Animal Behaviour 82 (2011) 651–658

Contents lists available at ScienceDirect

Animal Behaviour

journal homepage: www.elsevier.com/locate/anbehav

Dogs, *Canis familiaris*, communicate with humans to request but not to inform

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ARTICLE INFO

Article history:
Received 24 February 2010
Initial acceptance 28 April 2010
Final acceptance 10 June 2011
Available online 29 July 2011
MS. number: 10-00128R

Keywords:
Canis familiaris
communication
dog
helping
showing behaviour
social cognition

Dogs are especially skilful at comprehending human communicative signals. This raises the question of whether they are also able to produce such signals flexibly, specifically, whether they helpfully produce indicative ('showing') behaviours to inform an ignorant human. In experiment 1, dogs indicated the location of an object more frequently when it was something they wanted themselves than when it was something the human wanted. There was some suggestion that this might be different when the human was their owner. So in experiment 2 we investigated whether dogs could understand when the owner needed helpful information to find a particular object (out of two) that they needed. They did not. Our findings, therefore, do not support the hypothesis that dogs communicate with humans to inform them of things they do not know.

Dogs are especially skilful at comprehending human communicative gestures. If confronted with a situation in which they are not informed about the location of a piece of food, dogs can successfully find the food if a human points, gazes or even glances towards the correct location (reviewed in Miklosi & Soproni 2006). Several pieces of evidence suggest that these skills are indeed special. Apes, humans' closest living relatives, do not seem to use human-given gestures in a cooperative communicative context as readily as dogs if both species are directly compared (Hare et al. 2002; Bräuer et al. 2006; K. Kirchhofer, F. Zimmermann, J. Kaminski & M. Tomasello, unpublished data). Furthermore, a number of studies have shown that dogs' abilities do not simply reflect a general canid skill. Wolves, *Canis lupus*, dogs' closest living relatives, do not use human-given pointing gestures to the same extent as dogs, even if raised under identical conditions (Hare et al. 2002; Miklosi et al. 2003; Virányi et al. 2008) unless they experienced a certain learning period or are specially trained, for example with a clicker (Udell et al. 2008; Gacsi et al. 2009; for a recent debate about this issue see Udell et al. 2008; Hare et al. 2010). Finally, there is evidence suggesting that extensive learning during ontogeny alone cannot account for dogs' abilities in this domain. Puppies follow human pointing from an early age (6 weeks), even when that gesture requires them to move away from the human's hand (Hare et al. 2002; Riedel et al. 2008). Taken together, this evidence suggests that dogs' readiness to receive and act on human communication may have its roots in their relatively long evolutionary history alongside humans (Miklosi et al. 2003; Hare & Tomasello 2005; Udell et al. 2010).

Dogs' skill in comprehending human cooperative signals raises the question of whether they are also able to produce such cooperative signals flexibly. There is evidence that dogs produce context-specific barks (Yin 2002; Yin & McCowan 2004), which humans can classify even if they are naïve to interactions with dogs (Pongrácz et al. 2005, 2006). There is also evidence that dogs produce indicative behaviours (e.g. jumping, running back and forth, gaze alternation, etc.) persistently to indicate the location of food to a human who has not seen the food being placed there (Hare et al. 1998; Miklósi et al. 2000; Gaunet 2010). Miklósi et al. (2000) defined and summarized these behaviours under the term 'showing behaviour'. They tested dogs in three different conditions to see whether they would inform the owner of the location of a reward if they themselves could not reach it. The dog was treated in one of the following three ways: it remained with the owner after another individual had hidden the reward in one of three bowls; it was left alone after the food was hidden; or it remained with the owner after a helper had entered and petted the dog but did not hide an object. When both reward and owner were present, the dogs looked more frequently at their owner and the location of the reward, and alternated their gaze between the two more frequently than in the other conditions. The fact that they behaved

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doi:10.1016/j.anbehav.2011.06.015

differently when they were alone with the reward as opposed to with their owner suggests that this type of 'showing' behaviour was indeed communicative (Miklósi et al. 2000). However, even though clearly produced communicatively, it is as yet unclear whether the dogs' behaviour in this setting was produced with the intent to inform the human about something. This would imply that dogs understood the informative value of their behaviour as well as took into account when information was necessary (e.g. interpret the human's state of knowledge) and relevant. Alternatively, the dogs' behaviour in these settings may be a form of begging behaviour or simply a direct request produced because the dogs were unable to obtain the reward for themselves (Gómez 2005). The difference is that here dogs would simply produce the behaviour without taking into account the human's need for information and/or their behaviour may not be underlain by any helpful motive.

