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Young and juvenile chimpanzees' (*Pan troglodytes*) reactions to intentional versus accidental and inadvertent actions

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Abstract

Chimpanzees were tested for their ability to discriminate between accidental/inadvertent and intentional actions with equivalent adverse consequences. Subjects were first trained to 'point' to human trainers in order to receive food rewards. In Experiment 1, six 5-year-old subjects were alternately presented with two unfamiliar human actors. In condition 1, each actor either started to hand a cup of juice to the trainer but then pulled it back and intentionally poured it onto the floor, or accidentally spilled it while handing it to the trainer. In condition 2, the actors either accidentally spilled it as above, or aggressively threw the juice onto the floor. The subjects were then presented with both actors and were allowed to choose between them. In Experiment 2, seven 6–7-year-old chimpanzees were confronted with unfamiliar actors who either (a) intentionally withheld and consumed food intended for the subjects, (b) attempted to hand the intended food to the subjects but were victimized by a third party who consumed the food, or (c) always succeeded in delivering the food to the subjects. In general, the subjects showed little evidence of using the accidental/inadvertent versus intentional distinction in their choices between the actors, although they did display some evidence of favoring the actor involved in the most passive role in both conditions in Experiment 1. © 1998 Elsevier Science B.V.

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1. Introduction

The distinction between intentional and accidental behavior is fundamental to our common-sense (folk) theory of intention. The early investigations of Piaget (1932) into the development of moral responsibility in young children capitalized upon this distinction. He argued that young children attend more heavily to the consequences of actions than to the intention underlying them. Later investigators established that

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when the severity of consequences are held constant, young children demonstrate that they understand the distinction between actions that an individual intends versus those that occur by accident (King, 1971; Berndt and Berndt, 1975; Imamoglu, 1975; Shultz et al., 1980; Shultz and Shamash, 1981). Although the exact age at which children make this distinction is unclear, the studies cited above have found evidence for this ability by 5–6 years of age, and in some cases even 3-year-olds have displayed an understanding of intended and accidental outcomes (Yuill, 1984).

There are other lines of evidence that preschoolers possess an understanding of the role that intentions play in human behavior (Karniol, 1978; Smith, 1978; Miller and Aloise, 1989). For example, Shultz et al. (1980) showed that by 3 years of age children were able to distinguish intended actions from mistaken ones, although they did not distinguish intended actions from reflexes and passive movements until age 5. Some researchers have interpreted the younger children's difficulties as evidence of the 'overattribution' of intention (Miller and Aloise, 1989). In other words, this view holds that not only do young children appreciate the existence of intentions, but they assume that they are more ubiquitous than is, in fact, the case. In this view, the major developmental achievement for the child is to learn to limit their attributions of intention to appropriate situations. Recent evidence from toddlers' and preschool children's spontaneous language utterances support this interpretation. Bretherton and Beeghly (1982) reported the use of mental state verbs related to intention (i.e. 'want') by at least 28 months. Similarly, in an exhaustive analysis of longitudinal records of the spontaneous language use by 10 young children, Bartsch and Wellman (1995) report that 'genuine' references to intention (desire) begin to emerge in 2-year-olds. Finally, Meltzoff (1995), using an ingenious nonverbal technique, has recently reported evidence that 18-month-old human infants understand the actions of persons (but not inanimate objects) in terms of intentions and goals. All of these abilities can be viewed in the context of a broader attempt to understand the evolution and development of what has been termed the 'theory of mind'—a psychological framework for interpreting the behavior of the self and other in terms of various mental states and events, such as wanting, thinking, knowing, and believing (Premack and Woodruff, 1978; Wimmer and Perner, 1983; Flavell, 1988; Wellman, 1990; Astington and Gopnik, 1991; Perner, 1991; Povinelli, 1993; Whiten, 1993; Flavell et al., 1995).

Are humans unique in their attribution of intentions as a cause of the behavior of others? At least three extreme answers to this question are possible (Povinelli and Preuss, 1995). One tradition holds that humans are alone in their ability to reason about unobservable mental states such as intention. Descartes was an early champion of this view, and his general thesis finds adherents today, such as Fodor (1987) who argues that humans are the only species born knowing their own minds. From an evolutionary perspective, this view sees the theory of mind as a cognitive specialization of the human species, and interprets the behavior of animals as being the result of some combination of basic learning principles and more developmentally invariant epigenetic pathways controlling the ontogeny of social behavior. A very different answer to the question of human uniqueness in this area is that most, if not all, animals have some awareness of mental states such as intention and desire (Griffin, 1976, 1992). Finally, a third answer is that the capacity to conceive of intentions and other mental states links humans with some, but not all, other animal species. For example, at least one researcher has proposed that theory of mind evolved in the common ancestor of the great apes and humans (Gallup, 1982, 1985). Experimental attempts to ascertain whether animals possess an understanding of mental states in general is limited and largely confined to nonhuman primates. Premack and Woodruff (1978) offered some evidence that chimpanzees may spontaneously attribute intentions or desires to others. Other research has focused on the ability of chimpanzees and some monkey species to engage in role-taking, their ability to understand various mental aspects of visual perception, and their understanding of false belief (Woodruff and Premack, 1979; Premack, 1988; Cheney and Seyfarth, 1990a; Povinelli et al.,

1990; Gómez, 1991; Povinelli et al., 1991, 1992a,b; Hess et al., 1993; Povinelli et al., 1994; Gómez, 1996; Povinelli and Eddy, 1996a,b,c, 1997). Although there is some suggestive evidence for chimpanzees, it has thus far been difficult to determine with much definitiveness whether even they possess a true appreciation of any unobservable mental states (critiques by Premack, 1988; Cheney and Seyfarth, 1990b; Heyes, 1993; Povinelli, 1993; Whiten, 1993; Tomasello and Call, 1994; Povinelli and Preuss, 1995; Povinelli, 1996; Whiten, 1996). One of the central methodological difficulties has been teasing out the confounding effects of learning in the experimental paradigms.

