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ORIGINAL ARTICLE

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Are readers of our face readers of our minds? Dogs (*Canis familiaris*) show situation-dependent recognition of human's attention

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Abstract The ability of animals to use behavioral/facial cues in detection of human attention has been widely investigated. In this test series we studied the ability of dogs to recognize human attention in different experimental situations (ball-fetching game, fetching objects on command, begging from humans). The attentional state of the humans was varied along two variables: (1) facing versus not facing the dog; (2) visible versus non-visible eyes. In the first set of experiments (fetching) the owners were told to take up different body positions (facing or not facing the dog) and to either cover or not cover their eyes with a blindfold. In the second set of experiments (begging) dogs had to choose between two eating humans based on either the visibility of the eyes or direction of the face. Our results show that the efficiency of dogs to discriminate between "attentive" and "inattentive" humans depended on the context of the test, but they could rely on the orientation of the body, the orientation of the head and the visibility of the eyes. With the exception of the fetching-game situation, they brought the object to the front of the human (even if he/she turned his/her back towards the dog), and preferentially begged from the facing (or seeing) human. There were also indications that dogs were sensitive to the visibility of the eyes because they showed increased hesitative behavior when approaching a blindfolded owner, and they also preferred to beg from the person with visible eyes. We conclude that dogs are able to rely on the same set of human facial cues for detection of attention, which form the behavioral basis of understanding attention in humans. Showing the ability of recognizing human attention across different situations dogs proved to be more flexible than chimpanzees investigated in similar circumstances.

Keywords Recognition of attention · Dog–human communication · Social context

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Introduction

Recognition of the other's attention could be very important in the communicative context when the sender of the signal needs to ensure that the receiver is in a position to attend to it. This ability is especially important in the visual modality of communication when the orientation of the receiver is crucial, unlike in the auditory modality where one could assume that in most cases the mere presence of the receiver in the vicinity of the signaler ensures successful transmission. Therefore, when communicating by visual signals the sender either has to wait (passively) until the receiver's visual attention is directed at him/her, or alternatively he/she should modify his/her own behavior (actively) to become the focus of the other's attention. This could be achieved by producing attention-receiving signals, which direct the other's attention to the signaler or, alternatively, the signaler moves into the actual visual field of the receiver. Although animals (including humans) probably use both strategies, especially the latter is taken as evidence for the recognition of attention.

However, there is a difference if one defines the recognition of attention at the behavioral or cognitive representational level. In the first case one assumes that the individual is sensitive to behavioral cues that are associated with seeing or "attending". Such observable cues could be the presence or absence of eyes, the direction of head or body or simply the presence or absence of the other individual. In the second case the recognition of attention goes beyond the observation and recognition of specific cues, and results in a mental representation about the mental state of the other. In a recent exchange of similar ideas, Povinelli and Vonk (2003) argued for a behavioral level of attention recognition in chimpanzees, in contrast

to Tomasello et al. (2003), who hypothesized that such recognition of attention goes "a bit below the surface and discerns something of the intentional structure of behavior".

This debate is mainly centered around the somewhat contradictory data on attention recognition in apes that have been published recently. There are a number of independent studies that seem to provide evidence that apes flexibly use cues associated with the attention of either apes or humans, suggesting that apes know what others see (Call and Tomasello 1994; Tomasello et al. 1994; Hostetter et al. 2001; Bodamer and Gardner 2002). In contrast, other experimenters failed to find supportive evidence in controlled studies using a restricted number of subjects (Povinelli and Eddy 1996; Povinelli et al. 2002). For example, using a similar method based on begging from a human for food, Theall and Povinelli (1999) reported no discrimination of an attentive (eyes open) and inattentive (eyes close) human, whilst Hostetter et al. (2001) provide data showing chimpanzees discriminate between an attentive (facing toward) and inattentive (facing away) experimenter. At present such discrepancies cannot be resolved as there are many methodological differences between the two approaches that relate to the origin and size of the sample, the level of socialization to the humans (i.e. "enculturation"), using discriminative (two-choice) or go/no-go procedures, familiarization to the experimental procedures, and the "naturalistic" context of testing etc.

In a recent discussion on social cognition Call (2001) argues for "representational account for mental processes". He suggests that some animals could be able to understand social problems, and use this ability to behave appropriately in novel situations. It seems that consistent or adaptive behavior in novel situations represents the sine qua non for many researchers (see also Heyes 1993) to prove representational capacities of the animal mind exist. In the case of understanding attention of the other, this would mean that the animal should be able to detect the focus of the other's attention independent of the actual context of the situation. To achieve this one needs to observe the same individuals in a series of tests, all presenting problems of recognizing the other's attention, and the hypothesis would be that finding intertest correlations in the performance of the subjects could reveal representational capacities. However, another line of arguments suggest that such cross-situational ability is less likely to surface as species might have acquired behavioral and/or cognitive adaptations that enable them to perform well only in specific circumstances.

