PAPER

'Unwilling' versus 'unable': capuchin monkeys' (*Cebus apella*) understanding of human intentional action

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Abstract

A sensitivity to the intentions behind human action is a crucial developmental achievement in infants. Is this intention reading ability a unique and relatively recent product of human evolution and culture, or does this capacity instead have roots in our non-human primate ancestors? Recent work by Call and colleagues (2004) lends credence to the latter hypothesis, providing evidence that chimpanzees are also sensitive to human intentions. Specifically, chimpanzees remained in a testing area longer and exhibited fewer frustration behaviors when an experimenter behaved as if he intended to give food but was unable to do so, than when the experimenter behaved as if he had no intention of giving food. The present research builds on and extends this paradigm, providing some of the first evidence of intention reading in a more distant primate relative, the capuchin monkey (Cebus apella). *Like chimpanzees, capuchin monkeys distinguish between different goal-directed acts, vacating an enclosure sooner when an experimenter acts unwilling to give food than when she acts unable to give food. Additionally, we found that this pattern is specific to animate action, and does not obtain when the same actions are performed by inanimate rods instead of human hands (for a similar logic, see Woodward, 1998). Taken together with the previous evidence, the present research suggests that our own intention reading is not a wholly unique aspect of the human species, but rather is shared broadly across the primate order.*

Introduction

Adult humans have an astonishing capacity to deduce the contents of each other's minds. We infer thoughts, attitudes, and intentions, and this leads to our expectations about future behavior. Over the past decade, infant cognition researchers have begun to investigate when and how these abilities develop. This work has revealed that infants acquire at least one of these abilities – a sensitivity to the goals and intentions of other agents – by the time they reach around 1 year of age (see Saxe, Carey & Kanwisher, 2004; Tomasello, Carpenter, Call, Behne & Moll, 2005; Woodward, Sommerville & Guajardo, 2001). More specifically, young infants distinguish between different entities, depending on the cues to animacy (e.g. Corkum & Moore, 1998; Johnson, Booth & O'Hearn, 2001; Johnson, Slaughter & Carey, 1998; Tronick, Als, Adamson, Wise & Brazelton, 1978). By 10 months, infants begin to expect humans and other agents to behave in goal-directed ways (Behne, Carpenter, Call & Tomasello, 2005; Csibra, Biro, Koos & Gergely, 2003; Csibra, Gergely, Biro, Koos & Brockbank, 1999; Gergely & Csibra, 1997; Gergely, Nadasdy, Csibra & Biro, 1995;

Kuhlmeier, Wynn & Bloom, 2003; Premack & Premack, 1997; Woodward, 1998; Woodward *et al.*, 2001). Woodward (1998), for example, habituated infants to a hand reaching for one of two objects, such as a ball on the left and a teddybear on the right. She then generated test displays in which the objects swapped locations. Infants look longer at displays in which the hand reached for the repositioned original object, than when the hand reached for the novel object in the previous location. In contrast, when shown the same sequence of actions with a rod instead of a hand, infants appear to encode the display in terms of mechanical trajectory, rather than goals (Woodward, 1998; Woodward *et al.*, 2001). Taken together, this body of research suggests that infants are sensitive to the goals and intentions of others.

The crucial role that intention reading plays in human development, and more broadly in adult human societies, has led many researchers to investigate the evolutionary history of this capacity. Despite decades of research, there was until quite recently little experimental evidence of intention reading in other primates (e.g. Povinelli, Bering & Giambrone., 2000; Tomasello & Call, 1997). More recent research, however, calls this pattern into question (for a review, see Tomasello, Call & Hare, 2003).

In one study, Call, Hare, Carpenter and Tomasello (2004) explored whether chimpanzees (*Pan troglodytes*) could discriminate between different human intentional states. They presented chimpanzees with situations in which an experimenter acted as if he did not intend to give food, or as if he did intend to give food, but was unable to do so. The chimpanzees exhibited more frustration behaviors and left the testing area sooner when confronted with an *unwilling* experimenter, who behaved as if he had no intention of giving a treat, than when confronted with an *unable* experimenter.

