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FAST-TRACK REPORT

Enculturated chimpanzees imitate rationally

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Abstract

*Human infants imitate others' actions 'rationally': they copy a demonstrator's action when that action is freely chosen, but less when it is forced by some constraint (Gergely, Bekkering & Király, 2002). We investigated whether enculturated chimpanzees (*Pan troglodytes*) also imitate rationally. Using Gergely and colleagues' (2002) basic procedure, a human demonstrator operated each of six apparatuses using an unusual body part (he pressed it with his forehead or foot, or sat on it). In the Hands Free condition he used this unusual means even though his hands were free, suggesting a free choice. In the Hands Occupied condition he used the unusual means only because his hands were occupied, suggesting a constrained or forced choice. Like human infants, chimpanzees imitated the modeled action more often in the Hands Free than in the Hands Occupied condition. Enculturated chimpanzees thus have some understanding of the rationality of others' intentional actions, and use this understanding when imitating others.*

Introduction

From before their first birthdays human infants understand some basic aspects of intentional action. For example, they understand that others act in object-directed ways (Woodward, 1998, 2003) and that others persist in pursuing their goals when they are not achieved, as in the case of failed attempts or accidents (Behne, Carpenter, Call & Tomasello, 2005). By 12 months of age, infants use this understanding of others' goals when they imitate, copying others' actions selectively according to their goals (e.g. Carpenter, Akhtar & Tomasello, 1998; Carpenter, Call & Tomasello, 2005; Meltzoff, 1995).

But 1-year-old infants' understanding of intentional action goes beyond a basic understanding of others' goals. They also understand that actors choose means or plans to achieve their goals, that is, they understand others' intentions. Thus, Gergely, Bekkering and Király (2002) had 14-month-old infants watch an adult switch on a lamp with her forehead. For half of the infants the adult was forced to use this unusual means because her hands were occupied (she was holding a blanket around her shoulders for warmth; Hands Occupied condition). The other half of the infants saw the adult use the same unusual means even though she could have more easily used her hands, which were not occupied (Hands Free condition). When later given the possibility to act on the lamp themselves (with no constraints), more infants reproduced the adult's unusual action when her hands had been free (69%) than when they had been occupied (21%). In the Hands Free condition, infants apparently understood that the adult must have chosen the unusual action for some reason (even if they did not know exactly what that reason was) and they copied the action in order to find out what that reason might have been. In the Hands Occupied condition, in contrast, the adult's reason for choosing that action was clear – her hands were constrained – and, since infants were not constrained in this way, they did not copy the action. Subsequent research has found that even 12-month-olds show the same pattern of results in a similar task (Schwier, van Maanen, Carpenter & Tomasello, 2006). Thus, 1-year-old infants understand something of others' intentions as rational choices of action plans to achieve goals, and they use this understanding when deciding what to imitate from them (see Gergely *et al*., 2002, for a slightly different interpretation involving infants' evaluation of the adult's *actions* in terms of their efficiency or rationality, as opposed to infants' understanding of others' *intentions*).

An interesting question is whether our nearest primate relatives, chimpanzees, might also imitate others' actions

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rationally. Recent evidence suggests that chimpanzees and other apes do understand something about others' goals (Call, Hare, Carpenter & Tomasello, 2004; Call & Tomasello, 1998). Some chimpanzees can even use this understanding when imitating, differentially copying intentional over accidental actions and completing others' failed attempts (Tomasello & Carpenter, 2005; see also Call, Carpenter & Tomasello, 2005, and Myowa-Yamakoshi & Matsuzawa, 2000, for other studies of this with less clear results). Generally, though, in social learning situations, apes who were raised by conspecifics mostly reproduce the end result of an action ('emulation' learning) without copying the behavioral means that led to that result, especially as compared with human children (Call *et al*., 2005; Nagell, Olguin & Tomasello, 1993; Tennie, Call & Tomasello, 2006; Whiten, Custance, Gomez, Teixidor & Bard, 1996; see Call & Carpenter, 2003, for a review). However, there is evidence that human-raised or enculturated apes often copy the specific actions of others (Bering, Bjorklund & Ragan, 2000; Bjorklund & Bering, 2003; Tomasello, Savage-Rumbaugh & Kruger, 1993). Enculturated apes thus may pay closer attention to others' actions than do non-enculturated apes, and so it is conceivable that they might imitate others rationally, taking into account the reasons behind their actions.