In recent years dogs have been the focus of many experimental studies of social cognition. Dogs are able to rely on cues of human attention (body/head orientation) in a food-choice situation (Soproni et al. 2001, 2002), and they are also able to direct the human's attention to the location of hidden food (Miklósi et al. 2000). The present study has two aims. First, we want to establish whether dogs show evidence of being able to perceive the attentional state of a human in different contexts and change their behavior in an appropriate manner. Second, by using a relatively large sample we would like to see to what extent individual dogs show consistent behavior across contexts, which would provide support for a representational interpretation of attention.

Experiment 1: the effect of human bodily orientation and eye visibility on fetching actions

Dogs are known for their ability to retrieve objects. This retrieval is often part of a game between owner and dog, or dogs can be instructed to retrieve objects as part of their "work", as is the case in hunting dogs, or guide dogs for disabled people. Both from the practical and theoretical point of view, when a dog retrieves an object for its owner it should take it to the front of the body, perhaps also taking into account the head orientation of the human. Hare et al. (1998) reported that two dogs retrieved a ball to the front of the human sitting on the ground independent of whether he/she was facing toward or away from the approaching dog. In the present experiment we staged three different situations involving retrieval. In one situation owners were asked to play an instructed retrieval game with their dog; in the other two situations the dog was commanded to take an object to the owner. Humans were asked either to face or turn away before the dog started to approach them and had a blindfold either over their eyes or on their forehead in both positions (see Fig. 1). We supposed that if dogs attend human attentional cues then they should behave consistently across situations and take the object to the front of the owner.

Methods

Subjects

Seventeen family dogs (11 males and 6 females; 15 Belgian Tervuerens, 1 Mudi and 1 mongrel, mean age=5.4 years ±2.8SD) participated in this experiment. Dogs and their owners were recruited from among participants of various dog training schools and dog competitions. Participation in the tests was voluntary. Owners were instructed how to behave and what to do (and what not to do) during the test. All dogs had basic obedience training and 14 of them had agility training as well.

Precondition

The reason for selecting the participating dogs was that we wanted to avoid training the dogs in a particular situation to fetch the objects that could later interfere with our testing procedures (see Introduction). Therefore, to participate in this study dogs had to be able to pass the following tests. First, they had to retrieve a ball and bring it to the owner standing at a given distance. The owner, who

Fig. 1 Arrangement of the tests in experiment 1 (*1* game situation, *2* object fetching/chair, *3* object fetching/ground) and experiment 2 (*4* rewarded begging in chair, *5* unrewarded begging at table)

was allowed to call the dog only once, threw the ball a distance of 10–15 m. After retrieving the ball the dog had to stand, sit or lie down within a distance of 1 m from the owner with the ball in its mouth or drop the ball to the ground but orient itself towards the owner or the ball. Second, the dog had to fetch a personal object of the owner given to him/her by a familiar person who was standing 4 m away from the owner. The owner was allowed to call the dog only once. The dog was supposed to stand, sit or lie down within 1 m of the owner with the object in its mouth, or drop it at that distance but orient itself toward the owner. Only dogs that were able to master both tasks in two subsequent trials were included in this study.

Procedure

The tests were carried out in a familiar open-air area, mainly at the training schools attended by the dogs. Observations were done at an isolated place at the training school so that disturbance to the dog was minimized. Only the owner, the dog, the experimenter (cameraman) and a helper (in the object-fetching tests) were present. We tested the dogs in three different situations that all involved fetching an object (test 1: game situation; test 2 and 3: object-fetching situations). In half of the trials the owners oriented themselves towards the dog ("facing" position) and in the other half away from the dog ("back" position). Additionally the "attention" of the owner was manipulated by having the owners' eyes covered (blindfolded), or not. Combinations of these variables resulted in four different types of conditions in each situation.

Test 1: fetching game with a ball (game situation)

There were two warm-up exercise trials in which the owner threw the ball for the dog and then took it back from it (in the usual way). During the test trials the owner threw the ball more than 3 m away, and commanded the dog ("Bring it!") to fetch it immediately after the throw. While the dog was running toward to ball, the owner took up the position indicated by the helper, placed his/her hands by his/her legs (thighs), remained still and waited for the dog to arrive. The owners practised the correct postures before the experiment.

The owner could take up one of the following body postures ("conditions"):

1. Facing and non-blindfolded: the owner stands facing in the direction of the throw. There is a blindfold on his/her forehead, leaving the eyes visible.
2. Back and non-blindfolded: the owner turns his/her back to the direction of the throw. There is a blindfold on his/her forehead, leaving the eyes visible.
3. Facing and blindfolded: the owner stands facing in the direction of the throw, and a blindfold covers the eyes.
4. Back and blindfolded: the owner turns his back to the direction of the throw, and a blindfold covers his/her eyes.