This study provides the best evidence to date that at least one non-human primate, the chimpanzee, is sensitive to human intentions. Unfortunately, these positive results must be interpreted with some caution. For one, despite the magnitude of the overall effects, significant differences were obtained only in the first and last trio of experimental trials, and significant differences in staying time were obtained only between the first and second segments of the first trio. These features of chimpanzee performance leave open the possibility that chimpanzees in this task may have attended to features other than the experimenter's intentional actions when deciding how long to remain in the testing area. Furthermore, the question remains as to whether intention reading is unique to humans and chimpanzees, or is more broadly distributed in the primate lineage. For these reasons, we chose to extend this paradigm to captive capuchin monkeys (*Cebus apella*), a much more distantly related primate, and borrowed some methods from infant cognition research to more carefully tease apart intentional and mechanistic explanations of primate performance.

Experiment 1

In Experiment 1, we chose to replicate the conditions in which Call and colleagues (2004) achieved their most robust staying time effects, this time with capuchin monkeys instead of chimpanzees. As in the previous research, an experimenter faces the participant through plexiglass and offers food. When the monkey reaches for the reward, the experimenter behaves as if she is either unwilling or unable to give it.

Methods

Participants

We tested six socially housed capuchin monkeys (see Table 1).

Apparatus

During testing, a monkey was moved from the main social cage and isolated in a smaller holding enclosure ($3 \times 3 \times 1$ m), which was attached to a smaller testing

Table 1 *Subject information for monkeys tested in Experiments 1–4*

Monkey	Sex	Age	Rearing history	Tested in
Felix Leiter	M	Adult	Mother-reared	Expts 1–4
NickNack	M	Adult	Mother-reared	Expts 1–4
Auric Goldfinger	M	Adult	Mother-reared	Expts 1–4
Jill Masterson	F	Adult	Mother-reared	Expts 1–4
MayDay	F	Adult	Mother-reared	Expts 1–4
Holly Goodhead	F	Adult	Mother-reared	Expts 1–4
James Bond	M	Juvenile (2 yrs)	Mother-reared	Expt 4

enclosure (0.8 m^3). The monkey could reach through a large hole (6 cm diameter) in the front wall of the testing enclosure. There was also a small hole in the front of the testing enclosure (1 cm in diameter). Finally, there was a ramp underneath the large reach hole declined away from the hole (40 cm long $\times$ 10 cm wide $\times$ 10 cm high at the top of the ramp); the full length of the ramp was visible to the monkey.

Procedure

Sessions began when a monkey was isolated in the testing enclosure. The experimenter stood facing the participant, such that her outstretched hand was just beyond the monkey's reach (roughly 35 cm). Each monkey received just one session. At the start of each session, the experimenter gave the monkey two grapes, one at a time. Each monkey then received three test trials in random order – *unwilling-tease*, *unable-ramp*, and *unable-blocked hole* – as described below.

Unwilling-tease:
The experimenter held out a grape. When the monkey reached for it, the experimenter pulled it away. The experimenter then repeated this sequence.

Unable-ramp:
The experimenter held out a grape. When the monkey reached for it, the experimenter dropped the grape on the ramp and it rolled away from the monkey. The experimenter then retrieved the grape and repeated the sequence.

Unable-blocked hole:
The experimenter held the grape up to the small hole, but when the monkey reached for it, the blocked hole was too small to get the grape.

The experimenter repeated the action until the monkey left the testing area. The next trial began as soon as the monkey re-entered the testing area, generally within a minute of the end of the previous trial.

Coding

All trials were acquired digitally using iMovie software and we measured the amount of time that monkeys
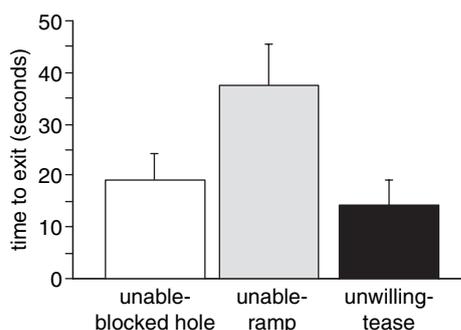
Figure 1 *Mean amount of time (± standard error) monkeys remained inside the testing box across conditions during Experiment 1.*

took to leave the testing area[1]. Coding began when the experimenter first pulled the treat away from the participant and ended as soon as some part of the monkey's body crossed the threshold of the exit. A second coder who was blind to the experimental hypothesis then recoded all trials for reliability ($r = 0.997$).