In this paper, we describe the results of two experiments that were designed to probe young and juvenile chimpanzees' understanding of intention by presenting them with instances of accidental/inadvertent versus intentional behavior on the part of unfamiliar humans which resulted in adverse consequences. There have been limited previous efforts to determine if chimpanzees are capable of discriminating between intentional and accidental events. Premack (1986) alluded to an unsuccessful attempt to teach an adolescent chimpanzee to discriminate between videotape sequences depicting 'intentional and unintentional acts' (p. 85), but no details were provided. Povinelli (1991) briefly described a pilot project involving an 8-year-old chimpanzee who was exposed to actors involved in staged accidental and aggressive episodes resulting in the loss of food intended for the subject. The present experiments sought to conduct a preliminary test of the ability of young and juvenile chimpanzees to discriminate between accidental and intentional events. In particular we pitted two of the explanatory frameworks described above against each other. On the one hand, a learning or epigenetic interpretation of the social behavior of chimpanzees would argue that they ought not to discriminate between intentional and accidental/inadvertent events (if the events have equivalent outcomes). On the other hand, an intentional (or mentalistic) account of chimpanzees' social behavior predicts that chimpanzees interpret behavior at both the level of outcomes and intentions, and indeed, in many cases (like humans) they may weigh intentions more heavily than outcomes (Meltzoff, 1995). Thus, our tests were designed to provide a preliminary attempt to determine which of these frameworks generated more accurate predictions about how chimpanzees would behave when exposed to unfamiliar persons engaging in accidental (or inadvertent) versus intentional actions which resulted in negative outcomes (the loss of desired food rewards) for the animals.

2. Experiment 1: method

2.1. Subjects

The subjects were six young chimpanzees who ranged in age from 4 years, 4 months (4;4) to 5;1 when the training for this experiment began. At the time of the test sessions the subjects were all 3–5 months older. Five of the subjects were female (Megan, Kara, Mindy, Jadine, Brandy) and one was male (Apollo). Except during testing, the animals had continuous access to two indoor rooms and three outdoor runs which were connected to each other by passageways to allow free movement between them. The enclosure included wooden perches at various heights in each section, ropes, tires, barrels, and a variety of other hard plastic toys. The animals were fed a variety of fresh fruits, juices and treats (vanilla wafers and candies) during testing sessions in the morning and afternoon, and were fed monkey chow twice daily. The subjects had been participating in a number of other cognitive studies for two years (details of their rearing and experimental histories can be found in Povinelli and Eddy, 1996a).

2.2. Procedure

2.2.1. Training

The subjects were trained to 'point' (hereafter no scare quotes, but see Section 5) to familiar human trainers in order to receive food rewards. The training proceeded as follows. Before testing, the subjects were locked out of one of the outdoor runs (hereafter referred to as the outdoor waiting area), which was connected by a shuttle door to

Fig. 1. Procedure and setting of test of young chimpanzees ability to discriminate between accidental and intentional events.

an indoor testing room. In order to test the subjects individually, each subject was in turn separated from the group and ushered into this outdoor waiting area, from which they could be let into the indoor testing room. All of the subjects were extensively familiar with this general procedure. The testing room was divided into a test unit for the subjects (which consisted of a wire mesh top and a clear plexiglas front) and a working space for the experimenters (Fig. 1). The plexiglas panel had several 14 cm diameter holes cut into it at a height that made it comfortable for the subjects to reach through in order to participate in testing. The animals were accustomed to reaching through these large holes in order to participate in other, unrelated tests. The subjects entered the testing unit through a shuttle door into the waiting area and were restricted to this space during the initial phase of training. On each trial, a human experimenter stood approximately 100 cm from the front of the testing cage directly in front of either the right or left hole in the plexiglas panel. In the initial stages of training a wooden screen covered the holes in the plexiglas panel. At the start of each trial, the screen was removed by the chimpanzees' trainer and the subject was allowed to reach through either the right or left hole. If the subject extended her or his arm through the hole in front of the experimenter, this person reached down to a small table which was positioned between the right and left positions, picked up a small food reward (a piece of apple, banana, cookie, or candy), and handed it to the subject (Fig. 1). In the early sessions of training, if the subjects did not respond immediately, the experimenter and trainer verbally encouraged them to do so, and occasionally reached toward the food table in order to attract their attention. This preliminary training continued in sessions of either 10 or 20 trials each morning until the

subjects reached a criterion of approximately 90% correct across two sessions.

At this juncture, two variations were added into the procedure in order to familiarize the subjects with procedures that were to be used in testing. First, at the beginning of each trial, the subject was ushered out of the testing unit through the shuttle door and the wooden screen was placed over the doorway. The subject remained in the outdoor waiting area until the experimenter was in position on the right or left. The trainer then removed the wooden screen and immediately exited the test unit, and stood facing away from the subject. The subject entered and made a response by reaching through one of the two holes as before. The purpose of this modification was to eliminate the possibility that the trainer might unconsciously wait to remove the screen until the animal was sitting in front of the correct position before allowing a response. Beginning at this point a decision rule was adopted whereby the animal was judged to have made a choice once any part of his or her hand passed through the plane of the plexiglas panel. The second variation was that on approximately half of the trials, instead of picking up a food reward and handing it to the subject, after the chimpanzee pointed correctly, the experimenter poured a small amount of juice into a cup, stepped forward and held it up to a smaller hole in the plexiglas panel, allowing the chimpanzee to drink it. The subjects were trained in this fashion until they averaged 95% correct in four consecutive training sessions (38/40 or better).