The experimenter told the owner when he/she was allowed to take the ball away from the dog, and what position to adopt for the subsequent trial. As soon as the owner received the ball, the test was continued with the next trial. A trial came to an end if the dog retrieved the ball and sat, stood, lay within 1 m of the owner either with the ball in its mouth, or dropped the ball but oriented itself toward the owner or the ball for at least 2 s. The trial was terminated after 20 s if the dog did not fulfill any of the

above requirements within this time limit. The test consisted of 20 trials with each condition occurring five times. The order of the conditions was defined randomly in the case of each dog with the restriction that the same condition could not be taken in succession more than twice.

Test 2: fetching an object for the owner sitting in a chair (object fetching I)

There were no warm-up trials before this test. The owner sat in an armchair with a blindfold on his or her head, keeping the hands on the legs with the palms facing down. Four meters from the owner a familiar person (helper) held the dog by its collar, orienting it toward the owner. The helper gave a personal object of the owner to the dog (placed it in the dog's mouth) and said "Take it to the master!". Immediately after this command was uttered, the owner commanded the dog by saying "Bring it!". If the dog released the object or did not start approaching the owner both commands could be repeated once. The dog could be praised verbally after each trial. Then the helper gently directed it back to the starting position for the next trial. The trial came to an end when (1) the dog took the object either to the owner's hands, lap or in close proximity to the owner's body, (2) the dog sat, stood, or lay within 1 m of the owner for at least 2 s with the object in its mouth, or (3) dropped the article but gazed at the owner at least once during this time. The trial was terminated after 20 s if the dog did not fulfill any of the above requirements within this time limit. The owners were told to take up one of the four postures relating to the conditions described above (see test 1) before the start of the next trial, while the helper took the dog back to the starting position, making it turn and look away from the owner. This test consisted of eight trials, so each condition occurred twice. The order of the conditions was defined randomly for each dog with the restriction that the same condition could not be staged twice in succession.

Test 3: fetching an object for the owner sitting on the ground (object fetching II)

The participants and the procedure were identical to the previous situation with the exception that the owner was sitting cross-legged on the ground with hands on thighs. We expected that the back of the owner and the back of a chair did not represent the same stimuli for the dogs because the back of the chair might not be recognized by the dogs as a "part of the owner".

We presented the game situation to all dogs first. As it was based on an everyday situation we supposed it would not influence the result of the other tests. Then the dogs were randomly divided into two groups. One group was first presented with test 2, and the other group started with test 3. There was at least 1 day between the two experiments. All tests were video recorded and analyzed later.

Behavioral variables

Fetching score. The dog was given a score of 1 if it held or dropped the ball/object directly in front of the owner. The dog was given a score of zero if it did not hold or drop the ball/object directly in front of the owner. Scores for the same conditions for each test were summed for each dog.

Hesitative behavior. The dog was given a score of 1 if during the retrieval it showed one or more of the behaviors listed below.

1. The dog made a move towards the owner with the object in its mouth but then turned back (i.e. toward the helper), but in the end it took the object to the owner.
2. The dog made a move towards the owner with the object in its mouth then stopped for at least 1 s, but then it took the object to the owner.
3. The dog made a move towards the cameraman with the object in its mouth but then took it to the owner.
4. The dog did not take the object to the owner within 20 s.

A dog was given a score of zero if during the retrieval it did not show any of the above behaviors. Hesitation scores for the same conditions for each test were summed separately for each dog.

Latency of fetching(s). Latency was measured by a timer and was defined as the time elapsed between the dog's start with the object in its mouth and the handing over (in case of physical contact) or taking a sitting/standing/lying position while holding the object in its mouth or dropping it within 1 m of the owner. Maximum latency was 20 s. (Time was measured by the timer of the camera.) If the dog did not take the object to the owner, maximum latency was recorded. This measure was only taken in test 2 and 3 because in the game situation the distance the owners threw the ball could not be controlled for.

Interobserver agreement was assessed by means of parallel coding of 24% of the total sample (involving altogether 12 dogs, four different subjects in all three situations). We assessed agreement using Cohen's kappa, a statistic that corrects for chance agreement (Martin and Bateson 1986). The kappa scores are for fetching score; game situation: 0.91; object fetching/chair: 0.93; object fetching/ground: 1.0. The kappa scores are for hesitation; game situation: 1.0; object fetching/chair: 0.84; object fetching/ground: 1.0.

Analysis of data

Fetching scores have been transformed to a percentage scale, with maximum possible scores in the trials equaling 100% performance. To be able to compare mean latency of retrieval in the different body positions (facing vs back) 1 s was subtracted from all latency data in the "back" condition. This was necessary because the dogs had to drop or hold the object in front of the human to obtain a fetch-

ing score. Pilot observations have determined that on average dogs need 1 s for going around the human if they approach the person from the back. Fetching and hesitation scores were analyzed by using non-parametric statistical tests. As latency data distributed normally, parametric statistics were applied.

