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Understanding of human communicative motives in domestic dogs

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ABSTRACT

Chimpanzees find it easier to locate food when a human prohibits them from going to a certain location than when she indicates that location helpfully. Human children, in contrast, use the cooperative gesture more readily. The question here was whether domestic dogs are more like chimpanzees, in this regard, or more like human children. In our first study we presented 40 dogs with two communicative contexts. In the cooperative context the experimenter informed the subject where food was hidden by pointing helpfully (with a cooperative tone of voice). In the competitive context the experimenter extended her arm towards the correct location in a prohibitive manner, palm of hand out (uttering a forbidding command in a prohibitive tone of voice). Dogs were successful in the cooperative condition ($P = 0.005$) but chose randomly in the competitive condition ($P = 0.221$). The second study independently varied the two characteristics of the communicative gesture (the gesture itself and the tone of voice). In addition to replicating dogs' better performance with the cooperative gestures, this study suggests that tone of voice and context had more effect than type of gesture. In the context of food acquisition, domestic dogs, like human children, seem more prepared to use human gestures when they are given cooperatively.
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1. Introduction

Dogs are extremely skilled in using human cooperative social signals, such as various kinds of pointing, when trying to find hidden food (e.g., Agnetta et al., 2000; Hare et al., 2002; Hare and Tomasello, 1999; Soproni et al., 2001, 2002; and for a review see Miklosi and Soproni, 2006). The most common experimental procedure used to test dogs' use of human communication is called the object choice task, in which subjects have to choose among multiple hiding places with the help of an experimenter cue (Miklosi, 2007). When tested in the object choice task, dogs outperform their closest living relatives, wolves, if the two species are raised under the same conditions and tested at comparable ages (Hare et al., 2002; Miklosi et al., 2003; Viranyi et al., 2008). Dogs also outperform human's closest living relatives the apes in this test (Bräuer et al., 2006; Hare et al., 2002). Furthermore, dogs do not seem to have to learn to use the pointing cues and ontogeny does not seem to play a major role (Hare et al., 2002; Riedel et al., 2008; Viranyi et al., 2008). This combined evidence suggests that selection pressures during domestication influenced dogs' skills in this domain (see Hare et al., 2010 and Udell et al., 2008, for a recent discussion on the domestication hypothesis). Unlike great apes, domestic dogs have evolved to interact with humans cooperatively and to follow humans when they suggest or command that they do things (Topal et al., 2009). However, it remains unclear to what extent dogs are able to draw conclusions regarding the motive of human gestural communication and how dogs interpret the communicative situation presented in the object choice task.

Herrmann and Tomasello (2006) presented chimpanzees and human children with communicative gestures underlain by two different communicative motives in an

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object choice task test design. In the prohibiting condition the experimenter first established a competitive relationship with the subject by stealing food from her, and then forbade the subject to take the baited cup (extending her arm, palm out, with a prohibitive tone of voice saying "No, don't take this one"). The question was whether the subjects could use the prohibiting motive and the competitive relationship to realize that the forbidden cup held the reward (making the inference: "she would only prohibit it if there was something good there"). In the informing condition the experimenter instead first established a cooperative relationship with the subject by giving her food and then informed the subject helpfully where the food was hidden with a pointing gesture (and cooperative tone of voice saying "Look here"). The apes succeeded in finding the food in the competitive condition, as did children aged 18 months, but neither succeeded in the informing condition. Children aged 24 months only succeeded in the informing condition. Herrmann and Tomasello (2006) suggest that both species understand communicative motives, but that the apes' ability to do so is limited to competitive situations. One explanation for this may be that apes, unlike humans, do not understand others' motives to share (e.g., information) but rather interpret the communicative interaction as an action imperative, in the competitive case telling them what not to do.

In the current study, we investigated domestic dogs' understanding of different communicative motives in a similar communicative situation. In study 1 we adapted the method of Herrmann and Tomasello (2006) to test whether dogs differed in their response to cooperative and competitive cues. In study 2 we varied the gestural and vocal components of the cues, trying to investigate which components of a communicative cue are the most relevant for dogs.

As previous studies show that dogs are sensitive to human cooperative communication, we predict that they will successfully choose the baited cup in the cooperative situations. However, what they will do in the competitive conditions is not clear. It is possible that they will follow the human prohibition and avoid the prohibited cup. On the other hand, they might infer that if the human is prohibiting a cup, it is likely that something good is inside and thus prefer the forbidden cup. If they choose randomly in the competitive condition, it would suggest that in the context of food acquisition, dogs expect humans to be helpful and so when a human is prohibiting them from a location in a food finding game, they are not sure what to do and thus ignore the human cues. Lastly, it is possible that the dogs do not choose at all in the competitive context. However, the results of Call et al. (2003) shows that dogs are likely to take food if the experimenters back is turned, as will be the case in our study.

2. Study 1

The general setting of Study 1 was based on Herrmann and Tomasello (2006). Thus, to be able to compare the different species, the cues and procedures were kept as similar as possible to those used in that study. The goal of the study was to see whether dogs understand both a human experimenter's cooperative and competitive motives in a communicative task.

2.1. Methods

2.1.1. Subjects

We tested 40 dogs of various breeds and ages (see Table 1). The dogs were registered on a database at the Max Planck Institute for Evolutionary Anthropology where the owners had volunteered them for tests. All dogs lived with their owners as pets in a German middle sized town. The dogs had no special training beyond normal obedience, except for one dog that had undergone hunting training. The dogs had participated in up to two similar test situations before, but all were naïve to the testing equipment and the exact test procedure used in this experiment.

2.1.2. Material

The testing equipment consisted of a box made from Plexiglas (140 cm × 16 cm × 20 cm). Two Plexiglas dividers were fixed within the box to create compartments at either end of a longer and inaccessible central chamber. The two compartments were accessible from above. The food was placed within one of these compartments and was covered with an upturned, white plastic cup (measuring 9.0 cm in opening diameter). An identical upturned cup was placed in the other compartment, though this one was not baited. The entire Plexiglas box had a sliding lid: its length was such that when the top of one compartment was accessible it shut off the other compartment, and vice versa. At the beginning of trials the lid was positioned centrally so that both compartments were partially accessible. Magnets at either end of the box and on the top of the sliding lid were able to lock the lid in place once it had been pushed to one side, thereby ensuring that only one choice was possible (see Fig. 1). Food, inaccessible and invisible to the dog was hidden in each compartment of the box to mask olfactory cues given off by the bait. The bait was dry dog food of the brand Frolic, and a set of curtains positioned between the dog and the apparatus was used to block the dog's view when necessary (see Fig. 1 for experimental set up). All testing was recorded using a Panasonic NVDS60 videocamera.

