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Do domestic dogs interpret pointing as a command?

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Abstract Domestic dogs comprehend human gestural communication flexibly, particularly the pointing gesture. Here, we examine whether dogs interpret pointing informatively, that is, as simply providing information, or rather as a command, for example, ordering them to move to a particular location. In the first study a human pointed toward an empty cup. In one manipulation, the dog either knew or did not know that the designated cup was empty (and that the other cup actually contained the food). In another manipulation, the human (as authority) either did or did not remain in the room after pointing. Dogs ignored the human's gesture if they had better information, irrespective of the authority's presence. In the second study, we varied the level of authority of the person pointing. Sometimes this person was an adult, and sometimes a young child. Dogs followed children's pointing just as frequently as they followed adults' pointing (and ignored the dishonest pointing of both), suggesting that the level of authority did not affect their behavior. Taken together these studies suggest that dogs do not see pointing as an imperative command ordering them to a particular location. It is still not totally clear, however, if they interpret it as informative or in some other way.

Keywords Communication · Domestic dog · Pointing · Comprehension · Imperative

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Introduction

Domestic dogs (*Canis familiaris*) are flexible in comprehending human forms of communication. One example is dogs' comprehension of the human pointing gesture in the so-called object choice paradigm. In this paradigm, a human experimenter hides a reward (e.g., food) in one of two identical cups that are out of view of the subject. After the reward is hidden, the experimenter provides the subject with a cue, e.g., by pointing (and/or gazing) toward the correct cup after which the subject is free to make a choice between them. When compared to other species dogs are outstandingly flexible in their use of human pointing, and there is cumulative evidence suggesting that dogs' skills in this domain are special and may have resulted from domestication. This is corroborated from several sources, such as the following. First, when directly compared, dogs out-compete humans' closest living relative the chimpanzee (Bräuer et al. 2006; Hare and Tomasello 2005). Chimpanzees (*Pan troglodytes*) and other primate species do not seem to use human-given pointing gestures in an object choice task (Barth et al. 2005; Povinelli et al. 1997; Tomasello and Call 1997). Second, dogs also out-compete the wolf (*Canis lupus*) when it comes to using human communicative gestures spontaneously (Hare et al. 2002; Miklósi et al. 2003). This is also true if both species were raised under the same conditions (in a human household) and were then tested at the same age (Miklósi et al. 2003; Virányi et al. 2008). Dogs proved significantly more successful in finding the food than the wolves (Miklósi et al. 2003). Wolves are only found to perform above chance level when a very salient cue (proximal pointing) is used and subjects were specially trained (Udell et al. 2008; Virányi et al. 2008).

Finally, dogs do not seem to need major training to be able to follow pointing, and so ontogeny does not seem to

play an important role. By the age of 6 weeks, puppies are already able to follow a human pointing gesture even if that means moving away from the human's hand (Gácsi et al. 2009; Hare et al. 2002; Riedel et al. 2008; Virányi et al. 2008). Taken together this evidence suggests that selection pressures during domestication may have affected dogs' ability to use human communication.

However, as of yet, it is not clear how dogs actually interpret the pointing gesture in these settings. One possible interpretation is that dogs, like humans, interpret a pointing gesture as an informative communicative act, informing them where to find the hidden food. Children from an early age reliably follow an adult's pointing gesture to distal targets (Carpenter et al. 1998) and they seem to understand the communicative intentions behind that gesture. One prerequisite for an understanding of pointing as an informative gesture is the ability to attribute certain psychological states to other individuals, such as knowledge, desires, intentions, etc. An extreme alternative to this hypothesis would be that dogs learn to use pointing exclusively by associating the hand of the human with the provision of food during and therefore only follow the hand because they expect to find food (e.g., Dorey et al. 2010; Wynne et al. 2008). But the fact that young puppies even in the age of 6 weeks follow a human pointing gesture speaks at least against a major influence of learning on the observed behavior (Riedel et al. 2008).

