated between videotape and mirror stimulus sessions thereafter. Each session was separated by 24 hr. The shuttle door that allowed access between the indoor and outdoor portions of the cage was inadvertently left open for the 2nd mirror session for the 7- to 10-year-old group.

Videotape Rating

Each type of session was recorded on a separate videotape for each group of animals and later labeled by Timothy J. Eddy with a code that provided no information about the content of the tape. Because the chimpanzees appeared to lose interest in both stimuli after about 10 min, only the first 10 min of each testing session were scored.

Videotaped reactions of individual chimpanzees were scored

[1] While collecting pilot data with a different group of animals, we discovered that the lighting conditions of the room in conjunction with a relatively darkly lit portion of the television monitor combined to produce a reflective mirror-like surface on the television monitor.

with regard to four behavior categories. The first category of behavior was called *out of sight* (OOS) and was used as a measure of disinterest toward the mirror and videotape stimuli. An animal was scored as *out of sight* whenever it was not in immediate proximity to the stimulus. An imaginary line originating at a concrete wall approximately 3 m from the center of the recording camera's frame (and hence, the stimulus) and extending to the edges of the camera's frame served as the decisive points at which an animal was considered out of sight.

The three other categories of behavior that were scored correspond to the CF and CB movements and SE behavior categories from the ethogram described in Povinelli et al. (1993). Briefly, CF refers to an animal looking at the stimulus and making unusual contortions of the face. CB refers to an animal looking in the direction of the stimulus and repetitively (but not stereotypically) moving arms, hands, legs, or feet in front of the stimulus, sometimes while alternately glancing back and forth between the stimulus and the body part. SE behavior was noted when an animal apparently used the stimulus in conjunction with its digits to visually explore parts of its body that could not be seen without the aid of a mirror, such as the corners of the eye, inside the nose or mouth, or the ano-genital region. Unlike the Povinelli et al. (1993) protocol, the rater for this study was simply instructed to code all instances that met the formal ethogram definitions. Judgments about weak or ambiguous instances of the categories were not included.

All subjects were scored for the four behavior categories with a computerized event recording program that summarized the frequency and total duration of each behavior category. For each type of segment, animals in the separate age groups were scored individually; one animal was scored, the videotape was rewound and another subject was scored, and so on.

Occasionally, a subject remained *out of sight* of the stimulus for the entire 10-min scoring session. When this occurred, the following steps were taken: First, an *out of sight* score with a frequency of 1 and a duration of 600 sec was assigned. Then, scores of zero frequency and duration for each of the CF, CB, and SE categories for that particular test session were assigned.

An observer who successfully identified the individual subjects when shown on different videotapes (100% accuracy) did the scoring. This individual was thoroughly familiar with chimpanzee behavior in general and mirror-behavior in particular, and had served as a rater in a prior mirror study (Povinelli et al., 1993).

Before our experiment, interobserver reliability was established over five 10-min videotaped sessions of chimpanzees' reactions to mirrors. Agreement between the senior author and the rater with respect to the timing and occurrence of the behaviors ranged from 78.2% to 96.6% with an average of 88.4% for the five scoring sessions.

The rater was informed of neither the purpose of this study nor of the fact that the different videotapes depicted reactions to different stimuli.

Data Analysis

One subject from the 7- to 10-year-old age group showed relatively high levels of behavioral stereotypies. Because it was nearly impossible to distinguish these movements from those shown by this subject under normal circumstances (especially with regard to the CB category), this subject's data were excluded from the analysis.

To ensure that interest in the stimuli did not differ as a function of age, stimulus type (mirror or videotape), or test day (1st or 2nd presentation), we subjected the animals' total duration of OOS scores to a 2 × 2 × 2 (Age × Stimulus Type × Test Day) mixed analysis of variance (ANOVA) with age as a between-subjects variable and stimulus type and test day as within-subjects variables.

To examine the possible effects of age, stimulus type, or test day on the degree to which the chimpanzees performed the various behaviors, we performed four separate 2 × 2 × 2 (Age × Stimulus Type × Test Day) ANOVAs on the frequency and total duration scores for the CF and CB categories. To meet the ANOVA assumption of homogeneity of variance, raw data were subjected to log $(x + 1)$ transformations where appropriate. Because the pattern of responses for the SE category precluded valid parametric analyses, data for this measure were analyzed nonparametrically.

Results

First we describe the results of our general measure of the chimpanzees' interest in the stimuli, and then we describe the effects of the independent variables on the individual CF, CB, and SE measures.

