Anim Cogn (2006) 9
DOI 10.1007/s10071-005-0013-4

ORIGINAL ARTICLE

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Apes' use of iconic cues in the object-choice task

Received: 21 December 2004 / Revised: 23 August 2005 / Accepted: 31 August 2005 / Published online: 5 January 2006

Abstract In previous studies great apes have shown little ability to locate hidden food using a physical marker placed by a human directly on the target location. In this study, we hypothesized that the perceptual similarity between an iconic cue and the hidden reward (baited container) would help apes to infer the location of the food. In the first two experiments, we found that if an iconic cue is given in addition to a spatial/indexical cue – e.g., picture or replica of a banana placed on the target location – apes (chimpanzees, bonobos, orangutans, gorillas) as a group performed above chance. However, we also found in two further experiments that when iconic cues were given on their own without spatial/indexical information (iconic cue held up by human with no diagnostic spatial/indexical information), the apes were back to chance performance. Our overall conclusion is that although iconic information helps apes in the process of searching hidden food, the poor performance found in the last two experiments is due to apes' lack of understanding of the informative (cooperative) communicative intention of the experimenter.

Keywords Apes · Object-choice task · Iconic · Communicative intention

Introduction

In a number of different studies from a number of different laboratories great apes have shown very inconsistent performance in the object-choice task. In this experimental paradigm, food is hidden in one of two or three opaque containers, a human experimenter then gives some kind of communicative cue indicating where it is, and the subject then chooses one (and only one) container. Despite being highly motivated for the food, apes generally are not very skilful to use what for humans are fairly obvious cues like the human pointing to the correct container, or staring at it, or placing a marker on top of it (Tomasello et al. 1997; Call et al. 1998, 2000; Peignot and Anderson 1999; Povinelli et al. 1999; Hare et al. 2002; Barth et al. 2005). Itakura et al. (1999) used a trained chimpanzee conspecific to give some cues, but still found mostly negative results.1[1]

Some weak positive results have been found when the experimenter actually approaches the correct container and actively inspects it, as if actually foraging for food (Itakura et al. 1999), or if he makes chimpanzee body movements or vocalizations or noises in combination with the cue (Povinelli and Eddy 1996; Itakura and Tanaka 1998; Call et al. 2000). But human children perform much more consistently in all versions of this task at a fairly young age (Tomasello et al. 1997), in some cases even before language acquisition begins (Behne et al. 2005). And domestic dogs also do much better in all versions of this task than do chimpanzees (Hare et al. 1998, 2002; Miklósi et al. 1998; Hare and Tomasello 1999; Agnetta et al. 2000), presumably because they have been selected (domesticated) to interact with humans and to read their behavior and communicative cues (although see Hare et al. 2005).

It is important to note that apes' struggles in this task are not due to their inability to follow the directionality of the cues. Apes follow gazing and pointing to outside locations quite readily (e.g., Itakura 1996; Tomasello et al. 1998). It is simply that in this context they do not know that the human intends his looking, pointing, or placing of a marker to be taken as a communicative act informing them of the location of the food. Simply said, they

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[1] Of course, if given enough trials many animals are able to learn to associate an arbitrary cue with the location of the food. But the point of the object choice task is that if the subject understands the meaning of the cue the experimenter is attempting to communicate, they should be successful in a very few trials – many fewer than if a totally arbitrary cue was used; for example, in Call and Tomasello (1998), using an arbitrary indexical marker, it took an average of 90 trials per subject to learn the cue.

do not understand cooperative communicative intentions. This point is clearly illustrated in a recent study by Hare and Tomasello (2004). In a replication of the basic object-choice task, chimpanzees failed to locate hidden food when a cooperative human pointed to its location (and alternated gaze between subject and target location). However, when a human who had established a competitive relationship with the same chimpanzees reached effortfully for the container containing the hidden food (no gaze alternation) in an unsuccessful attempt to get it for himself, they suddenly knew where the food was – even though the superficial behavior of an arm extended toward the location containing food was highly similar in the two cases. Chimpanzees can read intentions, just not cooperative communicativeintentions.

All of the cues that have previously been used in the object-choice paradigm with apes have been basically indexical in nature, that is, they direct the recipient spatially to a particular location, and the recipient must then infer why her attention is being so directed. Perhaps if apes had more information of a different kind this inference might be easier, or they might not need to make it at all. In particular, apes have shown skill at recognizing or otherwise making use of pictures (Parr et al. 1998, 2000; Parr and de Waal 1999; Tanaka 2001), videos (Menzel et al. 1978, 1985; Poss and Rochat 2003), and scale models (Kuhlmeier et al. 1999; Kuhlmeier and Boysen 2001, 2002) – three different forms of iconic information. Perhaps this kind of information would be useful in the object-choice task because it provides additional information. One attempt in this direction was made by Tomasello et al. (1997) who signaled for apes the container containing food by holding up a replica of that container (which again requiring an inference from the ape about why the human was doing this). But apes performed uniformly poorly with this communicative cue (whereas young human children performed quite well). However, it is important that this iconic cue was presented without any indexical/spatial information, as the replica was held up for the subject in the middle of the three containers.

In the current four experiments we investigated the conditions under which apes might be able to use iconic information in the object-choice task. In a first experiment we simply placed an iconic marker – either a photograph or a replica of the food being hidden – on top of the correct container (as arbitrary markers have been placed in previous studies). In some cases, we gave overt communicative cues while doing so (e.g., the human alternated gaze between the ape and container while placing the marker), whereas in other cases the ape did not even see the placement process. In a second experiment, we placed a photograph or a replica of the hidden fruit on the baited container and a distracting photograph or an object that did not match the hidden fruit on the empty one – which eliminated any kind of local enhancement information associated with the placement of things only on the correct container. In a third experiment, we removed the indexical information altogether by having the human hold up a photograph of the correct location communicatively, but equidistant between the two containers. In a final experiment, we removed the indexical information in a different way, by having two types of food each visible in a Plexiglas container, only one of which was openable (which apes had learned in a warm-up session), and then holding up a photograph of the food that was accessible. We predicted that apes would be able to use the iconic information in combination with indexical (spatial) information, since the iconic feature would make the cue more specific – and they would be able to do this in a relatively few number of trials (i.e., within the 18 trials most often used in object-choice studies). However, by removing the indexical component, apes could only make an inference about the location of the hidden food if they understood the informative representational significance of the cue, since it was not located directly on top of the hidden food's location. Therefore, we hypothesized that if apes do not understand the experimenters' cooperative communicative intentions motivating the given cues, they should have more difficulties to make use of iconic information in the absence of any index indicating location directly (i.e., again, within a few number of trials).