Results and discussion

At first we wanted to see whether the visibility of the eyes had any effect on the behavior of the dogs. One could argue that if seeing ("presence" of the eyes) is an important variable then we should find differences in the facing and back conditions in the effect of the blindfold. The reason for this is that in contrast to the facing condition, if dogs approach the back-turned owner they cannot realize whether the owner has a blindfold over his/her eyes or not. Therefore if dogs are sensitive to the presence of the eyes then we should observe a difference in their behavior with regard to the visibility of the eyes only in the facing condition. Combining all three situations our analysis revealed partial support for this argument because dogs showed somewhat worse performance (fetching scores) if the blindfold covered the owners' eyes in the facing position (blindfolded vs non-blindfolded: Wilcoxon matched pairs signed ranks test, t=2, n=17, P<0.08), in comparison to the back position (blindfolded vs non-blindfolded: Wilcoxon, t=7, n=17, P=0.81). More support for the idea was gained by the analysis of the occurrence of hesitative behaviors. Dogs showed significantly more hesitative behaviors when they fetched the ball/object to a facing owner whose eyes were covered by the blindfold in comparison to the seeing owner (Wilcoxon, t=1, n=17, P<0.02). No such difference was observed with the owners turning their back toward the fetching dog (Wilcoxon, t=4, n=17, P=0.42). These observations suggest that dogs might be sensitive to the presence of the eyes of humans during fetching interactions. Though the present effect of the blindfold covering the eyes is not very strong, note that the dogs had little possibility to choose having only the owner nearby. However, these results do not necessarily mean that they regard the visible eyes as indicators of attention. Therefore, for practical reasons we decided to combine blindfolded and non-blindfolded trials both in the facing and in the non-facing positions (but see experiment 2 on further elaboration of this effect).

Analyzing the effect of body position on the fetching score we found a significant overall variability among the six different groups (three situations×two positions) (Friedman ANOVA: χ^2=32.4, df=5, P<0.01) (Fig. 2). However, comparing "facing" and "back" trials for the different situations separately, there was no variability among facing trials (Friedman ANOVA: χ^2=1.6, df=2, P=0.43), that is, dogs fetched the ball/object very reliably in all situations if the owner was facing toward them. In contrast, if the human turned his/her back to the dogs (back position) the dogs' performance was influenced by the situation (Friedman ANOVA: χ^2=14.0, df=2, P<0.01). The dogs took the

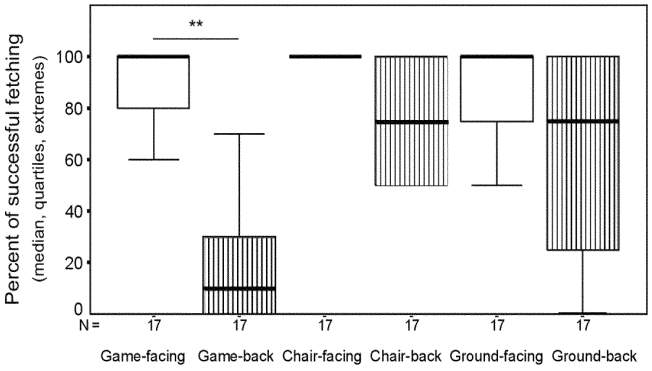

Fig. 2 Median of the fetching results (showing the success at fetching the ball/object to the front of the owner). Paired comparisons of the two different positions (facing and back) in the three experimental situations (game; object fetching/chair; object fetching/ground). Summary plot based on the median, quartiles, and extreme values. The *bold line across the box* indicates the median. The *box* represents the interquartile range, which contains 50% of the values. The *whiskers* extend from the box to the highest and lowest values, excluding outliers. For game-facing and game-back, $^{**}P$<0.01

object to the human's front only when he/she was sitting in the chair or on the ground, and they were rarely successful during the game situation. The pairwise comparisons of facing and back positions in the different situations showed no difference if the owner was sitting in the chair (Wilcoxon, t=2, n=17, P=0.12), in contrast to the significant effect in the game situation (Wilcoxon, t=1, n=17, P<0.01) when dogs did not show a preference for approaching the owner from the front if he/she turned his/her back to the dog while it was fetching an object. Dogs showed intermediate behavior (between the significant effect in the *g*ame situation and the non-significant effect in the *c*hair situation), if the human was sitting on the ground (Wilcoxon, t=4, n=17, P=0.055).

Hesitative behavior also showed an overall variability among the six groups (Friedman ANOVA: χ^2=12.3, df=5, P<0.04). This effect was mainly due to differences in the owners' position (facing vs back) because combining all situations along this dimension led to significant differences (Wilcoxon, t=2, n=17, P<0.01) (Fig. 3). Comparing the three situations in the facing and back positions separately we found no effect of the situation in either case (Friedman ANOVA: χ^2=3.0, df=2, P=0.22; χ^2=4.13, df=2, P=0.13, respectively).