2.2.2. Training of the actors

In order to test the subjects for an ability to discriminate between intentional and accidental behavior, we first selected two pairs of adult human females to serve as actors. The actors were brought into the testing room at a time when none of the subjects were present and their roles were rehearsed. First they were shown how the chimpanzee subjects would enter the room and point to them. They were then instructed to reach down, pour a small cup of juice or pick up a cookie, and hand it to the trainer, who would give it to the subject. Next, each actor and the trainer learned to perform three staged events. One involved an accident which consisted of pouring the juice and handing it to the trainer, but in the process of doing so accidentally spilling the cup. The two other roles involved intentional events. In the passive intentional role, the actors first poured the juice, started to hand it to the trainer, but then pulled it back deliberately, and slowly poured the juice onto the floor. In the aggressive intentional role, the actors learned to repeat the passive role except that instead of passively pouring the juice onto the floor, they aggressively threw the cup toward the base of the plexiglas panel directly in front of the subject while maintaining a hostile posture.

2.2.3. Preference tests

In order to control for the possibility that the subjects might have some a priori preferences for the actors based on features unknown to us, on the day prior to testing we gave each subject a preference test with the two actors consisting of 10 trials. On each trial, both actors were present, one on the right, one on the left, counterbalanced across trials. The subject was let into the room through the shuttle door and allowed to freely choose between one of the actors. At the end of the 10 trials if the subject had selected one actor more than another, we brought the least chosen actor back into the room for additional trials until the total number of times the subject had been rewarded by each actor was equated. For the cases in which the subjects showed a preference, the actor most preferred was designated as the intentional actor for the test session on the following day and the least preferred was designated as the accidental actor. In those cases where the subject selected each actor five times, a coin was flipped to determine their roles in the test session.

2.2.4. Testing

Each subject was tested twice. In Condition 1, one actor performed the accidental role, the other performed the passive intentional role. Condition 2 contrasted the accidental role and the aggressive intentional role. The order of testing conditions was counterbalanced so that half the subjects received Condition 1 first and half received it

Table 1
Total and Trial 1 choices of individual subjects following staged accidental and intentional events in Experiment 1

Subject	Condition 1		Condition 2	
	Accidental actor	Intentional actor	Accidental actor	Aggresive actor
Kara	2	4[a]	1[a]	5
Megan	3	3[a]	4[a]	2
Apollo	4	2[a]	2[a]	4
Mindy	2	4[a]	1	5[a]
Jadine	3[a]	3	3[a]	3
Brandy	3[a]	3	3[a]	3
M	2.8	3.2	2.3	3.7
Trial 1	2	4	5	1

[a] Trial 1 choice.

second. Each subject was exposed to a novel pair of actors for each test.

The structure of the test was as follows. On Trials 1–4, only one actor was present either on the right or left. On Trial 1, the subjects entered the test unit, pointed to the actor, and the actor picked up a cookie and handed it to the trainer, and the trainer then handed the reward to the subject. On Trial 2 the procedure was repeated with the second actor. Trials 3 and 4 were reserved for the staged accidental and intentional events. Again only one actor was present, but when the subject pointed to her, she performed her assigned role. The order of the events (accidental versus intentional) and the side on which the event type took place were counterbalanced across subjects within each condition. Six critical paired choice test trials were conducted beginning approximately 2 min after the accidental and intentional events. Thus, approximately 5 min had elapsed since the subject had last received a juice reward (on Trial 2). On the paired test trials both actors were present (one on the right, one on the left), and the subject was allowed into the testing unit to point to one of the actors (see Fig. 1 for the general setting). On all paired test trials the subjects were reinforced by the actors to whom they gestured, regardless of what role (accidental versus intentional) they had played. The position of the two actors was counterbalanced so that each was on either side of the same number of trials.

3. Results

3.1. Training

Most of the subjects were readily reaching through the holes from the first session and were responding at above-chance levels after several sessions. This is probably due to the fact that we capitalized on the existing begging gesture common in wild and captive chimpanzees. However, the subjects took considerably longer to meet the stringent criterion of 38/40 correct. The number of trials to criterion averaged 452 for the six subjects with a range 250–750. The topography of the final pointing gesture varied across subjects. In some cases it matched a natural begging gesture quite well, in other cases it only loosely approximated it.

3.2. Preference tests

In 10 of the 12 preference tests the subjects showed a preference for one individual over the other of the actors. In these cases the actors were assigned to the conditions as described in Section 2.

3.3. Testing

The main results of the tests are presented by condition in Table 1. In Condition 1 (accidental versus passive intentional contrast), the subjects

showed no clear preference for either actor on the six open choice trials following the two staged events (Student's t-test, $t(5) = 0.54$, ns). Similarly, in Condition 2 (accidental versus aggressive intentional contrast), the subjects did not show an overall preference for the accidental actor over the aggressive actor (Student's t-test, $t(5) = 1.35$, ns). However, although the subjects did not show an overall preference when all trials are averaged for Condition 1, four of the subjects chose the intentional actor on Trial 1 in Condition 1, whereas only two did the opposite. In contrast, in Condition 2 five of the six subjects chose the accidental actor on Trial 1, whereas only one chose the aggressive actor. Although these results are by no means definitive, they do suggest that the subjects may have been basing their initial preference upon the actors involved in the event with the fewest sudden (startling) movements (the intentional actor in Condition 1 and the accidental actor in Condition 2). On the other hand, it might have been the case that the animals simply preferred the most aggressive actor.

