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Dogs respond appropriately to cues of humans' attentional focus

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Abstract

Dogs' ability to recognise cues of human visual attention was studied in different experiments. Study 1 was designed to test the dogs' responsiveness to their owner's tape-recorded verbal commands (Down!) while the Instructor (who was the owner of the dog) was facing either the dog or a human partner or none of them, or was visually separated from the dog. Results show that dogs were more ready to follow the command if the Instructor attended them during instruction compared to situations when the Instructor faced the human partner or was out of sight of the dog. Importantly, however, dogs showed intermediate performance when the Instructor was orienting into 'empty space' during the re-played verbal commands. This suggests that dogs are able to differentiate the focus of human attention. In Study 2 the same dogs were offered the possibility to beg for food from two unfamiliar humans whose visual attention (i.e. facing the dog or turning away) was systematically varied. The dogs' preference for choosing the attentive person shows that dogs are capable of using visual cues of attention to evaluate the human actors' responsiveness to solicit food-sharing. The dogs' ability to understand the communicatory nature of the situations is discussed in terms of their social cognitive skills and unique evolutionary history.

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1. Introduction

The recognition of the presence of the eyes has primary importance in many vertebrate species. Many investigations have demonstrated that facing eyes or schematic representations of eyespot patterns evoke antipredator behaviour (e.g. Coss, 1978; Csányi and Lovász, 1987; Topál and Csányi, 1994). There is also evidence that animals find approaching humans threatening and the intensity of their reactions depends on both the direction of head and the visibility of eyes (e.g. Burger et al., 1992; Ristau, 1991; Burghardt and Greene, 1990).

Apart from providing cues for agonistic and predatory interactions, in social species gaze perception could play also a role in communicative interactions. Many assume that in social species the ability to detect the direction of attention of others by relying on behavioural cues is adaptive because it may function as an important predictor of the companion's future actions. Attention as a behavioural phenomenon can be characterised by observable cues like gaze-direction. Although in humans the eyes provide the primary source of such information, even in our species social gaze is not limited to the eye cues alone. In certain situations, the orientation of the head and/or the body (combined with the position of participants of social situation) provides sufficient cues for evaluating the focus of another individual's attention (Perret et al.,

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1992). At present there is increasing evidence that in non-human animal species cues other than those of the eyes play dominant role.

Human and non-human primates have been in the main focus of studies on gaze perception and related abilities (e.g. gaze-following, Povinelli and Eddy, 1997; visual perspective taking, Reaux et al., 1999; Hare et al., 2000; recognition of others' attention, Povinelli et al., 2002), although not only primates live in sophisticated social systems that rely on visual signals (Chance, 1967; McNelis and Boatright-Horowitz, 1998). There is a growing body of research showing that animals from several different species are sensitive to the visual orientation of conspecifics (e.g. common raven: Heinrich and Pepper, 1998; domestic pig: Held et al., 2001; domestic goat: Kaminski et al., in press) and that the domestic dog could also be a promising subject for investigating the emergence of finely tuned attention-reading abilities (Miklósi et al., 2004).

There are at least three possible reasons why dogs are expected to have these skills in social interactions. First, the dog (as its nearest relative the wolf, Mech, 1970) is a highly social species that shares many characteristics of the complex social systems known in primates. Second, recent molecular genetic approaches to dog evolution date the emergence of the dog somewhere between 35,000 and 100,000 years (Vilá et al., 1997; Savolainen et al., 2002), which makes the dog the first species that has lived in close cohabitation with humans and suggests that the process of transformation from the wolf-like ancestor to the dog was a unique event requiring special skills and social-ecological circumstances (Schleidt, 1998). Since then the many 10,000 years of human influence led to the selective advantage of the individuals who had more sophisticated skills for interaction and communication with humans. Third, the fact that dogs live in human social setting makes them naturally 'encultured' animals. Enculturation, that is, the lifelong opportunity to experience human contact and interact with our species (Call and Tomasello, 1996), offers the individuals extensive experience to interpret human social cues. Based on previous results suggesting that enculturation facilitate the emergence of social cognitive skills in a more sophisticated level in primates (e.g. Call and Tomasello, 1994; Gomez, 1996) a similar effect may be expected in dogs.

