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PAPER

'Unwilling' versus 'unable': chimpanzees' understanding of human intentional action

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Abstract

Understanding the intentional actions of others is a fundamental part of human social cognition and behavior. An important question is therefore whether other animal species, especially our nearest relatives the chimpanzees, also understand the intentional actions of others. Here we show that chimpanzees spontaneously (without training) behave differently depending on whether a human is unwilling or unable to give them food. Chimpanzees produced more behaviors and left the testing station earlier with an unwilling compared to an unable (but willing) experimenter. These data together with other recent studies on chimpanzees' knowledge about others' visual perception show that chimpanzees know more about the intentional actions and perceptions of others than previously demonstrated.

Introduction

Understanding the intentional actions of others is a fundamental part of human social cognition and behavior. Human social norms, legal systems and even the games people play (e.g. football) are governed by the way individuals interpret the intentional actions of other persons. From a developmental point of view, seeing and understanding the behavior of others not as bodily motion, but rather as intentional, goal-directed action is one of the major cognitive achievements of 1-year-old human infants (Malle, Moses & Baldwin, 2001; Zelazo, Olson & Astington, 1999). This understanding is one of the first steps in children's building of a theory of mind, and paves the way for language, symbolic play and the acquisition of a number of other cultural activities and skills during the second year of life (Tomasello, 1999).

For the past 25 years, cognitive scientists have been attempting to determine if nonhuman primates, specifically apes, also understand the behavior of others as intentional, goal-directed activity. Some theorists believe that this is one of the main social-cognitive differences between humans and other animals (Tomasello, 1999). In the first study of this kind, Premack and Woodruff (1978) showed the laboratory-trained, language-trained chimpanzee Sarah videotapes of human actors coming upon obstacles in problem solving situations. For example, Sarah saw a human looking up to an out of reach banana hanging from the ceiling, or a human wishing to exit through a locked cage door, or a human trying to operate a hose that was unattached to the faucet. The videotape was then stopped and Sarah was presented with a pair of photographs, one of which represented, from the human point of view, a solution to the problem: such things as the person mounting a box under the banana or a hose attached to a faucet. In general, Sarah performed in a seemingly insightful fashion on these tasks. Premack and Woodruff argued that Sarah's success constituted evidence that she 'recognized the videotape as representing a problem, understood the actor's purpose, and chose alternatives compatible with that purpose'.

But Savage-Rumbaugh, Rumbaugh and Boysen (1978) pointed out that Sarah may have been simply choosing 'solutions' based on associations among objects developed from her experiences with caretakers and their behavior with keys, hoses and the like. They examined each item Sarah was presented with and found that, in general, the items for which such associative procedures were most straightforward were the ones on which Sarah performed best (e.g. key with lock, hose with faucet); those that were more obscure associatively were items

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Sarah did more poorly on. In addition, Savage-Rumbaugh *et al.* presented two different language-trained chimpanzees with a match-to-sample procedure in which they were shown, for example, a picture of a foot and asked to choose between pictures of a shoe and a key. The animals had no training in this task, but both chimpanzees chose the closely associated objects on 25 of 28 trials.

Subsequent research on chimpanzees' understanding of intentions has produced mixed results. Thus, Premack (1986) reported on an attempt to train Sarah to discriminate between videotaped sequences that depicted intentional actions versus those that depicted non-intentional actions. Sarah never learned the discrimination. Similarly, Povinelli, Perilloux, Reaux and Bierschwale (1998) presented six captive juvenile chimpanzees with two alternatives. In one, a human experimenter, on the way to deliver juice to the chimpanzee, accidentally spilled the juice. In the other, the experimenter intentionally poured the juice on the floor. When chimpanzees were later asked to choose between experimenters from whom they would receive juice, none of the six chimpanzees showed a preference for the 'clumsy' over the 'mean' human experimenter. If chimpanzees understood the intentions of the two actors, they should have chosen to receive the juice from the well-intentioned one. However, since they received no juice from any experimenter, it is unclear whether there was any motivation to choose between any of them. Chimpanzees, however, avoided a threatening experimenter, but this could simply be a result of the negative emotional charge produced by aggressive behaviors, rather than its intentional or accidental nature.

There are also two attempts to study understanding of others' unfulfilled intentions in chimpanzees using Meltzoff's (1995) behavioral re-enactment procedure, but both yielded ambiguous results. Myowa-Yamakoshi and Matsuzawa (2000) and Call, Carpenter and Tomasello (submitted) found that chimpanzees performed the target action equally as often when they saw a failed attempt as when they saw the completed action. However, in both studies, chimpanzees also performed the target action at high levels in a baseline condition, limiting what we can conclude about their understanding of others' intentions from these studies.

Call and Tomasello (1998) trained chimpanzees and orangutans to identify a marker placed on top of one of three opaque buckets as an indicator for the location of hidden food. During training the apes never saw the human actually placing the marker on the bucket, but the marker was already on top of one of the buckets when they were presented to the ape. On test trials a human experimenter then placed (or dropped) the marker on one of the buckets intentionally, but either before or after this he let the marker fall accidentally onto one of the other buckets. The marker was removed at the time of choice for the ape, so for test trials the ape was faced with a choice in which one bucket had been marked with the marker intentionally and the other accidentally. Apes as a group chose the bucket that was marked intentionally (with the intentional drop showing the strongest effect), although no individual except a language-trained orangutan was above chance on his own.