2.1.3. Experimental set up

All testing took place at the Max Planck Institute for Evolutionary Anthropology, Germany, in testing rooms specifically for dog studies. Three people were needed during the experiment, two different female experimenters (E1 and E2), and one assistant experimenter (AE) who remained neutral towards the dog. The warm-up and the test trials took place in the same room, whereas the introduction trials took place in a separate room. During both the warm up and the test trials dogs were seated facing the box at a pre-determined mark 120 cm away from the center of the box. During the test trials the experimenter (E1 or E2) stood on the other side of the box facing the dog, at a point 90 cm behind the center of the box. AE held the dog, standing on its right side. A curtain was placed between the

Table 1
Cooperative and competitive columns show number of correct choices in each condition.

Subject	Sex	Breed	Age	Starting condition	Cooperative	Competitive
Drops	M	Parson Jack Russell	6	Competitive	3	3
Hanna	F	Golden Retriever	1,5	Competitive	3	3
Zuela	F	Golden Retriever	2	Competitive	2	4
Wanja	M	Mix	6	Competitive	4	2
Caja	F	Mix	4	Cooperative	4[a]	0[a]
Max	M	Mix	8	Cooperative	4	4
Paula	F	Mix	2	Cooperative	3	3
Jacko	M	Labrador	1	Cooperative	4	4
Kimi	F	Border Collie	8.5	Cooperative	5	3
Senta	F	Mix	12	Cooperative	6	4
Gerry	M	Mix	4	Competitive	3	4
Ole	M	Mix	3	Cooperative	4	3
Fanny	F	Golden Retriever	10	Competitive	3	3
Balu	M	German shorthaired Pointer	3	Cooperative	4	4
Pipo	M	Mix	10	Competitive	5	5
Mira	F	Mix	6	Cooperative	3	4
Paula K	F	Mix	5	Cooperative	5	6
Carrie	F	German wirehaired Pointer	3	Competitive	3	4
Pitty	F	Rottweiler	9	Competitive	4	3
Loki	M	Doberman	3	Competitive	3	3
Bleibda	M	German Shepherd	6	Cooperative	2	2
Panda	M	Mix	10	Cooperative	4	3
Nele	F	Labrador	3	Competitive	2	0
Eddie(Yukon)	M	German Shepherd	8	Competitive	4	6
Luna	F	Mix	3	Competitive	6	4
Finnwolf	M	American White Shepherd	3	Competitive	4	4
Cora	F	Labrador	8	Competitive	4	3
Merlin	M	Dalmatian	8	Cooperative	5	3
Yula	F	Labrador	4	Cooperative	4	3
Evita	F	Labrador	6	Cooperative	3	4
Baro	M	Berner Sennen	8	Competitive	4	3
Emma	F	Weimeraner	2	Cooperative	3	4
Balou	M	Flat coated Retriever	5.5	Competitive	1	3
Frida	F	Mix	2	Cooperative	3	3
Carus	M	Parson Jack Russel Terrier	3	Competitive	3	1[a]
Bora	F	Labrador	9	Competitive	3	3
Susi	F	Mix	1.5	Competitive	3	4
Ned	M	Border Collie	2	Cooperative	3	2
Chester	M	Beagle	3.5	Cooperative	2	2
Lumi	F	German Shorthair	1	Cooperative	2	3

[a] Indicates the dog that received 5 trials only, in both conditions.

dog and the box (see Fig. 1). During the warm up the roles were reversed so that AE baited the box and E held the dog.

2.1.4. Procedure

Each dog first participated in a warm-up phase to become familiarized with the experimental setting. Then the dogs were tested in a cooperative and a competitive context, with one session each containing three introduction trials and six test trials. In each of the two contexts different experimenters (E1 and E2) presented the cues for each subject. A cooperative or competitive relationship between the dog and experimenter was established during the introduction trials. The order of the two sessions (cooperative and competitive) was counterbalanced across subjects in such a way that half the dogs received the cooperative first and the other half received the competitive first. Within each group we also counterbalanced, across subjects, which experimenter behaved cooperatively and which experimenter behaved competitively.

2.1.4.1. Warm-up. The warm up was conducted to familiarize the dogs with the experimental set up. Here AE interacted with the dogs to ensure that the dogs were later not biased towards one of the two experimenters. The warm-up aimed to teach the dogs that they had to manipulate the cups in order to find the food and also aimed to teach the dogs how the Plexiglas box worked. First, the cups, which contained the food, were presented outside the Plexiglas box. Food was placed in one of the two cups in full view of the dog. During the baiting process, AE always manipulated both cups, touching the left cup first. The dog was released and was allowed to make one choice. This phase continued until the dog had learned to flip the cup over to get to the food. In the second phase of the warm-up, the cups were placed inside the Plexiglas box and the food was again baited in one of the two cups in full view of the dog. The location of the food was counterbalanced and semi-randomized with the stipulation that it could not be baited on the same side on more than two consecutive trials. After the baiting, AE returned to the center of the box and the dog was allowed to make its choice. In order to proceed to the test trials, all subjects had to pass (i.e. choose the correct cup and take the food) six consecutive trials of the second phase of the warm up, three to the left and three