A third and more intermediate hypothesis would be that instead of interpreting pointing as information about where to find food, dogs interpret pointing as a command, ordering them where to go. Evidence for this is found in a study by Szetei et al. (2003) in which a human experimenter pointed to one of two locations, one of which contained strong-smelling food which was potent enough for dogs to be able to detect it from a distance. In one condition of this study the human pointed to the empty (and therefore not smelly) location. In 79 % of cases dogs ignored their own, better information in order to follow the pointing gesture. This finding is difficult to reconcile with the assumption that dogs interpret pointing as information telling them where to find the reward. Instead this evidence suggests that dogs interpret pointing as some kind of command ordering them where to go even if it is against their own better knowledge.

In a series of studies, we aimed to test the hypothesis that dogs interpret pointing exclusively as a command, ordering them to move to a particular location. By the term "command", we refer to a combination of ostensive stimuli (pointing + gaze + attention + addressing the dog) of the human, which might contain an instructive or directive message for the dogs. The term "authority", we define loosely as a person who is able to control the behavior of dogs in a directive way.

In the first study, we tested dogs in a standard object choice paradigm in which food was hidden in one of two possible locations. We systematically varied three factors, the dogs' knowledge of where the food was hidden, the presence of the authority (the human) during their choice and whether the human used additional ostensive cues or not. A human always pointed to the incorrect location; that is, to the empty cup. Sometimes dogs knew that this cup was empty and sometimes they did not. If dogs interpret the pointing gesture as a command ordering them where to go they should follow the gesture irrespective of their own (and sometimes better) knowledge. If dogs perceive pointing as an informative gesture they should rely on their own and sometimes better knowledge and sometimes ignore the point of the human. We also varied whether the human (and therefore the authority) was present while the dog made its choice. When the authority was present the dogs' motivation to follow a command should be enhanced, as this has been shown in other studies (Call et al. 2003).

In the second study, we varied the authority of the person pointing. Sometimes this person was an adult human and sometimes a child, whom we assumed dogs would consider less of an authority. We confirmed this assumption in study 2. If dogs interpret pointing as a command we expected dogs to differentiate between those situations in which an adult and those in which a child pointed since the latter is less of an authority figure for them. If they perceive pointing as an informative gesture they should follow both, adult and child to the same degree since level of authority would not play a role in this situation. We also varied whether the experimenter pointed to the baited or non-baited cup. In the former case, dogs witnessed the baiting of the food and in the latter one they could not witness the baiting process, and hence had no knowledge about the food location.

Study 1

Subjects

Ninety-six dogs (50 females and 46 males) of various breeds (19 Mongrels, 15 Labrador Retrievers, 7 German Shepherds, 4 Golden Retriever, 4 Jack Russel Terriers, 4 Beagles, 3 Boxers, 2 Magyar Vizslas, 2 Border Collies, 1 Husky, 1 Fox Terrier, 1 Bearded Collie, 1 Giant Schnauzer, 1 Portuguese Waterspaniel, 1 Miniature Schnauzer, 1 Sheepdog, 1 Schapendoes, 1 Cocker Spaniel, 1 Rottweiler, 1 Dogo Canario, 1 West Highland White Terrier, 1 Bullterrier, 1 Flat Coated Retriever, 1 Bardino, 1 Berger de Pyrenees) and ages ($M = 5.5$ years; range 1–13 years) participated in this study and were included in the analysis.

Twenty-five additional dogs had to be excluded after pre-testing for various reasons (e.g., they showed signs of discomfort in the testing room or with the apparatus). Their data were not included in the analysis.

All subjects lived as pets with their owners and were tested at the Max-Planck Institute for Evolutionary Anthropology in Leipzig, Germany. All dogs had received the training typical of pet dogs. The owners were registered in a database of the MPI EVA and had agreed for their dogs to participate in the study. The pre-conditions for participation were that dogs had to be food motivated and would be comfortable remaining in the testing room without their owner.

Materials

The study was conducted in quiet rooms at the MPI EVA (3.96 m × 3 m; 5,9 m × 3,6 m). Recordings were made with two cameras (both a Panasonic NV-GS180) connected by a splitter (VC-VC-CQ4ZSA). To ensure that dogs could only make a single choice, even when the human was not present, the cups (height 9 cm, bottom diameter 8 cm, top-diameter 5 cm) were placed in a special Plexiglas box (140 cm × 16 cm × 20 cm). At each end of the box were compartments (opening: 23 cm × 20 cm) in which the cups were placed: there was a distance of 1.20 m between them (see Fig. 1). The whole box had a sliding cover, which had to be moved to one side in order to reach the content of a compartment. The cover ensured that by opening one compartment, the other was closed simultaneously by a magnet. Dogs could, therefore, only choose one side of the box in each trial. To control for odor additional food was hidden in the box below a cover such that the dog could not see it but could smell it. In addition, a curtain was used which was placed in between the subject and the experimenter. The helper handling the dog also had to manipulate the curtain depending on the condition.