Experiment 1

In this experiment, we investigated apes' ability to use an iconic cue (added to an indexical cue) to find hidden food. This was done by attempting to communicate to apes (inform them) about the location of a hidden banana by marking the baited location with either a photo that depicted a banana or with a rubber banana replica. DeLoache (1987, 1991, 1995) has found that three-dimensional replicas (e.g., a scale model) pose more difficulties for human children in similar tasks as compared to photographs. She proposes that replicas have more 'other' affordances for action, and so children have a harder time using them as a communicative representation (the so-called dual representation hypothesis). Following this logic, the apes should perform better in the photo condition.

In addition, each of these iconic representations was placed on the baited container in two different ways: in one condition the placement of the cue took place out of view of the subject, while in the second manipulation the experimenter alternated gaze between the cue and the subject before placing the cue on top of the cup in full view of the subject. Making the experimenter's communicative intentions more salient in this way might be expected to help apes understand the significance of the cue.

Method

Subjects

Twelve chimpanzees (*Pan troglodytes*), 6 orangutans (*Pongo pygmaeus*), 6 gorillas (*Gorilla gorilla*), and 4 bonobos (*Pan paniscus*) participated in this experiment. A male gorilla did not pass the warm-up phase and was excluded from further testing. There were 18 females and 9 males ranging from 4 to 31 years of age (Table 1

Table 1 Species, age, sex, rearing history and the experiments in which each subject participated

Name	Species	Age (years)	Sex	Rearing history	Experiment participation
Robert	Chimpanzee	26	Male	Nursery	1
Fraukje	Chimpanzee	26	Female	Nursery	1
Corry	Chimpanzee	25	Female	Nursery	1
Ulla	Chimpanzee	25	Female	Nursery	1
Riet	Chimpanzee	24	Female	Nursery	1
Natascha	Chimpanzee	22	Female	Nursery	1
Jahaga	Chimpanzee	9	Female	Mother	1
Gertruida	Chimpanzee	9	Female	Mother	1
Fifi	Chimpanzee	9	Female	Mother	1
Sandra	Chimpanzee	9	Female	Mother	1
Frodo	Chimpanzee	8	Male	Mother	1, 2, 3, 4
Patrick	Chimpanzee	5	Male	Mother	1
Dunja	Orangutan	31	Female	Mother	1
Bimbo	Orangutan	22	Male	Unknown	1
Pini	Orangutan	14	Female	Mother	1, 2, 3, 4
Walter	Orangutan	13	Male	Mother	1, 2, 3, 4
Toba	Orangutan	8	Female	Mother	1, 2, 3, 4
Padana	Orangutan	4	Female	Mother	1, 2, 3, 4
N'diki	Gorilla	24	Female	Mother	1
Bebe	Gorilla	23	Female	Unknown	1
Viringika	Gorilla	7	Female	Mother	1
N'kwango	Gorilla	5	Male	Mother	1, 2, 3, 4
Ruby	Gorilla	4	Female	Mother	1, 2, 3, 4
Joey	Bonobo	19	Male	Nursery	1, 2, 3, 4
Ulindi	Bonobo	8	Female	Mother	1, 2, 3, 4
Limbuko	Bonobo	6	Male	Nursery	1, 2, 3, 4
Kuno	Bonobo	5	Male	Nursery	1, 2, 3, 4

shows each subject's sex, age, rearing, and experimental participation). All subjects were housed at the Wolfgang Köhler Primate Research Center in the Leipzig Zoo, Germany. They lived in social groups and had access to indoor and outdoor enclosures. Subjects were individually tested in a familiar indoor testing room and could stop participating at any time. Water was available ad libitum and subjects were not food deprived for testing. Several subjects had participated in at least one other object-choice study in which gazing, pointing (Barth et al. unpublished data) or marker cues (Hare et al. 2002) were given.

Materials

A wooden table (84 cm × 32 cm × 52 cm) with a sliding wooden platform (66 cm × 29 cm) and a sliding Plexiglas panel (65 cm × 10 cm) attached to the long side of this platform was used. The sliding Plexiglas panel could be moved to the right or left. Two brown opaque cups (11 cm in diameter × 7 cm height), used to cover the food reward (banana), were placed on the sliding platform 42 cm apart. This table was placed in front of a Plexiglas testing window (69 cm × 48 cm) with two hand holes (6 cm in diameter). These holes allowed the subject to reach their fingers out to move the sliding Plexiglas. The movement of the Plexiglas to one side of the table allowed the subject to have access to only one of the two cups, making its choice completely unambiguous. The baiting procedure was hidden from the subjects' view by a white plastic occluder (100 cm × 50 cm). A picture of a whole banana (9 cm × 13 cm, glossy) or a rubber replica of a half banana (11 cm × 4 cm) was used to indicate the rewarded (banana) cup.

Procedure and design

The experimenter (E) sat facing the subject behind the table. E waited until the subject approached the table to start the trial. Subjects were first introduced to the testing apparatus with the sliding Plexiglas screen (which prevented them from pointing simultaneously to both cups), and to the general procedure of the object-choice task. During this introduction E attracted the subject's attention by showing him/her a piece of food and placing it on one side of the table in full view of the subject. In order to make a choice, subjects had to stick one finger through the opening in the Plexiglas window and slide the Plexiglas screen sideways, so that they could point to the chosen cup on the table. Once subjects were able to push the Plexiglas screen aside and choose the correct side four times in a row the testing phase began.

Before each experimental condition subjects participated in four warm-up trials in which a piece of food was shown to the subject before hiding it under one of two opaque cups in full view of the subject. Afterwards, the subject was

allowed to make a choice. To participate in the experimental conditions, the subject had to choose the correct cup four times in a row. All apes but one gorilla reached the criteria and participated in the experimental conditions. The gorilla who did not meet these criteria did not participate.

During the experimental conditions, E attracted the subject's attention by showing her/him a piece of banana and then lifted an occluder, which was attached to the testing table in order to hide the baiting process. After hiding the piece of banana, subjects were presented with the following four conditions.

Photo-see placing: A picture of a whole banana was used to indicate the baited cup. After finishing the baiting process and in full view of the subjects, E held the photo in her hand and alternated her gaze three times between the photo and the subject. Then, while looking straight to the subject, E placed the photo on top of the baited cup. After E pushed the platform with the cups forward, subjects were allowed to make a choice.