Interest in the Stimuli

On average, the chimpanzees spent 22.6% of the time in spatial and visual proximity to the stimuli with a range of averages from 14.8 to 69.3% for the various age–stimulus type–test day combinations. No effects of age, stimulus type, or test day were obtained for these variables alone or in interaction for OOS data. These results indicate that the chimpanzees were generally equally interested in mirror images of themselves and videotaped images of conspecifics. Thus, any possible subsequent differences in the performance of particular behaviors under the various conditions cannot be attributed to differences in general interest in the stimuli.

Contingent Facial Movements

There was no effect of age or test day on the frequency of CF movements, but there was a significant effect of stimulus type, $F(1, 20) = 4.201$, $p = .05$. As shown in Figure 2, chimpanzees made more CF movements to the mirror than to videotaped images of other chimpanzees. There were no significant interactions in the analysis of the frequency of CF movements.

With regard to the total duration of CF movements, there was similarly no effect of age or test day, but a significant effect of stimulus type was revealed, $F(1, 20) = 4.54$, $p < .05$. As shown in Figure 3, the chimpanzees spent more total time engaging in CF when in the presence of a mirror than when in proximity to videotaped images of conspecifics.

Contingent Body Movements

As can be seen in Figure 2, the animals performed more contingent body movements in the presence of a mirror than when shown a videotape of conspecifics, $F(1, 20) = 5.06$, $p < .05$. There were no effects of age or test day on the

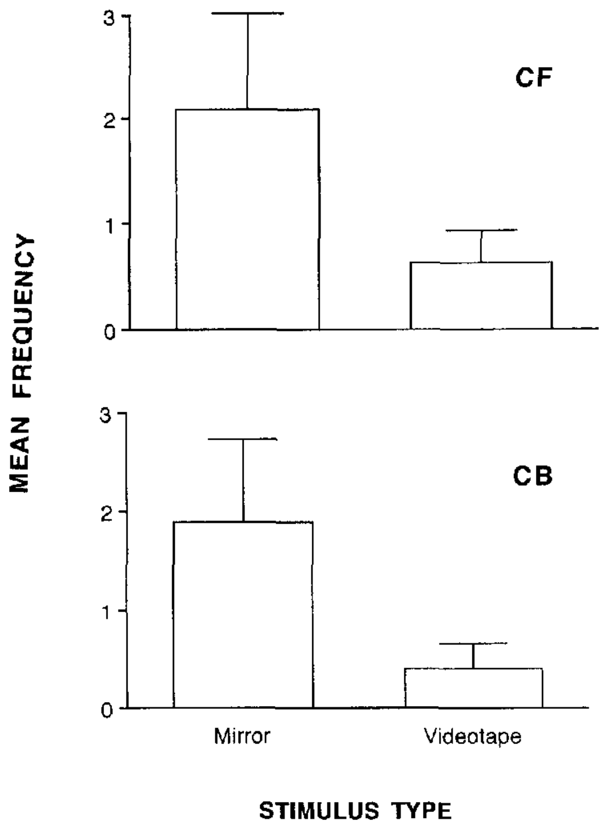

Figure 2. Mean frequencies and standard errors of contingent facial (CF) and contingent body (CB) movements per 10-min session as a function of stimulus type.

frequency of contingent body movements, nor were there any interactions between any of these variables.

As shown in Figure 3, the chimpanzees spent more total time engaging in contingent body movements when viewing mirrors than when viewing videotapes, $F(1, 20) = 6.34, p < .05$. There were no effects of age or test day on the frequency of CB movements, nor were there any interactions between any of these variables.

Self-Exploratory Behavior

The pattern of responses for the frequency of self-exploratory behavior were very different than those for the other two behavior categories, primarily because no instances of this behavior were noted for 3-year-old chimpanzees. Because of this fact, parametric analyses of the SE data could be misleading. As can be seen in Table 1, however, chimpanzees from the 7- to 10-year-old age group engaged in nonzero levels of self-exploratory behaviors, and SE was more frequent in the presence of a mirror.

Table 1 also shows a similar pattern for the durations in which 7- to 10-year-old chimpanzees (but not 3-year-olds) engaged in sustained levels of SE while watching mirrors, but not when watching videotapes of other chimpanzees.