In the current study, therefore, we tested eight enculturated chimpanzees with three different tasks using the basic procedure of Gergely *et al*. (2002). Each demonstration involved a human using an unusual body part to operate an apparatus (he pressed it with his forehead or foot, or sat on it). Each task had two versions: one involved an apparatus which, when pushed, resulted in the illumination of a light, and the other involved an apparatus which, when pushed, resulted in the production of a sound. Each version of each task was demonstrated for different chimpanzees either as a free choice – the demonstrator used the unusual body part even though his hands were free, in which case the chimpanzees should use the same body part – or as a choice forced by circumstances because the demonstrator's hands were occupied, in which case the chimpanzees could safely ignore the demonstration because those circumstances did not apply to them (their hands were always unoccupied).

Method

Participants

Eight chimpanzees (mean age = 5;5, range = 3;2 to 8;1; three females, five males) participated in the study. All had been raised from birth by humans, and lived in an animal park open to the public. For the first 12 months of life they were raised within a human family. They were subsequently introduced into a group of other human-raised chimpanzees, but all still interacted directly (i.e. not through caging) with humans for at least 2 hours per day in various training and enrichment activities.

Materials and design

There were three tasks, each of which involved a different unusual body part (see below). For each of the three tasks there were two apparatuses, for a total of six apparatuses. One of the apparatuses in each task produced an illumination effect when operated (light version) and the other apparatus produced a sound effect when operated (sound version). Along with each apparatus an additional object was present during demonstrations, as the 'constraint' object or its counterpart, depending on the condition (see below). The tasks were as follows:

Head task

For the light version of the Head task the apparatus was almost identical to the one used by Gergely and colleagues (2002): a rectangular box (27 × 20 × 6 cm) with a round lamp (diameter 12 cm) attached to it (see Figure 1a). The lamp could be switched on by pushing the top. For the sound version of this task the apparatus was a triangular plastic box with an electronic keyboard inside (see Figure 1b). When the sloped surface (60°, 52 × 35 cm) of the box was pushed, the keyboard produced a sound. Each apparatus was attached to a table (80 × 80 cm) during both the demonstration and the response phase. The demonstrator (E1) acted on the light apparatus while sitting opposite the chimpanzee (as in the original task), but he acted on the sound apparatus while sitting next to the chimpanzee, because this allowed the chimpanzee a better view of the demonstrator's action. The additional objects for this task were a blue blanket for the light version and a brown blanket for the sound version (150 × 200 cm each).

Foot task

For the light version of the Foot task the apparatus was a semi-transparent, multicolored triangular box (31 × 31 × 40 × 6 cm) attached to a brown wooden board (80 × 80 cm, see Figure 2a). When the front of the box was pushed a light illuminated inside. For the sound version of this task, the apparatus was a large, prism-shaped, yellow box (122 × 80 cm) with a red square panel (22 × 22 cm) on the front and an electronic keyboard inside (see Figure 2b). When the square panel was pushed, a sound emerged. Both apparatuses stood on the floor against