The dogs' sensitivity to human gestural cues involving cues of visual attention has been reported in many independent studies using food choice tasks (Miklósi et al., 1998; Hare and Tomasello, 1999; Agnetta et al., 2000; McKinley and Sambrock, 2000; Soproni et al., 2002). Additionally, dogs learn very fast to utilise eve cues only in such tasks (Miklósi et al., 1998). These studies suggest that dogs are able to use broad range of human given cues-even novel ones-in social situations and they are more skilful in this respect than primates. When using human visual cues to find hidden food, the superior performance in dogs has been confirmed by direct (Hare et al., 2002) and indirect (Soproni et al., 2001; Povinelli et al., 1999) comparisons. In these latter studies the human informant either turned her head and eye gaze toward the correct bowl ('At target' trials) or turned her head to the direction of the correct bowl, but looking above it at the upper corner of the room ('Above target' trials). 'At target' gesture can be considered as a complex sign that consists of a referential component (orientation of the head at the target) and an accompanying attention cue (gazing at the baited bowl). In contrast 'Above target' gesture can be regarded as having only a discriminative function (indicating the correct side), and it consists of inadequate referential and attention component (orienting at the ceiling). Results show that both dogs (Soproni et al., 2001) and children (Povinelli et al., 1999) performed significantly above chance on 'At target' trials whereas they were at chance level on 'Above target' trials. In contrast, chimpanzees' performance (in Povinelli's study) was significantly above chance in the 'Above target' trials too. It seems that chimpanzees' choice was based on the observable discriminative stimuli presented by the human informant, and they were not sensitive to the referential and attention components of the cues.

Dogs' sensitivity to others' attentional cues has been investigated in some additional situations, one of which is the fetching tasks in which dogs seemed to discriminate 'attentive' and 'inattentive' behaviour of humans (Hare et al., 1998; Gácsi et al., 2004). As a further elaboration of these observations, Call et al. (2003) found that dogs are sensitive to whether a human is watching them or not in a situation, where dogs compete with a human over food. Dogs picked up the food more frequently when the human competitor was inattentive (eyes closed, back turned or distracted) in

comparison to the trials when the human showed cues of visual attention toward them (facing the food/dog).

All experiments cited have observed how dogs respond to human cues of attention in feeding or playing contexts, in which subjects aimed to get some desirable food or play by interacting with a cooperative or a competitive human partner. However, it has not been investigated whether dogs can take into account that a human is attending to them or another human subject when communicating in a social situation where no food or toy is involved.

In Study 1 dogs were commanded to perform a mildly aversive action (to lie down on command). The question was whether dogs are more disposed to omit fulfilling the command if the owner is inattentive with them than if she is looking at them. Further on, to test whether dogs have a more sophisticated sensitivity going beyond discriminating between a human's attentive and inattentive states, a third party was involved into the communicative situation. We wanted to see whether dogs are able to discriminate between the attentional focuses of a human in a triadic social situation when there are two 'competing' agents present as possible targets for the command. The second study focused on the question whether the same dogs utilise human visual attention in begging for food.

2. Study 1

Dogs living in a family can often participate in complex social interactions that are also accompanied by verbal utterances on the part of the human companions. Most of these are aimed at other humans in the group, and a lesser part is directed at the dogs. Such situations allow dogs not only to learn about the significance of a given utterance directed at them but also about significance of specific behaviours (orientation of face and body, eye direction, etc.) that accompany changes in human attention. We can hypothesise, that if dogs are able to perceive the focus of visual attention of the human, they should behave differentially in situations when their owner's verbal command is accompanied by different head and bodily orientation. That is, they respond predominantly to commands if the verbal cue is accompanied (or is in accordance) by appropriate visual cues directed at them.