Humans communicate with the intent to inform others. One cognitive prerequisite for this form of communication is the ability to determine when information is needed. Children from early on seem to be able to determine when others are knowledgeable or ignorant about certain aspects of the environment (e.g. Onishi & Baillargeon 2005; Moll & Tomasello 2006), and they take this into account when communicating with them. For example, they only inform others about certain entities when this information was not shared before and is therefore new to the other (Liszkowski et al. 2006, 2008). A second prerequisite is a cooperative communicative motivation to provide others with information when they need it (Tomasello 2008). Thus, while apes, for example, seem to understand quite a bit about others' knowledge states (reviewed in Call & Tomasello 2008), humans seem uniquely motivated from an early age to share interest and information with others (Tomasello et al. 2005; Tomasello 2008). From a very early age they thus provide others with the information they need, even if doing so has no direct benefit for themselves (Liszkowski et al. 2008; Bullinger et al. 2011).

One important question is thus whether dogs' 'showing behaviour' has this human-like cooperative structure of informing (i.e. recognizing an ignorant recipient and being motivated to help by providing the needed information). If dogs' comprehension of human-given gestures is based on a general understanding of the cooperative nature of the situation, we might expect the same general motivation to underlie dogs' production of communicative signals, or at least we can ask whether they do. This would then support the idea that the communicative signals produced by dogs are more flexible and cooperative than was formerly thought. The aim of the current study, therefore, was to investigate how flexible dogs are in their production of indicative behaviours ('showing behaviour'). In experiment 1, we examined not only whether dogs would request a hidden object in which they were interested but also whether they would inform a human about an object she desired. In experiment 2, we investigated whether dogs are able to understand when the human needs helpful information to find a desired object.

EXPERIMENT 1

The aim of this experiment was to investigate whether dogs indicate the location of a hidden object not just to request a desired object but also to inform others about it. We therefore confronted the dogs with a situation in which an object was placed out of reach behind an occluder and the experimenter was not informed about the object's location. The dog's interest in the object as well as the human's varied. We measured whether the dog's communication towards this location depended on their or the human's interest in the object.

Methods

Subjects

Forty dogs (20 females and 20 males) of various breeds and ages (range 1–13 years old, mean age = 5.45 years) participated in this experiment. All dogs lived with their owners as pets. All but eight dogs had participated in other studies. The owners were recruited through personal contacts and took part in the experiment voluntarily. The precondition for every dog was that they were interested in toys. This was tested in a short prephase during which the experimenter played with the dog. If dogs could not be motivated to play with a toy (e.g. ignored the toy when the experimenter was throwing it) they were dropped from the experiment. Six of the dogs tested were specially trained rescue dogs from the 'Rettungshunde' centre. Dogs were divided into two groups: 24 (14 males and 10 females) were tested without their owners, while the other 16 (six males and 10 females) were tested with their owners to see whether this would change the dogs' behaviour. To avoid potential training by the owners, the precise research question was not explained to them until after the experiment was finished. Dogs were tested individually between April 2005 and June 2006.

Procedure

All tests were performed in a test room (8.67 × 3.98 m) at the Max Planck Institute for Evolutionary Anthropology (see Fig. 1) by two experimenters (E1 and E2). Four cupboards (80 × 26 cm), serving as hiding places for the objects, were attached to the walls at a height of 1.80 m. The distance of each cupboard to E1 was the same (4.50 m). On each cupboard stood an occluder (25 × 18 cm), which ensured that neither the dog nor E1 could see the object during the trial. The room had two doors: E1 always left and entered the room through door 1 and E2 always entered and left the room through door 2.

One experimenter (E1) handled and later requested the object and another (E2) hid the object. The role of E1 was performed by the owner for dogs tested with their owners; for those dogs tested without an owner present this role was performed by a stranger (M.N.).

At the beginning of each trial, E1 (stranger or owner) held the object while entering the room through door 1 with the dog. She sat down on the marked area and either handled or ignored the object for 1 min, depending on the condition. We manipulated whether the dog and/or E1 were interested in the object resulting in the following four conditions.