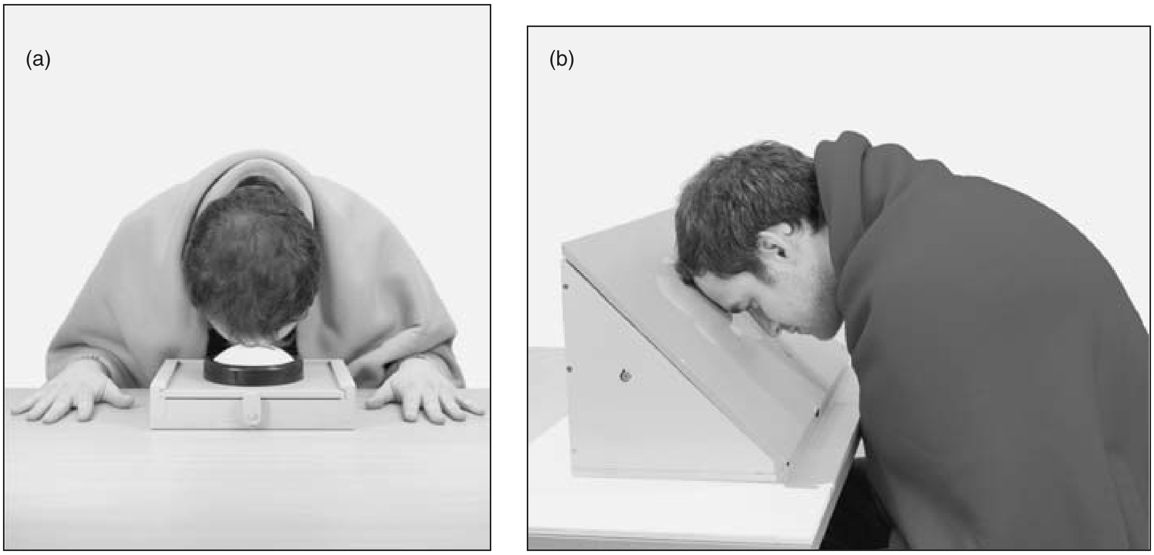

Figure 1 *The Head task: E1 performing a demonstration (a) in the Hands Free condition of the light version and (b) in the Hands Occupied condition of the sound version as seen from the participants' perspective.*