Recently, Suddendorf and Whiten (2001) have indicated that there is evidence that apes recognize certain mental states such as attention and intention. Besides the experimental studies previously cited, these authors used observational data to support this idea. Although suggestive, these positive results (both observational and experimental) must be interpreted with caution. Observational data can be problematic because isolated observations can often be interpreted in multiple ways. On the other hand, experimental data can be problematic because usually there is a fairly extensive amount of training involved before or during the test. Moreover, both observational and experimental approaches have the potential problem that because intentional and accidental actions differ from one another in a number of ways, it is possible that the apes were focused on one of these superficial characteristics rather than the underlying mental states. In the current study, therefore, we sought a method for investigating apes' understanding of intentional action that involved (1) no training, (2) the presentation of multiple conditions to minimize success by using a single superficial cue (thus creating a triangulation procedure) and (3) which used apes' natural reactions as responses.

Experiment 1

The basic set-up was that a human experimenter (E) began giving food normally to an ape through a hole in a Plexiglas wall. Occasionally during this feeding routine, E conducted a test trial in which the food transfer was delayed: E brought out another piece of food and either refused to give it to the ape or else attempted to give it to the ape unsuccessfully. E was thus unwilling or unable, respectively, to give the food during test trials. There were three trios of different conditions, with one unwilling and two unable conditions in each trio. We used two unable conditions for each unwilling condition to obtain a broader comparison between conditions. Within each trio all conditions were matched for the gazing behavior of the experimenter and, as closely as

possible, for general body motions and position of the food. However, it was of course necessary that each condition presented specific behaviors so that conditions could be differentiated from each other. We used multiple conditions (each depicting different behaviors) to guard against the use of single superficial cues as an explanation for our results. For instance, a difference in a particular unwilling–unable pair could be explained by a single superficial cue (rather than its underlying intentions), but such a single cue would lose some of its explanatory power if individuals still differentiated between other unwilling and unable pairs in the absence of that specific superficial cue. Using multiple and disparate tests that share a common psychological feature has been previously used in other studies (e.g. Meltzoff, 1995; Premack & Woodruff, 1978). The experimental question was whether the apes would behave differently when the human was unwilling to give them food as opposed to when he was unable to do so, for example, by waiting patiently during his well-intentioned attempts but trying to spur him into action or leaving when he simply was refusing to give the food.

Method

Participants

Twelve captive born chimpanzees (4–26 years old; mean 15.4 years) participated in this study. All chimpanzees were housed together in several large enclosures at the Wolfgang Köhler Research Center, Leipzig Zoo, Germany. Table 1 presents the age, sex and rearing history of each chimpanzee. All the chimpanzees had been moved to the Leipzig Zoo only 6 months prior to testing and were still becoming accustomed to their new home. They had never completed any cognitive experiments before this test began.

Table 1 *Age, sex and rearing history of each subject*

Name	Age (years)	Sex	Rearing history
Robert	26	M	Nursery
Reit	25	F	Nursery
Natascha	24	F	Nursery
Dorien	22	F	Nursery
Fraukje	26	F	Nursery
Ulla	22	F	Nursery
Jahaga	8	F	Mother
Fifi	8	F	Mother
Sandra	8	F	Mother
Gertruida	8	F	Mother
Frodo	8	M	Mother
Patrick	4	M	Mother

Figure 1 *The testing situation.*

Procedure

A chimpanzee was allowed into a set of three testing rooms, and moved into one of the extreme rooms (180 cm × 130 cm). The doors between the rooms were left open. Once the chimpanzee was in position, E (always the same in all experiments) sat facing the chimpanzee at eye level separated by a transparent Plexiglas panel with three feeding holes cut into the bottom (6 cm in diameter and 23 cm apart), through which food could be given. A small transparent Plexiglas panel (12 cm × 69 cm) with smaller holes (3.5 cm diameter) was placed over the holes in the Plexiglas panel so that chimpanzees could only stick their fingers through the holes toward E. In front of E there was a small table (80 cm × 30 cm) flush against the Plexiglas panel underneath the feeding holes. On this table there was a small wooden ramp (66 cm × 30 cm) that was also flush against the Plexiglas panel and angled down toward E (see Figure 1).

Within a session there were motivational and test trials. Before and after each test trial there were a set of motivational trials, in which the chimpanzee received between two and six grapes in succession (counterbalanced across subjects). In test trials, which lasted 30 seconds, the chimpanzee did not receive any food. There were two types of test trials, unwilling and unable, represented by three and six conditions, respectively. In the six unable conditions E was unable to transfer the food because something in the situation prevented it (e.g. the feeding hole was too small) or he was distracted, whereas in the three unwilling conditions E simply refused to transfer the food for a variety of reasons.