In the present study the dogs' behaviour was tested in an everyday situation experienced often by the dogs: The owner's chatting with another human is suddenly interrupted by a 'Down!' command uttered by the owner for the dog waiting nearby. The command was given in four situations that differed in the owner's orientation while commanding. In one situation the owner faced the dog while saying 'Down!', whereas in the other three ones she turned away from the dog, facing other directions. In one of these three situations she looked at the other human so in this case the focus of her attention was obvious. In the other two situations. however, the focus-subject of the command was ambiguous. In the 'Look away' situation the owner faced neither the dog nor the third person but turned to the direction between them, and in the 'Visual separation' situation the dog could not see the owner's orientation (i.e. she was visually separated from the dog). Our hypothesis was that the dogs are most ready to fulfil the command if the owner is looking at them, they fail to obey if the owner is looking at a third person while commanding and they show intermediate behaviour if the target of the command is ambiguous.

2.1. Methods

2.1.1. Subjects

Thirty-one adult pet dogs and their owners were recruited on voluntary basis at a dog training school. Eight dogs were excluded from the experimental group after the pretest trial because they did not respond to the owner's command and/or they displayed definite signs of stress when they were taken on leash in the experimental room (see below). After their exclusion our sample consisted of 23 adult dogs from different breeds (11 males, 12 females, mean age 5.7±2.6 years, 14 Belgian Tervuerens, 3 Groenendaels, 2 Boxers, 1 Great Dane, 1 Mudi, 1 Schnauzer, 1 Collie).

2.1.2. Procedure

Trials were recorded in a room $(4\,\mathrm{m}\times5\,\mathrm{m})$ that was unfamiliar to the dog. A big (width: 1.2 m, height: 2 m) vertical screen was positioned near one side of the room. The dog, the owner (Instructor) and the experimenter (Partner) were in the room during the observations. Each condition was video-recorded and analysed later. The dogs were led into the room by the Instructor and allowed to explore the room for a

few minutes. During it the Instructor and the Partner were talking to each other while they were standing at their predetermined points in the middle of the room 3 m apart and facing each other. At the beginning of all trials the Instructor put the dog on leash and tethered it at a predetermined point in the corner. In this way the Instructor, the dog and the human Partner were standing so that they formed an isosceles triangle. By gently touching its body the Instructor got the dog to stand orienting towards the middle of the room, and went back to his/her predetermined position in the room. The human participants continued to talk to each other taking apparently little notice of the dog. (If the dog changed its position during the discourse, the Instructor re-positioned the dog.) After 10-20 s, when the dog was orienting towards them, they suddenly stopped talking, the Instructor took up the predetermined body orientation (see below) and gave a verbal command (Down!—'Fekszik!' in Hungarian). In the pretest trial the owner gave the instruction live but in the four experimental trials the command was given by playing back the pre-recorded verbal command of the Instructor (see below). The Partner kept on facing the Instructor without moving in all trials. Having finished instructing the dog both human participants stayed in their positions for further 5 s then the Instructor turned back to the Partner and resumed talking. The trial was terminated when the Instructor turned back to the Partner. The dog did not get any feedback (praise/scolding) at all.

The behaviour of the dogs was observed in the pretest trial and in each of the four different conditions. The dogs started with the pretest trial and the order of the four subsequent playback conditions was chosen at random. There were 2–3 min breaks between the trials when the dog was allowed to move freely in the room.

2.1.3. Pretest trial: 'Face to face/live/'

This condition served to test the dogs' reaction to the experimental situation and whether they obey the 'Down!' command given by the owner. The content of the verbal command was discussed with the Instructors in advance and was the same for all dogs.

In the beginning of the pretest trial the Instructor and her Partner stood in the predetermined position (Fig. 1a) and were talking while facing each other. Before giving the verbal command the Instructor turned towards the dog and looked directly at it. 'Down!' command was uttered only once but the Instructor's non-verbal gesturing was not restricted. Only those dogs (23) that lay down within 5 s after the command were involved to experimental trials.

2.1.3.1. Recording and replaying of the verbal instruction. Because we wanted to avoid the variation of the repeated command to influence the behaviour of the dogs in the different experimental conditions (see below), we have standardised the verbal cues by recording them on tape and this record was used in all further conditions.