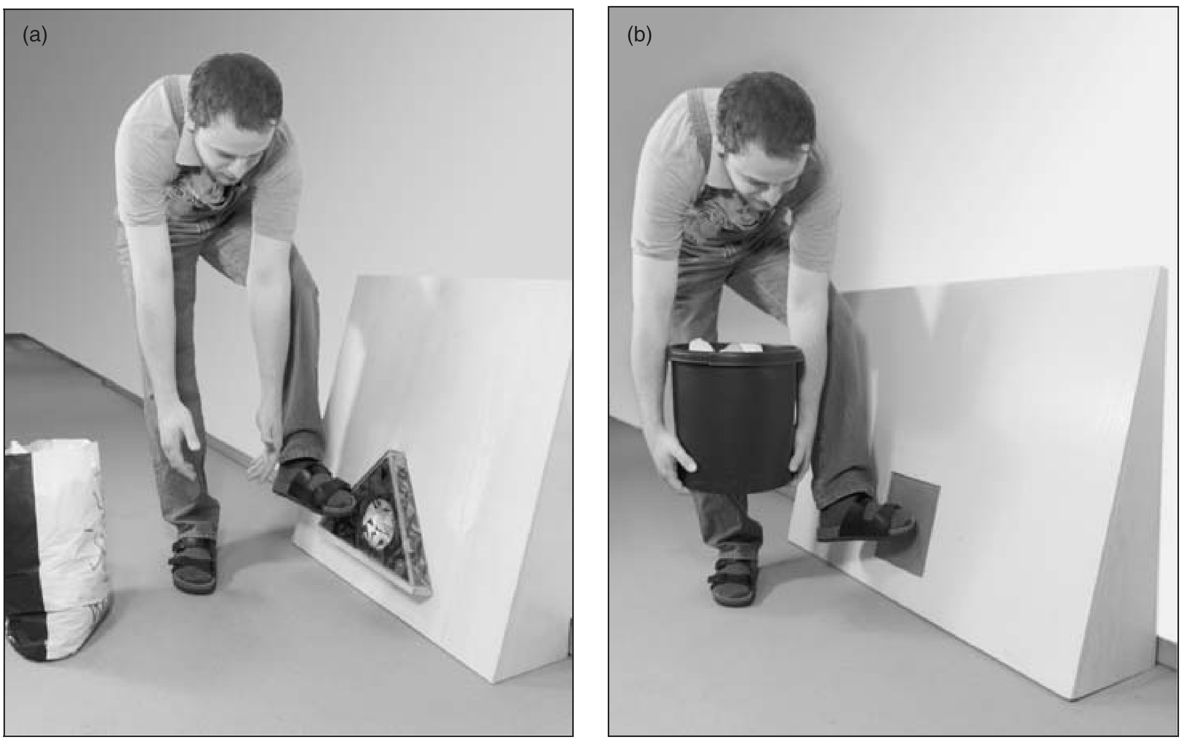

Figure 2 *The Foot task: E1 performing a demonstration (a) in the Hands Free condition of the light version and (b) in the Hands Occupied condition of the sound version as seen from the participants' perspective.*

a wall during both the demonstration and the response phase. The additional objects for this task were a plastic bag filled with cloth (30 × 25 × 42 cm) for the light version and a plastic bucket (height 32 cm, diameter 28 cm) filled with various items for the sound version.

Sit Task

For the light version of the Sit task the apparatus was a rectangular plexiglass box (60 × 22 × 21 cm) with six small lamps inside (see Figure 3a). For the sound version of this

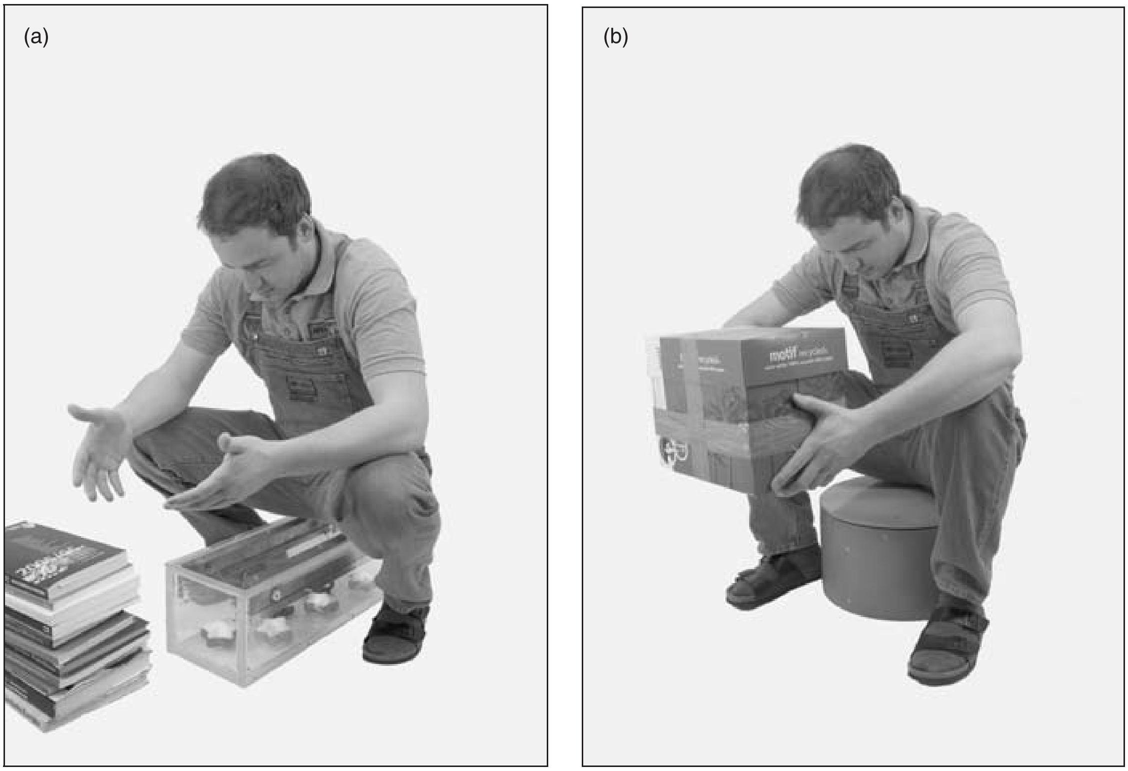

Figure 3 *The Sit task: E1 performing a demonstration (a) in the Hands Free condition of the light version and (b) in the Hands Occupied condition of the sound version as seen from the participants' perspective.*