The nine different conditions were organized into three trios of conditions. Each trio contained one unwilling

condition and two unable conditions. The trios were formed based on the similarity of E's surface movements across conditions. Within each trio, E's looking behavior and body movements were highly similar, and the food was placed in identical locations as well. In each condition, E repeated or continued the action for 30 seconds. The three trios were the following:

(i). Tease trio (E alternated gaze between the food and the S's face; food moving back and forth):

Unwilling Tease: E held up a grape for the chimpanzee to see and then moved it toward the hole in the Plexiglas to transfer it to the chimpanzee. Once the chimpanzee attempted to take the grape with her lips or fingers, E pulled the grape back from the hole toward himself and looked up at the chimpanzee (the grape was held above a designated spot on the table).

Unable Clumsy: E held up the grape for the chimpanzee to see and moved it toward the hole in the Plexiglas to transfer it to the chimpanzee. However, when E tried to transfer the grape he accidentally dropped it after touching the chimpanzee's protruding mouth or finger or after hitting the Plexiglas panel above the feeding hole. The grape rolled down the ramp on the table toward E and E looked up at the chimpanzee.

Unable Blocked Hole: At the end of the motivational trial E quickly reversed the small Plexiglas panel so that it almost completely blocked the three feeding holes. E held up the grape for the chimpanzee to see and attempted to push the grape through the small hole left in the Plexiglas. After unsuccessfully trying to push the grape through, E pulled it back toward himself and looked up at the chimpanzee.

(ii). Refuse trio (E looked at S's face; food remained still):

At the beginning of this session a small (22 cm × 8 cm) opaque occluder was attached to the ramp on the table so that any grape that might roll down the ramp could be seen by the chimpanzees but not by E.

Unwilling Refuse: E placed a grape on top of the opaque occluder so that both chimpanzee and E could see the grape, and then E stared at the chimpanzee.

Unable Distracted: E placed a grape on top of the opaque occluder so that both chimpanzee and E could see the grape, and then E crossed his arms and vigorously scratched his arms, shoulders and back while staring at the chimpanzee.

Unable Can't See: While giving the last grape in a motivational trial, E surreptitiously dropped another grape so that it rolled under his arm into the opaque occluder (8 cm below the top of the container so that the chimpanzee could see the grape but E could not). E then stared at the chimpanzee.

(iii). Eat Trio (E looked down at what he was doing; food remained in front of E):

Table 2 *Example of testing order for each of the conditions in each of the three trios for the chimpanzee Ulla. Motivational trials (not shown) were interspersed between test trials*

	Session 1	Session 2	Session 3
Trial 1	Clumsy	Search	Distracted
Trial 2	Tease	Eat	Refuse
Trial 3	Blocked Hole	Stuck	Can't See
Trial 4	Clumsy	Search	Distracted
Trial 5	Tease	Eat	Refuse
Trial 6	Blocked Hole	Stuck	Can't See

In all of these trials E was holding a bucket of grapes between his legs.

Unwilling Eat: E took a grape from the bucket, bit off a small piece, and then held the grape just above the table surface for 4–5 seconds while continuing to chew while staring at the table.

Unable Search: E took a grape from the bucket and placed it on the table while looking at and searching inside the bucket with both hands in order to get more food.

Unable Stuck: E took a transparent plastic tube containing a trapped grape, held it over the table, and attempted to dislodge the grape by putting his finger into the tube, hitting the tube or shaking it slightly while staring at the tube.

Each subject received three test sessions, one for each trio (see Table 2). Test sessions took place on different days. Each session contained two trials per condition for a total of six test trials per session. Thus each subject received 18 trials in all. The order of the conditions was counterbalanced across subjects.

Scoring and analysis

All trials were videotaped and scored from the tape. We recorded two dependent measures during the 30 seconds of each test trial: behavioral rate and participation. Behavioral rate consisted of the frequency of relevant behaviors divided by the time the subject was in view of the camera. For instance, if during a trial the subject was in view 20 seconds and produced behavior A five times and behavior B once, the corresponding behavioral rate would be 0.3. The behaviors considered were those commonly used by chimpanzees to request food from humans. Thus they include a mixture of begging and assertive/coercive acts. In particular, we coded the following behaviors:

finger poking: the rate at which the chimpanzee put its finger(s) through any of the three feeding holes;
move apparatus: the rate at which the chimpanzee pushed the Plexiglas panel or wooden ramp on the table out of its normal position;

knocking: the rate at which the chimpanzee used any part of its body to make an audible noise by striking an object (e.g. by striking its hand against the Plexiglas panel). Vocalizations and hand clapping were not included because they appeared at very low rates.

Participation consisted of the amount of time the chimpanzee remained at the testing station (since they could leave any time during the trial because the doors were left open). We used the latency (in seconds) to leave the station once the trial had started.

A second coder, unaware of the study rationale and blind to the experimental conditions, scored 20% of trials to assess inter-observer reliability. Reliability was excellent (behavioral rate: Spearman $r = 0.97$; participation latency to leave: Spearman $r = 1.0$). In all analyses we used two-tailed Wilcoxon and Friedman tests.