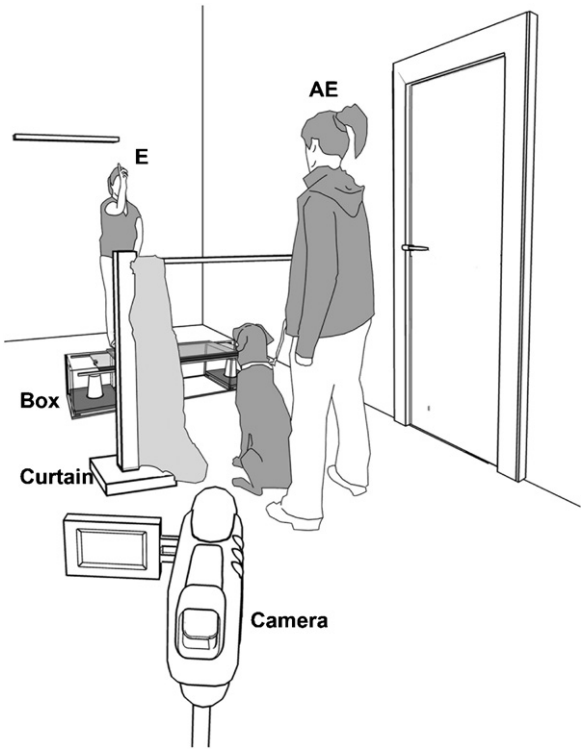

Fig. 1. Experimental set up.

to the right. The dog was given a maximum of 30 min to complete this. Nine dogs were excluded during the warm up, eight for not learning to flip the cup over to get the food in phase 1 and one for not being motivated enough to take the food.

2.1.4.2. Introduction trials. Directly after the warm-up, the dogs participated in introduction trials, in which E1 and E2 established either a cooperative or competitive relationship with the subject. This was done to set a mood for the test trials, i.e. to assist the dog in realizing that one experimenter was helpful whereas the other did not want it to have the food. The cooperative introduction trials were immediately followed by the cooperative test trials and the competitive introduction trials were immediately followed by the competitive test trials. During the introduction trials, E1 or E2, sat alone on the floor with the dog. E did not speak to the dog during the trials. In the cooperative introduction, E placed a piece of food on the floor and the dog was allowed to eat the food. In the competitive introduction, E placed a piece of food on the floor but when the dog was about to take it, she quickly took it away. The dogs were exposed to three identical trials in the cooperative and the competitive condition. Immediately after the competitive introduction, AE gave the dogs three pieces of food to ensure equal satiation in the two conditions.

2.1.4.3. Test trials. All test trials started with E1 or E2 showing the dog the food she was going to hide. Then AE closed the curtain so the dog could not see the baiting. E hid the food in one of the two cups. The location of the food was counterbalanced and semi-randomized for each dog, with the stipulation that food should not be placed on the same side on more than two consecutive trials. Care was taken to make equal noise on both sides of the box and after the baiting E also made a noise in the center so the dog would not be guided to either side by auditory cues. In addition, E always touched the left cup first, irrespective of where the food was going to be hidden. After the baiting, E returned to her starting position and AE opened the curtain. E called the dog's name until it was attending to her. Then the dog received one of two possible distal momentary cues.

Cooperative test trials: The E who had a cooperative relationship with the dog said "Pass auf" (German for "Look") in a high-pitched voice and pointed momentarily two times towards the baited cup, holding her arm cross-laterally (see Fig. 2) and pointing towards it with an extended index finger. At the same time she alternated her gaze between the dog and the cup three times.

Competitive test trials: The E who had a competitive relationship with the dog forbade the dog to approach the baited cup by saying "Aus" or "Nein" (German for "Don't take it" and "No") in a low-pitched, forbidding, voice. The word used depended on what the dog was usually told by the owner in forbidding contexts. She simultaneously made a momentary stop gesture two times holding her arm, cross-laterally, in the direction of the baited cup, with the palm of her hand lifted so that it was directed at the cup (see Fig. 2). At the same time she alternated her gaze between the dog and the cup three times.

In both conditions, after the cue was given, E turned around so that her back was turned towards the box and the dog was released by AE. AE also turned around so that no one observed the dog when it made its choice. If the dog chose the baited cup it was allowed to eat the food and was then taken back to the starting position by AE. If the dog chose the empty cup it was taken back to the starting position by AE, where E showed the dog the location of the hidden food by taking the baited food out from underneath the baited cup and holding it up towards the dog, not allowing the dog to eat it. If the dog did not make a choice within 1 min after the release, the trial was coded as a 'no choice' and was repeated at the end of the test session. The same trial was repeated a maximum of three times for each dog. In the competitive condition a total of 17 trials were repeated because 12 dogs scored no choice on one or more trials. In the cooperative condition 4 trials were repeated because 4 dogs scored no choice on one trial. If the dog did not move from the starting position when it was released it was verbally encouraged to do so by AE who would say "Geh ab" or "Such" (German for "go" or "search") until the dog started to move. Each dog received six trials of each condition.

2.1.5. Coding and analysis

All trials were coded from the video material by the first author. A choice was scored if the dog touched the cup so that it moved. The latency was coded from the moment the dog was released from the leash by AE to the moment it touched the cup. All choice trials were included in the latency data and we calculated the means based on the number of trials the dog had participated in. 20% of the

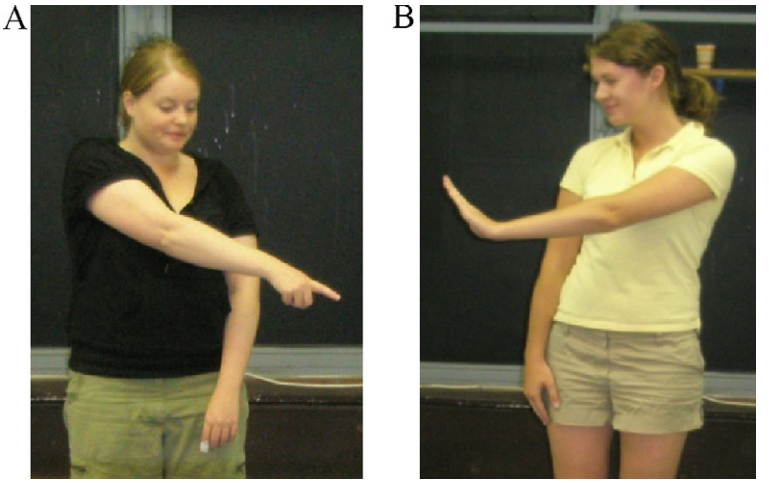

Fig. 2. Gestural cues: (a) pointing gesture and (b) stop gesture.

choice data and 20% of the latency data were also coded for reliability by a person unfamiliar with the test. Reliability for choice was 100%. Reliability for latency was excellent; cooperative trials: Pearson's correlation $\rho = 0.99$, $P < 0.001$, competitive trials: Pearson's correlation $\rho = 0.98$, $P < 0.001$. One subject only chose in five out of six trials in the cooperative condition and therefore a mean percentage of correct choices for each subject was calculated and used in the data analysis. We checked whether the assumptions for parametric testing and ANOVA were fulfilled by visually inspecting plots of residuals versus expected values. This did not indicate any obvious violations of the assumptions.