Warm-up

Before the experimental trials began subjects participated in a short warm-up phase. This phase was conducted to ensure that the subject was food motivated and to familiarize the subject with the Plexiglas box. In this phase, the subject, the experimenter (female, 27 years), and the helper (female, 25 years) were standing at predetermined positions and the experimenter caught the attention of the subject by tongue-clicking. The experimenter then baited one of the cups, which were placed in the Plexiglas Box in full view of the subject. Her visual orientation was directed to the box while she baited it. The helper then released the subject so that a choice could be made—either by touching the cup with the muzzle or paw. When the subject chose the correct cup it was allowed to eat the food; if the subject chose the empty cup it got no reward though the food in the other cup was shown to the subject. The location of the reward was counterbalanced such that it appeared alternately on the right and left equally often. The intertrial interval was around 20 s. This was repeated until the subject could recover the food from the box without any manual and/or verbal help from the experimenter one time on each side.

General procedure

At the beginning of each trial, the helper guided the subject to the predetermined position. Before a trial started, the experimenter always ensured that the dog was attentive to her. The experimenter faced the subject and if it was not attentive, she made noises (e.g. clicking the tongue) to get the subject's attention. Then the experimenter pointed three times to the empty location using a distal dynamic pointing gesture accompanied by gaze alternation. The maximum intertrial interval was 90 s. We used a between-subjects design with half of the dogs participating in the experimental trials, the other half in the control trials. Dogs in each group were divided into two subgroups. For one subgroup of dogs the experimenter used additional ostensive cues (high-pitched voice, saying "Luna, pass' mal auf; pass' auf, Luna!"—the German equivalent of: "Luna, pay attention; pay attention, Luna!"), for the other subgroup, the experimenter remained quiet while giving her gesture. The rationale for this was to see whether the dogs' behavior would differ between the two conditions. They could either be distracted by the ostensive cues of the experimenter, or it could make them more attentive to the procedure. The procedure that followed depended on the condition:

Authority leaves: dog knowledgeable

The experimenter showed the subject a piece of food then baited one of the cups in full view of the dog and lifted the other (empty) cup to demonstrate that it was empty. After the baiting process, the experimenter produced her cue (toward the empty cup) and left the room. Immediately afterward the helper released the subject and left the room as well. The dog then had 1 min to make a choice.

Authority leaves: dog ignorant condition

The experimenter showed the subject a piece of food and directly afterward the helper closed the curtain such that the dog could not see the baiting process. The experimenter then baited one of the cups and sham baited the other to make sure that the dog could not receive uncontrolled audible information. The helper opened the curtain and the