Results

We performed a repeated measures ANOVA with condition (unable-blocked hole, unable-ramp, and unwilling-tease) as factors. We observed a significant main effect of condition ($F(2, 10) = 9.69$, $p = .005$). Planned comparisons revealed that monkeys left the testing area sooner in the unwilling-tease condition ($M = 14.37$ s $\pm$ $SE = 4.6$ s) than in the unable-ramp condition ($M = 37.5$ s $\pm$ $SE = 8.2$ s; $t(5) = 3.54$, $p = .02$) (see Figure 1). Non-parametric statistics confirmed the pattern of results (Wilcoxon Signed Rank: $Z = 2.20$, $p = .03$). Additionally, like Call and colleagues (2004), we did not observe a significant difference between the unwilling-tease ($M = 14.37$ s $\pm$ $SE = 4.6$ s) and unable-blocked hole conditions ($M = 19.0$ s $\pm$ $SE = 5.5$ s; $t(5) = 1.51, p = .19$).

Discussion

As predicted, monkeys left the testing area sooner in the unwilling-tease condition than in the unable-ramp condition, when the experimenter appeared to accidentally drop the food. In addition, like Call and colleagues (2004), we did not find a significant difference between the unwilling-tease condition and the unable-blocked hole condition. The results of Experiment 1 are remarkably consistent with the results of Call and colleagues (2004).

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[1] The rate of frustration behaviors, such as banging on the glass, was so low that it did not warrant coding, thus, we measured only the amount of time the monkeys took to leave the testing area.

One possible objection to Experiment 1, and to Call and colleagues' (2004) tease trio data, is that the effects could have been due to the monkeys' sensitivity to physical differences in the actions of the experimenters, as opposed to differences in the intentions of the human experimenter. For example, the unwilling action involved an experimenter rapidly pulling away food with his hand, whereas the two unable conditions did not. In Experiment 2, we countered this objection by constructing unwilling and unable conditions *in which the repeated physical actions were more similar*. Specifically, we presented monkeys with unwilling and unable conditions that both included a human hand offering and then rapidly pulling away food, predicting again that they would leave sooner in the unwilling condition.

Experiment 2

Methods

Participants

We tested the same six capuchin monkeys. Though Experiment 1 is here presented first for clarity, Experiment 2 was conducted 16 months before Experiment 1.

Apparatus

We used the same set-up as in Experiment 1, except that the small hole and the ramp were not used.

Procedure

Sessions began when a monkey was isolated in the testing enclosure. Each monkey received exactly two sessions, on separate days. One experimenter stood in front of the enclosure facing the monkey, such that her hand was just out of reach when outstretched (35 cm). A second experimenter stood shoulder to shoulder, to the right of the first experimenter, oriented towards her at an angle of 45 degrees (see Figure 2). At the start of each session, the first experimenter gave the monkey two raisins, one at a time. Monkeys then received two test trials – an *unwilling trial* and an *unable trial* – in a counterbalanced order, for a total of four trials per monkey.

Unwilling:
The first experimenter held out a raisin, but when the monkey reached for it, the experimenter pulled it away.

Unable:
The first experimenter held out a raisin, but when the monkey reached for it, the second experimenter snatched it from the first experimenter's hand and pulled it away.