(1) Dog only: E1 put the object on the marked spot in front of her and read a paper or a magazine while ignoring the dog. The dog was

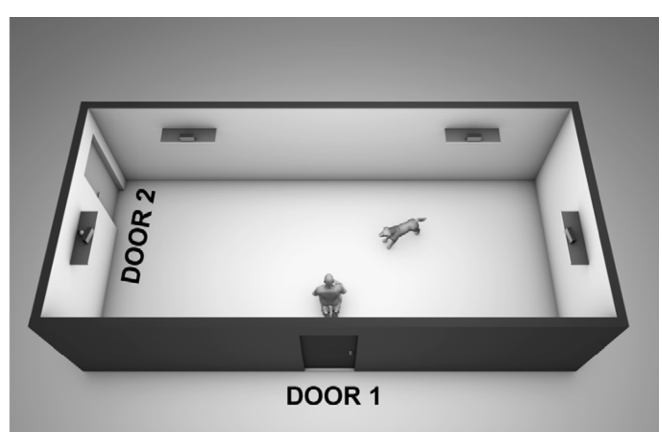

Figure 1. General setting for experiments 1 and 2.

allowed to play with the object, which was the participating dog's favourite toy.

(2) Dog & Human: E1 and the dog handled the object together. Both parties interacted with one another and played with the object, which was a dog toy but not the dog's favourite one.

(3) Human only: E1 handled the object while ignoring the dog. The object was a hole-puncher and E1 used it to punch holes in some sheets of paper.

(4) Neither: E1 put the object on the marked spot in front of her and read a paper or magazine while ignoring both the dog and the object. The object was a porcelain vase.

After 60 s had elapsed (indicated by a timer with an alarm), E1 left the object on the marked area and left the room (again through door 1), pretending to answer a phone call: the dog could hear her on the phone. This manipulation served to remind the dog about the presence of the experimenter outside the room. While E1 was outside the test room E2 entered through door 2, picked up the object from the ground and hid it in one of the four hiding places. E2 made sure that the dog saw the hiding process by attracting the dog's attention. After E2 left the room, E1, who was naïve to the location of the object, returned immediately and sat back on the marked area and then began to search for the object in four distinct phases.

(1) Phase 1: E1 came back into the room and immediately sat on the marked spot. The length of this phase varied but it was never longer than 5 s.

(2) Phase 2: E1 looked at a clock on the wall and searched for the object for 20 s while doing the following: lifting her arms and shoulders, looking around the room by turning her head in every direction at random, saying for example 'Hmm…, that's weird. It was there, and now it's gone. I don't understand it.' and repeatedly mentioning the dog's name. While doing so, E1 remained seated the entire time. There were variations in exactly what was said, but it was important that E1 did not ask specifically for the object.

(3) Phase 3: E1 began asking the dog specifically by addressing the question directly, 'Where is it? Where has it gone?', for 15 s while producing the same arm and shoulder movements and repeatedly mentioning the dog's name. Again E1 remained seated the entire time.

(4) Phase 4: E1 stood up and looked around while remaining silent. The length of this phase varied but was again not longer than 5 s.

After the 35 s had elapsed, E1 tried to guess the location of the hidden object. As E1 had no information about the location of the target and also could not see it (because of the barriers located on the shelves), she had to rely on the behaviour of the dog before making a decision. If E1 felt that she could make a decision, she checked a particular hiding location and went to the place where she thought the object was hidden. E1 never checked more than one location. If she found the object, she picked it up saying 'Wow, there it is! Great!', without giving it to the dog. When E1 investigated a hiding place but did not find the object, E1 said 'Oh, too bad! It's not here'. If E1 could not infer from the dogs' behaviour where the object might be, she just lifted her arms and shoulders saying 'Too bad, we can't find it'. After each of those possible events, E1 left the room and called E2 back into the room and the trial was over.

Each dog received four sessions (with a break of 1–4 days between sessions) and each session included four trials, one of each condition. In each session there was a pause between trials, in which the experimenter played with the dogs, but not with the toys brought by the owners. The starting condition for each dog varied and was counterbalanced across sessions and dogs. The hiding places were administered in a counterbalanced order to assess potential carryover effects across sessions. Each object was hidden at least once in every hiding place. The allocation of the four hiding places was randomized in such a way that E1 could not guess the location based on previous trials; that is, within one session the object could have been hidden in the same hiding place twice.

Analysis

At the time of the experiment, we considered coding the dog's behaviour in detail. The problem is that the same behaviour seems to have different meanings in only slightly different contexts. For example, barking might have a totally different meaning depending on the direction in which the dog was looking. Turning and looking at the experimenter would have a totally different meaning depending on whether the dog was attempting to communicate or simply checking on her whereabouts. We therefore decided that a more global measure, a human's overall judgement about the dog's behaviour towards the object, would be most appropriate. In the one behaviour we did code in detail, gaze alternation, we could not get interobserver reliability, but nevertheless we saw the same basic pattern of results.