Replica-see placing: This condition was identical to the previous Photo-see placing condition, but instead of using a photo to indicate the baited cup, a replica of a half-banana was used.

Photo-not see placing: A picture of a whole banana was used to indicate the baited cup. After finishing the baiting process, E placed the photo on top of the baited cup behind an occluder out of view of the subject. After this placement, E lowered the occluder and pushed the platform with the cups forward, allowing the subjects to make a choice.

Replica-not see placing: This condition was identical to the previous Photo-not see placing condition, but instead of using a photo to indicate the baited cup, a replica of a half-banana was used.

After the baiting process and the given cue, E looked always in the direction of the subject and never to the cups. Before each of the two replica experimental conditions, subjects were given control trials to assure that they were able to distinguish the fake banana from the real one. Each subject was given the choice between a real piece of banana and the banana replica. If subjects chose the rubber banana, E handed it to them so that they could smell and touch it. Subjects had to choose the real banana four times in a row in order to be tested in the replica experimental conditions. All apes reached this criterion within eight trials.

Each subject participated in all four conditions, but in only one condition per day (i.e. session). The total number of trials per condition was 18. Subjects received either the two photo conditions or the two replica conditions first (medium blocked), whereas the type of placement (i.e. see placing, not see placing) alternated always across sessions. Half of the subjects started with a see placing condition and the other half with a not see placing condition. Thus, there were four possible orders in which the four conditions were presented and these were counterbalanced across subjects. The position of the reward (left vs. right) was randomly determined with the constraints that it appeared the same number of times on each side and not be hidden on the same side more than two times in a row.

Scoring and analysis

E scored live which of the two cups was chosen first by each subject (sliding the Plexiglas screen to one side made the choice totally unambiguous). All trials were videotaped and a second observer independently scored 20% of the trials. Interobserver reliability was excellent (Cohen's kappa = 0.97). All statistical tests throughout Experiments 1–4 were two-tailed.

Results

Figure 1 presents the mean number of correct responses across conditions. The 27 apes as a group performed above chance in three out of four conditions (replica-see placing $t(26)=3.05$, $p=0.005$; photo-see placing $t(26)=3.37$, $p=0.002$; photo-not see placing $t(26)=3.70$, $p=0.001$, one-sample t-test). In the replica-not see placing condition the subjects as a group did not perform above chance ($t(26)=1.10$, $p=0.283$).

A $2\times2\times4$ mixed ANOVA, with medium (photo, replica) and type of placement as the within-subjects variable and species as the between-subjects variable, found no main effects of medium, $F(1, 23)=1.27$, $p=0.272$ and type of placement, $F(1, 23)=0.57$, $p=0.459$ (see Fig. 2). However, there were significant interactions between medium and type of placement, $F(1, 23)=5.19$, $p=0.032$ and between medium and species, $F(3, 23)=3.32$, $p=0.038$. Post-hoc analyses of the first interaction revealed that subjects performed better with the photo than with the replica in the not see placement condition ($p=0.041$), whereas no significant difference was found for the see placement conditions ($p=0.970$). Post-hoc analyses of the second interaction, using the Bonferroni–Holm correction (Holm 1979), revealed that with the replica cue bonobos outperformed the other three species (compared to chimpanzees $p=0.006$, compared to orangutans $p=0.012$ and compared to gorillas $p=0.006$ – and the performance of these three species did not differ). No species differences were found with the photo cue. A comparison between the two media for each species revealed that only the gorillas performed better with the photo than the replica ($p=0.017$), whereas the other three species did not differentiate between the two media.

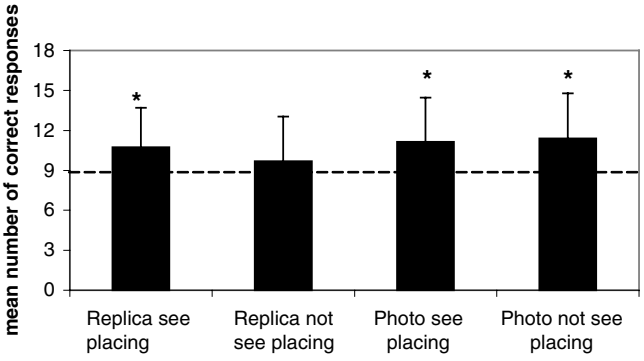

Fig. 1 Mean number of correct responses (with standard deviation bars) across the four conditions in Experiment 1, $^{*}p<0.05$

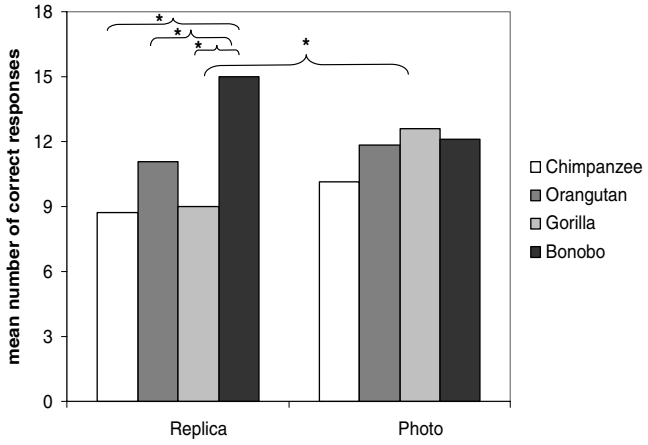

Fig. 2 Mean number of correct responses across the two media for each species in Experiment 1, *pair-wise comparison $p<0.05$

Table 2 shows the individual scores for each of the 27 subjects in each of the four experimental conditions. Each subject in each condition was compared to chance. Chance performance was 0.5 (food was only in one of the two containers), so that 9 out of 18 correct was expected by chance for one subject. Fourteen out of 18 was considered above chance ($p<0.05$, two-tailed binomial probability). As can be seen in Table 2, 11 subjects were at least in one condition above chance. One chimpanzee, four orangutans, two gorillas, and all four bonobos used at least one of the given cues reliably.

To analyze whether the order in which the subjects received the four conditions had an effect on their performance, a one-factor analysis of variance (ANOVA) was conducted. No order effect was found, $F(3, 78)=1.098$, $p=0.355$.

Finally, we compared the first condition with which each subject was confronted (18 trials) to the last condition to analyze any possible learning effects throughout the four conditions (paired sample t-test). There was no significant change in subjects' performance between the first condition and last condition they participated in, $t(26)=-1.378$, $p=.180$.