We used a repeated measures ANOVA to analyze whether the context itself or the order in which the subjects received the two contexts had an effect on the subjects' choices. In addition, the subjects' correct choices were compared to chance performance (test-value = 0.5), using a one-sample *t*-test. The subjects' first trial performance was analyzed using a Fisher's exact test and binomial tests. To control for learning effects on the subjects' performance within the test trials, we used ANOVA to compare the number of correct choices within the first three trials to that in the last three trials. In addition, one repeated measures ANOVA was conducted to analyze whether the dogs' latency to choose differed between conditions. Where a significant difference was detected, the performances in the two different conditions were compared, using a paired sample *t*-test. All statistical tests were two-tailed and results were considered significant if $P < 0.05$.

2.2. Results

Table 1 presents the results for each of the 40 dogs in the two conditions. The mean correct choices for the different conditions are shown in Fig. 3. A repeated measures ANOVA with the within subject factor condition (cooperative vs. competitive) and the between subject factor order (competitive first vs. cooperative first) showed that there was no effect of condition ($F_{1,38} = 1.7$, $P = 0.20$) and no interaction between the two factors condition and order ($F_{1,38} = 0.917$, $P = 0.344$). Also dogs which started with the cooperative condition did not choose the correct cup more often than the dogs which started with the competitive condition, as the between factor alone had no effect ($F_{1,38} = 0.198$, $P = 0.659$).

We then compared each condition against chance. Dogs' choices differed from chance in the cooperative condition (one-sample *t*-test: $t_{39} = 2.98$; $P = 0.005$, mean percent: 58.67, STD ± 18.37), but not in the competitive condition (one-sample *t*-test: $t_{39} = 1.243$; $P = 0.221$, mean percent: 53.96, STD ± 20.15). We then looked at the data of the very first trial of each dog. A Fisher's exact test showed that there was also no significant difference between the two conditions in the first trial ($P = 0.112$). Two binomial tests, one for each condition (cooperative and competitive), showed that the dogs' first trial choices differed from a chance choice in the cooperative condition where 15/20 dogs chose the baited cup ($P = 0.041$), but not in the competitive condition where 11/20 dogs chose the baited cup ($P = 0.824$).

To analyze any possible learning effect, we conducted an ANOVA with the factors condition (competitive vs. cooperative) and the factor half of trials (first half vs. second

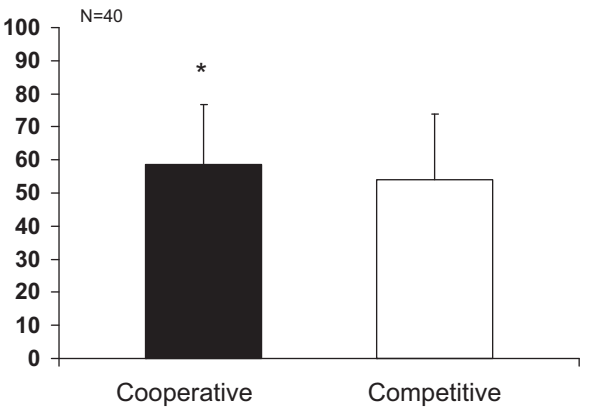

Fig. 3. Mean percentage of correct choices (+STD) in Study 1, $N = 40$. *Indicates significant difference from chance.

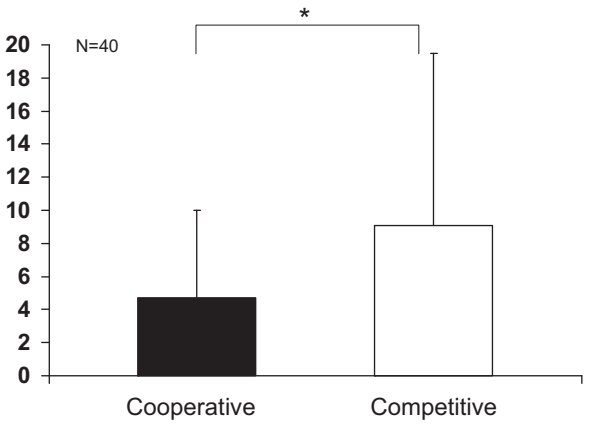

Fig. 4. Study 1 latency (time elapsed from release until choice) in seconds (mean + STD), $N = 40$. *Indicates statistically significant difference between the conditions.

half). Half of trial had a significant main effect with dogs being generally more successful in finding the food in the first compared to the second half of trials ($F_{1,38} = 6.51$, $P = 0.015$). No other factor or their interactions reached significance.

Further, we looked at the latency to take the food and these results are illustrated in Fig. 4. In a first step we conducted a 2×2 ANOVA with the within subject factor condition (competitive vs. cooperative) and the between subject factor order (competitive first vs. cooperative first). The main effect of condition was significant, as dogs retrieved the food faster in the cooperative than in the competitive condition ($F_{1,38} = 12.066$, $P = 0.001$) and that was irrespective of the order in which dogs received the trials ($F_{1,38} = 0.001$, $P = 0.999$). Finally, we looked if the performance changed over trials and conducted a 2×2 ANOVA with the factors context (competitive vs. cooperative) and the factor half of trials (first half vs. second half) and found an interaction between the two factors ($F_{1,38} = 10.044$, $P = 0.003$). Pair-wise post hoc comparisons revealed that dogs did not distinguish between the competitive and the cooperative context in the first half of trials (paired-sample t-test: $t_{39} = 1.65$, $P = 0.107$), but in the second half of trials (paired-sample t-test: $t_{39} = 3.99$, $P < 0.001$). This was owing to a significant increase of latency in the competitive context over time (paired-sample t-test: $t_{39} = 3.613$, $P = 0.001$), while the latencies in the cooperative context remained stable (paired-sample t-test: $t_{39} = 0.612$, $P = 0.544$).