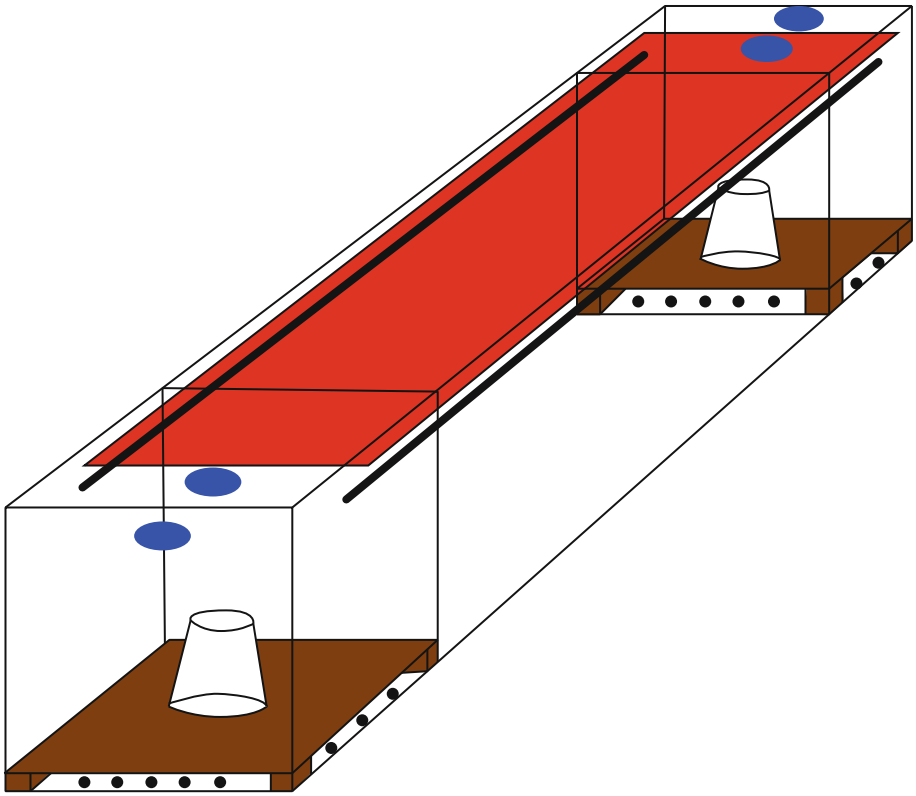

Fig. 1 The box used in Studies 1 and 2

experimenter produced the cue. Then both the experimenter and the helper left the room, as described above.

Authority stays: dog knowledgeable

The procedure was identical to the *Authority leaves—Dog knowledgeable* condition but now the experimenter remained in the room after producing the pointing gesture, standing motionless with arms hanging down, head bowed, and eyes open. The helper left the room 5 s after the experimenter gave the cue and came back into the room after 1 min had elapsed if the subject had not already made a choice.

Authority stays: dog ignorant

The procedure was identical to the *Authority leaves—Dog ignorant* condition except that experimenter stayed after giving the cue as described in the above condition.

The control trials were administered in the same way except that the experimenter did not make a pointing gesture. In none of these conditions did the experimenter look at the door or pay any attention to the helper leaving and entering the room. The location of the food was counterbalanced and semi-randomized with the stipulation that the food could never be in the same location for more than two consecutive trials. Each dog received six trials in each condition resulting in 24 experimental trials altogether. Trials were presented in two sessions, which were conducted on two different days with a maximum break of 14 days between them and a minimum break of 1 day. The four conditions were counterbalanced and semi-randomized with the stipulation that neither the authority state (human absence or presence) nor the dog's knowledge state (knowledgeable or ignorant) could ever recur in more than two consecutive trials.

Scoring

We considered two different measures. The first was the dogs' choice. It was scored as a "cue" response if a dog chose the cup that the experimenter was pointing at (chose the empty cup in the control); if the dog chose the other cup, it was scored as a "food" response. A choice was made when the subject touched a cup directly with the muzzle or paw. If a dog did not choose at all it was scored as a "no choice"; those trials were excluded from the analysis, so results are reported as percentages.

For the main analysis, we first looked at the mean percentage of trials in which the dogs followed the pointing gesture to the empty cup (chose the empty cup in control; see Fig. 2). A visual inspection of a plot of residuals against predicted values showed no pattern, we therefore concluded that an ANOVA should be conducted.

A second coder coded 20 % of the original video material for reliability purposes. Reliability was excellent (kappa = 0.99).

The second measure taken was the latency until the dog made a choice. Time was measured from the moment the helper released the dog to the moment the dog made a choice. A second coder coded 20 % of the original video material for reliability purposes. Reliability was excellent (Pearson $r = 0.99$).

Results

We conducted a repeated measures ANOVA with the two main within-subjects factors "presence of the authority" (present vs. absent) and the dogs' "knowledge of the food location" (knowledgeable vs. ignorant) and the two between-subjects factors "use of additional ostensive cues" (yes vs. no) and "condition"(experimental vs. control). Whether or not the dogs knew the location of the food had a significant effect on their choices as dogs followed the pointing gesture to the empty cup (chose the empty cup in the control condition) significantly more if they had no information about the real location of the food ($F(1,92) = 191.33$, $P < 0.001$). Whether or not the authority was present during the dogs' choice had no effect ($F(1,92) = 0.46$, $P = 0.50$) and there was no interaction between both of these factors ($F(1,92) = 2.94$, $P = 0.090$). The between-subjects factor "condition" had a significant effect ($F(1,92) = 22.31$, $P < 0.001$) showing that dogs in the experimental condition generally chose the non-baited cup (= followed the gesture) significantly more often than in the control condition. No other factor or their interactions were significant.