Verbal commands were tape-recorded after the pretest trial in the absence of the dog. The Instructors were told to give the 'Down!' command in the same way as in the pretest trial and to repeat it two times with noting the dog's name before the last command ('Down!' . . . 'Down!!' . . . 'dog's name + Down!!!'). In this way commands had the same verbal structure for each dog with the obvious difference regarding the dog's name. The Instructors were asked to increase the imperative mode of the utterance as they proceed with approximately 3 s pauses between the repetitions. So the total duration of the verbal instructions ranged between 8 and 10 s for each dog.

The tape recorder was remote controlled by the Partner in all conditions and was stopped after the command after which the dog lay down (e.g. if the dog lay down after the first command had been given, neither the second nor the third commands were played back). The commands were recorded on a Panasonic RQL 500 tape recorder and replayed using the same tape recorder and a PC loudspeaker. The loudspeaker was positioned on the top of the screen so close to the face of the Instructor as it was possible and it was directed between the dog and the Partner's usual place. The loudness was adjusted to the human ear.

2.1.4. Experimental conditions/playback/

2.1.4.1. Face to face. This condition was identical to the pretest trial (Fig. 1a), except that now the tape-recorded command, described above, was given.

2.1.4.2. Visual separation. The position and the behaviour of the human participants in this case were the

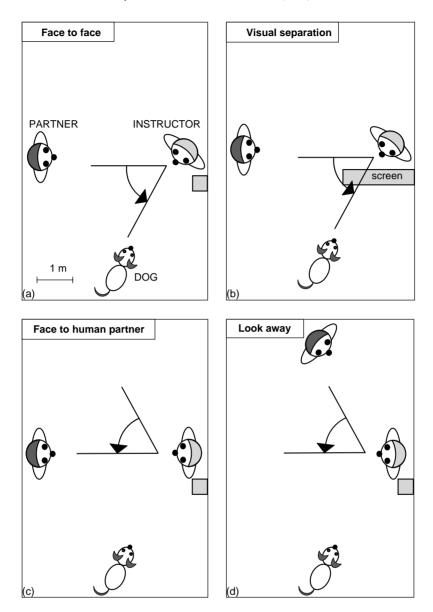


Fig. 1. Schematic representation of the different conditions in Study 1 (drawn not to scale, view from above).

same as in the 'Face to face' condition with the only difference, that an opaque screen was placed between the dog and the Instructor in the beginning of this trial, so the dog could not see the Instructor's body orientation (Fig. 1b).

2.1.4.3. Face to human partner. The starting position of the participants was identical to that in

the 'Face to face' condition. After stopping their talk the Instructor, however, turned away from the Partner to the right for 2–3 s. When the command was started to replay she turned left with a definite movement in the same way as in the 'Face to face' condition but as a result of this turning now she oriented towards the human Partner (Fig. 1c).

2.1.4.4. Look away. In the beginning of this trial the Partner changed his position by stepping 3 m sideways away from the dog. The Instructor and the Partner looked at each other and talked in this position. Before commanding the Instructor turned left toward the Partner's original place. In this way the orientation and the movements of the Instructor were exactly the same as in the 'Face to human partner' condition but she faced at empty space when the command was replayed (Fig. 1d).

2.1.5. Behaviour of the Instructor

Great care was taken to make the non-verbal gestural behaviour of the Instructor similar across all condition. This was essential to do since in three experimental conditions ('Visual separation', 'Face to human partner', 'Look away') the uttering of the command took place in a quite unnatural situation for the Instructors. The Instructors were instructed that they should try to behave as they usually do and in a standard way in all conditions. To account for any of the potential gestural influence on the part of the Instructors, their behaviour was recorded for statistical analysis according to the following variables.

- A. Head-turning towards the predetermined direction.
- B. Body orientation towards the predetermined direction.
- C. Nodding when the command is given.
- D. Bending forward of the upper torso when the command is given.
- E. Hand-gesture (stretching out the arm and making a movement directed to down).