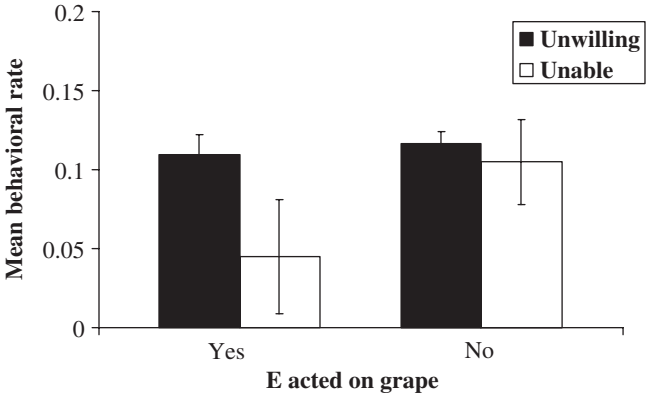

Figure 3 *Mean behavioral rate (SEM) for the unwilling and unable conditions as a function of whether E acted on the grape during the trial.*

Results

Behavioral rate

Overall, chimpanzees produced a higher behavioral rate in the unwilling than in the unable conditions (Wilcoxon T = 73, $N = 12$, $p = .008$; unwilling: mean = .11, SEM = .02; unable: mean = .08, SEM = .02). However, this was not the case equally across trios. Figure 2 presents the behavioral rate for each of the three trios separately. There were also significant differences across conditions in the Tease trio by itself (Friedman test = 17.64, df = 2, $p < .001$) and the Eat trio by itself (Friedman test = 10.17, df = 2, $p = .006$), but not in the Refuse trio (Friedman test = 1.27, df = 2, $p = .53$). Multiple comparisons within the Tease trio revealed that chimpanzees significantly increased their behavioral rate in the Unwilling Tease condition compared to the Unable Blocked Hole condition (Wilcoxon T = 66, $N = 11$, $p = .003$) but not the Unable Clumsy condition (Wilcoxon T = 48, $N = 11$, $p = .18$). Multiple comparisons within the Eat trio revealed that chimpanzees' behavioral rate was significantly higher in the Unwilling Eat condition than in the Unable Stuck condition (Wilcoxon T = 73, $N = 12$, $p = .008$) but not the Unable Search condition (Wilcoxon T = 55.5, $N = 12$, $p = .20$). Thus, in two of the three trios, chimpanzees had a higher behavioural rate in the unwilling condition than in one of the two unable conditions.

This pattern shows that differences were especially large when we distinguished between conditions in which E actually acted on the grape (i.e. Tease, Clumsy, Blocked Hole, Eat, Stuck), rather than just ignored it while he did something else (i.e. Refuse, Distracted, Can't See, Search; see Figure 3). There were significant differences between these two groups of conditions (Friedman test = 13.0, df = 3, $p = .005$). Pairwise comparisons revealed that chimpanzees produced more behaviors in the

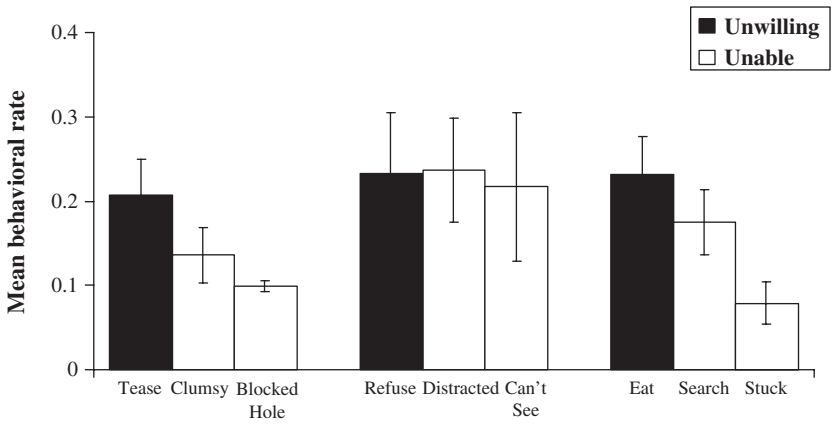

Figure 2 *Mean behavioral rate (SEM) for each of the three trios of conditions.*

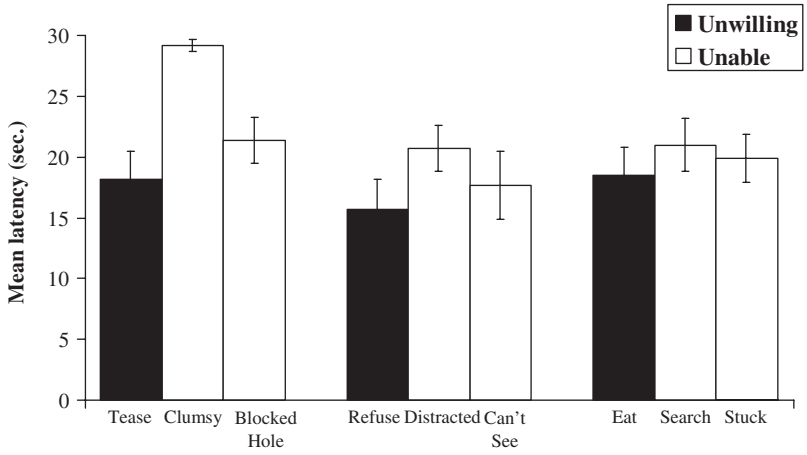

Figure 4 *Mean latency (SEM) to leave the testing station for each of the three trios of conditions.*

unwilling than in the unable conditions when E acted on the grape (Wilcoxon T = 78, $N = 12$, $p = .002$) but not when he did not act on the grape (Wilcoxon T = 43, $N = 12$, $p = .75$). Likewise chimpanzees produced more behaviors in those unwilling conditions in which E acted on the grape compared to those in which he did not (Wilcoxon T = 78, $N = 12$, $p = .002$).