To see if there are any learning effects during the study, we conducted a $2 \times 2 \times 2 \times 2$ ANOVA with within-subjects factors "presence of the authority" (present vs. absent), the dogs' "knowledge of the food location" (knowledgeable vs. ignorant), use of additional ostensive cues (yes vs. no) and 'half of trials' (first half vs. second half). 'Half of trials' had no effect on any of the other factors as none of these comparisons reached significance showing that dogs did not behave differently in the first half of trials compared to the second half.

In a second step, we looked at the latency until dogs made their choice. Again, we conducted a repeated measures ANOVA with the two main within-subjects factors "presence of the authority" (present vs. absent), the dogs' "knowledge of the food location" (knowledgeable vs. ignorant) and the two between-subjects factor "use of additional ostensive cues" (yes vs. no) and condition (experimental vs. control). A main effect of "knowledge" showed that dogs were faster to choose the cup in those trials in which they had witnessed the food being hidden ($F(1,92) = 4.46$, $P = 0.037$), but only in those trials in which the human stayed in the room as there was a significant interaction between the dogs' knowledge and the human's presence ($F(1,92) = 4.17$, $P = 0.044$).

There was a significant effect of the factor condition ($F(1,92) = 6.35$, $P = 0.013$) showing that dogs had significantly higher latencies in the experimental compared to the control condition. The between-subjects factor "use of additional ostensive cues" had no significant effect (ANOVA, $F(1,92) = 0.01$, $P = 0.921$). No other factor or their interactions were significant.

To see whether "no choice" trials were unequally distributed across conditions, we conducted a $2 \times 2 \times 2$ ANOVA with the two within-subjects factors experimenter (leaves vs. stays) and dog (knows vs. unknown) and the between-subjects factor condition (experimental vs. control). Since the between-subjects factor "use of additional

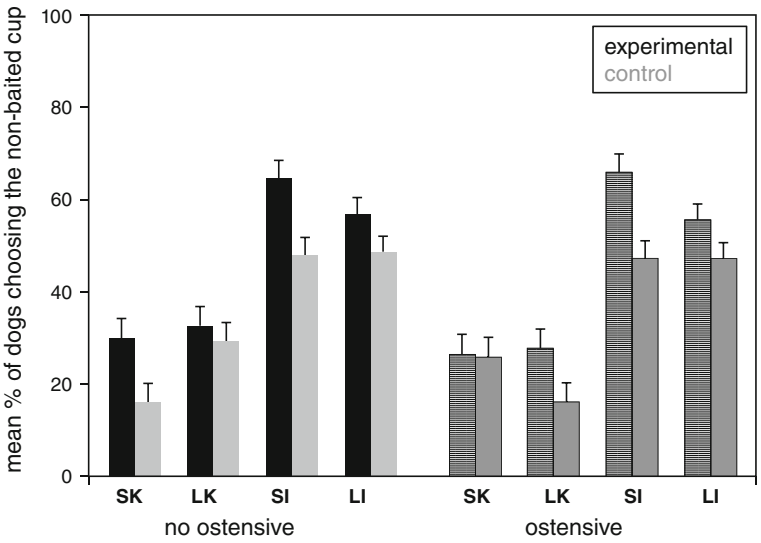

Fig. 2 Mean percentage of trials in which dogs ($N = 96$) chose the non-baited cup (following the pointing gesture in experimental condition) in the different conditions (*SK* authority stays/dog knows food location, *LK* authority leaves/dog knows; *SI* stays/ignorant, *LI* leaves/ignorant) in Study 1 (+SE)

ostensive cues" had no effect in all the previous analyses, we collapsed the data across that factor. 26 dogs were included, 18 in the experimental condition and 8 in the control condition. For the rest there were no "no choice" trials available. There were significant main effects of experimenter (ANOVA, $F(1,24) = 7.98$, $P = 0.009$) and dog (ANOVA, $F(1,24) = 12.09$, $P = 0.003$) showing that dogs choose not to choose more often in conditions in which they did not know the location of the hidden food and in which the experimenter left the room. None of the other factors or their interactions were significant.