Several methodological problems were identified in the procedure that may have compromised our test of the alternative hypotheses concerning young chimpanzees understanding of the intentions behind the actor's actions. For example, administering preference tests to the subjects was potentially problematic for three reasons. First, although we included them because we were concerned that the subjects might have some unknown preferences for certain human characteristics, the possibility exists that the process of administering the tests may have inadvertently created biases in the subjects for certain actors. On the one hand, we equated the total number of rewarded choices by the end of the preference tests, but these rewards were not received in exactly the same test configuration as the paired choice test trials. Second, use of the preference tests forced us to assign the most preferred actor to the intentional role in order to avoid prematurely rejecting the null hypothesis. On the other hand, there is an equal possibility that this assignment may have masked an understanding that was in fact present. Finally, the subjects' experiences in the preference tests may have led them to believe that both actors were generally reliable, and thus overwhelmed the information present on the single accidental and intentional trial they received. These, and other potential methodological problems were addressed in Experiment 2.

4. Experiment 2: method

In a second experiment (which began approximately 18 months after the completion of Experiment 1) we tested the hypothesis that the subjects could learn to discriminate among three different actors, each of whom portrayed a different role. In the context of doing so, we sought to improve our previous methodology. First, we eliminated the preference tests and instead counterbalanced the roles and actors across subjects. Second, we attempted to eliminate the possibility that the subjects interpreted the accidental actor in Experiment 1 as being clumsy, and hence as unreliable as the intentional actor. To mitigate this potential problem, we confronted the apes with an intentional actor as contrasted with a 'victim', who was unsuccessful at delivering the food to the subject because of the actions of the trainer. In addition, a third 'neutral' actor was used as well and always gave the subject the expected reward. Finally, in an attempt to make the events more salient to the subjects, instead of wasting the food rewards, the intentional actor ate the reward intended for the subject, and the trainer ate the reward he took from the victim. Repeated paired preference tests were used to determine if the subjects immediately preferred (or learned to prefer) certain types of actors over others. The intentional framework predicted that the subjects would exhibit the following linear ordering of preference: neutral > victim > intentional. A behavioristic framework predicted that the subjects would not discriminate between the intentional and victim actors, but might learn to prefer the neutral actor.

4.1. Subjects

The subjects were seven chimpanzees who ranged in age from 6;6 to 7;2 when the study

began. Six of the subjects (Kara, Jadine, Brandy, Megan, Mindy, Apollo) were the same subjects who had participated in the previous study which had concluded 18 months before the present study began. The seventh subject was a female (Candy) who was 6;5 at the time the study began. All of the subjects (including Candy) had participated in a number of cognitive studies since the conclusion of Experiment 1, but none had been involved in any other studies which sought to determine their ability to distinguish between accidental and intentional events. Since the conclusion of the previous study, their living and play areas had been expanded so that they had free access to five indoor-outdoor runs (interconnected by passageways), except during testing. Otherwise, their living and caretaking environment was unchanged.

4.2. Procedure

4.2.1. Selection of actors

Three undergraduate students (two males, one female) who the subjects had never seen were recruited and served as the actors for the study. The actors were physically distinct from each other, and were between the ages of 18 and 22 years.

4.2.2. Orientation

An initial phase of the study was conducted in order to provide the chimpanzees with an opportunity to see each of the actors in the testing unit and receive food rewards from them. Three sessions were conducted consisting of 12 trials each. At the start of each session, one of the subjects was separated from the group and remained in the outside waiting area while the configuration for the trial was prepared inside the test room. In the period between Experiments 1 and 2, a pulley-controlled, opaque shuttle door had been placed in the doorway between the outside waiting area and the interior test unit. Thus, the trainer no longer had to usher the subjects in and out of the test unit with a screen as in the previous study. Instead, the door to the plexiglas test unit was closed and locked with the subjects in the outside waiting area. The subjects were let in and out of the test unit by the trainer manipulating a pulley system (which controlled the shuttle door) in the rear of the test room. When the shuttle door was closed, the subject could not enter or see into the test unit or test room; when the trainer pulled down on the pulley, the shuttle door opened and the subject was free to enter and respond. Before each trial began (and while the subject waited outside), a small table containing a bowl of food rewards (pieces of apples and bananas, and small vanilla wafers) was positioned as in Experiment 1 (midway between the left and right holes), 100 cm in front of the partition. According to a randomized and counterbalanced schedule (see below), one of the actors situated themselves at a standardized position in front of the plexiglas partition either in front of the left or the right hole, with the table beside them. The shuttle door was then opened by the subjects' trainer, allowing the chimpanzees to enter the test unit, scan the room and point through one of the holes. If the subject pointed through the hole in front of the actor, the actor reached down, picked up a small food reward and handed it to the trainer who stepped forward from the rear of the room, accepted the food reward and handed it to the animal. These events were carefully planned and choreographed so that all of the relevant actions were clearly visible to the subjects. If the subject reached through the incorrect hole they were not handed a food reward and were ushered outside to the waiting area, and the shuttle door was closed. In order to ensure that the chimpanzees received equal reinforcement from each of the actors within each session, each of the three actors was randomly assigned to 4 of the 12 trials. For purposes of side counterbalancing, each actor was present on the left side twice and the right side twice. For this orientation session only, the correct side alternated from trial to trial.

4.3. Testing

4.3.1. Assignment of actors to roles

Three roles were created in order to embody the roles of interest: the victim, the intentional actor, and the neutral actor. A detailed description of each of these roles is provided below. In order to eliminate potential problems from Experiment 1,

we chose to counterbalance the persons and the roles they played across subjects and eliminate the initial preference tests altogether. Because there were three persons and three roles, there were a total of six unique combinations of actors and roles. These unique combinations were randomly assigned to the first six randomly selected subjects. The seventh subject was randomly assigned to one of the possible six person/role combinations. This assignment strategy meant that each subject witnessed the same person portray each of the three separate roles consistently throughout the study, but the actors portrayed different roles for different subjects.

