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SHORT COMMUNICATION

Gaze-following behind barriers in domestic dogs

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Abstract Although gaze-following abilities have been demonstrated in a wide range of species, so far no clear evidence has been available for dogs. In the current study, we examined whether dogs follow human gaze behind an opaque barrier in two different contexts, in a foraging situation and in a non-foraging situation (food involved vs. food not involved in the situation). We assumed that dogs will spontaneously follow the human gaze and that the foraging context will have a positive effect on dogs' gaze-following behaviour by causing an expectation in the dogs that food might be hidden somewhere in the room and might be communicated by the experimenter. This expectation presumably positively affects their motivational and attentional state. Here, we report that dogs show evidence of spontaneous gaze-following behind barriers in both situations. According to our findings, the dogs gazed earlier at the barrier in the indicated direction in both contexts. However, as we expected, the context also has some effect on dogs' gaze-following behaviour, as more dogs gazed behind the barrier in the indicated direction in the foraging situation. The present results also support the idea that gaze-following is a characteristic skill in mammals which may more easily emerge in certain functional contexts.

Keywords Gaze-following · Dogs · Inter-specific communication

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Introduction

A human face provides an array of social information about an individual, such as gender, age, emotional state and potential intentions or mental state (Emery 2000). Gaze-following was first tested in human infants by Scaife and Bruner (1975), who showed that two-month-old babies adjusted their gaze to the gaze direction of an adult. In a more recent study, Moll and Tomasello (2004) found that twelve-month-old infants can also follow gaze direction to locations outside of their current visual field.

A series of comparative studies using different methodologies revealed gaze-following in both mammalian and avian taxa (e.g. great apes: Bräuer et al. 2005; Call et al. 1998; goats: Kaminski et al. 2005; ravens: Bugnyar et al. 2004). In a recent study, Range and Virányi (2011) showed that intensively socialised wolves are excellent at using human gaze cues. Six-month-old wolves demonstrated gaze-following behind a barrier, while 4.5-month-old wolves followed human gaze into distant space. On this basis, it is interesting that so far the only study with dogs on gaze-following into space produced negative results (Agnetta et al. 2000), despite the fact that dogs are sensitive to gaze-based cues in communicative contexts (e.g. Hare et al. 1998; Miklósi et al. 1998). Dogs might have not followed the experimenter's gaze (Agnetta et al. 2000) because they were tested in a non-foraging situation (with

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no food involved in the experiment), which might have had a negative effect on the dogs' attentional state. In addition, the low sample size could also be responsible for the negative results. We hypothesised that a larger sample size and an ecologically more valid procedure would show that dogs display gaze-following behaviour.

In the current study, we examined whether dogs follow human gaze behind an opaque barrier by utilising a modified version of the "look behind a barrier" task (see e.g. Range and Virányi 2011). We tested the dogs in two different contexts, in a foraging and in a non-foraging context. We assumed that the presence of food in the foraging context would positively affect the dogs' motivational and attentional state by causing an expectation in the dogs that food might be hidden somewhere in the room and might be communicated by the experimenter. We presumed that the foraging situation would have a positive effect on dogs' gaze-following behaviour as well.

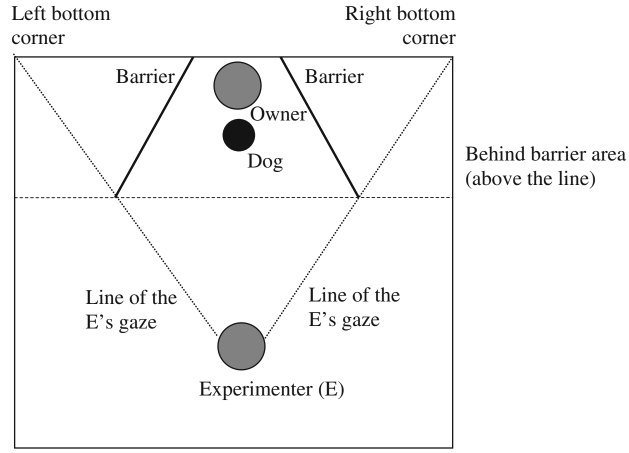

Fig. 1 Gaze-following behind barriers: the dog was kept on a leash by the owner between two barriers. The experimenter (E), facing the dog, snapped her fingers behind her back, established eye contact with the dog, then turned her head and eyes suddenly at the *bottom right* or *left corner*. Thus, her line of sight went behind the barrier. The *dotted lines* represent the line of sight of E, while the *broken line* represents the entry of the "behind barrier area" (size of the room: 4.5 × 3.5 m)

Methods

Subjects

For the testing, forty family dogs were divided equally between two groups (foraging group, non-foraging group). The average age of the dogs was 4.18 ± 2.65 years (mean ± SD). The groups were balanced for age and sex.