Discussion

The apes in this experiment were able to perform at above-chance levels in three of the four experimental conditions. There was no overall advantage for apes in seeing the placement of the marker, though there was one when the replica was involved. Apes' performance with the photos was above chance no matter whether they saw the marker

Table 2 Number of correct choices (out of 18) in the four conditions for each subject in Experiment 1

Name	Species	Replica-see placing	Replica-not see placing	Photo-see placing	Photo-not see placing
Robert	Chimpanzee	5	3	9	9
Fraukje	Chimpanzee	11	8	11	11
Corry	Chimpanzee	9	8	9	6
Ulla	Chimpanzee	8	7	7	9
Riet	Chimpanzee	9	5	11	9
Natascha	Chimpanzee	11	9	9	10
Jahaga	Chimpanzee	10	8	12	13
Gertruida	Chimpanzee	9	12	7	13
Fifi	Chimpanzee	13	10	11	9
Sandra	Chimpanzee	7	9	10	10
Frodo	Chimpanzee	8	10	15**	15**
Patrick	Chimpanzee	9	11	11	8
Dunja	Orangutan	10	7	12	9
Bimbo	Orangutan	11	12	11	9
Pini	Orangutan	16**	11	12	14*
Walter	Orangutan	11	7	16**	12
Toba	Orangutan	12	10	13	17**
Padana	Orangutan	11	15**	7	10
N'diki	Gorilla	10	7	9	11
Bebe	Gorilla	8	5	10	8
Viringika	Gorilla	10	9	7	9
N'kwango	Gorilla	9	12	18**	18**
Ruby	Gorilla	11	9	18**	18**
Joey	Bonobo	18**	11	8	8
Ulindi	Bonobo	14*	16**	13	16**
Limbuko	Bonobo	13	14*	8	11
Kuno	Bonobo	17**	17**	17**	16**
Mean		10.74**	9.70	11.15**	11.41**

*Above-chance performance, binomial probability (or t-test for groups), $p<0.05$

**$p<0.01$

being placed or not. In general, apes' performance in the current experiment was much better than in almost all previous object-choice studies. It is also important that no learning effect was found, indicating that what was being tested were skills that apes brought to the experiment, not ones learned during the course of the experiment.

In addition, the current results showed that if there was a difference between the two media, the performance with the photo cue was always better than with the replica cue. Thus, the dual representation hypothesis seems to apply to apes as well as to human children — although it is not clear if this is for the same reason. The main difference between the current experiment and that of Tomasello et al. (1997), the only previous object-choice study using iconic cues with apes, is that in this experiment indexical/spatial information was also given by placing the photo/replica on top of the baited container, whereas in the Tomasello et al. study no indexical information was available. It would thus seem likely that apes' superior performance in the current experiment is due to this additional source of information. In addition, in the current experiment the ape was informed about the hidden food rather than about the correct container, which might also have played a role. In terms of species differences, the bonobos outperformed the other three species with the replica cue. A closer look at the individual data showed that chimpanzees did not perform as well as the other three species (only 1 out of 12 chimpanzees was above chance). Future studies should further explore these differences.

In general, the results from this experiment suggest that to succeed in the object-choice task with a marker, apes need both a spatial/indexical cue indicating the correct location as well as iconic information about the contents of that container. However, it is the case that in the current experiment only one of the containers had a marker on it, and so it is possible that subjects were using this information only — as a kind of local enhancements — and not the iconic information provided by the photo or replica. From the poor performance of apes in previous marker studies (Tomasello et al. 1997; Hare et al. 2002), it is unlikely that just the spatial/indexical cue provides enough information for the subjects to make a correct choice. Alternatively, since the marker depicted or represented a colorful (and edible) object, subjects could just have been attracted to the "interesting" marker. We tested this possibility directly in the second experiment.

Experiment 2

The aim of this experiment was to investigate whether subjects in the previous experiment were using the iconic cue solely as an "interesting" indexical marker (leading them to the correct choice) or instead had a real understanding of the iconic nature of the cue. If they had some understanding of the iconic cue, they should still perform above-chance level when presented with the iconic photo or replica cue on the correct location alongside a distracting photo or replica cue representing something other than the hidden food on top of the empty location.

Method

Subjects

Only those subjects who performed above chance in at least one condition of the previous experiment participated in this experiment. These were two gorillas, four bonobos, four orangutans, and one chimpanzee (see Table 1).

Materials

The apparatus was the same as in the previous experiment. Several different fruit rewards were used in this experiment: banana pieces, orange slices, green and red grapes, kiwi slices, strawberries, and pineapple slices. Photos (9 × 13 cm, glossy) or replicas representing the specific fruit piece served as iconic cues. In addition, as distracting cues, photos of inedible objects (green and dark red wooden blocks, purple spots and a yellow pencil) or real inedible objects (wooden blocks, 7.5 × 6 × 2 cm, and a yellow pencil) matching the color of the hidden fruit piece were also used.

Procedure and design

The procedure was almost the same as in the previous experiment. Subjects participated in four warm-up trials before each test in which they witnessed the baiting process. To make sure subjects were able to distinguish the fake fruit (replica) from the real one, in a pre-test subjects were given the choice between the replica and the real fruit reward directly, and had to choose the real fruit reward twice in a row in order to continue with the test (all subjects met the criterion within five trials). Two replica control trials were also conducted after the test. Since in the previous experiment no differences in performance were found with regard to the type of cue placement, in this experiment the two cue placement variants alternated across sessions. During the experimental conditions, E attracted the subject's attention by showing her/him the specific piece of food before lifting an occluder in order to hide the baiting process. After hiding the piece of food, the subjects participated in the following four experimental conditions.

Object distractor (*photo and replica*): E hid a fruit reward underneath one of the two cups and marked the baited cup with a photo or replica representing the hidden fruit. In addition, E placed at the same time a second photo or replica depicting an inedible object (of the same color as the hidden fruit) on top of the empty cup (see Fig. 3A and B).