Two main measures were coded from videotape by M.N. The first measure was whether M.N. would have started searching for an object based on the dogs' behaviour or not. The second measure was whether M.N. would have found the object, based on watching the dogs' behaviour. Here M.N. tried to assess the location of the target object. The coder in a given trial was never aware where the target was actually hidden. She also was not able to see the experimenter's behaviour. As the experimenter was seated at a predetermined location, covering the screen ensured that the coder could not assess the experimenter's decision. M.N. coded from phase 1 until a predetermined moment towards the end of phase 3 of each trial when the tape was stopped. Then the coder had to make her decision on where the target may be hidden. Her decision could therefore only be based on the dogs' behaviour and we took the successful assessment of the target location as an indicator that the dogs had produced indicative behaviours. As the coder coded all video material and as she was never the owner of any of the tested dogs, more familiarity with the dogs' behaviour cannot explain any given group differences. (Note that the owner's decision about the target location during each trial produced nearly identical results to the coding from video.) The dogs produced different behaviours to indicate the location of an object, for example, by jumping against the wall beneath the location of the hidden object, barking, looking at the hiding place, etc.; these, however, were not coded specifically.

To see whether a naïve coder could also assess the location of the target object, a second coder, naïve to the purpose of the study, coded 20% of the video material for reliability purposes. This was done according to the method described above. Again, the part of the screen where the experimenter would have been visible was covered and the coder had to make her decision at the end of phase 3 of each trial. Reliability between coders was good (Cohen's Kappa $= 0.86$, $N = 132$, $P < 0.0001$).

Statistical Analysis

We used a generalized linear mixed model (GLMM; Baayen 2008) In this we included the interest of the human, the interest of the dog and the tester (owner versus stranger) and all their interactions as fixed effects and the dog's identity as a random effect. As the response we used the number of trials (per combination of human interest, dog interest and dog) in which the coder searched for or found the object. For the found variable, we controlled for the fact that in some trials the human did not search and included the number in which they did (log transformed) as an offset variable. For the model we assumed a Poisson error distribution and log link function.

In addition, the mean percentage of trials in which the target would have been obtained by the coder of the videotapes was compared to chance performance (test value = 0.25), using a one-sample *t* test. To test whether learning occurred over the course of the experiment (again with both measures, search and found) we ran a model over the individual response scores (searched yes/no or found yes/no, respectively). In this we included human, dog and tester and all their interactions up to order three as well as session and trial and their interaction as fixed effects, and the identity of the subject as a random effect. Prior to running this model, we *z*-transformed session and trial to a mean of zero and SD of 1. For the measure 'searched' a comparison of this full model with a reduced model not comprising session and trial and their interaction (but all other terms of the full model) revealed nonsignificance (likelihood ratio test: $\chi^2_3 = 5.01$, $P = 0.171$). Significances of the individual terms were $P = 0.734$ for the session*trial interaction and 0.120 and 0.110 for session and trial, respectively (determined from the model not comprising their interaction). For the model with 'found' as the response we ran a comparable model and got essentially the same findings (likelihood ratio test comparing full with reduced model: $\chi^2_3 = 3.94$, $P = 0.268$; *P* interaction = 0.36; *P* session = 0.749, *P* trial = 0.078).

We ran the model in R (R Development Core Team 2010) using the function lmer of the R package lme4 (Bates & Maechler 2010). We based our estimation on maximum likelihood (argument REML set to false). We found no indication that the model could have suffered from overdispersion ('search': dispersion parameter = 0.49, $\chi_{152} = 74.49$, $P = 1$ 'found': dispersion parameter = 0.46, $\chi_{107} = 49.37$, $P = 0.99$). Initially we tested the full model against the null model comprising only the random effect and the offset term as an overall test of the significance of the predictor variables and their interactions. This test was a likelihood ratio test (Dobson 2002). Once this revealed significance we inspected the significance of the three-way interaction, removed it as it did not reveal significance, and proceeded correspondingly to the two-way interactions. These tests were based on the *z* test provided by the function lmer. All statistical tests were two tailed.

Results

The GLMM was used for both measures 'search' and 'found'. Overall, the full model for the measure 'search' was clearly superior to the null model ($\chi^2_7 = 39.778$, $P < 0.001$) meaning that the predictor variables and their interactions clearly affected the success of the coder in finding the object (see Fig. 2). The three-way interaction (human interest, dog interest and experimenter) did not reveal significance ($z = 0.979$, $P = 0.328$) nor did the two-way interactions between human interest and dog interest ($z = 0.726$, $P = 0.468$) or human interest and experimenter ($z = 0.168$, $P = 0.866$; both assessed in the model without the three-way interaction). The final model hence comprised only the three main effects and the interaction between dog interest and experimenter and revealed the latter to be significant ($z = 2.583$, $P = 0.01$). Human interest was not significant ($z = 0.579$, $P = 0.563$).