Participation

Overall, chimpanzees left the testing station earlier in the unwilling than in the unable conditions (Wilcoxon T = 68, $N = 12$, $p = .023$; unwilling: mean = 17.5, SEM = 1.5; unable: mean = 21.7, SEM = 1.2). Once more, this was not the case equally across trios. Figure 4 presents the latency to leave the station for each of the three trios separately. There were significant differences across conditions in the Tease trio by itself (Friedman test = 12.76, df = 2, $p = .002$), but not in the Refuse (Friedman test = 2.4, df = 2, $p = .30$) or the Eat trios (Friedman test = 2.0, df = 2, $p = .37$). Multiple comparisons within the Tease trio revealed that chimpanzees left earlier in the Unwilling Tease condition compared to the Unable Clumsy condition (Wilcoxon T = 63, $N = 11$, $p = .008$) but not the Unable Blocked Hole condition (Wilcoxon T = 46, $N = 11$, $p = .25$). An analysis of other participation variables such as total time at the station produced identical results.

Again, differences were especially large when we distinguished between conditions in which E actually acted on the grape (i.e. Tease, Clumsy, Blocked Hole, Eat, Stuck), rather than just ignored it while he did something else (i.e. Refuse, Distracted, Can't See, Search). Figure 5 presents the mean latency to leave the station for the unwilling and unable conditions as a function of whether E acted on the grape during the trial. There

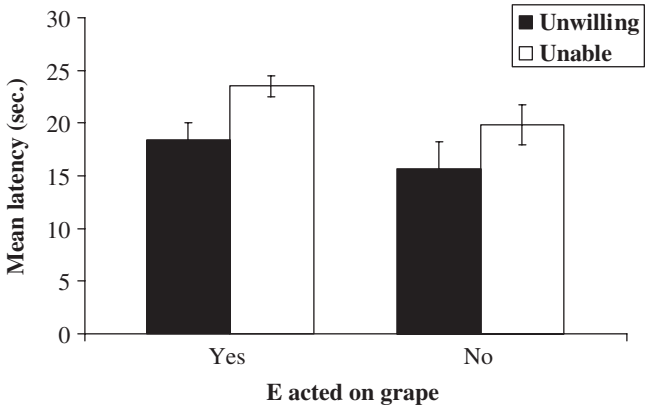

Figure 5 *Mean latency (SEM) to leave the testing station for the unwilling and unable conditions as a function of whether E acted on the grape during the trial.*

were significant differences between conditions (Friedman test = 9.66, df = 3, $p = .022$). Pairwise comparisons revealed that chimpanzees left earlier in the unwilling compared to the unable condition when E acted on the grape (Wilcoxon T = 77, $N = 12$, $p = .003$) but not when he did not act on the grape (Wilcoxon T = 45, $N = 10$, $p = .074$).

Discussion

Overall, chimpanzees produced more behaviors and left earlier in those conditions in which E was unwilling as opposed to unable to transfer the food. However, this difference in interpreting unwilling and unable actions existed only in those conditions in which E made contact with the food to be transferred.

This difference between unwilling and unable conditions was observed even within trios, in which E's looking

pattern and the movement pattern of the food were matched as closely as possible across conditions. Although surface behavioral cues such as the pattern of food motion or eye contact cannot easily account for these results, it is still possible that other factors may explain the differences between unwilling and unable conditions. One possibility is that instead of chimpanzees' differential behavior reflecting communicative attempts to change E's intention, the differences observed were simply the result of a general feeling of frustration at not receiving the food right away (e.g. knocking the Plexiglas) and/or simply reflected the chimpanzee's attempts to get the food on her own (e.g. finger-poking through the hole). This hypothesis could be tested by presenting a non-social condition in which E left the room after placing the grape on the platform. Alternatively, chimpanzees may have reacted to certain movements independently of what E was trying to achieve or what was happening to the grape. This could be tested by presenting the same movements with and without grapes. The next study was designed to address these two potential explanations.

Experiment 2

The purpose of this experiment was to establish with two control tests whether chimpanzees behaved the same way when some of the key elements in the situation – the presence of E or the presence of food – were removed. First, to assess whether the behaviors were directed at E for purposes of communication rather than being just the result of a frustrating situation, we used a non-social test in which we compared a condition in which E had left the room with the Unwilling Refuse and the Unable Can't See conditions from the previous study. The reason for choosing these two conditions was that they did not involve movements and therefore were the best matches for E not being present. Second, to assess whether the behaviors were interpreted the same way in the absence of food – that is, to test whether chimpanzees were responding based simply on something about E's bodily movements and not his goal-directed actions – we presented again three of the conditions that had produced clear results in the previous study (Unwilling Tease, Unable Clumsy and Unable Stuck) with and without food being involved.