4.3.2. Exposure trials

The animals were tested across six sessions. Each session was composed of two parts. First, the subject was administered six exposure trials during which only a single actor was present. These trials were designed to provide the context in which the actors executed their roles. Each actor was present on two of the trials (2 trials per actor $\times$ 3 actors = 6 trials). The neutral actor performed both of his trials in exactly the same fashion as he or she had during the orientation trials. In contrast, the victim and the intentional actor performed as during orientation on only one of each of their two exposure trials. On the other trial, each of them executed a standardized, extensively rehearsed role. For the trials on which the victim executed his or her rehearsed role, the events unfolded as follows. The chimpanzee entered the test unit, pointed to the victim, who then reached down to the table as usual, retrieved a food reward and handed it to the trainer. The trainer then took the reward, started to hand it to the subject, but then pulled it back and ate it in front of the subject. In turn, the victim watched this event carefully and exhibited facial expressions characteristic of the human emotion of surprise. The intentional role was identical, except that instead of handing the reward to the trainer, the intentional actor pulled it away from him at the last moment and ate it. In this case, the trainer exhibited surprise.

The following procedures were used to determine the order of presentation of the actors, the side on which they appeared, and the trial on which the intentional and victim actors executed their roles. First, each actor was presented once, then each actor was presented again. Within this constraint, all 36 possible orderings of role presentations were created. Each of six subjects was randomly and exhaustively assigned 6 of the 36 possible orderings (one ordering for each session for each subject). The seventh subject was then randomly assigned to 6 of the 36 possible orderings. As explained above, within each session, each subject received one exposure to the intentional role and one exposure to the victim role. For each subject, the odd-numbered sessions (1, 3 and 5) were selected, and half of the trials were randomly assigned to occur with the actor on the left and half on the right. Next, in order to counterbalance for the side on which the actors appeared, in the even-numbered sessions the actors were assigned to the opposite sides as in the odd-numbered sessions. Thus, if the intentional actor had appeared on the left side twice in Session 1, he or she appeared on the right twice in Session 2 (regardless of the actual trial numbers). Conversely, if the victim actor had appeared on the right side once and the left side once in Session 1, he or she was again assigned to the right once and left once in Session 2 (and in the opposite order, where other counterbalancing constraints allowed). In terms of the assignment of the specific trials on which the critical roles would be executed, for each subject, in half of the sessions ($N = 3$), the intentional role occurred first and the victim role appeared second, whereas in the other half the opposite order of presentation occurred. An equal number of exposures to each of the executed roles occurred on the right and left sides within each session. Within these constraints, the trials on which the exposures occurred were randomly assigned.

4.3.3. Test trials

After the six trials in the exposure portion of each session had occurred, three critical paired choice test trials (from which the primary dependent measures were derived) were executed so that each subject was confronted with each of the three possible pairwise comparisons of the two actors:

Table 2
Total choices of individual subjects following staged events in Experiment 2

Subject	Contrast 1		Contrast 2		Contrast 3	
	Intentional actor	Victim actor	Intentional actor	Neutral actor	Neutral actor	Victim actor
Kara	3	3	3	3	3	3
Jadine	3	3	3	3	3	3
Brandy	2	4	4	2	2	4
Megan	2	4	2	4	3	3
Mindy	4	2	4	2	3	3
Apollo	4	2	4	2	3	3
Candy	4	2	3	3	3	3
M	3.14	2.86	3.29	2.71	2.86	3.14

intentional versus victim, victim versus neutral, intentional versus neutral. The order of presentation of each of these three comparisons was counterbalanced across sessions within subjects. The order of presentation was counterbalanced across subjects to the extent possible (given the odd number of subjects). Finally, the left/right position of the actors in each pairwise comparison was also counterbalanced within subjects and across sessions. Within sessions, the left/right position of the actors was counterbalanced to the extent allowed by the odd number of subjects.

5. Results

The central prediction of both the intentional and behaviorist framework concerned the chimpanzees' responses during the paired choice tests. However, the data was first examined to determine if as a group the subjects displayed an unplanned preference for individual persons portraying the roles, independent of the roles themselves. The number of choices for each person (regardless of role) was summarized and a one-way repeated measures analysis of variance (ANOVA) was performed to determine if certain actors were chosen more than others. Although the female actor was chosen slightly more ($M = 6.9$, S.D. $= 1.2$) than the two male actors ($M = 5.4$ and 5.7, S.D. $= 0.8$ and 1.1, respectively) this result was not statistically reliable, $F(2, 12) = 2.400$, $P = 0.133$. Given that there was no effect of experimenter, we next summarized the subjects' choices in the paired choice tests across the six sessions. Table 2 displays these results by subject for each of the three contrasts (summed across the six sessions), along with the group means for each of the contrasts in question. Separate paired *t*-tests were conducted for each of the contrasts to determine if the subjects displayed a preference for pointing to one type of actor over another for each contrast. The results uniformly indicated that as a group the subjects did not display a reliable preference in any of the three contrasts (all $t\text{s} \geq 0.420 \leq 1.00$, $P\text{s} \geq 0.356$).