Table 1 *Overview of the procedure and design*

	Tasks in order of presentation					
	Session 1		Session 2		Session 3	
	Head light (2 trials)	Sit light (2 trials)	Sit sound (2 trials)	Foot light (2 trials)	Foot sound (2 trials)	Head sound (2 trials)
4 Participants	Hands Free	Hands Occupied	Hands Free	Hands Free	Hands Occupied	Hands Occupied
4 Participants	Hands Occupied	Hands Free	Hands Occupied	Hands Occupied	Hands Free	Hands Free

task the apparatus was a cylindrical grey plastic box (diameter 40 cm, height 22 cm; with a tape recorder inside; see Figure 3b). The lid of each of these boxes could be pushed down to illuminate the lamps inside the box (light task) or to play a melody (sound task). The apparatuses stood on the floor in the middle of the testing room during both the demonstration and the response phase. The additional objects for this task were a stack of books for the light version and a cardboard box for the sound version.

A within-subjects design was used. Each chimpanzee participated in both of the experimental conditions (see below) in each of the three tasks – in one condition in the light version and in the other condition in the sound version, with half the chimpanzees randomly assigned to each condition in each version (see Table 1). There were two trials for each apparatus, for a total of 12 trials, six in each condition. Chimpanzees were tested in three sessions, each lasting approximately 10–15 minutes per participant. In each session, chimpanzees received two apparatuses from different tasks (to reduce carryover effects). Each chimpanzee received the same order of tasks (see Table 1). The second session was conducted 85 days after the first session, and the third session was conducted 70 days after the second session.

One day before the second and the third sessions chimpanzees saw a 'hand demonstration'. In this demonstration, they watched, as a group, as E1 manipulated four different toys (e.g. xylophone, toy car) with his hands for approximately 1 minute each. This was done in order to demonstrate to chimpanzees that E1 normally acted on objects with his hands as the most general and effective way to handle things.

Procedure

Chimpanzees were tested individually in a familiar room (2.5 × 3.5 m) adjacent to their sleeping quarters, with two experimenters (E1 and E2) and two familiar human caretakers present in the room with them. When chimpanzees entered the testing room, the caretakers played with them for a few minutes to make them comfortable. One of the caretakers then led the chimpanzees to their position near the apparatus. Before every demonstration (in both conditions), E1 asked E2 for the blanket (Head task) or the other additional object (Foot and Sit tasks). After having received that object, E1 approached the apparatus, called the chimpanzees by name, waited for them to look, and then started the demonstration.

In both conditions, for the demonstration E1 operated the apparatus using an unusual body part. In the Head task he pushed on the top surface of the apparatus with his forehead so that the light switched on or the sound was produced. In the Foot task he approached the apparatus stooped over so that his hands were near the box/square, and then pushed the box/square with his foot so that the light/sound was produced. In the Sit task, he approached the apparatus so that he stood at an angle of 45 degrees to the chimpanzee and then sat down on the apparatus so that the light/sound was produced. What differed between conditions was whether E1's hands were occupied or free during this demonstration.

In the Hands Occupied condition, E1 modeled the action using the unusual body part because his hands were occupied. In the Head task, E1's hands were occupied because he used them to hold a blanket around his shoulders. In the Foot and Sit tasks, E1's hands were occupied because he held an object with both hands during the demonstration (see Figures 1b, 2b and 3b).

In the Hands Free condition, these additional objects were present as well, but they did not occupy E1's hands. In the Head task, E1 draped the blanket around his shoulders (without needing to hold it), put his hands on the table next to the apparatus and then pushed on the top surface of the apparatus with his forehead so that the light/sound was produced (see Figure 1a). In the Foot and Sit tasks, E1 held the object while approaching the apparatus, but then set the object down on the floor next to the apparatus. He then switched on the light/sound with his foot or by sitting on the apparatus in exactly the same manner as in the Hands Occupied condition but with the crucial difference that now his hands were free (but held in the same position as in the other condition, see Figures 2a and 3a).