In the foraging group, the mean age was 4.37 ± 2.99 years (mean ± SD) (range from 1 to 10 years), while in the non-foraging group, it was 4.00 ± 2.31 years (mean ± SD) (range from 1 to 10 years). The foraging group showed a sex ratio of 9 females and 11 males. The non-foraging group showed a sex ratio of ten females and ten males.

See the supplementary table for more details.

Material and procedure

The observations were done in an experimental room of 4.5 × 3.5 m (see Fig. 1). Two green opaque barriers of 201 × 103 cm were placed at an angle, at one of the walls, in a way that prevented the dog from seeing if there was something hidden behind. All trials were recorded on video from three different viewing angles.

Warm-up phase

Two barriers were already in place when the dog and the owner entered the experimental room for the warm-up phase in both situations. The warm-up phase lasted 1 min.

Foraging (food) condition (N = 20)

The aim of the warm-up phase in the foraging condition was to set-up an expectation in the dogs that they might find food hidden in the experimental room and that the experimenter might communicate the place of the food. Accordingly, in the foraging condition, four pieces of sausages were placed on the floor under four identical flower pots (brown plastic flower pots: 13 cm in diameter, 13 cm in height) distributed randomly in the middle of the room before the start of this phase. Then, the dog entered the room together with the owner and the experimenter. The dog was unleashed and could explore the room freely. The experimenter approached one of the pots, called the dog, bent down to the pot, showed the dog the food that was hidden under the pot by lifting it from the floor and then stroked the dog. The dog was allowed to eat the discovered sausage. The same procedure was repeated four times with the four pots. At the end of the phase, the dog and the owner left the room and the experimenter closed the door.

Non-foraging (neutral) condition (N = 20)

The aim of the warm-up phase in the non-foraging situation was to control for the social interactions between the dogs and the experimenter in the foraging condition, but without raising an expectation in the dogs for hidden food in the experimental room. The owner and the experimenter entered the room together with the dog. The dog was unleashed and could explore the room freely. The experimenter called the dog four times and initiated a short interaction (stroking the dog several times). There was no food in the room. At the end of the phase, the dog and the owner left the room and the experimenter closed the door.

Testing phase

There was no food in the room in the testing phase. The experimenter let the owner and the dog into the experimental room. They went to a designated location between the two barriers, where the owner sat behind the dog and kept it on the leash. The experimenter stood approximately one and a half metres away from the dog, facing it (Fig. 1).

The experimenter snapped her fingers behind her back in order to call the dog's attention. As soon as the dog looked at the experimenter and she could establish eye contact, she turned her head and eyes to the right or to the left bottom corner of the room behind one of the barriers, and remained in this position for 30 s. When the experimenter turned her head and gaze, the owner released the dog and it could move freely.

Observed behavioural variables

The following behaviours were analysed:

Direction of the first gaze of the dog

We coded the first spontaneous gaze turning after the experimenter turned her head left or right. The first gaze could be matching (in the direction indicated by the experimenter) or non-matching (in the opposite direction). Binary data were collected.

Gazing at the matching/non-matching barrier

This behaviour was coded only when the dog stayed between the two barriers. The dog was recorded as looking at the matching barrier when it turned its head to the barrier in the direction indicated by the experimenter. The same procedure was used for coding "gaze at the non-matching barrier". Latency of this behaviour was measured.

Gazing behind the matching/non-matching barrier

The dog was recorded as looking behind a barrier when its line of sight went behind the imaginary elongated line of either the matching or the non-matching barrier from a distance of a maximum two body lengths (see dotted line on Fig. 1). The number of dogs that showed this behaviour was measured.

Apart from the principal coder (A. Met), a naïve observer also coded the direction of the first gaze for six dogs by looking at the videotapes. Inter-observer agreement was 100 % ($\kappa = 1$).

Data analysis

Solomon Coder (Copyright © 2010 András Péter; http://solomoncoder.com) was used for the video analysis. For the statistical analysis, we used GraphPad InStat software.

The data did not show normal distribution, thus non-parametric procedures were used. Binary data of the very first gaze were analysed using binomial test. Wilcoxon's matched pair test was used to compare the data of gazing at the "matching" versus "non-matching" barrier. Fisher's exact test was used to compare the dogs' behaviour regarding the first gaze and the gazing behind the "matching" barrier variables in the non-foraging and in the foraging context (see below).