Overall, the full model for 'found' was also clearly superior to the null model ($\chi^2_7 = 17.97$, $P = 0.012$). The three-way interaction (human interest, dog interest and experimenter) did not reveal significance ($z = 0.604$, $P = 0.546$) nor did the two-way interactions between human interest and dog interest ($z = 0.584$, $P = 0.559$) or human interest and experimenter ($z = 0.120$, $P = 0.904$; both assessed in the model without the three-way interaction). The final model hence comprised only the three main effects and the interaction between dog interest and experimenter and revealed the latter to be significant ($z = 2.018$, $P = 0.044$). To investigate this finding further, we split the data by experimenter and found that when the experimenter was the owner the dogs' interest had a slightly negative although nonsignificant effect (estimate = −0.278, SE = 0.204, $z = -1.363$, $P = 0.173$), but a much larger and clearly significant effect when the tester was the stranger (estimate = −1.073, SE = 0.337, $z = -3.181$, $P = 0.001$).

To see whether the experimenter could indicate the correct location above chance, we compared each of the variables against chance (note that chance was 25% corresponding to the four possible locations). When the experimenter was a stranger, the target was found significantly above chance when only the dog had an interest in the object (mean ± SD = 75.39 ± 41.37%; one-sample *t* test: $t_{20} = 5.58$, $P < 0.0001$) and also when both human and dog had an interest in the object (mean ± SD = 51.19 ± 42.52%; one-sample *t* test: $t_{20} = 2.82$, $P = 0.011$). However, the coder could not identify the target location above chance if only the human had an interest in the object (mean ± SD = 13.09 ± 31.24%; one-sample *t* test: $t_{20} = 1.75$, $P = 0.09$) or if neither human or dog was interested in the object (mean ± SD = 14.29 ± 32.61%; one-sample *t* test: $t_{20} = 1.51$, $P = 0.148$). When the experimenter was the owner the target was found significantly above chance in all four conditions (dog only: mean ± SD = 80.56 ± 27.94%; one-sample *t* test: $t_{14} = 7.7$, $P < 0.0001$; human & dog: 57.78 ± 30.45%; one-sample *t* test: $t_{14} = 4.17$, $P = 0.001$; human only: 56.11 ± 30.12%; one-sample *t* test: $t_{14} = 4.0$, $P = 0.001$; neither: 49.44 ± 41.6%; one-sample *t* test: $t_{14} = 2.28$, $P = 0.039$).

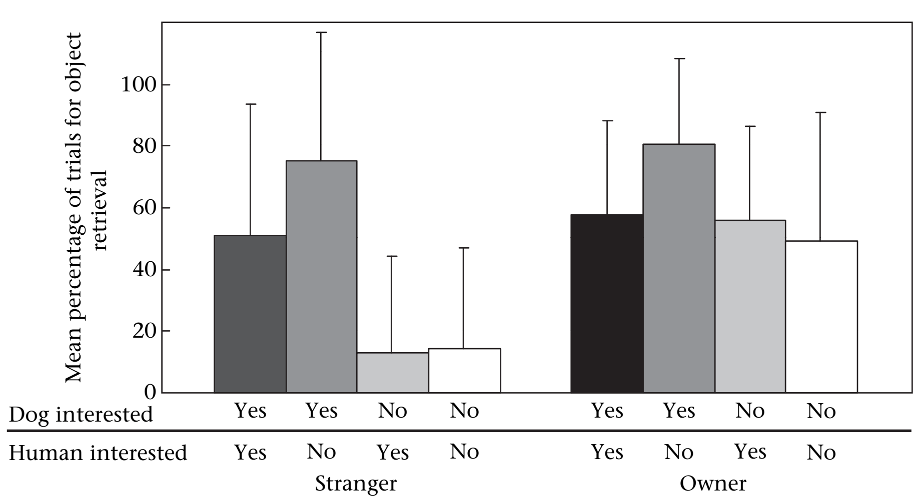

Figure 2. Mean + SD percentage of trials in experiment 1 in which the human found the object in trials where dogs were with a stranger ($N = 21$) or their owner ($N = 16$), respectively.

Discussion

Experiment 1 shows that based on dogs' behaviour the coder started searching for the object and also found the object mainly when the dog had an interest in the object. The human's interest in, and need of, the object did not elicit the same behaviour as the dogs' direct interest in the object. However, this was mainly true if the experimenter interacting with the dog was the stranger. With the owner as the experimenter, the coder found the object, irrespective of condition.