Fruit distractor (*photo and replica*): E baited only one of the cups but hid across different trials two different types of food rewards (e.g. orange and red grapes) – showing the subject what she was hiding before each trial. As in the object distractor conditions, both cups (empty and baited)

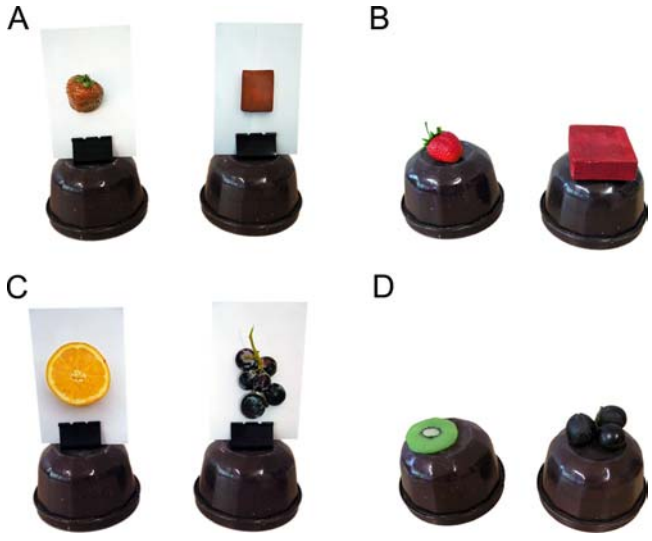

Fig. 3 Examples of the four experimental conditions of Experiment 2. In the Object distractor conditions the baited cup was marked with either a photo (**A**) or a replica (**B**) representing the hidden fruit. In the Fruit distractor conditions, both cups were marked with either a photo (**C**) or a replica (**D**) representing a potential food reward. These two different types of food rewards changed across trials and only one of the fruits was hidden; the corresponding iconic cue indicated the baited cup

were each marked with a photo or replica, but in this case each photo depicted a potential food reward. Only the photo or replica depicting the hidden fruit on a given trial indicated the baited cup. Subjects were required to pay attention and remember what type of fruit had been hidden on a given trial in order to be able to use the cue (see Fig. 3C and D).

After pushing the platform with the cups forward, subjects were allowed to make a choice. Once the given cue had been placed, E always looked in the direction of the subject and never to the cups.

Subjects participated in four sessions of each type of condition.[2] The total number of trials per session (i.e. per day) was 18. In the *Object distractor conditions* a different fruit type (and distractor) was hidden in each of the four sessions (e.g. strawberries vs. red wooden block was presented in only one session of 18 trials). In the *Fruit distractor conditions* the same two fruit types were hidden for two sessions (e.g. orange slice vs. red grapes was presented in a total of 36 trials). In the *Fruit distractor conditions* the two types of fruits were counterbalanced for the number of times that they were used (nine times each per session).

The type of iconic cue (photo vs. replica) was administered blocked, half of the subjects receiving first the photo conditions and half of the subjects the replica conditions. Subjects received two sessions of Object distractor conditions and two sessions of Fruit distractor conditions in alternating order. The position of the reward (left vs. right) was randomly determined with the constraints that it appeared the same number of times on each side and not be hidden on the same side more than two times in a row.

[2] The two gorillas were used as pilot subjects and participated in a slightly different number and order of sessions: Object distractor Photo (N'kwango, six sessions; Ruby, seven sessions), Object distractor Replica (N'kwango and Ruby, three sessions), Fruit distractor Photo (N'kwango, six sessions; Ruby, four sessions), and Fruit distractor Replica (N'kwango, five sessions; Ruby, two sessions). Two bonobos (Kuno and Ulindi) stopped participating in some sessions and these sessions were excluded from the analysis (Kuno, two sessions with the Object distractor Replica and Fruit distractor Replica; Ulindi, two sessions with the Object distractor Replica).

Scoring and analysis

E scored live which of the two cups was chosen first by each subject (sliding the Plexiglas screen to one side made the choice totally unambiguous). In order to analyze the data, the mean value was taken for all sessions of each condition. All trials were videotaped and a second observer independently scored 20% of the trials, and interobserver reliability with the main observer was excellent (Cohen's kappa = 0.99).

Results

Figure 4 presents the mean number of correct responses across conditions. The 11 apes as a group performed above chance in three out of four conditions (Object distractor Replica $t(10)=11.06$, $p<0.001$; Object distractor Photo $t(10)=3.12$, $p=0.011$; Fruit distractor Photo $t(10)=3.50$, $p=0.006$, one sample t-test). In the Fruit distractor Replica condition, the subjects as a group were not above chance $t(10)=0.91$, $p=0.386$.

A 2×2 mixed ANOVA, with medium (replica and photo) and distractor (object and fruit) as the within-subjects variable, found a significant main effect of distractor, $F(1, 10)=37.55$, $p<0.001$ but no main effect of medium, $F(1, 10)=1.32$, $p=0.278$ (no species comparisons were made because of the small number of subjects of each species). However, a significant interaction between medium and distractor was found, $F(1, 10)=12.41$, $p=0.006$. Pair-wise comparisons revealed that the subjects performed better in the object distractor condition with the replica than with

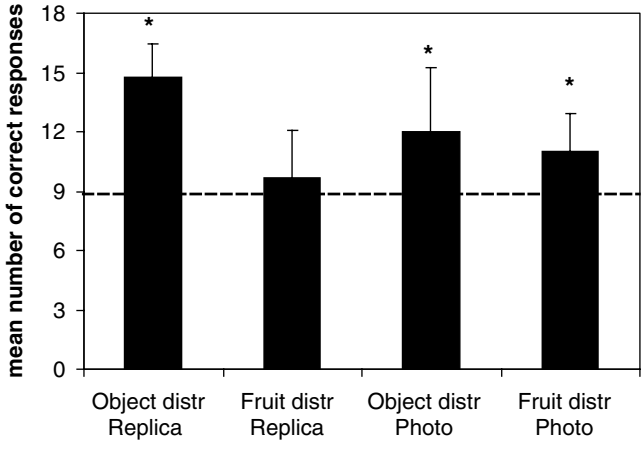

Fig. 4 Mean number of correct responses (with standard deviation bars) across the four conditions in Experiment 2, $^{*}p<0.05$

Table 3 Mean number of correct choices in the four conditions for each subject in Experiment 2

Name	Species	Object distractor Replica	Fruit distractor Replica	Object distractor Photo	Fruit distractor Photo
Frodo	Chimpanzee	13.5*	11	11.25	13.75*
Pini	Orangutan	17*	7.25	12.5	13
Walter	Orangutan	16.5*	10	8.75	8.75
Toba	Orangutan	14.5*	9.25	7	8.75
Padana	Orangutan	15*	9	10.25	9.25
N'kwango	Gorilla	16.33*	15.75*	17.83*	13*
Ruby	Gorilla	14.67*	8.5	16.5*	10
Joey	Bonobo	11.5*	6.75	10.25	9
Ulindi	Bonobo	16.5*	10.5	14*	11.75
Limbuko	Bonobo	13.25*	8.25	11.25	12.5
Kuno	Bonobo	13.5	10	12.75*	11.5
Mean		14.75*	9.66	12.03*	11.02*

*Above-chance performance in at least two sessions of the given condition, binomial probability (or *t*-test for groups), $p<0.05$

the photo ($p=0.016$), whereas no significant difference was found for the Fruit distractor conditions. A pair-wise comparison within the medium showed that there was a significant difference between the different distractors in the medium replica ($p<0.001$), whereas no difference was found in the medium photo (Fig. 4).