Results

The analysis of the very first gaze of the dogs showed that, in the foraging group, 80 % of the dogs (sixteen dogs out of twenty) gazed at the indicated direction, which is significantly above the fifty per cent chance level (binomial test $p = 0.01$), while in the non-foraging context, only 55 % of the dogs (eleven dogs out of twenty) gazed at the matching side (binomial test $p = 0.82$). Fisher's exact test showed no significant difference between the two groups ($p = 0.17$).

Examining the gazing behaviour in more detail, we found that the dogs gazed significantly earlier at the matching barrier than at the non-matching barrier in both experimental groups (Wilcoxon's matched pair test: foraging group: $(T-) = -100.0$; $p = 0.001$; non-foraging group: $(T-) = -120.0$; $p = 0.04$).

In addition, we found that, while in the foraging group, seven dogs out of twenty gazed behind the matching barrier, none of the dogs gazed behind the matching barrier in the non-foraging group (Fisher's exact test $p = 0.008$).

Discussion

Our findings suggest that dogs follow human gaze to some extent both in a foraging and in a non-foraging situation: they gazed at the barrier in the indicated direction earlier in both contexts. Moreover, we found that the context also had some effect on dogs' gaze-following behaviour. The results showed that more dogs gazed behind the matching barrier in the foraging group. In addition, in the foraging situation, dogs tended to gaze first at the matching direction above chance. We assume that the foraging context has a positive effect on dogs' gaze-following behaviour by affecting their motivational and attentional state, as presumably the possible presence of food enhances the dogs' attention towards the experimenter.

Considering that the ability of gaze-following (either into distant space or behind barriers) has been already described in many different species, these findings in dogs are not that surprising. Earlier comparative data have also suggested that the skill is present across mammals (Fitch et al. 2010).

Range and Virányi (2011) suggested that following the gaze of other individuals has different functions in different species, suggesting that the ability is under different selection pressures. For example, gaze cues in birds primarily have the function of predator detection, while gaze cues in wolves presumably have important function during group hunting. In the case of dogs, following a human gaze could be essential, e.g. when hunting with humans as dogs might have watched human eyes for directional cues.

Regarding the underlying cognitive mechanisms, it has been suggested that gaze-following into distant space and gaze-following behind barriers might reflect different cognitive mechanisms (Range and Virányi 2011; Tomasello et al. 1999). While gaze-following into space can be considered a simple co-orientation with another individual, following another individual's gaze behind barriers probably requires higher level mental representations (e.g. taking the difference between their own and another individual's perspective into account) (Tomasello et al. 1999). In line with this assumption, it is not surprising that ravens and wolves, for example, have been reported to be skilful at gaze-following into space at a considerably earlier age, while their ability to follow human gaze behind a barrier developed months later (Range and Virányi 2011; Schloegl et al. 2007). In the case of dogs, however, the results are rather contradictory. Our study provided some evidence that dogs are able to follow a human gaze behind barriers. Applying a different testing procedure, however, Agnetta et al. (2000) previously found that dogs do not follow human gaze into space in non-foraging situations. A possible explanation for the contradictory results can be the effect of the testing context (foraging vs. non-foraging context). In the present study, dogs might have anticipated finding food in the foraging context which could have affected their sensitivity to human gaze directions positively; in the earlier study, by Agnetta et al. (2000), there was no food in the testing situation. Thus, our findings reinforce the importance of the methodology and context when measuring dogs' visual communicational abilities.

However, the fact that dogs are used to follow human pointing gestures into empty spaces (Hare et al. 1998), even in non-foraging situations, suggests that they are probably more accustomed to using such gestural human cues and consequently tend to ignore the more subtle gazing cues.

Agnetta et al. (2000) suggested that dogs rely so much on hearing that a simple gaze cue needs some kind of auditory supplement. Accordingly, the finger snap given before each cue in the present study could also have enhanced the dogs' gaze-following response. Téglás et al. (2012) also found that dogs follow the gaze of a videotaped human if the human first attracts the dog's attention by speaking to it and looking at it. These findings suggest that the use of ostensive cues would lead to further improvement in dogs' gaze-following behaviour (see also Topál et al. 2009).

In summary, our results suggest that dogs show spontaneous gaze-following behaviour and this gaze-following behaviour can be evoked more easily by positively affecting dogs' attentional state.

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