The presence (1) or absence (0) of these gestural cues was recorded for each repeated command in each of the experimental conditions. The average frequency of the occurrence of a given gesture was calculated for each dog—Instructor pair in each experimental condition dividing the number of occurrences by the number of command-repetitions.

2.1.6. Behaviour of the dog

In order to compare the dogs' reaction to commands uttered in the different conditions the 'Response score' was established as follows:

• *Score* 1: The subject responded to the first 'Down!' command (i.e. started to lie down before the first

- repeat and finished the action before the trial was terminated (before the Instructor turned back to the Partner to resume talking (see procedure))).
- Score 2: The subject started to lie down after the beginning of the second command ('Down!!') but before that of the third one ('name + Down!!!') and finished it before the trial was terminated.
- Score 3: The subject started to lie down when the last command ('name + Down!!!') had been given and finished the action within 5 s (i.e. before the Instructor turned back to the Partner to resume talking).
- *Score* 4: The dog was resistant, namely it did not lie down within 5 s after the last command had been given.

Interobserver agreement was assessed by means of parallel coding of 50% of the total sample by two trained observers. Cohen's kappa for the response score was found to be 0.89.

2.1.7. Statistical analysis

Friedman ANOVA was used to compare the behaviour of individual dogs across conditions and similar tests were used for analysing the behaviour of the Instructors. Within-group differences were further analysed by planned comparisons (Wilcoxon tests, Miliken and Johnson, 1992).

2.2. Results and discussion

2.2.1. Behaviour of the Instructors

Analyses of the non-verbal behaviours of the Instructor by Friedman ANOVA across the five experimental conditions failed to show any significant differences (head-turning, body orientation, nodding, bending the upper torso, hand-gesture; *P*: NS in each case). That is, Instructors showed similar patterns of non-verbal gesturing in each of the experimental conditions, which suggests that the behaviour of Instructors cannot explain the possible condition-specific differences in dogs' responsiveness.

2.2.2. Dogs' response scores

2.2.2.1. The effect of 'playback method'. Although dogs were pre-selected on the basis of their responsiveness in the pretest trials (i.e. only dogs that

fulfilled live command were involved) there might have been differences in the quality between the pre-recorded command and the commands uttered by the Instructor live. Therefore, in order to analyse the effect of the application of the playback method on the dogs' reaction first we made comparison between the response scores in 'Face to face/live/' (pretest) and 'Face to face/playback/' conditions. Importantly, while all dogs were ready to obey in the 'live' condition (response score = 1), 6 out of the 23 dogs failed to lie down even after the repeated command in the 'Face to face/playback/' situation (scores = 3, and 4) which difference approaches significance (Wilcoxon, N = 23, Z = 1.88, P = 0.059). It seems that these six individuals had severe difficulties with the 'playback method', which is further supported by the fact that they failed to show any corresponding reaction in the other playback conditions. In order to concentrate the analysis on the direction of human attention on the dogs' responsiveness, the non-responding subjects in the play back situations (four Tervuerens and two Boxers) were excluded from further analysis.

2.2.2.2. The effect of human attentional focus. The overall comparison of the response scores in the four experimental conditions resulted in highly significant differences (Friedman ANOVA, $\chi^2 = 24.16$ (16, 3); P < 0.001, Fig. 2). Although all of the 17 dogs lay down in the 'Face to face' condition the majority of them proved to be resistant in the situation where the Instructor faced the human Partner or was visually separated while the command was replayed (12 and 11 out of 17). The number of dogs ignoring the command in the 'Look away' condition (7 out of 17) shows intermediate responsiveness (Table 1).