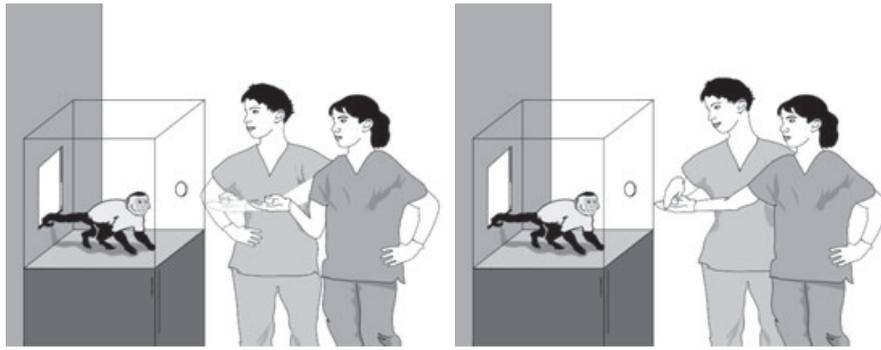The experimenters repeated each action until the monkey left the testing area.

Figure 2   *A depiction of unwilling (left) versus unable (right) test events in Experiment 2.*

Coding

Data were coded as in Experiment 1. A second coder who was blind to the experimental hypothesis then recoded all trials ($r = 0.996$).

Results

As predicted, monkeys left the testing area sooner in the unwilling condition ($M = 10.26$ s $\pm$ $SE = 1.47$ s) than in the unable condition ($M = 35.19 \pm SE = 8.43$ s; $F(1, 5) = 15.06$, $p = .006$) (see Figure 3). Non-parametric Wilcoxon signed rank tests confirmed this pattern ($Z = 3.06$, $p = .01$). We also observed a significant main effect of session number ($F(1, 5) = 26.17$, $p = .002$). Monkeys spent less time in the testing area in their second session than in their first, suggesting a general decline in monkeys' inclination to participate over time. Additionally, we observed an interaction between session number and test condition ($F(1, 5) = 8.06$, $p = .02$). This interaction indicates that the magnitude of the difference between unwilling and unable conditions declined in the second session relative to the first.

Discussion

Participants left the testing area more than three times as quickly in the unwilling than the unable condition. Like chimpanzees, capuchins seem to be sensitive to an experimenter's intentions when determining how long to wait for food. Although Experiment 2 was designed to

Figure 3   *Mean amount of time (± standard error) monkeys remained inside the testing box during Experiment 2.*

make the unable and unwilling actions more similar, the actions did differ physically, therefore the effects could be due to physical rather than intentional differences between the conditions. We dealt with this objection in Experiment 3 by performing similar actions as in Experiment 2, but, following Woodward (1998), *varying whether the actions were performed by animate actors or inanimate objects.* The experimenters performed the actions from behind curtains using either hands or sticks. If previous results were due just to differences in physical motions, then we would expect monkeys to perform similarly in both hand and stick conditions. In contrast, if the results were due to differences in the experimenter's intentions as we predicted, monkeys should distinguish between unwilling and unable actions for hands, but not when the same repeated actions are performed with sticks.

Experiment 3

Methods

Participants

The same six capuchins participated. This experiment was conducted approximately 4 months after the completion of Experiment 2.