Thus, in both the Hands Occupied and Hands Free conditions, E1 operated the apparatus with the same unusual body part in the same way. The difference between conditions was whether he was forced to do so by some constraint (holding a blanket around his shoulders or an object in his hands) or whether he freely chose to do so despite being able to operate the apparatus with his hands.

For each apparatus, chimpanzees were given two trials in succession, each consisting of a demonstration period (both in the same condition) and a response period (with no delay). In each demonstration E1 performed the action three times. If there was some question about the chimpanzee's attention, the demonstration was repeated so that every chimpanzee was certain to have seen three demonstrations before the response period. For the Head task, the caretaker and the chimpanzee turned around between the demonstration and response periods while E1 and E2 quickly detached the apparatus from E1's side of the table and attached it to the chimpanzee's side of the table. In the Foot and Sit tasks, E1 moved the additional object away so that the chimpanzee had free access to the apparatus. In all trials, E1 stayed to watch the chimpanzee's response. When the chimpanzee first touched the apparatus the response period began. It lasted approximately 60 seconds. Caretakers were instructed not to give any verbal commands or gestures other than to call the chimpanzee by name or direct the chimpanzee's attention to the demonstration or to the apparatus by saying 'Watch that!' or 'Look!' if needed. Each session was videotaped from three different angles.

Coding, reliability and analysis

The first author coded chimpanzees' actions from the videotapes, blind to experimental condition. Following Gergely *et al.* (2002), the first 20 seconds of each response period were coded, starting with the chimpanzee's first touch of the apparatus. For each trial it was determined (1) whether the chimpanzee imitated the demonstrator, that is, used the demonstrated body part to operate the apparatus, and (2) with which body part the chimpanzee first acted on the apparatus. Given that chimpanzees often explore objects with their mouth, in the Head task we conservatively counted as imitation only those cases in which chimpanzees pressed the box with the upper part of their face, from the nose up (mainly forehead). For the Foot and Sit tasks, all presses using the foot or rear end, respectively, were coded as imitation.

To assess interobserver reliability, an independent coder also watched the videotapes, blind to experimental condition, and rated 100% of the trials for both measures. An excellent level of interobserver agreement was reached, with a Cohen's kappa of 0.89 for use of the demonstrated body part and an agreement of 96.9% for the first body part used (the independent coder recorded no instances of chimpanzees using the demonstrated body part first, so the kappa value was not calculable). Exact, two-tailed *p* values are reported for all analyses.

Results

Like human infants in Gergely and colleagues' (2002) study, chimpanzees imitated the demonstrator's action significantly more often in the Hands Free than in the Hands Occupied condition across the three tasks (means = 37.5% and 18.8% of trials, respectively), Wilcoxon $T^+ = 34.5$, $N = 8$, $p = .023$; see Figure 4 (note that the mean percentages of trials we report here are not directly comparable to the percentage of participants reported in Gergely and colleagues' study). In their first trials across tasks, chimpanzees also tended to imitate the demonstrator more often in the Hands Free than in the Hands Occupied condition (means = 41.7% and 16.7% of trials, respectively), $T^+ = 15.0$, $N = 5$, $p = .063$, but this difference was not significant for the second trials (means = 33.3% and 20.8% of trials, respectively), $T^+ = 8.5$, $N = 4$, $p = .375$; see Figure 5. For each of the tasks individually, again the same pattern of results was found, although not significantly, Wilcoxon tests, all *p*s > .125; see Table 2. Separate analyses of the light and the sound versions of the tasks revealed that chimpanzees imitated