The nonzero SE scores for older animals watching videotapes is probably due to the fact that the rater noted some apparent instances of self-exploratory behavior of short mean duration (about 3 s each) for two 7- to 10-year-old chimpanzees during the presentation of a videotape of conspecifics. This can be contrasted with the bouts of self-exploratory behaviors for 4 chimpanzees from the same age group that took place during the presentation of a mirror stimulus. These bouts were of relatively long duration (ranging from 7 to 13 s). In any case, the pattern is certainly one suggestive that the 7- to 10-year-old animals may have at least been capable of using the mirrored information as a source of information about their own bodies.

The pattern of responses for SE behavior were suggestive of an interaction between age group and stimulus type, wherein older animals showed greater SE reactivity in the presence of a mirror but younger animals were equally nonreactive in both situations. When considered in conjunction with the previously reported individual variation in the ability of adolescent and adult chimpanzees to recognize themselves in mirrors (Povinelli et al., 1993; Swartz & Evans, 1991), it became apparent that the suggestive effects of group and stimulus type on SE might be due to the fact that not all of the chimpanzees in the older group recognized themselves, and the ones that did not were contributing scores of zero to the SE measures. To explore this possi-

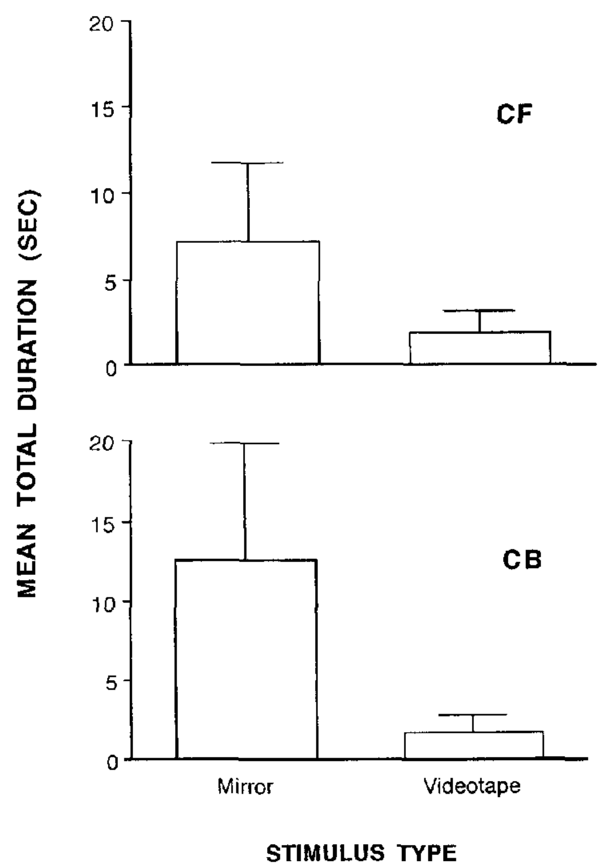

Figure 3. Mean total durations and standard errors per 10-min session of contingent facial (CF) and contingent body (CB) movements.

Table 1
Mean Frequency and Total Duration of Self-Exploratory Behaviors by Chimpanzees of Different Ages Toward Different Stimuli

	Stimulus type			
	Mirror		Videotape	
Measure/age group	*M*	*SEM*	*M*	*SEM*
Frequency				
3-year-olds	0.0	0.0	0.0	0.0
7- to 10-year-olds	2.7	1.4	0.4	0.2
Total duration				
3-year-olds	0.0	0.0	0.0	0.0
7- to 10-year-olds	23.4	15.1	1.4	0.9

bility, we performed subject-by-subject nonparametric analyses of the number of 3-year-old and 7- to 10-year-old animals whose responses (frequency and total duration scores) to the mirror stimulus were greater than their responses to the video stimulus with those whose responses to the mirror were less than or equal to their responses to the video stimulus.

The results of this analysis can be found in Table 2. Fisher's exact tests confirmed our impressions of a significant association between age group and responsiveness to mirrors compared with videotaped stimuli for both the frequency (p = .03) and total duration (p = .03) of SE behavior. Thus, significantly more 7- to 10-year-old chimpanzees showed SE to the mirror than the video than did the 3-year-olds.