When only the dog was interested in the object the coder found the object even more than when the human was also interested. This was probably because in the dog-only condition it was the dogs' favourite toy that was presented, while in the human & dog condition it was a toy they liked but not their favourite. Dogs' behaviour in this study is comparable to the behaviour of apes, who, unlike children, do not indicate the location of an object unless it is somehow relevant to them (Call & Tomasello 1994; Gómez 1996; Bullinger et al. 2011; but see Zimmermann et al. 2009). As explained above, there was an effect of the person present. When the experimenter in the room was the owner, the object could be found more frequently and irrespective of condition. One plausible explanation could be that dogs were more motivated to indicate the location and therefore be helpful in situations in which the object was relevant for the owner, even if it was irrelevant for them. If it was irrelevant for them, the dogs did not differentiate between the object the human had shown interest in and the object that neither of them had shown an interest in. This was irrespective of the person present (stranger or owner). If dogs were indicating the location to inform the human, they should do so more when it is actually necessary, that is, when the human has shown a clear interest in the object in the past. However, one could argue that in the current setting indicating an object, even one the human has not shown an interest in, is not wrong because upon her return the human is clearly looking for something. Indicating any object that was previously lying on the floor is the simplest thing to do because it is likely to be what the owner is looking for. We therefore conducted a follow-up experiment in which we presented dogs with a situation in which they witnessed the placement of two objects: one object that the owner had shown interest in and the other that the owner had briefly looked at but then ignored. If dogs truly indicate to inform the human about something, they should base their indicative behaviours on the past context.

EXPERIMENT 2

In this experiment the dogs always interacted with their owners and were always presented with two objects. One of the objects was relevant for the owner because it was needed for a certain activity. After both the relevant and the irrelevant objects had been hidden, the question was whether the dogs would indicate the relevant one, suggesting that dogs will helpfully inform humans about things in the environment.

Methods

Subjects

Sixteen dogs (nine females and seven males) of various breeds and ages (range 2–9 years old, mean age = 4.7 years) participated in this study. All dogs lived with their owners as pets. None of the dogs had participated in the first experiment, but the dogs had participated in other studies conducted at the Max Planck Institute for Evolutionary Anthropology. The owners were recruited through personal contacts and took part in the experiment voluntarily. All dogs were tested with their owner and to avoid potential training by the owners, all trials were conducted in a single session on 1 day.

Procedure

The general procedure resembled that of experiment 1, with the exception that now two objects were presented to the dogs and hidden in two of the four hiding locations. Subjects were presented with six pairs of objects (see Fig. 3 for an overview of the objects used), which were necessary for certain functions such as cutting or stapling paper. One object of each pair was the target object for half of the dogs, while it was the nontarget object for the other half. Locations of the targets were counterbalanced across trials and semirandomized with the stipulation that an object could not be in the same location in more than two consecutive trials.

The objects were placed next to each other (65 cm between them) in front of the owner, who was sitting 30 cm behind them. The location of the target object was counterbalanced and semirandomized with the stipulation that the target was not to be placed in the same location on more than two consecutive trials. The owner then manipulated both objects for roughly the same duration, always starting with the object on the left. The nontarget object was only lifted and inspected by the owner; however, the target object was lifted and then used, for example to cut or staple

Figure 3. Pairs of objects used in experiment 2.

paper. After 30 s had elapsed, the owner left the room and E2 entered. E2 placed the objects in their hiding locations, starting with the one on the left, irrespective of whether or not it was the target object. E2 ensured that the dog was attentive while both objects were hidden.

After E2 had finished hiding the objects, the owner returned and behaved according to the same procedures as in experiment 1. The owner returned with the piece of paper in her hand to emphasize that she was about to continue her former activity before having been distracted. To increase the probability of success, the owners were asked always to guess the location of the target object; in other words, the owners always inspected one location even if their dog did not explicitly indicate a location.

To ensure that the dogs were, in principle, motivated to indicate and could memorize the location of a relevant object, even if two objects had been hidden, a control condition was conducted which every dog received after the experimental condition. In the control condition, the two objects were toys, one of which was the dog's favourite toy. Other than this detail the general procedure was identical to the experimental condition. Each dog received six experimental trials, followed by four control trials. Between trials, dogs received a break of about 5–10 min.

Analysis

We analysed whether or not the owner found an object and if it was the target object. The mean percentage of trials in which an object was obtained was compared to chance performance (test value = 0.5), using a one-sample *t* test. As there were two objects hidden in four possible locations, chance performance for finding an object was 50%. In addition we compared the experimental with the control condition using paired-sample *t* tests. All statistical tests were two tailed.