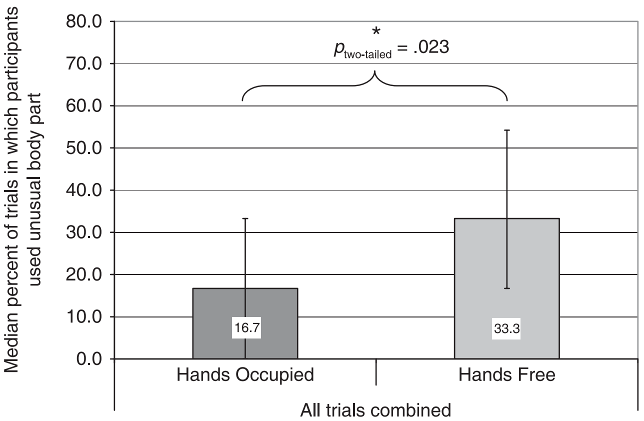

Figure 4 *Medians (+ interquartile ranges) of percentages of trials in which chimpanzees copied the target action (used the demonstrated unusual body part to operate the apparatus) in each condition, across all tasks, versions and trials combined.*

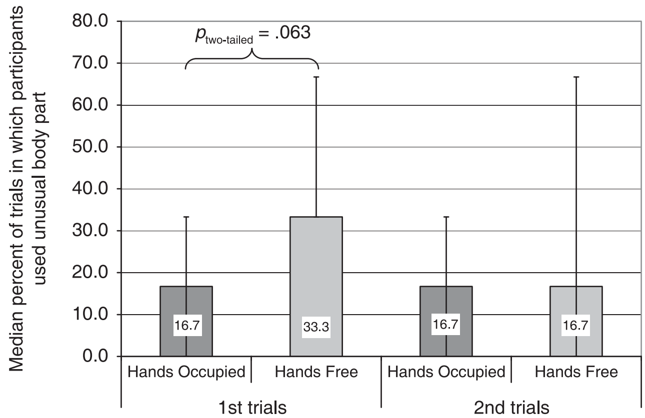

Figure 5 *Medians (+ interquartile ranges) of percentages of first and second trials in which chimpanzees copied the target action (used the demonstrated unusual body part to operate the apparatus) in each condition, across all tasks and versions.*

Table 2 *Mean percentages of trials in which chimpanzees used the unusual body part in each task separately (collapsed across versions and trials)*

	Task		
Condition	Head	Foot	Sit
Hands Occupied	6.3	12.5	37.5
Hands Free	18.8	43.8	50.0

the demonstrator significantly more often in the Hands Free than in the Hands Occupied condition in the light versions, which were always administered first (means = 43.8% and 12.5% of trials, respectively), $T^+ = 28.0$, $N = 7$, $p = .016$, but this difference was not significant in the sound versions (means = 40.6% and 21.9% of trials, respectively), $T^+ = 20.0$, $N = 7$, $p > .391$. To enable a direct comparison between our task and that of Gergely and colleagues (2002), we looked at chimpanzees' (between-subjects) performance on the first trial of the Head light task. Fifty percent of chimpanzees imitated the demonstrator in the Hands Free condition whereas no chimpanzees did this in the Hands Occupied condition. On the individual level, all chimpanzees imitated at least once. Overall, seven of the eight chimpanzees imitated the demonstrated action in more trials in the Hands Free than in the Hands Occupied condition, binominal test, $p = .070$.

Also like infants in the Gergely *et al.* (2002) study, in almost all trials (96.9%) chimpanzees' first action on the apparatus involved a body part other than the one used by the demonstrator – usually the hand or mouth (in two trials chimpanzees used the hand and the demonstrated body part at the same time and in one trial a chimpanzee used the demonstrated body part first and then used his hand). These undemonstrated first actions were usually (75.3%) successful in producing the light or sound.

Discussion

It is possible to understand the intentional actions of others at different levels of analysis. It is likely that even very young infants (and many nonhuman primates) understand that actors pursue goals in the sense that actors attempt to make the world match some desired state. But adult humans understand as well that actors perceptually monitor the overall situation as they pursue their goals, and choose plans of action that fit the opportunities and constraints of the current situation; that is to say, they understand others' intentional actions rationally. The finding of Gergely *et al.* (2002) that infants as young as 14 months of age (and even 12 months of age; Schwier *et al.*, 2006) imitate flexibly using this understanding is truly remarkable.