2.3. Discussion

The dogs used the cooperative/informative gesture from the first trial, which is consistent with most previous studies and with the initial prediction of this study. The interesting new finding was that the dogs choose randomly when presented with the competitive/prohibitive gesture. As the dogs were most successful in the first half of the trials, they did not seem to learn their strategy over time. The latency data supports the finding that dogs interpret the two situations differently. The dogs hesitated longer making their choice in the competitive condition than in the cooperative. This may suggest that dogs simply feel more intimidated in the competitive than in the cooperative situation. However, the experimenter turned around after giving the command, and as several studies have suggested, dogs do not hesitate to disobey as soon as the authority (in this case the experimenter) has turned her back on the dog (Call et al., 2003; Schwab and Huber, 2006). In addition dogs were encouraged to move and make a choice if they did not move when released and this should have further reassured them that they could take the food if they knew where it was.

It might also be argued that since the dogs received food from AE before the competitive test situation they expected AE to be a second source of food in the competitive context and that this lead to an increased latency in searching for food inside the box. However, the dog's hesitation was smallest in the beginning of the test when the memory of AE as a source of food would be strongest. Also if the dogs were expecting to obtain food from AE we would expect a high number of no choices in the very first trials of the competitive context but this was clearly not the case. Most likely dogs expect the human to be helpful in this communicative situation which is why her behavior in the prohibitive context is confusing for the dogs and they are not sure what to do. This might in turn account for the increased latency over time in the competitive context as the dogs either lost motivation when they did not know what was expected from them or further increased their time to make a decision as the test progressed.

One interesting question is which aspect of the human communication determines whether dogs perceive the interaction as cooperative or prohibitive. The gestures and verbal commands that were used may be encoded separately and therefore may have given conflicting information in the current study. The stop gesture is physically quite similar to the pointing gesture, while the verbal command is clearly different in the two conditions. Also, Lakatos et al. (2009) have recently confirmed previous suggestions that dogs seem to use not only the pointing gesture, but also any protruding limb, as guidance in the object choice task. This indicates that dogs could interpret the stop gesture to mean the same thing as the pointing gesture. So combining a certain gesture with a certain context makes it hard to disentangle which aspect of the interaction is the relevant one for the dogs. One way to control for this is to present dogs with a situation in which the gesture and the verbal command are varied independently. In addition, to see how dogs would react if the gesture is eliminated completely, we decided to present dogs with a situation in which the human simply approaches both cups but vocally indicates which one contains the food either in a cooperative and informing way or in a competitive and prohibiting way.

3. Study 2

In this study we investigated which components of a communicative cue, the vocal or gestural, are more likely to affect a dog's behavior. First, as in Study 1, a human

Table 2
Cooperative and competitive columns show number of correct choices in each condition.

Subject	Sex	Breed	Age	Start condition	Cooperative			Competitive		
					Point	Approach	Stop	Point	Approach	Stop
Ben	M	Mix	10	Cooperative	5	2	4	4	5	4
Nikos	F	German Shepherd	5	Competitive	3	5	2	4	5	2
Emeli	F	Labrador	4	Cooperative	3	4	4	3	3	5
Paula	F	Labrador	2	Cooperative	5	3	3	3	2	3
Contessa	M	Labrador	6	Cooperative	5	3	4	3	3	5
Amur	M	Golden retriever	1.5	Competitive	5	3[a]	4	1	3	4
Walter	F	Weimeraner	5	Cooperative	3	5[a]	4	3	3	2
Joy	F	Mix	8	Cooperative	5	3	6	5	4	4
Shila	M	Mix	1.5	Cooperative	3	4	2	2	4	4
Jazz	F	Border Collie	4	Cooperative	3	4	5	1	5	1[a]
Tina	F	German Shepherd	8	Competitive	2	4	4	4	2	2
Taira	F	Mix	1.5	Competitive	3	3	3	5	6	3
Helga	M	Mix	7	Competitive	2	3	3	3	3	3
Merlin	F	Mix	6	Competitive	3	3	3	5	3	4
Cessy	F	Labrador	4	Competitive	4	2	3	3	2	2
Sunny	M	Jack Russel	3	Cooperative	3	3	3	3	3	3
Vincent	M	Labrador	4	Competitive	2	3	3	3	3	5
Bruno	F	Golden retriever	8	Cooperative	6	4	4	5	3	5
Kira	F	Riesenschnauzer	6	Competitive	3	3	3	3	3	3
Jessi	F	Mix	6	Cooperative	3	1	6	1	2	2
Daisy	F	Labrador	5	Competitive	4	4	5	3[a]	0[a]	4
Laika	M	German Shepherd	7	Cooperative	4	4	5	3	3	4
Bodo	M	Mix	5	Competitive	6	4	2	2[a]	2[a]	2
Boss	M	Minature Schanuzer	5	Competitive	3	4	2	4	3[a]	2[a]
FeFo	M	Parson Jack Russel	1	Cooperative	1	3	2	3	3	4
Laika	F	Husky	5	Competitive	2	4	2	3	3	4
Bazi	M	Mix	1	Competitive	4	5	4	4	2	0
Cora	F	Labrador	2.5	Competitive	4	5	4	2	2	3
Chappi	M	Labrador	3	Competitive	3	3	3[a]	3	3	5
Ruepel	M	Cocker Spaniel	4	Competitive	4	3	4	4	4	3
Kara	F	Mix	10.5	Cooperative	3	5	3	4	3	3
Laila	F	Golden Retriever	1	Cooperative	3	4	5	6	5	3
Fara	F	Mix	8	Competitive	3	3	4	3	3	3
Nino	M	Mix	8	Cooperative	2	3	2	1	0[a]	3
Bruno	M	Labrador	4	Cooperative	5	1	2	3	2	2
Jody	F	Magyar Vizsla	3	Cooperative	2	3	2	4	4	1

[a] indicate dogs that received only 5 trials in those specific conditions.

experimenter established a cooperative or competitive relationship with the dog and then gave six different communicative cues which varied in their gestural and vocal components.