Method

Participants

The same chimpanzees served as participants.

Procedure

The general procedure was identical to that of Experiment 1, with the only difference being the conditions tested:

(i). Social Control test

Unwilling Refuse: Same as Experiment 1.

Unable Can't See: Same as Experiment 1.

No Experimenter: E placed the grape on the platform as in the other conditions and then left the room for 30 seconds.

(ii). Food Control test

Unwilling Tease: Same as in Experiment 1.

No Food Tease: E performed the same actions (and gaze alternation) as in the Unwilling Tease condition but without a grape in his hand.

Unable Clumsy: Same as in Experiment 1.

No Food Clumsy: E performed the same actions (and gaze alternation) as in the Unable Clumsy condition but without a grape in his hand.

Unable Stuck: Same as in Experiment 1.

No Food Stuck: E performed the same actions (while staring at the tube) as in the Unable Stuck condition but without a grape inside the tube.

Half of the subjects received the Food Control conditions first and the other half received the Social Control conditions first. Each group of conditions was tested on a different day. Within a session chimpanzees received two trials of each condition, for a total of 12 test trials in the Food Control session and six test trials in the Social Control session. The order of conditions was counterbalanced across subjects. All trials were videotaped.

Scoring and analysis

Same as in Experiment 1. Inter-observer reliability (based on 20% of the trials) was excellent (behavioral rate: Spearman $r = .96$; participation latency to leave: Spearman $r = 1.0$).

Results

Social control test

Figure 6 presents the behavioral rate for each of the three conditions. There were significant differences across conditions (Friedman test = 8.58, df = 2, $p = .014$). Multiple comparisons across conditions revealed that chimpanzees' behavioral rate was significantly lower in the No Experimenter condition compared to the Unwilling Refuse (Wilcoxon T = 39, $N = 9$, $p = .051$) and the Unable Can't See (Wilcoxon T = 40, $N = 9$, $p = .038$) conditions. As in Experiment 1, there were no significant differences between

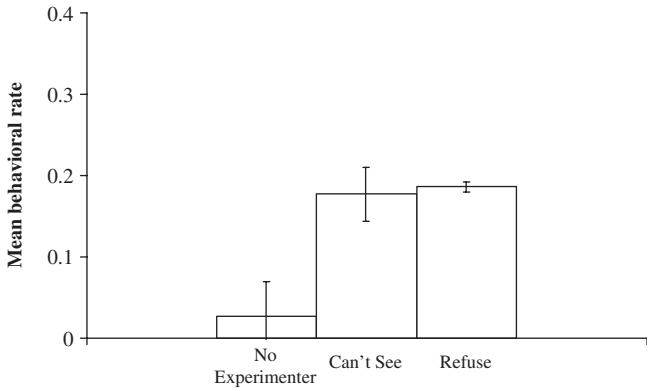

Figure 6 *Mean behavioral rate (SEM) for each of the conditions in the Social Control test.*

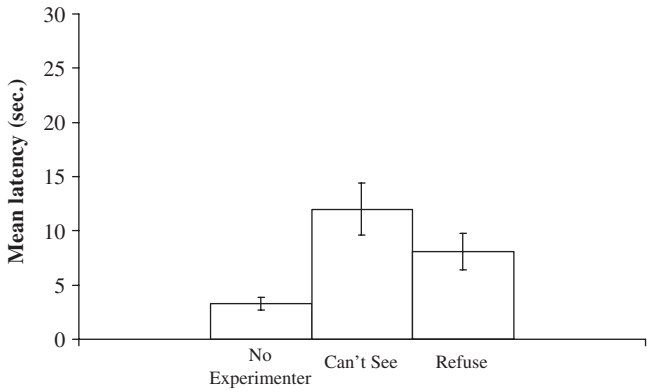

Figure 7 *Mean latency (SEM) to leave the testing station for each of the conditions in the Social Control test.*

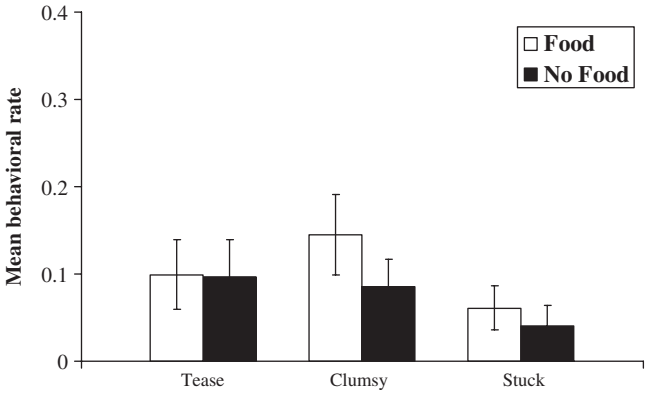

Figure 8 *Mean behavioral rate (SEM) for each of the conditions in the No Food Control test.*