Discussion

This experiment provides no support for Heyes's (1994) contention that the self-directed behavior of chimpanzees in front of mirrors is an artifact of the displacement of grooming behaviors by social ones, and their subsequent re-emergence on habituation to the image. If this account of chimpanzees' self-directed behavior in front of mirrors were correct, then there should have been no difference between the chimpanzees' reactions to mirrors and to videotaped images of other chimpanzees. Rather, the data reported here demands that any proposed explanation for chimpanzees' mirror-behavior must indicate why some types of behavior (CF, CB, and SE) are mostly (though not uniquely; see Figures 2 and 3 and Table 1) associated with one form of social stimulation (mirrors) as opposed to another (videotapes of other chimpanzees). Historically, the explanation of choice has been that mirrors provide some types of feedback (complete self or referent visuospatial contingency) that are not afforded by other types of stimulation (social or not). The data from this experiment support the notion that chimpanzees are able to use information from mirrors that is simply unavailable from other types of stimulation, and that this psychological disparity is reflected in their differential behavior.

Table 2
Classification of Chimpanzees According to Relative Levels of Self-Exploratory Behavior Displayed to Mirrors as Compared With Videotaped Images of Conspecifics

	Reactivity	
Age group	Mirror > video	Mirror ≤ video
3-year-olds	0	12
7- to 10-year-olds	4	6

Note. Subjects were classified on both frequency and duration measures of reactivity, which produced identical classifications.

The pattern of responses between age and stimulus type for SE behaviors are also inconsistent with Heyes's (1994) proposal. If Heyes is correct that chimpanzees' reactions to mirrors are primarily social in nature, then there should be no reason for older chimpanzees to engage in SE behavior in front of mirrors (but not videotapes of others), whereas their younger counterparts never engage in any of these behaviors. Nothing in Heyes's account explains what it is about the "other" chimpanzee that causes the subject to self-groom when watching itself in a mirror as opposed to when viewing other chimpanzees, or why younger animals display only CB and CF behavior, whereas older animals also show SE behavior. One possibility is that young chimpanzees self-groom less often regardless of what stimulus happens to be present. However, although there is evidence that young chimpanzees are less likely to groom *others* than are older chimpanzees (Goodall, 1986), there is no evidence that 3-year-old chimpanzees groom *themselves* less often than 7- to 10-year-old ones. In fact, Gallup et al. (1995) have recently reported data that indicate that there is no difference between 3- and 6- to 7-year-old chimpanzees in the mean number of ambient touches to their own face during a 5-min observation period. Furthermore, even if such a difference existed, it would not account for the Age × Stimulus Type effect on SE.

The age difference in SE behavior in our experiment is especially interesting when one considers the lack of an age effect for CF and CB movements. Our data show that CF and CB movements, although more frequently observed in the presence of a mirror than in the presence of a videotape of other chimpanzees, may be developmentally dissociable from SE behavior. Povinelli et al. (1993) noted similar evidence for such a dissociation and interpreted this to mean that CF and CB movements may reflect the workings of earlier emerging forms of sensorimotor intelligence, whereas SE may be delayed until the completion of later sensorimotor stages that support the development of self-representation (see Povinelli, 1995). This suggests that Gallup's (1970) original conglomerate of self-directed behaviors may have actually comprised a number of functionally distinct, developmentally dissociable behaviors.

A final issue addressed by this study concerns Heyes's (1994) contention that the term *self-directed behaviors* implies a functional use of mirrors by animals which, strictly speaking, is inaccessible to human observers. The ambiguity of observational data has long been recognized and was partly responsible for the original rationale for more objective convergent measures (i.e., the mark test; see Gallup, 1994). In our study, the blind coding procedure effectively dealt with this problem. Because our rater was unaware of the type of stimulus the animals were viewing during particular segments, differential projections of the functional use of the two stimuli were impossible. We feel that the fact that the rater was able to determine that the animals behaved differently in some segments than in others (as evidenced by the data in Figures 2 and 3 and Table 1) should not be viewed as compromising our results. Rather, it provides further support for the idea that the behavior of chimpanzees observing their own mirror images is clearly different than that displayed when shown other chimpanzees, and that this information can be discerned by human observers who have no previous knowledge of this fact.

The generally accepted explanation for chimpanzee self-exploratory behavior is that, with time and experience, chimpanzees (like humans) develop an ability to use mirrored information about themselves to gain visual access to otherwise visually inaccessible areas of the body (recall that an animal had to be judged as looking in a particular direction for behaviors to be coded as positive instances in this study). The results of this experiment are clearly consistent with such an interpretation. These findings also further reinforce the results of Povinelli et al. (1993) concerning the inadequacy of CF and CB as indicators of self-recognition and make previous claims of self-recognition based on such criteria (e.g., Parker, 1991) difficult to interpret. They also highlight the need to conduct other independent assessments of self-recognition (mark tests) to validate impressions based on informal observations.

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