3.1. Materials and methods

3.1.1. Subjects

36 dogs were tested of which none had participated in Study 1. Dogs were recruited from the same database as in Study 1 and had no special training other than normal obedience. The dogs had experienced up to four similar test situations before but all were naïve to the testing equipment and exact test procedures of this experiment (see Table 2).

3.1.2. Material

The same test equipment was used as in Study 1. All testing took place at the Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany, in special test rooms specifically designed for dog studies. The general experimental set-up was identical to that used in Study 1 (see Fig. 1).

3.1.3. Procedure

The general experimental design was identical to Study 1, i.e. each dog was given a warm-up phase, introduction trials and test trials in the same order as described in Study 1. As in Study 1 the dogs were tested in two different contexts, namely one cooperative and one competitive. However in Study 2 we expanded the number of test trials to 18 per context and exposed the dogs to three different cues within each context. Because of the increase in test trials, the two contexts were presented to the dogs on separate days. The cues and the procedure are described in detail below. The study was counterbalanced in the same way as Study 1 with the addition that the order in which the dogs received the cues within the contexts was also counterbalanced so that the same number started with each of the cues.

3.1.3.1. Warm-up. Each dog first participated in the warm-up phase, which was shortened compared to Study 1, such that the dogs only had to pass two consecutive warm-up trials in phase 2 to proceed to the introduction trials and test trials. The reason for this was the increased total test time of Study 2. Seven dogs were excluded during the warm up.

3.1.3.2. Introduction trials. The introduction trials were identical to those in Study 1. The cooperative introduction trials were followed by the cooperative test trials and the competitive introduction trials were followed by the competitive test trials.

3.1.3.3. Test trials. As in Study 1, immediately after the introduction trials, subjects participated in the test trials. Again there were two different contexts, cooperative and competitive, however three different cues were used within each context. As in Study 1 the cooperative or competitive contexts were conducted by different experimenters (E1 and E2), but given to the dogs on separate days as mentioned above.

As in Study 1 the cue was given by E1 or E2 and AE held the dog. The start and the baiting of the box in the test trials were identical to Study 1. After baiting was completed the dogs received one of the three possible cues. Each of the three cues was presented in the two communicative contexts.

Cooperative context: The experimenter, who had previously established a cooperative relationship with the subject, attracted the attention of the dog by saying "Pass Auf" (German for "Look") in a high-pitched voice and gave one of the three different gestural cues.

Competitive context: The experimenter, who had previously established a competitive relationship with the subject, attracted the attention of the dog by saying "Aus" or Nein" (German for "Don't take it" or "No") in a low-pitched/prohibiting voice and gave one of the three different gestural cues.

The cues, given to the dogs, were:

Pointing: The pointing cue, which was identical to the one used in the cooperative condition in Study 1 (see Fig. 2).

Stop: The stop cue, which was identical to that used in the competitive condition of Study 1 (see Fig. 2).

Approach: The approach cue was not started with the experimenter uttering either the cooperative or competitive command as described above. Instead, E approached the box and then looked under each of the two cups by momentarily tilting it towards the dog, so that the dog could not see under the cup. While positioned in front of the baited cup the experimenter commented on the food either in a positive/cooperative way ("Pass auf" German for "Look" using a high-pitched voice) or in a prohibiting/competitive way ("Aus or nein" German for "Don't take it and No" using a low-pitched voice). Then she alternated her gaze between the cup and the dog three times. While positioned in front of the empty cup E remained neutral and did not look at the dog but just at the empty space beneath the cup. Care was taken that E spent an equal amount of time at each cup. The order in which E approached the cups was counterbalanced and semi-randomized, with the stipulation that she would not start with the same cup in more than two consecutive trials.

After the cue was given, as in Study 1, both the experimenter and AE turned their backs to the dog. If the dogs did not immediately move from the starting position when they were released, AE encouraged them to move by saying such things as "Geh" or "Such" (German for "Go"). AE continued to encourage the dog until it had moved from the starting position. As in Study 1, if the dog did not make a choice within 1 min after it was released, the trial was repeated. In the competitive context 23 trials were repeated and in the cooperative a total of 10 trials were repeated because no choice had been made. In addition three dogs stopped participating in the competitive condition and thus received fewer trials then the others (one, two and two, respectively). One dog stopped participating in the cooperative condition and thus received one trial less then the others. If the dog did not move from the starting position during the repetitions it was again encouraged to do so by AE. Furthermore, if during repetition trials the dog merely walked around the room and was not in the vicinity of the box AE continued to verbally encourage the dog to search for the food.

Each dog participated in all six conditions. On the first day the warm-up was conducted, followed either by the cooperative or competitive conditions (introduction trials and three test conditions). On a consecutive testing day (maximum break of three days) the second set of conditions were presented to the subjects. Each dog received six trials per condition. Thus each dog was exposed to 18 cooperative test trials and 18 competitive test trials and the total number of test trials over the two days was 36. If a trial needed to be repeated this was done at the end of each testing session, so for example, the repetitions of the point trials took place immediately after the point trials, before the next cue, etc. for each context.

3.1.4. Coding and analysis

All trials were coded from video by the first author. To the check for reliability 20% of the original material was coded by a person unfamiliar with the test. Reliability for choice was 100%. Reliability for latency was excellent (Pearson's correlation for competitive conditions: *point*: $\rho = 0.996$, $P < 0.001$, *approach*: $\rho = 0.997$, $P < 0.001$, *stop*: $\rho = 1$, $P < 0.001$. Pearson's correlation for cooperative conditions: *point*: $\rho = 0.919$, $P = 0.027$, *approach*: $\rho = 0.991$, $P = 0.001$, *stop*: $\rho = 1$, $P < 0.001$). Six dogs received fewer trials than the others, because they failed to choose or because of experimental errors. Therefore a mean percentage of correct choices for each subject was calculated and used in the data analysis. We checked the data for the assumption of normal distribution and conducted visual inspection of a plot of residuals against predicted values. As there was no visible pattern, we assumed distributions were effectively normal and proceeded to conduct parametric statistical testing.