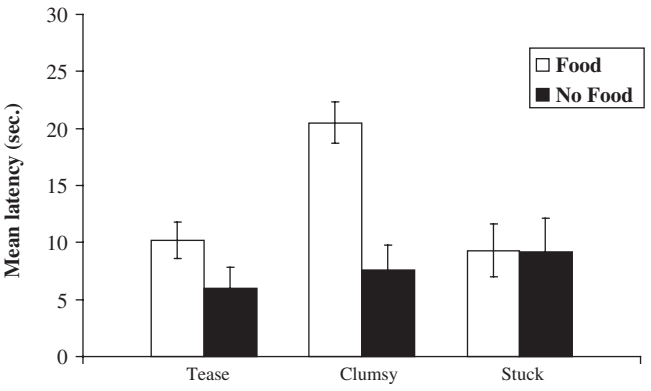

Figure 9 *Mean latency (SEM) to leave the testing station for each of the conditions in the No Food Control test.*

the Unwilling Refuse and Unable Can't See conditions (Wilcoxon T = 31, $N = 10$, $p = .72$). Thus, chimpanzees produced more behaviors when E was present.

Figure 7 presents the latency to leave the testing station across conditions. There were significant differences across conditions (Friedman test = 11.49, df = 2, $p = .003$). Pairwise comparisons revealed that chimpanzees left earlier in the No Experimenter condition compared to the Unwilling Refuse (Wilcoxon T = 48, $N = 10$, $p = .037$) and Unable Can't See (Wilcoxon T = 65, $N = 11$, $p = .004$) conditions. As in Experiment 1, there were no significant differences between the Unwilling Refuse and Unable Can't See conditions (Wilcoxon T = 51, $N = 11$, $p = .11$).

No Food control test

Figure 8 presents the behavioral rate for each of the six conditions in this test. There were no significant differences across conditions (Friedman test = 9.0, df = 5, $p = .11$).

Figure 9 presents the latency to leave the testing station across conditions. There were significant differences across conditions (Friedman test = 26.03, df = 5, $p < .001$). Pairwise comparisons within each pair revealed that chimpanzees left earlier in the absence of food than when food was present for the Unwilling Tease (Wilcoxon T = 56, $N = 11$, $p = .04$) and the Unable Clumsy (Wilcoxon T = 66, $N = 11$, $p = .003$) conditions but not for the Unable Stuck condition (Wilcoxon T = 23, $N = 9$, $p = .95$). Thus, in two of the three conditions tested, chimpanzees left earlier when E acted without food. Focusing on the food conditions, as a replication of Experiment 1, there were significant differences across conditions (Friedman test = 15.40, df = 2, $p < .001$). Pairwise comparisons revealed that, as in Experiment 1, chimpanzees left earlier in the Unwilling Tease condition compared to the Unable Clumsy condition (Wilcoxon T = 66, $N = 11$, $p = .003$). There were no differences between the Unwilling Tease and the Unable Stuck conditions (Wilcoxon T = 37, $N = 11$, $p = .72$).

Discussion

With the conditions that were identical across Experiments 1 and 2, we replicated our previous results. More interestingly, the Social control test showed that chimpanzees produced less behaviors and left earlier when E had left the room than in those conditions in which E remained in the room. This suggests that in Experiment 1 their behavior was directed at E, and it is unlikely that the chimpanzees' responses were solely a result of frustration or an attempt to reach the food on their own. Instead, we argue that chimpanzees' responses constituted communicative attempts to encourage E to transfer the grape similar to those reported in previous studies (Call & Tomasello, 1994; Leavens & Hopkins, 1998).

Furthermore, the No Food control test showed that chimpanzees left earlier in the no-food than the food condition in two of the three conditions investigated. There were no differences in the mean behavioral rate across conditions with or without food, however. Thus this test offered partial support to the idea that the results of Experiment 1 were not solely based on the use of certain movements independently to what E was trying to achieve or what was happening to the grape.

General discussion

The current study provides suggestive evidence that chimpanzees spontaneously (i.e. without training) are sensitive to others' intentions. Observing the behavior of a human not giving them food, chimpanzees demonstrated in their spontaneous behavior that they recognized a difference between cases in which he was not giving food because he was unwilling to or because, for various reasons, he was unable to. Chimpanzees thus did not just perceive others' behavior, they also interpreted it. They did this with no training of any kind, and despite the fact that E's gazing pattern was identical within trios and with a variety of behaviors indicating that E was unwilling or unable, thus making discrimination on the basis of specific superficial cues highly unlikely. Control tests suggested that chimpanzees were trying to influence E's behavior with communicative gestures and were not responding solely as a result of frustration or expectation.