Discussion

In this study, dogs clearly differentiated conditions in which they had seen the baiting process from conditions in which they had not. Dogs followed the human-given pointing gesture in trials in which they had no additional information about the location of the hidden food other than the pointing gesture. When the dogs had seen the cup being baited they relied on their prior visual experience and chose the baited cup, ignoring the pointing gesture. The human's (the authority's) absence or presence had no influence on the dogs' choice suggesting that the pointing gesture was not interpreted as a strong command, which had to be obeyed even against their own knowledge.

Furthermore dogs distinguished between the experimental and control trials, which were administered identically except that in the control trials the human did not use any pointing gesture. Dogs chose the non-baited cup in the experimental trials more often than in the control trials. This was irrespective of the presence or absence of ostensive cues, but also irrespective of all the other conditions indicating that the gesture clearly had an effect, but is not necessarily seen as a command. However, when dogs were informed about the food location, they still followed the pointing gesture of the human to the incorrect location in approximately 30 % of the cases. This was significantly more often than in the control conditon in which there was no gesture. This indicates that this was not a mere attention problem, but may indeed indicate that dogs interpret pointing to some extent as a command.

Dogs also took longer to decide for one of both cups in the experimental trials over the control trials which might reflect a longer time to process the information provided by the pointing gesture. In contrast, no choice trials did not vary in frequency between the experimental and control trials. Here dogs avoided choosing either cup more often in those trials in which the experimenter left the room, but only when the dogs were ignorant about the food location. It could be that dogs were simply distracted by the movement of the experimenter in addition to being unsure about what to do when there was no information provided whatsoever.

If dogs interpret the pointing gesture as an imperative command, we would also expect dogs to follow the pointing gesture more often in those cases in which the human, and therefore the authority, was still present after the command had been given. There is evidence that in situations in which dogs receive a command to, e.g., not take a certain piece of food, they obey that command if the authority remains in the room, but nearly always disobey if the authority leaves them on their own (Call et al. 2003). This shows that the presence or absence of the authority clearly influences dogs' obedience. The fact that dogs do not distinguish between these situations here supports the idea that in this study dogs do not interpret the pointing gesture as a command.

Study 2

In this study, we varied the level of authority of the human pointing. Sometimes the person pointing was an adult human (always female), and therefore an individual with a normal level of authority for the dogs. Sometimes, the person pointing was a four-and-a-half to five-and-a-half-year-old child (female or male), with a lower level of authority for the dogs. If pointing is seen as a command, dogs should follow the pointing gesture more often if it is coming from a person with a normal level of authority, compared to a person whom we assumed to have a lower level of authority. In addition, we varied, as a between-subjects factor, whether the experimenter gave an "honest" pointing gesture, meaning it was given to the baited cup (honest group), or whether the experimenter gave a "deceptive" cue, which was given to the non-baited cup (deceptive group). In the former case, dogs did not witness the baiting process, and hence had no knowledge about the food location. In the latter case, dogs knew about the food location through witnessing the baiting process. If pointing is seen as a command, dogs should follow the pointing gesture more often if it comes from a person with a normal level of authority, compared to a person with a lower level of authority. This would mean following the gesture against their knowledge about the food location.

Subjects

Forty-six dogs (24 females, 22 males) of various breeds (15 Mongrels, 8 Labrador Retrievers, 3 Golden Retrievers, 3 Border Collies, 3 Jack Russel Terrier, 2 Magyar Vizlas, 1 Tibet Terrier, 1 Flat Coated Retriever, 1 German Shorthaired Pointer, 1 West Highland White Terrier, 1 Rhodesian Ridgeback, 1 Beagle, 1 Boxer, 1 Rottweiler, 1 Airdale

Terrier, 1 Bolonka Zwetna, 1 Papillon, 1 Cocker Spaniel, 1 Parson Jack Russel Terrier, 1 Berger de Pyrenees) and ages ($M = 3.6$ years, range: 1–10 years) participated in the honest group. Eight additional dogs had to be excluded from the analysis because after coding the data, we recognized that there were some experimenter errors in all conditions (see below). A further eight dogs had to be excluded before the study started for various reasons (e.g., because they could not remain in a room without their owner). Their data were not included in the analysis either. Twenty-two dogs participated in the honest group; twenty-four dogs participated in the deceptive group.