The one-way repeated measures ANOVA showed significant variability in the latency of fetching among the groups (two positions×two situations; note that no latency was calculated for the game situation) [$F_{(3,48)}$=9.0, P<0.01]. The post hoc pairwise comparisons of the situations revealed no differences between trials belonging to the same position (facing: P=1.00 or back: P=0.48), but within the situations dogs were faster in fetching the object if the owner was facing them during the approach (in chair: P<0.02; on ground: P<0.03).

Summing up the present observations it seems that the largest difference is between the game situation and the

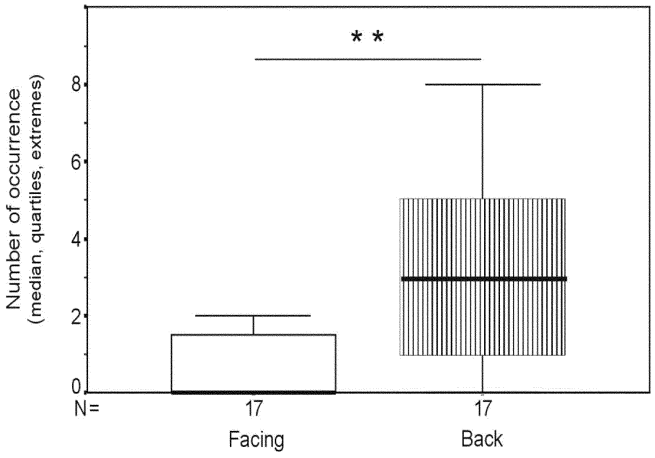

Fig. 3 Median of hesitation (the total number of "hesitative" behaviors during fetching in the two positions (facing and back) combining the three experimental situations (game; object fetching/chair; object fetching/ground). Summary plot based on the median, quartiles, and extreme values. The *bold line across the box* indicates the median. The *box* represents the interquartile range, which contains 50% of the values. The *whiskers* extend from the box to the highest and lowest values, excluding outliers. $^{**}P<0.01$

two other fetching situations. The low performance in the fetching game contradicts in some sense the findings of Hare et al. (1998) because even looking at individual performance in our sample we found only 2 dogs out of 17 that performed over chance level (16 and 17 correct out of 20, binomial distribution, $P<0.05$). It might be that the actual context of that experiment was more similar to a fetching task as applied in our tests 3. In our case the dogs fetched the object to the front of the owner independent of the body position of the human only in the sitting-on-the-ground situation or in the chair situation. However, increased hesitative behavior and longer latency indicate that the dogs were influenced by the change in body orientation even in the object-fetching tasks. Since dogs rarely face such situations under natural circumstances (see discussion that follows), this might indicate that their choice is based more on a kind of cognitive processing than on an automatic response to the situation.

Experiment 2: the effect of bodily orientation and eye visibility on begging behavior

The begging gesture in chimpanzees is often interpreted as an attention-receiving signal for "asking for food". This raises the possibility that the beggar might take the attentional state of the provider into account and adjust its begging behavior accordingly. Povinelli and Eddy (1996) introduced the "begging test" in the study of attention recognition when begging chimpanzees were offered a choice between two humans displaying different "attentional states" (seeing vs non-seeing). The results showed that the chimpanzees needed considerable experience to learn to choose the seeing person. Since dogs also display functionally similar "begging behavior" by regularly approaching and looking at eating humans, we applied a version of this test to look for attention recognition abilities in dogs.

In the present experiment we tested the begging behavior of the dogs in two tests differing in four main dimensions: the position and familiarity of the two eating persons, the way in which the eyes were made invisible and the availability of the food ("reward"). This was done in part to see whether a more natural situation would improve performance. In both tests the dogs could beg from two women, both holding a sandwich in their hands. One of the women oriented herself toward the dog and tried to make eye contact with it. The other woman's eyes were covered with a blindfold (test 4) or her head was turned away from the dog (test 5). In order to avoid the dogs' learning during the trials as much as possible they either received a food reward after each trial (test 4) or did not receive a reward at all (test 5) independent of their choice. The two tests also differed in another respect, because in test 4 both women were gazing forward, so that the only difference between them was the visibility of the eyes. In test 5 their head orientation was different (but not the body posture), presenting a more obvious difference at the behavioral level of attentional state.

Methods

Subjects

Nineteen family dogs (12 males and 7 females; 13 Belgian Tervuerens, 2 Hungarian Vizslas, 1 Beagle, 1 mongrel, 1 Boxer, 1 Basenji) participated in this study. The mean age of the dogs was 5.8 years ±3.0SD. They all had basic obedience training and with four exceptions they had been trained for agility competition. Thirteen of these dogs were also tested in experiment 1.