Results

We looked first at the mean percentage of trials in which the owners actually found an object, irrespective of which object it was. In the experimental condition the owners found an object in a mean ± SD of 71.88 ± 23.35% of trials, which was significantly above chance, with chance for finding an object being 50% (one-sample *t* test: $t_{15} = 3.748$, $P = 0.002$). In the control trials, the owners found an object in a mean ± SD of 85.94 ± 22.3% of trials, which was also significantly above chance, with chance for finding an object again being 50% (one-sample *t* test: $t_{15} = 6.446$, $P < 0.0001$). To see whether dogs lose interest over time in indicating the location of an object to their owner, we compared the first half of trials with the second half. The owners found an object equally often in the second half as in the first half of trials (paired-sample *t* test: $t_{15} = 0.813$, $P = 0.429$). Owners found an object significantly more often in the control than in the experimental condition (paired-sample *t* test: $t_{15} = 2.183$, $P = 0.045$).

We then looked at the subsample of trials in which the owners actually found an object and compared how often owners found the target over the nontarget object in the two conditions (see Fig. 4). In the experimental condition, the dogs did not differentiate the target from the nontarget object (paired-sample *t* test: $t_{15} = 0.22$, $P = 0.829$), whereas in the control condition the dogs clearly indicated their preferred object over the other toy (paired-sample *t* test: $t_{15} = 5.372$, $P < 0.0001$).

Discussion

This experiment has two major findings. First, the dogs did not differentiate between the object that the owner needed and the nontarget object, which is shown by the fact that the owner found

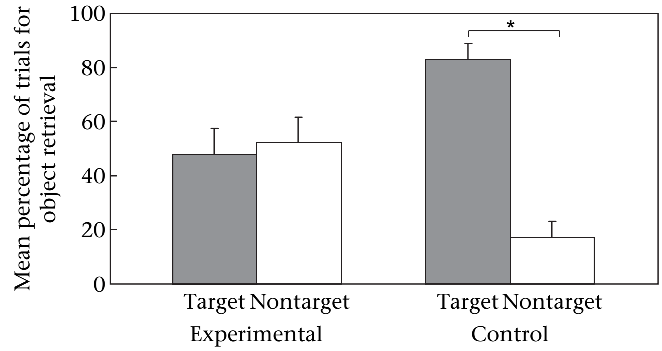

Figure 4. Mean + SD percentage of trials in experiment 2 in which the owner found the target versus the nontarget object in the experimental and control trials ($N = 16$). $^*P < 0.05$.

a target irrespective of whether or not it was the one she needed. Therefore the dogs' behaviour seemed not to be based on the previously established context, as dogs seemed to ignore the human's need for one object over the other. The owners found an object significantly above chance in both the experimental and the control condition; thus the dogs indicated the target location only when they themselves had an interest in one of the two objects. This could have several explanations. It could be that dogs have problems interpreting the human's lack of knowledge and difficulties connecting past events with current events and therefore lack the necessary cognitive skills needed to assess when information is actually necessary. The difficulty dogs have in attributing knowledge and ignorance to others has been established in other studies (Kaminski et al. 2009). On the other hand, the dogs' behaviour shows that they took the past events into account to some extent as the owners found an object, irrespective of whether or not it was the target, significantly above chance. In other words, the dogs did not forget where at least one of the objects was hidden. This was also illustrated by the fact that the dogs were able to indicate their preferred object in the control condition.

It could also be the case that the dogs did not interpret the human's behaviour as goal directed. Instead, it is possible that they simply interpreted the human's behaviour as a request to 'fetch', which they then interpreted as fetching anything that the human had touched. The human's searching behaviour, which was accompanied by certain ostensive cues, may have been interpreted by the dogs as a directive, telling them when to start indicating. Ostensive cues are certain communicative cues such as a high-pitched voice or eye contact, which are produced in human–human interactions to indicate when information is relevant (Sperber & Wilson 1986; Csibra & Gergely 2009). Different studies have shown that dogs are sensitive to various ostensive cues such as eye contact (e.g. Viranyi et al. 2004; Topal et al. 2009). Ostensive cues sometimes lead to more arousal and more active behaviours in dogs (Range et al. 2009) and therefore the ostensive cues may have elicited indicative behaviour in the dogs.