Although the subjects did not display preferences when their results for all six sessions are collapsed, it is possible that they learned preferences during the course of the experiment which were masked by collapsing sessions. In order to examine this possibility, we examined the subjects responses for each of the three contrasts separately in blocks of two sessions. This meant that for each subject within each contrast, there were two trials available in each block for analysis. For purposes of statistical analysis the subjects' data were transformed into percent correct scores. Correct scores were assessed from the perspective of the predictions generated by the intentional framework. Thus, for the intentional versus victim contrast, choices for the victim were considered correct; for the intentional–neutral contrast, choices for the neutral actor were considered correct; and for the neutral–victim contrast, choices for the neutral actor were considered correct. This

resulted in assigning each subject a score of either 0, 50 of 100% correct for each block of two trials for each of the three contrasts. Separate one-way repeated measures ANOVAs were conducted for each of the contrasts, and uniformly yielded no effect of session (all Fs < 0.500, $P > 0.619$). Thus, these results provide no support for the predictions generated by the mentalistic framework. Indeed, the failure of the subjects to base their decisions upon the repeated exposure to the intentional actor's behavior is consistent with the view that the subjects did not interpret the different intentions behind this event as compared with the others. However, the fact that they did not tend to prefer the neutral actor over both of the others raises interpretive problems for the straightforward interpretation that the learning framework was supported.

6. Discussion

The results presented here provide little evidence that 5- to 7-year-old chimpanzees understand the distinction between accidental and intentional actions. Although this finding is consistent with the idea that chimpanzees in general do not appreciate this distinction (Tomasello et al., 1993; Povinelli, 1996; Povinelli and Eddy, 1996a) there are both developmental and methodological limitations that must be considered. First, it may be that the chimpanzees investigated here were simply too young to show evidence for the capacity. If our sample of humans were limited to 2-year-olds, for example, we would not want to conclude that the human species is incapable of understanding the accidental–intentional distinction. There is some empirical precedence for keeping an open mind on this point. First, our cross-sectional and longitudinal research on the development of self-recognition in mirrors in chimpanzees suggests that this ability is markedly delayed in chimpanzees relative to human development, with most captive chimpanzees, at least, not showing evidence of the ability until 4.5 years or older (Povinelli et al., 1993; Eddy et al., 1996, but see Lin et al., 1992). At the time of Experiment 1, for example, three of the subjects (Jadine, Mindy, and Megan) had displayed positive evidence of self-recognition in mirrors, whereas three others had consistently not (Kara, Apollo, and Brandy). Second, there are other areas as well in which research seems to suggest that cognitive achievements typical of 18- to 24-month-old human infants do not show up until 5 to 8 years of age in chimpanzees (Mathieu and Bergeron, 1981; Chevalier-Skolnikoff, 1983; Mignault, 1985; Spinozzi, 1993; Savage-Rumbaugh et al., 1993). Collectively, these data hint at heterochronic shifts in cognitive development in either the human or chimpanzee lineages (or both) in the course of evolution within the great ape–human clade (Povinelli, 1996). This is important with respect to the research presented here because the theory of mind skills may emerge in chimpanzees, but either not until absolutely later than in humans, and/or perhaps relatively later as compared to other cognitive skills.

Our research is limited from a number of methodological directions as well. First, chimpanzees may be able to 'perceive' the distinction between accidental/inadvertent actions and intentional ones, without being able to use an instrumentally shaped gesture to capitalize upon it. In other words, there may be a lag between comprehension of intentional behavior on the one hand, and effective production of behavioral strategies to use this information on the other. Second, it may also be that the subjects both comprehended the distinction and possess the ability to capitalize upon it, but did not do so because the severity of the outcome was too mild. This latter explanation would seem to carry with it the hypothesis that the subjects could actively choose between two actors who were differentially associated with more severe adverse consequences than those used here. To some extent, we attempted to investigate this in Experiment 1 by presenting the subjects with the accidental-aggressive/intentional contrast, with mixed results. Although the subjects' overall choices do not support that hypothesis, their Trial 1 results are consistent with this view (5 out of the 6 subjects avoided the aggressive actor on Trial 1). Finally, it is possible that the subjects attributed a different intention at the time of the occurrence of the two events, but did not interpret

these intentions as having any lasting consequences. This may be due to a general failure to engage in stable dispositional attributions. Indeed, there is indirect evidence from research on the development of children's understanding of stable personality traits, that it may not be until 5 or 6 years of age that they realize that people's intentions and personalities at one point can serve as a useful guide to their behavior at another time or place (Rholes and Ruble, 1984, 1986). If true, it would mean that long before children were able to understand that someone with malevolent intentions at one point are likely to have similar ones at a future timepoint, they would be able to show evidence of understanding intentions on other, less demanding tests of the distinction between accidental/inadvertent versus intentional actions. We attempted to combat this problem by giving the apes repeated exposure to the same intentions in the same context, but it may be that more exposure with more salient events are needed.

From the opposite extreme, it may have been premature to ask the subjects about the intentional nature of the behavior of other individuals until we had obtained a definitive resolution concerning their understanding of their own behavior. It is possible that young and juvenile chimpanzees do not even understand the intentions underlying their own gestures. In other words, although in the course of several hundred trials we successfully trained them to gesture in front of the location where a trainer stood, we have no guarantee that the final near-perfect accuracy of their gesture was accompanied by a concomitant awareness of the intention underlying it. Although it may be tempting to interpret their action in an anthropomorphic manner (i.e. 'I want you to get me some food'), this may not be the correct interpretation. Several distinct questions present themselves. First, do the subjects know that their extended arm has a referent in space, or have they simply learned to execute a rule of the following type: 'extend arm through hole in front of person; receive food'? In other words, are they 'choosing' the person, or are they simply expressing an imperative (i.e. 'want food') with our training techniques having simply localized that imperative gesture to the correct hole? If this were true, when confronted with two trainers, it would be inaccurate to label their behavior as making a 'choice' between the two actors. Because virtually all of their hundreds of training trials involved pointing with a single trainer present, their performance on the test choice trials (where two trainers were present) could be expected to follow either a random or default pattern precisely because the rule 'extend arm through hole in front of person; receive food', can be satisfied by either choice. Povinelli and Eddy (1996a) recently explored aspects of this problem with the same subjects used in these studies by examining under what conditions the subjects would deploy their begging gesture. For instance, in paired tests superficially similar to those used here, the subjects would selectively gesture to someone offering food as opposed to an undesirable block of wood. In addition, they would gesture in front of someone facing them, as opposed to someone facing away. However, careful examination of the conditions which elicited their gestures indicated that the subjects did not appreciate that their gesture needed to be seen by an experimenter in order for it to be effective (Povinelli and Eddy, 1996a). This suggests that chimpanzees may not even understand the gesture they used to make their 'choices' in the same manner as young children understand the pointing gesture (for discussions of the various ways in which human children can 'mean' a pointing gesture, Bates et al., 1975; see also Goodhardt and Baron-Cohen, 1993).