Procedure

The tests were carried out in a familiar open-air area, mainly at the training schools the dogs attended.

Test 4: the effect of the visibility of the eyes

Warm-up trials. Two women, familiar to the dog, were sitting in a chair 2 m apart oriented toward the dog. There was a blindfold on both women's forehead and there was a sandwich in their right hands as if they were eating. The owner held the dog at a distance of 3–4 m from both of them. One of the women called the dog by its name, waited for 2 s and gave the approaching dog a small piece of the food. After the dog had received the food the owner took it back to the starting position. Then the other woman carried out the same procedure.

Test trials. There were 12 trials. Both women sat in each chair for six trials (three blindfolded trials, and three trials with the blindfold on their forehead but leaving their eyes uncovered). To overcome possible individual differences the position of the women and their role of seeing or not seeing were varied. The order of the positions (chair×blindfold) was defined randomly for each dog with the restriction that the same position could not be taken twice in succession.

The owner held the dog at a distance of 3–4 m and turned it away when the women changed their positions. Then the owner turned the dog towards them and waited for 5 s standing motionless behind him. During this time the woman with uncovered eyes tried to make eye contact with the dog without moving any part of her body. After 5 s the owner let the dog go saying "You can go!". The seeing woman maintained eye contact without moving. The dog received a reward for begging in each trial after the experimenter's signal, irrespective of from whom he was begging.

The following behavior patterns were regarded as begging:

1. The dog sat, stood or lay within 1 m in front of a person and looked at her or her sandwich for at least 3 s. Time was measured by the timer of the camera.
2. The dog pushed or jogged a person with its nose or paw.
3. The dog jumped up at a person or tried to give its paw to a person.
4. The dog vocalized while looking at a person.

After the dog had received the reward, the owner took the dog back to the start position and the next trial began.

Test 5: the effect of the orientation of the face

Warm-up trials. The owner held the dog 3–4 m away from two unfamiliar women who were sitting on the opposite sides of a table facing each other sideways to the dog. A third, familiar woman held a liver sandwich in her hand, turning her back to the table and facing the dog. She called the dog's name and when it approached her, gave a bit of the food she was eating. Then the owner took the dog back to the start position again. After two warm-up trials the familiar person left.

Test trials. Each dog was tested on two different days so that they received two warm-up trials and four test trials at both times.

Two unfamiliar women were sitting on opposite sides of a table, holding a sandwich in one hand, and sideways to the dog. One of them turned her head towards the dog and tried to make eye contact with it, while the other turned her head away from the dog. The women sat on each side of the table twice, on one occasion turning towards the dog, on the other turning away from it. The order of the positions was defined randomly for each dog. The owner held the dog at a distance of 3–4 m from the table, and turned it away when the women changed their positions. For the trial the owner turned the dog towards the eating persons and waited for 3 s. Then the owner let the dog go by saying "You can go". The seeing person tried to maintain eye contact with the dog. Begging was determined the same way as described above.

Behavioral variables and scoring

A score of 1 was given if the dog begged from the person who tried to make eye contact with it. The dog received a score of zero if it begged from the person who did not look at it, or we could not decide definitely which person it was begging from. We added up the scores for each dog, and calculated the percentage of "correct" choices in both tests. The data were distributed normally, so parametric tests were used (paired *t*-test).

Results and discussion

One sample *t*-tests showed that dogs performed over chance level in both situations (sitting at the table t=4.48, df=18, P<0.01; sitting in chairs: t=2.51, df=18, P<0.02) (Fig. 4). However, they begged more from the attentive person when the humans were sitting at the table and there was a difference in the direction of their face (paired t=2.34, df=18, P<0.03). We found positive correlation between the performance of dogs in the two situations (r=0.45, n=19, P=0.05), which suggests that dogs preferring the