Individual scores for each of the 11 subjects in each of the four experimental conditions (and condition means) are presented in Table 3. Each subject was compared to chance (50%) in each session, and again 14 out of 18 correct were above chance ($p<0.05$, two-tailed binomial probability). A condition marked with an asterisk in the table means that a given ape was above chance in at least two sessions of that condition. As can be seen, all apes performed better than chance in at least two sessions in at least one condition.

Discussion

As a group, apes were successful in using both types of cues (photo and replica) when the distractor was a depiction of an object (Object distractor), and one type of cue (photo) when the distractor was a depiction of a fruit (Fruit distractor). These results suggest that apes were using these iconic cues iconically and not just based on local enhancement – since both containers had markers on them and these differed only in their iconic dimensions. In terms of individual or species differences, the two gorillas, N'kwango and Ruby, were extremely skillful from the very first trials in the object distractor conditions.

The better performance of the apes in the object distractor condition with the replica could be explained with the individual scores of three orangutans and one bonobo. A possible explanation for the good performance of Walter, Pini, Padana, and Ulindi in the replica trials is their high interest in new interesting objects serving as replicas; thus, their results could just be based on reaching to the interesting object. This explanation is supported by inspection of the control trials. In these trials, these four apes showed much interest in obtaining the replicas themselves, by choosing them several times before they reached criterion. In general, the results of the object distractor conditions could not show that the apes understand the representational feature of iconic cues because they could have used the strategy of choosing the cue that depicted a food item and not an inedible object. However, the fruit distractor condition suggests that not all subjects were using this strategy, as the individuals N'kwango and Frodo and the apes as a group performed quite well in a situation where both photo cues represented an edible food item. This condition was of special importance, since the apes had to consider both aspects of an iconic object to solve the task, that is, they had to understand the picture or replica on its own and that it represented the specific food item being hidden. In these conditions, the apes could use the photo cue but not the replica cue. This difference between two- and three-dimensional objects was already supported in Experiment 1 and provided further support for the dual representation hypothesis. Kuhlmeier et al. (1999), and Kuhlmeier and Boysen (2001, 2002) conducted similar scale model studies with chimpanzees as DeLoache (1987, 1991, 1995) did with human children and did not find a difference between these two media. Why we found such a difference is a question for future research.

Together, Experiments 1 and 2 demonstrated that apes can be successful in the object-choice task, from the very first trials, if the indexical information typically given is supplemented with an iconic cue. But it is still an open question whether the iconic cue by itself, in the absence of the indexical information, would by itself be sufficient. This is an important question, as our hypothesis is that if apes fully understand the experimenter's communicative intentions they should be able to use iconic information without indexical information – and indeed if they cannot do this, it would suggest that in the first two experiments subjects may have been succeeding by some simpler strategy, for example, by reaching for the picture/replica of the thing they wanted.

Experiment 3

In this experiment, the apes were presented with two very different looking boxes, one of them with a reward inside.

To indicate the rewarded box, the apes were shown a color photo depicting this box. The photo cue was presented between the two boxes and so had no indexical relationship to the baited container. The experiment is thus similar to that of Tomasello et al. (1997), except that in this case a photo rather than a replica was used (and the previous two experiments suggest this might be helpful) and only two, rather than three, boxes were used (which might make the process of choice easier).

Method

Subjects

The subjects were the same as in Experiment 2.

Materials

The same table was used as in the previous two experiments. As hiding places, six different containers were used: one red plastic cup (6.5 cm in diameter, 9.5 cm in height), one straw box (15 cm in diameter, 7 cm in height), a gray plastic tube (8.5 cm in diameter, 11.5 cm in height), a colored paper house (8 × 8 × 10.5 cm), and a yellow plastic box (10 cm in diameter, 7 cm in height). Two out of these six containers were randomly chosen for each session. In addition, photos (10 × 15 cm, glossy) depicting these containers were used. Grapes or banana pieces were used as rewards.

Procedure and design

In the current experiment, each subject was given a pre-test and two sessions of an experimental condition. In both the pre-test and the experimental condition, E sat facing the subject behind the table. E waited until the subject approached the table to start the trial.

Pre-test: E placed two different containers on the platform and showed the reward to the subject. E baited one of two containers in full view of the subject and presented the subject a photo depicting the baited container. E held the photo in front of her body equidistant from the two containers. At the same time, E alternated her gaze three times between the photo and the subject then pushed the platform forward to let the subject choose, still holding the photo in the middle. This pre-test allowed the subject to get experience with the boxes and their photos, which were now presented in the middle. The pre-test consisted of eight trials with the same pair of containers. To participate in the experimental condition, the subject had to choose the correct container six times in a row. All 11 apes reached this criterion and participated in the experimental condition.

Experimental condition: In the experimental condition, E placed two different containers on the platform and showed the reward to the subject. Then E baited one of the two containers behind a screen and showed the subject a photo depicting the baited container. Like in the pre-test, the photo was held in front of E's body and in between the two containers. At the same time, E alternated her gaze three times between the photo and the subject and afterward pushed the platform forward to let the subject choose, still holding the photo in the middle. Each individual participated in two sessions with 18 trials each, which differed in the choice of the container pairs. These containers were also different from the pair chosen in the pre-test to avoid any kind of training effect.

Each subject was tested on two different days. On the first day, the pre-test and the first session of the experimental condition were conducted. The second session of the experimental condition took place on a following day. After the baiting process and the given cue, E looked in the direction of the subject and never to the containers. The position of the reward (left vs. right; or container) was randomly determined with the constraints that it appeared the same number of times on each side and in each container and could not be hidden on the same side or in the same container more than two times in a row.

Scoring and analysis

E scored live which of the two cups was chosen first by each subject (sliding the Plexiglas screen to one side made the choice totally unambiguous). All trials were videotaped and a second observer independently scored 20% of the trials, and interobserver reliability with the main observer was excellent (Cohen's kappa = 1.0).