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References

Astington, J.W., Gopnik, A., 1991. Theoretical explanations of children's understanding of the mind. Br. J. Dev. Psychol. 9, 7–31.

Bartsch, K., Wellman, H., 1995. Children Talk About the Mind. Oxford University Press, Oxford.

Bates, E., Camaioni, L., Volterra, V., 1975. The acquisition of performatives prior to speech. Merrill-Palmer Q. 21, 205–226.

Berndt, T.J., Berndt, E.G., 1975. Children's use of motives and intentionality in person perception and moral judgment. Child Dev. 46, 904–912.

Bretherton, I., Beeghly, M., 1982. Talking about internal mental states: the acquisition of an explicit theory of mind. Dev. Psychol. 18, 906–921.

Cheney, D.L., Seyfarth, R.M., 1990a. Attending to behaviour versus attending to knowledge: examining monkeys attribution of mental states. Anim. Behav. 40, 742–753.

Cheney, D.L., Seyfarth, R.M., 1990b. How Monkeys See the World: Inside the Mind of Another Species. Chicago University, Chicago.

Chevalier-Skolnikoff, S., 1983. Sensorimotor development in orangutans and other primates. J. Hum. Evol. 12, 545–561.

Eddy, T.J., Gallup, G.G. Jr., Povinelli, D.J., 1996. Age differences in the ability of chimpanzees to distinguish mirror-images of self from video-images of others. J. Comp. Psychol. 110, 38–44.

Flavell, J.H., 1988. From cognitive connections to mental representations. In: Astington, J.W., Harris, P.L., Olson, D.R. (Eds.), Developing Theories of Mind. Cambridge University Press, Cambridge, pp. 244–267.

Flavell, J.H., Green, F.L., Flavell, E.R., 1995. Young children's knowledge about thinking. Monographs of the Society for Research in Child Development, Serial No. 243, vol. 60.

Fodor, J., 1987. Psychosemantics: The problem of Meaning in the Philosophy of Mind. MIT Press, Cambridge, MA.

Gallup, G.G. Jr., 1982. Self-awareness and the emergence of mind in primates. Am. J. Primatol. 2, 237–248.

Gallup, G.G. Jr., 1985. Do minds exist in species other than our own?. Neurosci. Biobehav. Rev. 9, 631–641.

Gómez, J.C., 1991. Visual behaviour as a window for reading the mind of others in primates. In: Whiten, A. (Ed.), Natural Theories of Mind: Evolution, Development and Simulation of Everyday Mindreading. Blackwell, Cambridge, pp. 195–207.

Gómez, J.C., 1996. Non-human primate theories of (non-human primate) minds: some issues concerning the origins of mind-reading. In: Carruthers, P., Smith, P. (Eds.), Theories of Theories of Mind, Cambridge University Press, Cambridge, pp. 330–343.

Goodhardt, F., Baron-Cohen, S., 1993. How many ways can the point be made? Evidence from children with and without autism. First Language 13, 225–233.

Griffin, D.R., 1976. The Question of Animal Awareness. Rockefeller University Press, New York.

Griffin, D.R., 1992. Animal Minds. University Chicago Press, Chicago.

Hess, J., Novak, M.A., Povinelli, D.J., 1993. 'Natural pointing' in a rhesus monkey, but no evidence of empathy. Anim. Behav. 46, 1023–1025.

Heyes, C.M., 1993. Anecdotes, training, trapping and triangulating: do animals attribute mental states?. Anim. Behav. 46, 177–188.

Imamoglu, E.O., 1975. Children's awareness in usage of intention cues. Child Dev. 57, 567–582.

Karniol, R., 1978. Children's use of intention cues in evaluating behavior. Psychol. Bull. 85, 76–85.

King, M., 1971. The development of some intention concepts in young children. Child Dev. 42, 1145–1152.

Lin, A.C., Bard, K.A., Anderson, J.R., 1992. Development of self-recognition in chimpanzees (*Pan troglodytes*). J. Comp. Psychol. 106, 120–127.

Mathieu, M., Bergeron, G., 1981. Piagetian assessment on cognitive development in chimpanzees (*Pan troglodytes*). In: Chiarelli, A.B., Corruccini, R.S. (Eds.), Primate Behavior and Sociobiology. Springer, New York, pp. 142–147.

Meltzoff, A.N., 1995. Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. Dev. Psychol. 31, 838–850.

Mignault, C., 1985. Transition between sensorimotor and symbolic activities in nursery-reared chimpanzees (*Pan troglodytes*). J. Hum. Evol. 14, 747–758.

Miller, P.H., Aloise, P.A., 1989. Young children's understanding of the psychological causes of behavior: a review. Child Dev. 60, 257–285.