We used repeated measures ANOVAs to analyze whether the type of cue (point, approach or stop) as well as the context in which it was presented (competitive or cooperative) had an effect. In addition, the mean percentage of the subjects' correct choices was compared to chance performance (test-value = 0.5), using a one-sample *t*-test. The subjects' first trial performances were analyzed using a Fisher's exact test and binomial tests. To control for learning effects on the subjects' performance within each context, we used ANOVA comparing the number of correct choices within the first 9 trials to that in the last 9 trials, within each context. In addition, a repeated measures ANOVA was conducted to analyze whether the dogs

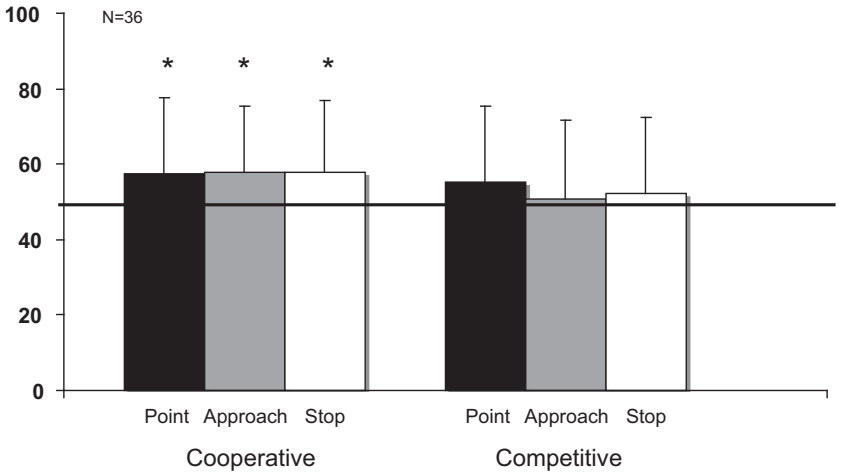

Fig. 5. Mean percentage of correct choices (+STD) in Study 2, $N = 36$. *Indicates significant difference from chance.

latency to choose differed in the competitive and cooperative conditions. All statistical tests were two-tailed and results were considered significant if $P < 0.05$.

3.2. Results

Table 2 presents the results for each of the 36 dogs in the six conditions. The mean correct choices for the different conditions are shown in Fig. 5. A repeated measures ANOVA with the within subject factors cue (point, approach and stop) and context (competitive and cooperative) and the between subject factor order (competitive first vs. cooperative first) was conducted to analyze whether the subjects' responses differed in the two different contexts or cues. The dogs did not choose differently depending on cue ($F_{2,68} = 0.205$; $P = 0.815$) and on context ($F_{1,34} = 2.992$; $P = 0.093$). Also none of the interactions reached significance. Order, as the between subject factor had also no effect ($F_{1,34} = 0.2$, $P = 0.66$).

The dogs' choices differed from a chance choice in all three conditions within the cooperative context: *point:* $t_{35} = 2.212$; $P = 0.034$, with a mean 57.4% of the choices being the correct cup, *approach:* $t_{35} = 2.63$; $P = 0.013$, mean 57.7%, *stop:* $t_{35} = 2.39$; $P = 0.022$, mean 57.7%. However, the dogs' choices did not differ from chance in any of the three conditions within the competitive context: *point*: $t_{35} = 1.57$; $P = 0.12$, mean, 55.3%, *approach*: $t_{35} = 0.267$; $P = 0.791$, mean 50.9%, *stop*: $t_{35} = 0.63$; $P = 0.533$, mean 52.1%.

10 out of 18 dogs chose the baited cup on their first trial in the cooperative context (binomial test: $P = 0.815$) and 9 of the 12 dogs chose the baited cup in the competitive context (binomial test: $P = 1.0$). No significant difference was found in the dogs' performance between the two contexts (Fisher's exact test: $P = 0.25$). As cue did not seem to have an overall effect, we did not differentiate between the cues in this analysis.

To analyze any possible learning effect, we conducted an ANOVA with the factors context (competitive vs. cooperative) and the factor half of trials (first half vs. second half). None of the main factors or their interactions reached significance.

Finally, we compared the dogs' latency to make a choice across the different conditions and contexts and the results are illustrated in Fig. 6. A 3×2 repeated measures ANOVA with the factors cue (point, approach and stop) and the factors context (cooperative and competitive) showed that the dogs hesitated longer in the competitive compared to the cooperative conditions as there was a significant main effect of context ($F_{1,34} = 4.91$, $P = 0.034$). No other factor or their interactions reached significance. Order as a between subject factor had no main effect ($F_{1,34} = 1.29$, $P = 0.263$), neither did it affect any of the within subject factors as none of the interactions reached significance.

To analyze any possible learning effect, we again conducted an ANOVA with the factors context (competitive vs. cooperative) and the factor half of trials (first half vs. second half). This showed again a significant effect of context with dog hesitating longer in the competitive than in the cooperative context ($F_{1,34} = 4.94$, $P = 0.033$) but this was irrespective of half of trials ($F_{1,34} = 0.47$, $P = 0.49$) and also there was no main effect of half of trials ($F_{1,34} = 0.36$, $P = 0.553$).