Pair-wise comparisons showed higher responsiveness in the 'Face to face' condition than in 'Visual separation' (Wilcoxon, N=17, Z=3.25, P<0.001) and in the 'Look away' (Z=2.97, P=0.003) conditions. Moreover, verbal instructions were more likely ignored when Instructor oriented to the Partner than to an empty space ('Face to human partner' versus 'Look away' conditions: Z=2.15, N=17, P=0.032). However, we failed to find significant difference between the 'Face to human partner' and the

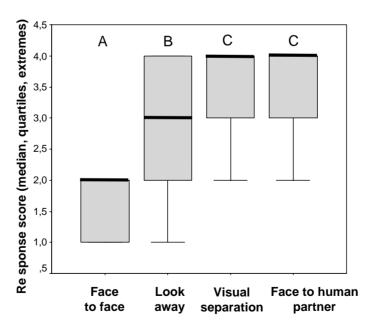


Fig. 2. The dogs' response score in the different experimental conditions (median, quartiles and extreme values). Different letters indicate significant differences between the conditions (Wilcoxon tests; P < 0.05). Score 1: prompt fulfillment after the first command; Score 2: lie down after the second command was uttered; Score 3: lie down after the third command (name of the dog + Down!!!); Score 4: command ignored.

Table 1

The number of dogs that behaved according to their owner's verbal command (Down!) in the different experimental conditions

Response	'Face to face'	Look away	Visual separation	Face to human partner
Lie down promptly. Response $score = 1$	6	3	1	0
Lie down after the first repeat. Response score $= 2$	11	3	3	3
Lie down when its name was given. Response score $= 3$	0	4	2	2
Command ignored. Response score $= 4$	0	7	11	12

'Visual separation' conditions (Z = 0.85, N = 17, P = 0.395).

The findings of the present experiment suggest that in situations where the command is replayed by a tape recorder, the dogs' behaviour is influenced by the behavioural cues (head and body orientation, presence/absence) relating to the actual visual attention of the Instructor. Importantly, dogs are able to differentiate situations where the human visual attention is unambiguously directed to them (they fulfil the command) or to a human Partner (they ignore the command). Moreover, in a more ambivalent situation in which the focus of the owner's attention was not unequivocal (e.g. in the 'Look away' condition the Instructor looked at a direction where there was nobody) the behaviour of the dog reflects a kind of hesitation (intermediate responsiveness). The focus of human attention was similarly unidentifiable for the dog when a screen was positioned between the dog and the 'Instructor' ('Visual separation'). In this case, however, the dogs tended to avoid responding to the command. This was probably so, because dogs either needed to see the visual cues provided by the Instructor (e.g. gestures) in order to understand the situation, or alternatively, they were non-responsive because loosing the visual contact with the owner in this strange, restrictive situation made them stressful.

3. Study 2

Following the first experiment, another study was carried out to demonstrate that the same dogs are sensitive to human visual attention in a different context, since we wanted to see whether their sensitivity showed in the first experiment was strongly related to their previous experience of being trained to respond the command given (for instance possibly they learnt also about the significance of the owner's orientation

while they learnt how to react to the command) or their recognition of attention reflects a more flexible strategy in behaviour. This time we used a test that relies on a more spontaneous behaviour natural to many dogs. Subjects were offered the opportunity to beg for food from two unfamiliar female human participants one of whom was facing the dog whilst the other turned her head away. We wanted to see whether the dogs were able to use such cues of attention to choose between humans for soliciting food-sharing (for using this method with chimpanzees see also Povinelli and Eddy, 1996).

3.1. Methods

3.1.1. Subjects

The same 23 dogs participated in this study. Four subjects that were trained to refuse food given by unfamiliar persons and/or did not beg in the warm up trials were excluded from subsequent testing (three Tervuerens (one female and two males) and a male Great Dane).

3.1.2. Procedure

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

3.1.3. Warm-up trials

The owner held the dog 3–4 m far from the two unfamiliar women who were sitting on the opposite sides of a table facing each other sideways to the dog (Fig. 3). A third, familiar woman held a liver sandwich in her hand pressing her back to the middle of the table facing the dog. She called the dog by name and gave a little piece of food when it approached her. Then the owner took the dog back to the starting position. After two such warm-up trials the familiar person left. The warm-up trials were immediately followed by the testing trials.