Results

Table 4 presents the results (number of correct trials) for each of the 11 subjects in each of the two sessions of the experimental condition. As in the previous studies, the dependent measure was the number of correct choices, and 14 out of 18 correct was above chance ($p<0.05$, two-tailed bi-

Table 4 Number of correct choices in the two sessions of the experimental condition for each subject in Experiment 3

Name	Session 1	Session 2
Frodo	11	12
Pini	7	8
Walter	8	12
Toba	6	8
Padana	12	10
N'kwango	10	13
Ruby	12	12
Joey	8	8
Ulindi	11	12
Limbuko	10	9
Kuno	9	10
Mean	9.45	10.36*

*One-sample t-test, $p<0.05$

nomial probability). No subject reached above-chance performance in any session of the experimental condition. The apes as a group were also not above chance ($t(10)=1.70$, $p=0.120$, one-sample t-test). It should be noted, however, that the 11 subjects as a group performed above chance in the second experimental session, $t(10)=2.37$, $p=0.040$ but not in the first session, $t(10)=0.75$, $p=0.472$.

Discussion

The apes in this experiment were not successful in using the iconic cue with the indexical component taken away. Specifically, when the experimenter showed them a picture of the correct box – holding it up midway between the two choices – no subject was above chance in either session. As a group, the apes were not above chance across the two sessions combined. This finding supports the previous finding of Tomasello et al. (1997) using a photo as iconic cue and having only two choices available – both of which should have enhanced performance.

However, it is noteworthy that the apes as a group were above chance in the second session. Apparently, some learning took place during the course of the experiment. On the one hand, it might just be that it took this long for the apes to get used to this new experimental set up in which there were no longer any indexical cues, and the iconic cue did not depict the food, but the location. This might suggest that apes have some skills in using iconic cues by themselves, but they just had to adjust to the new situation. On the other hand, of course, the learning might simply reflect some lower-level contingency or association learning and not any understanding of the communicative intentions underlying the iconic cue.

By itself, the current experiment cannot decide between these two alternatives. Our strategy, therefore, was to run a final experiment in which we used an iconic cue related to the food. This meant that coming into this final experiment, all of the apes had much experience with iconic cues depicting the hidden food as well as experience from this Experiment 3 in using iconic cues without an indexical component.

Experiment 4

In this experiment, we investigated whether apes were able to use an iconic cue without a spatial component if the subject was informed about the food instead of the container (as in Experiment 3). E presented two different fruit items, each placed in one of two transparent containers. One of the food items was obtainable by opening the container, the other container was locked and therefore the food was not reachable. The subject was informed about the obtainable food item by being shown a photo depicting this item. The photo was presented at the spatial midpoint between the two choices, as in Experiment 3.

Method

Subjects

The subjects were the same as in Experiments 2 and 3.

Materials

The same table was used as in the previous three experiments. As hiding places, two transparent containers were used (9 × 9 × 8 cm) which were attached to a wooden board (66 × 10.5 cm) with hinges and were 41 cm apart. This board was mounted on the sliding platform with two screws. One container was fixed with a screw and a nut on the board (locked), while the other container was not fixed with a nut (unlocked) and could be pulled off the board when the subject tried to open the box (Fig. 5).

As fruit items we used banana pieces, orange pieces, and red or green grapes. In addition, we had four photos (10 × 15 cm, glossy) representing each of the different fruit items.

Procedure and design

The general procedure was similar to Experiment 3. Each subject was presented with a pre-test and two sessions of the experimental condition. In every session, E sat facing the subject behind the table. E waited until the subject approached the table to start the trial.

Before starting the pre-test, subjects were given introduction trials to show them that only one container was possible to open by flipping it over, and that the other container was locked. In these trials, both boxes were baited and subjects learned to flip over the unlocked box and experienced that only this box was openable.

Pre-test: E placed two different food items in each of the two transparent containers and locked one container out of view of the subject. Then E put the board on the sliding platform and showed the subject a photo of the obtainable food item. E held the photo in front of her body in between the two containers. At the same time, E flipped over the unlocked container and tried without success the same with the locked one. Afterward, E pushed the platform forward to let the subject choose, still holding the photo in the middle. This pre-test allowed the subject to learn how to play the game and to be exposed to the containers and the photos depicting food items. The pre-test consisted of

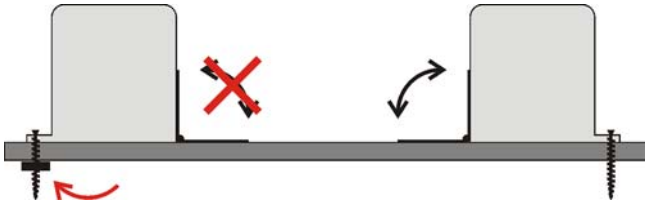

Fig. 5 Apparatus used in Experiment 4

eight trials with the same pair of food items. To participate in the experimental condition, the subject had to choose the correct container six times in a row. Ten apes reached the criterion during the eight trials. Joey and Walter, however, had a strong fruit preference for grapes and chose even the locked container with the grapes instead of the obtainable banana. Both individuals received an additional session and reached the criterion to participate in the experimental condition.

Experimental condition: Each individual participated in two sessions of the experimental condition which were different in the choice of the fruit pairs. These fruit pairs were also different from the pair chosen in the pre-test to avoid any kind of training effect. E placed two different food items each in one of the two transparent containers and locked one food item out of sight. Then E put the board on the sliding platform and showed the subject a photo depicting the obtainable food item. Thereby, E held the photo in front of her body and in the center of the two containers. At the same time, E alternated her gaze three times between the photo and the subject and afterwards pushed the platform forward to let the subject choose, still holding the photo in the middle. Each subject received 18 trials for each fruit pair.

Each subject was tested on three different days. On the first day, the subjects received the introduction trials to the two types of boxes (locked and unlocked). The second day, the pre-test and the first session of the experimental condition were conducted. The second session of the experimental condition took place on the third day. After the baiting process and the given cue, E looked in the direction of the subject and never to the containers. The position of the obtainable food (left vs. right) was randomly determined with the constraints that it appeared the same number of times on each side and that each fruit item was obtainable for the same number of trials. Each fruit item could not be hidden on the same side for more than two trials in a row and could not be the obtainable item in more than two successive trials.

Scoring and analysis

E scored live which of the two cups was chosen first by each subject (sliding the Plexiglas screen to one side made the choice totally unambiguous). All trials were videotaped and a second observer independently scored 20% of the trials, and interobserver reliability with the main observer was excellent (Cohen's kappa = 1.0).