3.3. Discussion

As in the first study, the dogs preferred the baited cup in the cooperative context but choose randomly in the competitive context. Interestingly this was irrespective of the type of gesture given, which indicates that the vocal aspect of the gesture was the more salient cue for the dogs. As in the first study, the dogs also hesitated longer before they made their choice in the competitive context than in the cooperative context. The fact that the dogs choose randomly in the competitive condition and that they required more time before choosing indicates that they were confused by the situation. It could be that dogs were strongly drawn to the cup the human was indicating because of her visually extended arm. It has been shown that dogs tend to use any limb that protrudes outside the body as a directive in the object choice task (Lakatos et al., 2009). The

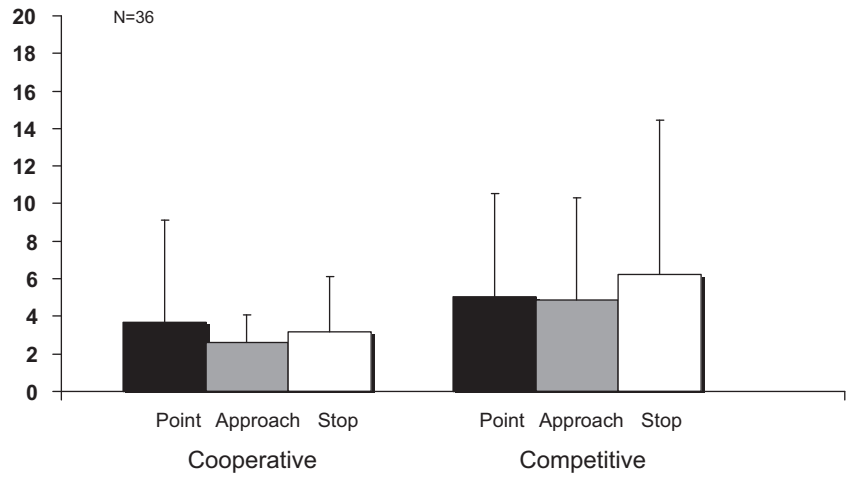

Fig. 6. Study 2 latency (time elapsed from release until choice) in seconds (mean + STD), $N = 36$.

tendency to follow this visual stimulus may thus overrule the tendency to obey the prohibition. Therefore, the visual and the vocal stimulus potentially create a conflict in the competitive setting, which leads to chance performance. In the condition where the human approached the cups and thus excluded the gesture, the dogs still chose randomly, indicating that the prohibiting vocal stimulus confuses the dog's decision in this communicative situation.

4. General discussion

In the current two studies, dogs used gestural communication if it was given with a cooperative motive but not if it was given with a competitive, prohibiting motive. Interestingly the type of gesture used to express the humans' motive is not as relevant as the type of vocal stimulus (e.g., type of verbal utterance and the tone of voice). Dogs' ability to use communicative gestures expressing a cooperative and informing motive is not surprising and supports earlier findings (for a review see Miklosi and Soproni, 2006). The new finding is that dogs tend to ignore the gesture in a competitive and prohibiting context, unlike chimpanzees in a similar setting but similar to 24-month-old children. There are several possible explanations for this result.

One possibility is that dogs always interpret communicative gestures as imperative commands (Kaminski et al., 2009; Topal et al., 2009). If this is so, they would have interpreted the pointing gesture as commanding them which cup to go to or (in the case of the competitive/prohibitive context) which cup to avoid. As dogs as a group did not avoid the cup that the human was pointing to in the competitive context, on the first trial or overall, this explanation is not the most plausible.

A second possibility is that the dogs interpret the gesture as informative in both contexts but are too intimidated by the prohibition in the competitive context to use the information the human has provided. Even though there is evidence that in competitive situations over food dogs tend to disobey if the authority has her back turned towards them (Call et al., 2003; Schwab and Huber, 2006), dogs may still find the competitive context too intimidating. This would also explain why the dogs hesitate longer before making a choice in the competitive than the cooperative context. However, we find it most likely that the dogs were confused about what was expected from them in the competitive context and thus needed more time to make a decision.

Interestingly the dogs in the current study behave like 24 month old children in a similar setting (Herrmann and Tomasello, 2006). Children at this age have been shown to understand communicative interactions as events during which information is shared. Liszkowski et al. (2004) showed that 12 month old infants point declaratively in order to express the motive that adults should share attention to an object. 12 month old infants also point informatively in order for adults to help them find lost objects (Liszkowski et al., 2006) and they point out the location of hidden objects more frequently to adults who do not know where they are hidden than for adults who do (Lizskowski et al., 2008).

However, the hypothesis that dogs use the pointing gesture as informative is difficult to reconcile with their seemingly limited understanding of others' mental states. Even though there is evidence that dogs understand when a human is or is not attentive (Call et al., 2003; Gacsi et al., 2004; Schwab and Huber, 2006; Viranyi et al., 2004) or does or does not have visual access to an object (Bräuer et al., 2004; Kaminski et al., 2009), it is as yet unclear as to whether this is based on a true understanding of others as mental agents. After being requested to fetch an object dogs do not differentiate between objects that the human is ignorant or knowledgeable about (Kaminski et al., 2009). Instead of interpreting a human's intentions and mental state, dogs' use of human gestures could be more behaviorally based. Evidence for this comes from other studies showing that in their use of human gestures dogs are highly sensitive to certain ostensive cues like tone of voice, eye contact, etc. (Kaminski et al., submitted for publication). Dogs do not follow gestures like pointing or gazing when, for example, the ostensive cues indicate that the experimenter is talking to another person. In contrast, children's communication from an early age seems to be based on

an understanding of others' intentions and on processes of shared intentionality (Tomasello, 2008; Tomasello et al., 2005), which are probably uniquely human features.

Our preferred interpretation of the current results draws on both of these possibilities but is importantly different. Domestic dogs typically experience cooperative communication and prohibitions in different contexts. When in cooperative contexts, dogs naturally trust human communicative acts; they understand them as "weak imperatives", that is, as suggestions. These are almost always directives about where they should go. In contrast, prohibitions are almost always about what the dog should or should not do – they should not chew on the chair or run out into the street or whatever. The current study set up a mainly cooperative context about where the dog might find some food, and so the cooperative communication was readily understood. But the prohibition to not go to a particular location/cup was simply confusing in this context, especially since the extended arm is morphologically similar to the pointing gesture, which they readily follow. The dogs did not make the inference that the prohibited cup contained food because they have never been in situations previously where such an inference would have been helpful. In situations where dogs are forbidden to take food the item is always visible to the dog and the dog does not have to apply any meaning to the communication other then the imperative "do not eat it".

In any case, the current results reinforce the overall conclusion that domestic dogs have evolved in the context of human culture to be especially cooperative and trusting of humans. In this regard, they seem to be more like human children than they are like other mammalian species, including humans' closest primate relatives.

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