Piaget, J., 1932. The Moral Judgement of the Child. Free Press, New York.

Perner, J., 1991. Understanding the Representational Mind. MIT Press, Cambridge, MA.

Premack, D., 1986. Gavagai!. MIT Press, Cambridge, MA.

Premack, D., 1988. 'Does the chimpanzee have a theory of mind?' revisited. In: Byrne, R., Whiten, A. (Eds.), Machiavellian Intelligence. Oxford University Press, New York, pp. 160–179.

Premack, D., Woodruff, G., 1978. Does the chimpanzee have a theory of mind?. Behav. Brain Sci. 1, 515–526.

Povinelli, D.J., 1991. Social intelligence in monkeys and apes. PhD Thesis. Yale University, New Haven, Connecticut.

Povinelli, D.J., 1993. Reconstructing the evolution of mind. Am. Psychol. 48, 493–509.

Povinelli, D.J., 1996. Chimpanzee theory of mind? The long road to strong inference. In: Carruthers, P., Smith, P. (Eds). Theories of Theories of Mind. Cambridge University Press, Cambridge, pp. 293–329.

Povinelli, D.J., Eddy, T.J., 1996a. What young chimpanzees know about seeing. Monographs of the Society for Research in Child Development, vol. 61, No. 2, Serial No. 247.

Povinelli, D.J., Eddy, T.J., 1996b. Chimpanzees: joint visual attention. Psychol. Sci. 7, 129–135.

Povinelli, D.J., Eddy, T.J., 1996c. Factors influencing young chimpanzees' (*Pan troglodytes*) recognition of attention. J. Comp. Psychol. 110, 336–345.

Povinelli, D.J., Eddy, T.J., 1997. Specificity of gaze-following in young chimpanzees. Br. J. Dev. Psychol. 15, 213–222.

Povinelli, D.J., Preuss, T.M., 1995. Theory of mind: evolutionary history of a cognitive specialization. Trends Neurosci. 18, 418–424.

Povinelli, D.J., Nelson, K.E., Boysen, S.T., 1990. Inferences about guessing and knowing by chimpanzees (*Pan troglodytes*). J. Comp. Psychol. 104, 203–210.

Povinelli, D.J., Parks, K.A., Novak, M.A., 1991. Do rhesus monkeys (*Macaca mulatta*) attribute knowledge and ignorance to others?. J. Comp. Psychol. 105, 318–325.

Povinelli, D.J., Nelson, K.E., Boysen, S.T., 1992a. Comprehension of social role reversal by chimpanzees: evidence of empathy?. Anim. Behav. 43, 633–640.

Povinelli, D.J., Parks, K.A., Novak, M.A., 1992b. Role reversal by rhesus monkeys, but no evidence of empathy. Anim. Behav. 44, 269–281.

Povinelli, D.J., Rulf, A.B., Landau, K., Bierschwale, D., 1993. Self-recognition in chimpanzees (*Pan troglodytes*): distribution, ontogeny, and patterns of emergence. J. Comp. Psychol. 107, 347–372.

Povinelli, D.J., Rulf, A.B., Bierschwale, D., 1994. Absence of knowledge attribution and self-recognition in young chimpanzees (*Pan troglodytes*). J. Comp. Psychol. 108, 74–80.

Rholes, W.S., Ruble, D.N., 1984. Children's understanding of dispositional characteristics of others. Child Dev. 55, 550–560.

Rholes, W.S., Ruble, D.N., 1986. Children's impressions of other persons: The effects of temporal separation of behavioral information. Child Dev. 57, 872–878.

Savage-Rumbaugh, E.S., Murphy, J., Sevick, R.A., Brakke, K.E., Williams, S.L., Rumbaugh, D.M., 1993. Language comprehension in ape and child, Monographs of the Society for Research in Child Development, Serial No. 233, vol. 58, Nos. 3–4.

Shultz, T.R., Shamash, F., 1981. The child's conception of intending act and consequence. Can. J. Behav. Sci. 13, 368–372.

Shultz, T.R., Wells, D., Sarda, M., 1980. Development of the ability to distinguish intended actions from mistakes, reflexes, and passive movements. Br. J. Soc. Clin. Psychol. 19, 301–310.

Smith, M.C., 1978. Cognizing the behavior stream: The recognition of intentional action. Child Dev. 49, 736–743.

Spinozzi, G., 1993. Development of spontaneous classificatory behavior in chimpanzees (*Pan troglodytes*). J. Comp. Psychol. 107, 193–200.

Tomasello, M., Call, J., 1994. Social cognition of monkeys and apes. Yearb. Phys. Anthropol. 37, 273–305.

Tomasello, M., Kruger, A.C., Ratner, H.H., 1993. Cultural learning. Behav. Brain Sci. 16, 495–552.

Wellman, H.M., 1990. The Child's Theory of Mind. Bradford, Cambridge, MA.

Whiten, A., 1993. Evolving theories of mind: The nature of non-verbal mentalism in other primates. In: Baron-Cohen, S., Tager-Flusberg, H., Cohen, D., Volkmar, F. (Eds.), Understanding Other Minds. Oxford University Press, Oxford, pp. 367–396.

Whiten, A., 1996. When does smart behaviour-reading become mind-reading? In: Carruthers, P., Smith, P. (Eds.), Theories of Theories of Mind, Cambridge University Press, Cambridge, pp. 277–292.

Wimmer, H., Perner, J., 1983. Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. Cognition 13, 103–128.

Woodruff, G., Premack, D., 1979. Intentional communication in the chimpanzee: the development of deception. Cognition 7, 333–362.

Yuill, N., 1984. Young children's coordination of motive and outcome in judgements of satisfaction and morality. Br. J. Dev. Psychol. 2, 73–81.