It is notable that the findings were especially strong for those individual experimental conditions in which E directed an overt behavior of one kind or another to the food (i.e. as opposed to conditions in which he did not touch the food). It is thus possible that chimpanzees understand intentions most readily when they are more or less directly perceivable in behavior – for example, through signs of effort, frustration, accident and so forth – what Searle (1983) calls 'intention in action'. Although certain actions such as those in which the experimenter acted on the grape may be especially important to infer intentions, the presence of these actions alone cannot be the whole explanation for the differences between unwilling and unable conditions. Note that in some cases the experimenter acted on the grape both in unwilling and unable conditions and subjects still reacted differently across conditions (see Figure 3). Chimpanzees may or may not understand the intentions of others when these can only be discerned more indirectly – what Searle calls 'prior intention'. Alternatively, it could be that chimpanzees perceived E's behavior in the unable conditions in which he did not act on the grape as unwilling instead of unable. That is, in the Distracted and Search conditions, E conceivably could have stopped scratching or searching just for a moment to give the chimpanzee the grape, and in the Can't See condition if E did not see the concealed grape, he should have moved on to the next trial. It would be interesting to test other unable conditions in which E does not touch the grape but is truly unable to give it, for example because his arms have been tied to his sides by an assistant. Future studies of apes' understanding of others' prior intentions are also needed.

Because chimpanzees only discriminated between unwilling and unable conditions when E acted on the food, there is a possible alternative explanation that does not involve understanding of others' intentions. Perhaps chimpanzees had learned from their previous experience to expect that certain actions usually result in them receiving food and certain actions usually result in them not receiving food (Behne, personal communication). For example, normally after humans drop a piece of food on the way to giving it to the chimpanzee, they pick it up and give it to the chimpanzee, whereas normally when humans are eating they do not share their food with the chimpanzee. Based on their perception of the human's action, chimpanzees thus might be more patient in the first instance and more likely to leave or beg for the food in the second instance, simply based on their expectation of the probability of receiving food. However, if chimpanzees were using their previous experience of E's actions to decide how to react, they would have had to have a separate learning history for each of the five conditions in which they discriminated successfully. This is unlikely because some conditions, at least, arguably were novel to the chimpanzees and because these chimpanzees had little experience with experimenters or testing situations in general because they were new to the facility. Note that chimpanzees could not have developed such an expectation during the test because they were not differentially rewarded in the experimental conditions and there was no training involved.

Another possibility is that chimpanzees were reacting to the physical constraints of the situation rather than the mental states of the experimenter. For instance, chimpanzees may have reacted to whether the action of the experimenter to get them the grape was impeded by some physical barrier. This could explain the difference between the Tease and Blocked Hole conditions and the Eat and Stuck conditions. In both unable conditions (Blocked Hole and Stuck), the grape could not be transferred to the chimpanzee because there was a physical barrier (a hole which was too small or a plastic tube) that prevented the grape's free movement. However, this explanation cannot account for all our results because (1) counterintuitively, subjects stayed *longer* when the path of the reward was blocked in the unable conditions and (2) subjects still left 11 seconds earlier in the Tease compared to the Clumsy condition even though there was no barrier blocking the path of the reward in either condition.

We believe that chimpanzees were using the actions of the experimenter not just as superficial discriminative cues but as a way to determine his goal. This is analogous to Whiten's (1994) invocation of the notion of intervening variable to explain disparate behavioral acts with an underlying mental cause. Goal would be the intervening variable governing the expression of those superficial cues. Whether 'goal' refers to a physical target (food in the mouth of the chimpanzee), a mental desired end state of affairs (E wants the chimpanzee to have the food), or an intention understood as a plan of action (E is trying to give the food to the chimpanzee) is a question that deserves further study. That is, intentions but not goals involve the actor's actions, and specifically the knowledge that the actor can choose one means among several possible means to achieve an end (Piaget, 1952; Tomasello, 1999). Note that Meltzoff (1995) also called attention to similar distinctions when discussing his results with 18-month-old children. In the current study, we believe that chimpanzees are using more than a superficial understanding of E's physical goal but we cannot determine from this study whether they have an understanding of E's mental goal or intention. In the unable conditions we believe that chimpanzees waited longer and gestured less frequently because they believed that E would continue to act until the transfer of the food was achieved. In the conditions in which E acted on the grape, he used slightly different means (e.g. in the Blocked Hole condition he first tried to insert the grape with one hand position and then rotated his hand or used more force with his further attempts), so this information was available to chimpanzees. To adult humans, this type of action would appear more unable/intentional/goal-directed than repeatedly pushing the grape into the hole with the exact same movements. Further study of different levels of understanding of intentions (including prior intentions and communicative intentions; Tomasello, 1999) is needed in chimpanzees, children and other animals.

In sum, the current study suggests that chimpanzees do not simply perceive the behavior of others, they also interpret it. In particular, they can distinguish between an experimenter that is either unwilling or unable to give them food. These data together with recent studies on chimpanzees' knowledge about what others can or cannot see (Hare, Call, Agnetta & Tomasello, 2000; Hare, Call & Tomasello, 2001; see also Suddendorf & Whiten, 2001) show that chimpanzees have more knowledge about some psychological states of others than previously believed by some authors (Heyes, 1998; Povinelli & Eddy, 1996; Tomasello & Call, 1997) and answers the call for more experimental evidence on this topic made by others (Whiten & Byrne, 1991). Currently, the debate on this issue is still open (see Povinelli & Vonk, 2003, and Tomasello, Call & Hare, 2003a, 2003b, for a recent discussion). Future studies should be devoted to pinpointing the level of sophistication of each of these types of social-cognitive understanding and to charting apes' knowledge about other mental states such as belief, desire and attention that fall under the umbrella of theory of mind research.

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