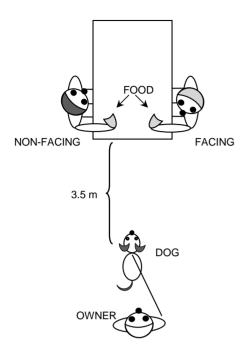


Fig. 3. Schematic representation of the begging situation in Study 2 (view from above).

3.1.4. Test trials

All dogs received four test trials in one session. Two unfamiliar women were sitting on the opposite sides of a table holding a liver sandwich in one hand sideways to the dog. The two sandwiches had the same size in all trials. One of the women turned her head towards the dog and tried to make eye contact with it, while the other turned her head away from the dog (Fig. 3). The side of the table with the eating person, and the woman who was eating were balanced out for the four trials, that is, each of them were sitting 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 in case of each dog. The owner held the dog 3-4 m away from both persons and turned it away each time when they changed their positions. Then the owner turned the dog towards the eating persons and waited for 3s standing behind it. Then the owner allowed the dog to go by saying a neutral command as 'You can go!' ('Mehetsz' in Hungarian). The person facing the dog maintained the eye contact with the approaching dog. The trial was terminated when the dog showed begging towards one of the two persons. The following

behaviour patterns were regarded as begging: (1) the dog sat, stood or lay in front of a person and looked at her or her sandwich for at least 3 s; (2) pushed part of the person's body with its nose or paw or put its nose or paw in the person's lap; (3) jumped up at a person or at the table orienting towards that person.

The next trial started after the owner took the dog back to the starting position. If the dog did not show any begging behaviour, the owner called it back after 30 s and the trial was scored as 'no begging'. Importantly, in order to avoid learning as much as possible during the trials dogs were never rewarded for their choice.

- 3.1.5. Behaviour scoring and statistical analysis
 The behaviour of the dogs was scored as follows:
- Score 1: The dog was begging from the person whose face was oriented towards it.
- Score -1: The dog was begging from the person who did not look at it.
- Score 0: The dog did not show any definite begging behaviour within 30 s after the releasing command of the owner.

The sum of the begging scores was calculated for each dog by adding up the scores of the four trials. This value, which in principle could range between -4 and +4, was used for later analysis (e.g. the value of +4 showed the exclusive preference for the attentive person while the value of 0 reflect no discrimination between the persons showing visual attention or inattention).

The side preference was calculated by giving a score of 0 to the person sitting on the left and score of 1 to the person on sitting on the right. Preference to either of the human individuals was calculated in the same way. For both cases we assumed that if dogs show no preference the median of the four values (scores of the four trials) should not differ from the expected value of 0.5.

The interobserver agreement was assessed the same way as in Study 1. Parallel coding of 50% of the total sample yielded a Cohen's kappa value of 0.82.

3.2. Results and discussion

We found no evidence of either side preference (one-sample Wilcoxon test: Z = -0.54, N = 19, P =

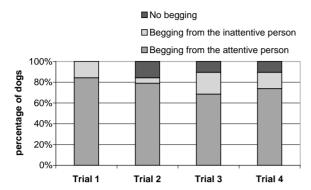


Fig. 4. The percentage of dogs that showed different types of begging behaviour in Study 2.

0.586) or any bias in the attraction of the persons involved in the begging trials (Z=0.00, N=19, P=1). At the same time, however, the analysis showed a highly significant preference for the person facing the dog (Z=-3.64, N=19, P<0.001). Twelve out of the 19 dogs never begged from the person with averted gaze and there were only two individuals who preferred more often the inattentive person than the attentive one while begging. (The numbers of dogs performed begging from the attentive/inattentive human are shown in Fig. 4.)

These results show that if dogs faced a situation where they had a possibility to beg for food from two human subjects they were capable of using visual attention to evaluate the human actors' responsiveness to soliciting for food. The discrimination between the two unfamiliar people was mainly based on attentional cues, and was not influenced by positional or personal preferences. This study further supports that dogs are sensitive to human head orientation and/or eye gaze and mirrors a flexible use of their understanding of human gaze cues.