Results

In terms of group performance, the 11 subjects as a group did not perform above chance when combining both sessions together ($t(10)=0.28$, $p=0.788$, one-sample t-test). or analyzing them alone (session 1: $t(10)=0.00$, $p=1.000$; session 2: $t(10)=0.45$, $p=0.659$). Table 5 presents the results (number of correct trials) for each of the 11 subjects on each session of the experimental condition. As in the previous studies, the dependent measure was the number of correct choices, and 14 out of 18 correct was above chance ($p<0.05$, two-tailed binomial probability). No subject performed above chance in any session of the experimental condition.

Table 5 Number of correct choices in the two sessions of the experimental condition for each subject in Experiment 4

Name	Session 1	Session 2
Frodo	9	9
Pini	8	8
Walter	10	9
Toba	9	9
Padana	7	9
N'kwango	11	13
Ruby	11	8
Joey	9	9
Ulindi	8	9
Limbuko	9	9
Kuno	8	9
Mean	9.00	9.18

A closer look at the subject choices showed that most of the subjects had a strong preference for one of the fruit items independent of which container they were placed in. Nine out of 11 subjects chose with 88.33% or more one of the two presented fruit items. The other two subjects had a slightly weaker preference in choosing at least 61.11% of the trials one of the presented items.

Discussion

Neither apes as a group nor apes individually used the iconic cues successfully in this experiment. As in the previous experiment, in which the subject was informed about the hiding place, the iconic cue indicating the obtainable food was not used reliably by the apes.

One problem that occurred in this experiment was the strong preference of the apes for one of the two fruit items. Although the subjects were familiarized with the two different containers in the introduction phase and in the pre-test, it seemed that the subjects could not inhibit their food preference when it was visible and did not pay therefore sufficient attention to the iconic cue (see Boysen and Berntson 1995, for evidence of chimpanzees' difficulties with inhibition). However, it is also possible that apes' inability to inhibit their preference was due to their lack of understanding of the procedure. Although subjects were given experience with both types of boxes, the fact that one of them was in an unobservable way locked might have represented an additional difficulty for the subjects. It is thus possible that apes may have some skills in this task that we were not able to detect because of their problems with inhibiting reaching for desired food or understanding the procedure. Nevertheless, it is the case that apes failed to reliably use iconic cues in either of the final two experiments in which

there was no spatial/indexical information about the correct choice available.

General discussion

Overall, the apes in the current study performed more skillfully in the object-choice task than the apes in any previous study using this task or some variant. In the first experiment, the apes used quite skillfully a single marker placed on top of the correct location, given that this marker was either a photo or a replica of the hidden food. They were especially good with the photo. The second experiment used two markers (one on the hidden food location and the other, either an object or fruit depiction as distractor, on the other location) so that the diagnostic indexical information in the first experiment (single marker located on top of correct location) was no longer available. However, even in this experiment the apes were still very skillful, demonstrating that they were indeed using the iconic information in the photos and replicas, in combination with indexical information, to locate the hidden food.

The third and fourth experiments were designed to investigate whether an iconic cue, in the absence of all indexical information, would by itself be sufficient to indicate for the apes the location of the hidden food. Although each of the experiments on its own has some interpretive difficulties – in the third experiment the apes were a bit better in the second session, and in the fourth experiment their food preferences or a lack of understanding of the procedure may have gotten in the way – they both produced negative results. The apes seemingly could not use an iconic cue that had no spatial relation to the correct location to locate the hidden food. This conclusion is corroborated by the previous findings of Tomasello et al. (1997), who also found negative results in a study that had neither of these two interpretive problems.

Recall that in the present study when subjects participated in Experiments 3 and 4, they already had a lot of experience with the type of iconic cues provided in Experiments 1 and 2. Furthermore, many of the subjects had been quite successful in the first two experiments using these cues to find the hidden reward. Thus, potentially subjects could have generalized this ability to the following experiments just by establishing a physical correspondence between the cue and the hidden reward or the baited container. Nevertheless, subjects were unable to succeed in the new set-up of Experiments 3 and 4, in which no spatial/indexical cue was provided. In our opinion, this lack of success and difficulty to use only iconic information (in the absence of spatial information) relies on their inability to read the experimenters' communicative intentions underlying these cues. Without this understanding, they probably could still solve the task but it would take them a much higher number of trials (see e.g. Oden et al. 1988). So, therefore, our results together with those from Tomasello et al. (1997) indicate fairly clearly that what apes are doing in these studies is not reading communicative intentions – in which case, they should have been able to use the iconic cue by itself, as human children did in Tomasello et al. (1997) — but rather they are doing something else.

It is not totally clear what they are doing, but one possibility is that they are searching for food and using whatever information they can, making inferences from this information as necessary, to locate the food. Because they are searching for a location, the iconic information about the food must coincide spatially with the location toward which they must reach to get the food. A similar but slightly different explanation applies to the study of Kuhlmeier et al. (1999), and Kuhlmeier and Boysen (2001), in which apes used a scale model of a space to locate hidden food. In this case, the apes would use the iconic and spatial information of the scale model about the location of a hidden replica of a juice bottle and then use their spatial cognitive skills to map the real juice bottle onto the real space. In both cases, apes require both iconic and spatial cues to be simultaneously present, and in neither case are they necessarily reading communicative intentions in the sense that they know someone has produced these cues for their communicative benefit.

And so the major finding of the current study is that apes are skillful at using the combination of spatial and iconic information to infer the location of hidden food. What they do not seem to be so skillful at, is understanding the kind of cooperative communication typical of human beings. Humans regularly indicate for one another cooperatively many helpful pieces of information, for example, the location of hidden things. This is not the natural communicative style of other great apes, who mostly compete with one another for valued resources such as food. Indeed, in two recent studies a direct comparison revealed that apes were quite skillful at inferring the location of hidden food when competing with a human, but not when the human tried to inform them helpfully about the location of that food (Hare and Tomasello 2004; Herrmann and Tomasello in press). And so it would seem that apes other than humans are much better at inferring things from the behavior of others (perhaps especially when competing) than at understanding cooperative (helpful, informative) communicative intentions directly.

Acknowledgements We thank the Wolfgang Köhler Primate Research Center animal caretakers for their help in collecting the data. We thank Daniel Stahl for his statistical advice. The reported experiments comply with all laws in Germany regarding animals' experiments.

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