Apparatus

We used the set-up of Experiment 2 with a few changes (see Figure 4). First, both experimenters were concealed behind black curtains (2 m high × 0.5 m wide), with 10 cm slits for reaching through. The shafts of the sticks were composed of wooden dowels (0.5 m long × 2 cm diameter). We attached a yellow plastic spoon to the end of the first experimenter's stick, which she used to offer and pull away food. The second experimenter's stick had a magnet on the end, which she used to steal magnetized objects from the first experimenter. Using fluff as an adhesive, we attached steel washers to the underside of each marshmallow so that the second experimenter could steal the marshmallows with her magnet stick.
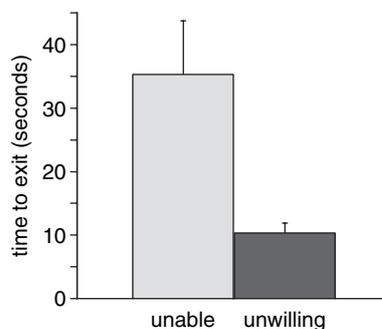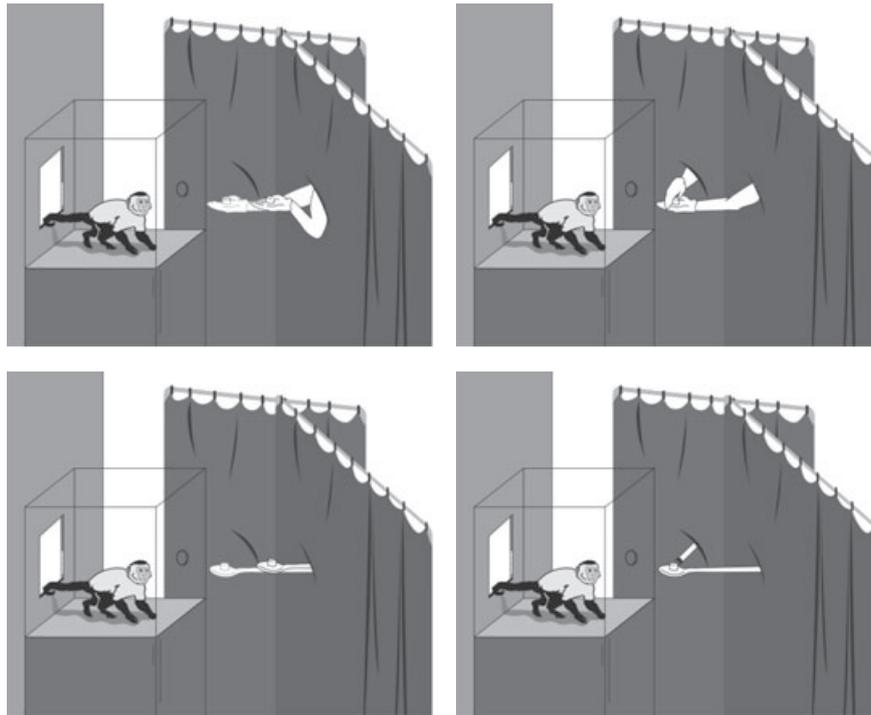
Figure 4 *A depiction of hand unwilling (top left), hand unable (top right), stick unwilling (bottom left), and stick unable (bottom right) test events in Experiment 3.*

Procedure

Each session began with two experimenters standing in front of the testing area, concealed behind the curtains (see Figure 4). Each monkey received exactly one *hand session* and one *stick session*, never on the same day. In order to prevent the monkeys from knowing about the concealed experimenters, the curtains and the experimenters were moved into position by the cameraman.[2] Additionally, the experimenters maintained complete silence while behind the curtains. By putting their faces close to the curtains, the experimenters could see through the fabric well enough to perform the experimental actions without being seen. The experimenters put either their hands or their sticks through the slots in the curtains and then concealed them behind the curtains again for every offer.

At the start of each session, the first experimenter gave the monkey two raisins, one at a time, using either her hand or her stick, depending on the condition. Monkeys then received two test trials: an *unwilling trial* and an *unable trial*. Both the order of the unwilling and unable trials in each session and the order of the hand and stick sessions were partially counterbalanced across monkeys, resulting in four test trials per monkey.

[2] We reasoned that if the experimenters had moved their own curtains into position, the monkeys might plausibly have inferred from this self-propelled motion that there were in fact humans behind the curtains. For this reason, we had both curtains moved into the testing room by the cameraman.

Hand unwilling: The first experimenter held out a marshmallow through the curtain using her hand, but when the monkey reached for it, the experimenter quickly pulled it back behind the curtain.

Hand unable: The first experimenter reached through her curtain with a marshmallow in her hand. When the monkey tried to take the marshmallow, the second experimenter reached her hand through the curtain, snatched the marshmallow from the first experimenter, and then she pulled it back behind the curtain.

Stick unwilling: The first experimenter held out a marshmallow through the curtain using her spoon stick, but when the monkey reached for it, she pulled it back behind the curtain.

Stick unable: The first experimenter held out a marshmallow through the curtain with her spoon stick. When the monkey tried to take the marshmallow, the second experimenter snatched the marshmallow from the first experimenter using her magnet stick, and pulled it back behind the curtain.