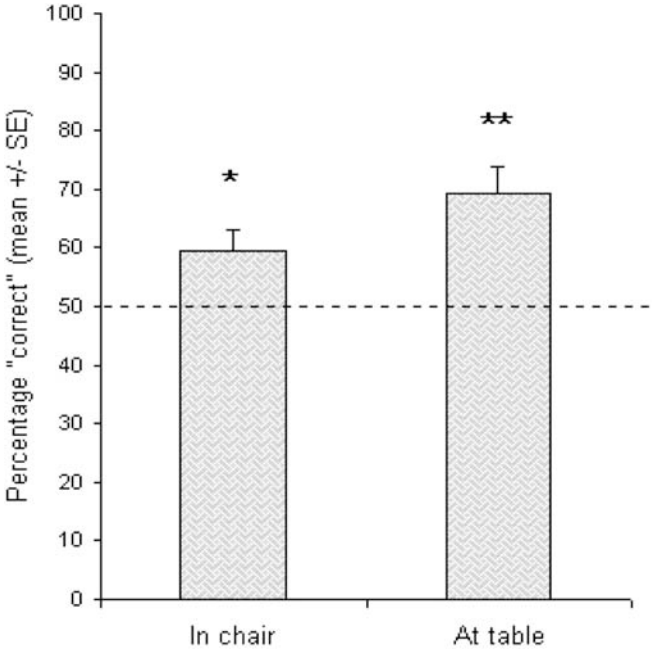

Fig. 4 Mean percentage (±*SE*) of trials when the dogs begged for food from the "attentive" person in the "rewarded/in chair" and "unrewarded/at table" situations. *Dotted line* represents chance performance level (50%). *P<0.05; **P<0.01

facing human when sitting in the chair were also more likely to beg from the person looking at them while sitting at the table. The results of these experiments showed that given appropriate conditions dogs choose the person to beg from on the basis of facial cues usually associated with attention. However, the present results also support earlier observations that the visibility of the face (and possibly also the orientation of the body) plays a key role in recognizing attention, while the visibility of the eyes might be of less significance.

General discussion

So far only a handful of experimental approaches have systematically investigated the effect of attention recognition in non-humans (e.g. Povinelli and Eddy 1996; Hare et al. 2000; Povinelli et al. 2002), and most of these are restricted to chimpanzees.

In the present study a group of dogs was investigated in five different, more or less natural situations to see whether they were sensitive to behavioral cues signaling human attention. We assumed that to show an animal's sensitivity to the attention cues of others, one needs to establish not only that as a group they respond appropriately to visible cues of attention, but also that individuals behave consistently across a variety of social situations. Our results show that dogs provide evidence of recognizing various behavioral cues associated with human attention, but their performance is variable and depends on the context in question, supporting the first but not the second assertion. Dogs seemed less likely to be discriminative in the context of play. In contrast, they performed well if they were commanded to retrieve an object for the owner. This variability can also be found in two structurally very similar situations that utilize begging behavior of the dog. Although we found significant choice in favor of the attending person in both situations, dogs chose more definitely if there was a clear difference in the head orientation of the experimenters (facing vs back). Nevertheless, their performance seem to be better than shown by chimpanzees tested in a similar situation (Theall and Povinelli 1999), and we should add that while the chimpanzees were rewarded only for correct choice, no such differential rewarding was used here. Therefore, from this point of view the performance of the dogs is even more impressive because they chose correctly over chance levels despite the fact that they either did not receive or always received a reward for their choice.

Before considering wider implications of this study, it is important to seek an explanation for the situational effect on the dogs' behavior that might be to some extent valid to related studies on primates. We would argue that both earlier experience and the artificial aspects of the testing situations could account for the observed results. Research on understanding of attention has its foundations in the psychology of human attention, being based on the assumption that the ability, if it exists, should be independent of the context, and eyes play a crucial role in the recognition process. Regarding the first assumption it is clear that in dogs we have found limited evidence for such an overall effect. However, we should take into account that it is very likely that during their life our dogs have experienced many situations like the present ones. They have retrieved hundreds of balls and many objects for their owners, and tried many times (probably successfully) to beg for food from eating persons. However, if an owner expects a dog to fetch an object he would take up the "correct" (attentive) body posture by turning toward the dog. One could suppose that in such situations we are faced with a kind of overtraining where the dog develops a "habitual" behavior that is processed at low cognitive levels like "approach the owner if you retrieve something". In our testing situations the owners were asked to turn their back toward the approaching dog, taking up a position, which they would never do. As a consequence we observed two different types of behavior. Some of the dogs continued to approach the owner from the front ("correct response"), while others showed hesitation (slowing down during approach, turning toward another potentially attentive person, i.e. the experimenter etc.), a sign of uncertainty about what to do because turning one's back to a dog could also signal ignorance on the part of the owner (see also Soproni et al. 2001, and discussion that follows). The fetching situation is of a cooperative nature, which means that if dogs are commanded to fetch something, based on their previous experiences they "rightly" expect appropriate coordinated behavior on the part of the receiver. In contrast, the ball-fetching game is usually not cooperative in the sense that many owners routinely pick up the ball from the ground wherever they find it (or from the mouth of the dog) and throw it away again for the dog. A similar argument can be made for the begging situations where dogs with "begging habits" could have become used to being noticed also if they start to stroll around eating humans (by being looked at) and there is no need to beg from a facing human if under natural circumstances both "facing" and "non-facing" humans are equally likely to provide a treat. The essence of this foregoing discussion is that recognition of attention in dogs (and possibly also in chimpanzees and children) might be strongly influenced by habitual factors that mask the sensitivity to human attention cues. Furthermore, the situations used for testing are often "caricatures" of natural situations, which are normally based on a dynamic interchange of coordinated and short onlooking behavior. The methods that rely on the use of "frozen gestures" are not the best candidates for tackling the existence of understanding of attention. Even if experimental approach might have a decisive role to play, not taking into account the ethological validity of a behavior could lead to serious misconceptions.