In the current study we found – perhaps even more remarkably – that even some great apes imitate rationally. The finding that the chimpanzees in this study readily imitated others' body movements is already impressive – many studies have found no evidence of this – but in addition the finding that these chimpanzees imitated rationally, copying the demonstrator's action more often when he freely chose his action than when he was forced to use it by some constraint, is unprecedented in any nonhuman animal. The main result across our three tasks was very clear, with chimpanzees imitating the demonstrated action approximately twice as often in the Hands Free as in the Hands Occupied condition. The same pattern was found in each of the three tasks separately (although not significantly), and seven of the eight chimpanzees showed the correct pattern of results across conditions. It is also noteworthy that the chimpanzees almost always acted on the apparatuses first with undemonstrated body parts (e.g. their hands) – usually successfully – before using the demonstrated, unusual body part, just as human infants have been found to do. As Gergely and Csibra (2006) have argued for infants, this indicates that these chimpanzees, too, were motivated to try the demonstrator's action in the Hands Free condition, even though they were already capable of successfully achieving the end result in their own way.

Indeed, it may be that we are actually underestimating these chimpanzees' abilities, due to a difference between our procedure and that of Gergely *et al.* (2002) which might have weakened our results. That is, unlike Gergely and colleagues, we gave participants repeated trials and tasks. We found that the difference between conditions was stronger in the first trials of the tasks than in the second trials. It is thus possible that over repeated testing some chimpanzees in the Hands Free condition may have learned that it was not necessary to use the demonstrator's unusual actions – that these actions offered no apparent advantage over their own. The only published study that has used repeated trials with infants found that infants showed the opposite pattern: their results only reached statistical significance in the second of two trials, not in the first (Schwier *et al.*, 2006). However, important methodological differences between these two studies – for example, the number of times the action was modeled during each demonstration and the number of different tasks presented – make direct comparisons between infants and chimpanzees impossible. It would be interesting to test infants using the current procedure to see whether they would show a different pattern of responding to that of chimpanzees, increasing rather than decreasing their imitation of the unusual action in the Hands Free condition across trials (Gergely, personal communication; see Gergely & Csibra, 2006).

An important issue is whether the special rearing history of these chimpanzees was somehow instrumental to their success. Recent research has found that chimpanzees not raised by humans, but rather by conspecifics, are not successful in similar tasks (Buttelmann, Carpenter, Call & Tomasello, submitted). The tasks were different because non-enculturated chimpanzees do not imitate well enough to do the tasks we used here (therefore the tasks involved the use or choice of an unusual tool to bring in a food reward, instead of the imitation of specific body movements to turn on a light or sound), but human infants behaved in them just as they have behaved in previous rational imitation tasks. Thus, it could be that enculturation makes chimpanzees more sensitive to human pedagogical cues indicating new and relevant information for them (Gergely & Csibra, 2006), or more motivated to pay attention to and make sense of humans' actions (Tomasello & Call, 2004), for example, and that this is what enables enculturated chimpanzees to succeed in these kinds of tasks while non-enculturated chimpanzees fail. However, the story may be more complicated than that, because Buttelmann and colleagues (submitted) also found that seven non-enculturated orangutans were successful on their tasks. It is not clear why this species difference exists. Some possibilities are that orangutans are calmer and more observant than chimpanzees, or less governed by a need to get food rewards as directly as possible (both of which were also qualities of the enculturated chimpanzees tested in the current study) – that is a question for future research. Taken together, these results suggest the possibility that all great apes possess the ability to understand others' intentions as rational choices of action plans to achieve goals, but that only some of them are able to show this understanding in these types of experiments due to special attentional or motivational qualities.

In any case, it is likely that the human ability to understand the rationality of action has significant evolutionary roots, at least as deep as the great apes. This raises the question of what enables humans to go even further in understanding the complex mental states of others – not just their goals and intentions, but also their beliefs and false beliefs – and to participate with others in collaborative activities involving shared goals and intentions – which, apparently, great apes do not do (Tomasello, Carpenter, Call, Behne & Moll, 2005). This is a central question for future research attempting to establish the evolutionary roots of humans' unique social-cognitive abilities and motivations.

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