As before, the actions were repeated until the monkey left the testing area. The order of session type (hand or stick) and trial (unable or unwilling) was pseudo-randomized across monkeys.

Results

We observed a significant interaction between hand/stick and unwilling/unable ($F(1, 5) = 4.14$, $p = .05$) – as predicted, participants left the testing area sooner in the unwilling condition ($M = 16.06$ s $\pm$ $SE = 11.6$ s)

than in the unable condition ($M = 27.21$ s $\pm$ $SE =$ 12.1 s) for human hands ($t(5) = 2.49$, $p = .03$), but not for sticks ($M = 12.40$ s $\pm$ $SE = 1.4$ s vs. 14.42 ± 2.55 s; $t(5) = 1.00$, $p = .18$) (see Figure 5). Non-parametric statistics confirmed the pattern of results observed in the hand condition ($Z = 1.99$, $p = .02$). We also observed an overall main effect of unwilling/unable ($F(1, 5) = 6.16$, $p = .03$). Collapsed across hand and stick conditions, participants stayed in the testing area longer during unable conditions than unwilling.

Discussion

As predicted, the monkeys left the testing area sooner for an unwilling human hand than an unable hand, but they did not display this pattern for sticks performing similar actions. Since the physical motions were matched between the hand and stick conditions, the results of Experiment 3 suggest that participants distinguished between the unwilling and unable conditions based not on simple physical motions, but instead on a sensitivity to the willingness with which the experimenter attempted to give the food. The results of Experiment 3 further suggest that capuchins have some sensitivity to the types of objects that count as agents. The monkeys showed no sensitivity to intentions when sticks (not humans) were involved in the action. This finding suggests that, like human infants (Meltzoff, 1995; Woodward, 1998), capuchins spontaneously distinguish between objects that can act intentionally, such as human hands, and those that cannot, such as sticks.

One possible objection to our interpretation is that the difference observed between the hand and stick conditions was not due to the monkeys' sensitivity to intentions, but was instead caused by a fear of sticks. There are two reasons to reject this alternative. First, the monkeys had no difficulty taking raisins from the stick at the start of each stick session. Second, there was no significant difference in overall staying times between hand and stick sessions.

Another objection to both Experiments 2 and 3 is that perhaps the active involvement of two animate actors is more interesting to capuchin monkeys (whereas the active involvement of two sticks is not). We test this alternative in Experiment 4 by varying the number of experimenters involved in an action without varying their intentions with respect to the monkey. Specifically, we presented monkeys with events in which either one experimenter or two experimenters acted unwilling to give food. If the monkeys performed as they did in Experiments 2 and 3 because they were more interested in two actors than in one, then they should stay longer in the latter condition of Experiment 4. In contrast, if the results were instead due to the differences in intentions across the unwilling and unable conditions, then the monkeys should remain in the testing area for an equal duration between conditions when those intention differences are removed.

Experiment 4

Methods

Participants

We collected data on the original six monkeys plus a juvenile male whom we judged old enough to participate by the time this experiment began. This experiment was conducted approximately 4 months after the completion of Experiment 1.

Apparatus

We used the same set-up as in Experiment 2.

Procedure

Each session began with two experimenters facing the monkey. The first experimenter then gave two raisins, one by one, to the monkey. We then presented monkeys with two trials in counterbalanced order: a *one experimenter trial* and a *two experimenter trial*.

One experimenter:
The first experimenter held a raisin in his right hand, beyond the reach of the monkey. The experimenter repeatedly passed the raisin back and forth between his hands.

Two experimenters:
The first experimenter held a raisin in his right hand, beyond the reach of the monkey. The second experimenter took the raisin from the first experimenter's hand, then the first experimenter took back the raisin, and they repeated these actions until the monkey left the testing area.