The second main finding is that the owners' success rate in finding an object did not decrease over time, suggesting that dogs remained motivated to indicate an object in which they themselves were not interested. Dogs therefore behave differently from chimpanzees, *Pan troglodytes*, in a similar study (Bullinger et al. 2011). In this study the chimpanzees' rate of indicating went down over time until they nearly stopped indicating the location of an object if it was irrelevant for them, while children tested in a similar setting continued to help the experimenter to a high level (Bullinger et al. 2011). One reason for this species difference could be that the dogs generally behave more cooperatively in their interactions with humans. Even though they have difficulties interpreting the human's behaviour as goal directed and therefore cannot detect which object is the target, they are motivated to indicate whatever object is there in order to follow the human's directives.

GENERAL DISCUSSION

The findings of the current experiments do not support the hypothesis that dogs communicate with humans to inform them of things they do not know. Based on the dogs' behaviour, the human found the target more frequently in situations where dogs requested an object for themselves than in situations where the human needed information, although this seemed to be different when the person the dogs were interacting with was their owner. In the latter case, dogs seemed to be motivated to indicate the location of an object even when there was no direct benefit for them. However, this was then irrespective of the owner's past interest in one particular object. Therefore it seems as if dogs have difficulties identifying the target based on the past events they have witnessed. This could be for several reasons.

One could be that dogs find it generally difficult to connect current with past events and therefore have difficulties with the owner's lack of knowledge. Being able to detect a human's ignorance is a necessary skill if dogs are to understand the context. There is currently conflicting evidence as to whether dogs understand knowledge/ignorance in humans. Virányi et al. (2006) showed that dogs indicated the location of a hidden toy more frequently if a helper, who could retrieve the toy for them, was absent during the hiding of the toy, compared to a condition during which the helper was present. It is possible, however, that in this study being alone in the room with the experimenter in the experimental condition made the dog more excited in the control condition when the helper (usually the owner) entered. This could have simply led to a higher level of arousal and an increase in indicatory behaviours towards the toy. In this case the dog's behaviour may simply depend on the presence or absence of the owner but not on the owner's knowledge state. In another setting, Kaminski et al. (2009) presented dogs with a situation in which the person who requested an object was always present but her knowledge of the location of the hidden objects varied. In this study, the dog and the human sat opposite one another. Two opaque barriers were positioned between them and an object was placed on the dog's side of each of the two barriers. The experimenter either observed or did not observe the placing of the object. If the experimenter requested the dog to fetch an object without referring to either of the two objects specifically, the dog did not prefer the object that the experimenter had seen being placed. This indicates that the dogs did not understand that the human's command was referring to the object they witnessed (Kaminski et al. 2009). Taken together this shows that detecting when a human is ignorant about something may not be a cognitive ability that is present in dogs.

Another possibility is that dogs lack the ability to interpret the human's search behaviour as intentional and goal directed. Instead, dogs may simply take the human's utterances and ostensive signals as a directive to fetch, irrespective of the object. This may explain why dogs in the first experiment seemed to need additional prompting to indicate the target object for the experimenter. Instead of interpreting the context and the human's past behaviour and using that information to inform the human, the dogs may have interpreted the current events, simply and exclusively, as directives to indicate the location of any hidden object. Human children in similar situations communicate information about objects that others are looking for even if they themselves are not interested in the object. In their communicative behaviour they clearly differentiate between relevant and irrelevant objects, indicating that they interpret the context and suggesting that they interpret the other's intentions and goals (Liszkowski et al. 2006; Liebal et al. 2009). In humans this communicative behaviour seems to be based on shared intentionality and a motivation to help others (Tomasello et al. 2005; Warneken & Tomasello 2006).

Dogs have been selected to interact with humans 'cooperatively'; in other words aggression and fear have been selected against (Coppinger & Coppinger 2002). However, whether this involves a selection for genuinely helpful behaviours is as yet unknown. The dogs' behaviour in our study is comparable to that of apes in some respects and different in others. Apes, just like the dogs, point more reliably and more frequently towards an object if it is necessary in order for them to receive a reward (Call & Tomasello 1994; Gómez 1996; Bullinger et al. 2011). This may indicate that apes, and potentially dogs, communicate only imperatively and use their behaviour to direct the human towards a certain location rather than inform her/him about something. However, while the apes' rate of indicating an object in which only the human was interested decreased over time until they nearly stopped indicating, the dogs in the current study continued to indicate the location. This suggests that the dogs' behaviour seems to be based on a motivation generally to act cooperatively. However, this cooperativeness seems to be based on a motivation to execute directives and requests rather than to inform others.

Acknowledgments

We thank the dog owners, without whose support this work would not be possible, Linda Scheider and Lisa Heynig for reliability coding and help with data collection, and Sandra Michaelis for help with Fig. 1. J.K. is supported by a grant from the Volkswagenstiftung.

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