4. General discussion

The results of the present experiments clearly support previous observations that dogs are able to recognise and differentiate the attentional behaviour of humans (Call et al., 2003; Soproni et al., 2001; Gácsi et al., 2004). The interesting aspect of the present study is that the dogs' performance shows more advanced features as being restricted only to

discriminate between others' states being attentive and inattentive with them. Instead of the 'all or none' response relying upon whether the human is facing to the dog or not, dogs displayed different responsiveness when the Instructor oriented to a human partner versus to empty space. This differentiation was significant, despite that the position, the head and body orientation and the verbal and non-verbal cues of the Instructor were the same in both conditions ('Face to human partner' versus 'Look away') and the only difference was that the human Partner was either in or out of the Instructor's focus of attention.

These results may also have some relevance to the concepts of gaze following and visual perspective taking (for the definition of terms see: Emery, 2000). We reported earlier that dogs are able to detect and to follow the line of human gaze onto an object in space in object choice situations (Miklósi et al., 1998; Soproni et al., 2001) and use gaze alternation between a human subject and the objects preferred in problem solving situations (Miklósi et al., 2000; Topál et al., 1997). The current study, however, shows that dogs do not only engage in gaze following but are capable of visual perspective taking what can be defined as differential responsiveness to humans as a function of the human visual access to some object, subject or critical event.

From a mentalistic viewpoint, both 'high-level' and 'low-level' explanation can be given for the underlying mechanisms, which may contribute to the dogs' sensitiveness to human gaze cues.

The more parsimonious low-level interpretation suggests that subjects respond to attention cues in terms of reinforcement and learning about stimulusresponse relationships. Accordingly, dogs are able to learn the role of specific attention cues in specific situations without the need for any complex cognitive capacities or awareness of human mental state of attention. A dog living in a human family has many opportunities for learning human behaviour as operants in the course of its individual life. Therefore present observations were merely responses to discriminative stimuli (the view of the human eye and face and his/her bodily orientation) that 'informed' the dogs in the experimental conditions when the instructions were to be fulfilled or which person should be solicited for food. This assumption is supported by the results of 'Visual separation' condition in Study 1

because when the human Instructor was out of sight (and therefore the discriminative stimuli were also absent), dogs showed weak responsiveness to 'Down!' command. However, this hypothesis is weakened by the results of the 'Look away' versus 'Face to human partner' conditions in Study 1 where, although the same discriminative cues were presented by the Instructor, dogs still showed some differentiation in their response. This suggests that the behaviour of dogs was influenced by not only the behavioural cues of the Instructor's attention but also by the human Partner's presence or absence in the attentional focus of the Instructor.

Moreover dogs had limited possibilities to learn about the experimental situation (observations were carried out in unfamiliar environment in Study 1 where they were tested only once in each condition; persons involved were unfamiliar in Study 2, and no reinforcement was given in any of the experiments).

Alternatively, it is possible that dogs' sensitivity to cues of human attention reflects more than individual associative learning about specific cues in specific situations. They may be able to gain some understanding about the significance of human bodily orientation and gaze direction in communicative interactions based on their numerous and various individual experiences. Moreover it can be assumed that dogs have been selected for a set of social-cognitive skills (Topál et al., 1997; Miklósi et al., 2001, 2003) and this adaptive specialisation makes them able to use their experiences to derive this knowledge (Call, 2001). This suggests that dogs are evolutionary prepared to learn to use cues of the human's gaze to interpret human action (i.e. intention to reach for an object or communicating with a subject), and they may also used these cues to extrapolate information from human attention. At the same time, although dogs seemingly understand the communicatory nature of the present experimental situation, this does not mean necessarily that they represent and learn any about the mental state of the human or understand that others perform acts intentionally (with a goal in mind).

Finally it should be pointed out that the result of this study is in line with other earlier observations on dog-human communicative interactions (e.g. Soproni et al., 2001, 2002; Miklósi et al., 1998, 2000; Call et al., 2003) showing that dogs are sensitive to the attentional cues of humans. These observations under-

line the importance of dogs in studying the evolution of social cognitive skills outside the primate line.

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