Each monkey received two sessions of two test trials per session, both in counterbalanced order, resulting in four test trials per monkey.
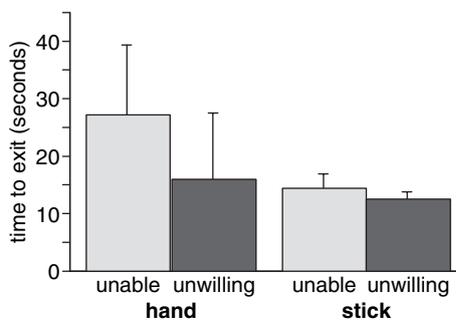

Figure 5 *Mean amount of time (± standard error) monkeys remained inside the testing box across session conditions during Experiment 3.*
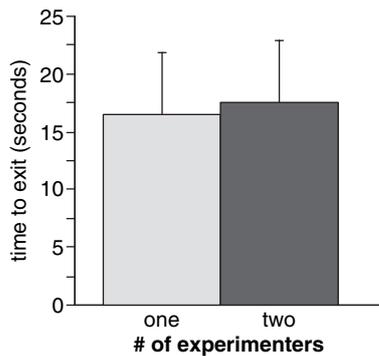
Figure 6 *Mean amount of time (± standard error) monkeys remained inside the testing box during Experiment 4.*

Results

We performed a repeated measures ANOVA with condition (one experimenter vs. two experimenters) and order (one experimenter first or two experimenters first) as factors. As predicted, we observed no main effect of condition ($F(1, 6) = 2.03$, $p = .20$). Monkeys remained in the testing area for approximately the same duration on one experimenter ($M = 16.52$ s $\pm$ $SE = 5.4$ s) and two experimenter trials ($M = 17.60$ s $\pm$ $SE = 5.3$ s) (see Figure 6). We did observe an interaction between condition and order ($F(1, 6) = 10.77$, $p = .02$); irrespective of condition, monkeys left sooner on their second trial in each session than they did on the first trial of each session.

Discussion

In Experiment 4, we presented monkeys with test trials that differed in terms of how many experimenters were involved (one vs. two), but were identical with respect to the intention being conveyed – both test trials involved experimenters who were unwilling to give food. As predicted, we found no difference in staying time between the one experimenter and two experimenter conditions. This rules out the hypothesis that the number of experimenters involved is sufficient to produce the effects of the previous experiments. In combination with the results of the previous experiments, this suggests that capuchin monkeys are sensitive to human intentions.

General discussion

Across three different experiments, capuchin monkeys distinguished between human experimenters with different intentional states, leaving the testing area sooner for an experimenter who behaved as if she was unwilling to share food than for one who behaved as if she was willing but unable to share food. Crucially, this unwilling/unable difference occurred only in situations in which it was appropriate to ascribe intentions: in Experiment 3, monkeys left the testing area sooner in the

unwilling condition when the experiment was performed with human hands, but not when the same actions were conducted with sticks. In addition, our studies further suggest that capuchins are sensitive to what counts as an appropriate intentional agent – what kinds of entities can and cannot act intentionally. Like human infants (Woodward, 1998), capuchins distinguish between intentional agents and unintentional objects – they recognize that human hands can act intentionally, but sticks cannot.

The present results fit with an emerging view that primates show success on theory of mind problems when tested with more ecologically relevant competitive tasks (e.g. Hare & Tomasello, 2004; Flombaum & Santos, 2005; Santos, Nissen & Ferrugia, 2006). For example, there is evidence using these competitive paradigms that the Rhesus monkey (*Macaca mulatta*), an Old World monkey and close relative to humans, is sensitive to what others see (Flombaum & Santos, 2005) and know (Santos *et al.*, 2006). The recent success of these competition experiments makes adaptive sense, as competition among conspecifics is surely a driving force in primate evolution. However, our results are unique in that previous experiments with captive capuchins have produced negative results (e.g. Hare, Addessi, Call, Tomasello & Visalberghi, 2003).

Our results suggest that, like humans (Behne *et al.*, 2005) and chimpanzees (Call *et al.*, 2004), capuchin monkeys are sensitive to the intentional actions of others. Additionally, we provide the first evidence that capuchin monkeys correctly attribute intentional actions to agents but not to inanimate objects. These findings provide some of the most compelling evidence to date that some aspects of human mind-reading are primitive not just developmentally, but evolutionarily as well.

Acknowledgements

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