Studies on attention recognition often emphasize the importance of the eyes (e.g. Emery 2000), and there is evidence that at least for humans eyes play an important role in many aspects of social behavior, like joint attention and communication (e.g. Baldwin 1991) or possibly mind reading (Baron-Cohen 1994). However, it is important to note that humans are the only primates that have white

sclera, and also have the largest sclera size in the eye outline (Kobayashi and Kohshima 1997). This could mean that our species has undergone a selection process that enabled humans to see the eyes of the others more clearly, and that also allows easier monitoring of the gazing direction of fellow conspecifics. Thus we could assume that the utilization of the presence of eyes as cues for attention is a human-specific trait, and as a consequence ignorance of such cues in other species does not necessarily result in the ignorance of attention in general. In this context it is less surprising that chimpanzees did not use the visibility of the eye as a discriminative signal for recognizing attention (Povinelli and Eddy 1996) even if some enculturated individuals were able to base their choice (in a two-way choice task) on the eye gaze direction provided by a human (Itakura and Tanaka 1998). According to the present results dogs seem to be more sensitive to the presence or absence of eye cues. We found that many dogs showed disturbed behavior in the fetching situations if the blindfold covered the owners' eyes, and they seemed to be able to base their choice on the eye cues alone in one of the begging situations. The sensitivity of dogs to eye cues is supported by the fact that they need only little training to choose on the basis of eye cues in a two-way food choice situation. (Miklósi et al. 1998). At present it is not clear whether the difference between apes and dogs is related to their differential training experience with humans or has a genetic basis.

It should be noted that in most cases of social interaction there is a strong correlation between the direction of face and eye. One can orient with an intent face in one direction and gaze to the opposite side but this subtle cue can only be recognized if the eyes are contrasted with the background, which is the case in humans but not in apes. Interestingly, in dogs we can observe that there is a variation in the amount of white sclera that is visible both individually and among breeds but it is not clear whether this change reflects only a selection on a morphological character or it has been accompanied by changes in their understanding of the importance of eyes as cues. (Alternatively, humans could have selected dogs with white sclera in order to easily monitor the dog's direction of attention.) Taken together, in our opinion, to recognize attention it is not necessary to use the eyes as "the only" cues. Even in human studies there is current debate whether we process cues provided by the eyes and face orientation hierarchically (Perrett et al. 1985) or in a parallel manner (Langton et al. 2000). Therefore, in itself the ability to discriminate facing versus back-turned (non-facing) humans, as demonstrated for dogs in the present study, can also serve as a basis to recognize attention.

In other investigations we have obtained independent evidence that dogs might have some understanding of the significance of looking at humans in particular situations. For example, we have found that dogs would look at the human if they were faced with an insoluble problem situation, for example, they could not attain access to some food, which is hidden out of their reach. In such situations dogs preferentially look at their owner, and also alternate their gaze between where the food is hidden and the owner (Miklósi et al. 2000). In another study we found that dogs are more sensitive to visual cues of attention in humans than in chimpanzees. Soproni et al. (2001) provided evidence that dogs discriminate between a person looking into a container (containing reward) or looking above the container. While the former behavior of the human could be interpreted as displaying attention, the later cue could signal inattentive behavior on the part of the human. Additionally, in a recent study we found that dogs can discriminate between the attentional focus of the human even if the human does not pay attention to them. Dogs preferentially fulfilled a command if the human was looking at an empty space and in contrast when he/she was looking at another human (Virányi et al. 2003).

At present we prefer to interpret our results in a framework provided recently by Call (2001), who suggested a knowledge-based approach to describe sociocognitive processes in apes. Using his theoretical framework, dogs are not only able to learn to associate some stimuli with certain responses but are also able to extract the relationship between stimuli, and based on this they formulate new rules that are used in novel situations. We should add that this rule extraction ability might depend on the evolutionary history of the species, so given human influence on the evolution of the dog, it is less surprising that they are superior to chimpanzees in certain tasks that rely on communicative abilities with humans. Furthermore, based on an ethological approach these results show that there is a limit to generalizational abilities of attention recognition across different situations. So even if animals can extract new rules they might rely on them mainly in functionally similar contexts. At present it is not clear whether this restricted ability is the result of species-specific predispositions, differential developmental experience or the inadequateness of the experimental procedures.

In sum we think that dogs have an understanding of the role of the human's face orientation in social interactions but that they pay less attention to whether such facing behavior is accompanied by the visibility of eyes. Dogs show somewhat better overall performance in the tested situations than previously reported for apes, but this difference could be due to differences in levels of socialization to humans and also to experimental conditions.

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