All subjects lived as pets with their owners and were tested at the MPI EVA. All dogs had received the training typical for pet dogs. The owners were registered in a database of the MPI EVA and had agreed for their dogs to participate in the study. The pre-conditions for participation were that the dogs had to be food motivated and comfortable remaining in the testing room without their owner. Also, dogs had to have lived in a household without children aged between 0 and 10 years.

We recruited 26 mother–child pairs as experimenters. A precondition was that neither mother nor infants had had major contact with dogs before, e.g., as a pet etc. The children (15 girls, 11 boys) had a mean age of 5.3 years (age range: 4.5–5.5 years).

Materials

The study was conducted in a quiet room (4 m × 3.8 m) at the MPI EVA. For safety reasons, children and adults were separated from the dogs by a Plexiglas wall (length 4 m, height 1.80 m). Two opaque (white) plastic cups were used (height 9 cm; bottom-diameter 8 cm; top-diameter 5 cm) to hide the food. The two cups were placed on a wooden board (1.80 m × 0.30 m) lying on the floor with a distance of 1.30 m between them. Cups were placed on the subjects' side of the barrier. The distance between subject and each cup was 2.10 m. The experimenter stood on a marked spot 2.40 m away from the dog and 50 cm away from the middle of the Plexiglas partition, and therefore 1 m away from each cup. Recordings were made with two cameras (both a Panasonic NV-GS180).

Warm-up (dogs)

Each dog participated in a warm-up to make sure they were familiar with the general procedure. The experimenter stood between the cups (without the Plexiglas wall) facing the dog, held by a second experimenter. Then the experimenter placed one piece of food on top of one of the two cups. The helper released the dog and it was free to make a choice by either touching one of the cups with the muzzle/paw or approaching it within a distance of 10 cm. If it made the correct choice it got the reward; if it made a wrong choice, it was shown the reward but it was not allowed to eat it. The same procedure was repeated for the other side. This was continued until the dogs made correct choices in 4 consecutive trials. We considered the criterion to be sufficient for being sure that dogs made the connection between food and the cup, and we did not want dogs to get more trials than necessary for motivational reasons. The intertrial interval was maximum 30 s.

General procedure

At the beginning of each trial, the experimenter (either child or adult) entered the testing room and positioned herself at the predetermined spot. Then the second experimenter baited one of the cups with a piece of food, while being watched by the experimenter. In the honest group, dogs did not witness the baiting process. Then the second experimenter left the room to fetch and guide the dog to its position. After positioning the dog on the predetermined spot, the experimenter (child or adult) began pointing at the baited cup. In the deceptive group, dogs could witness the baiting process. Therefore, the second experimenter entered the room with the dog and leashed the dog onto a hook, which was fixed on the wall next to the door so that the dog was standing in the middle of the two cups at the same distance that was used in the experimental trials of both groups. The second experimenter then made sure that the dog was attentive to the following baiting action. She showed to the dog a piece of food and hid it in one of the cups by always lifting the cup to her right and then lifting the cup to her left. The food was placed to the left or to the right in a randomized order. The experimenter was present from the beginning of each trial and also watched the baiting process. The second experimenter then released the dog from its leash and held it on its collar. The experimenter started to perform the gesture. Sometimes the children were asked again, before the dog entered the room in both groups, how they would help the dog find the food or trick the dog, respectively (to remind them of the condition etc.). The dogs then received one of four possible conditions:

Honest group

Adult pointing + gazing The adult human pointed and gaze alternated. After establishing eye contact with the dog the adult pointed (distal pointing) to the baited cup with the outstretched ipsilateral arm and index finger. Then the adult pointed three times and left the arm and finger outstretched in a motionless position directed at the baited cup until the dog made its choice. The gaze of the experimenter

always accompanied the pointing direction of the finger which alternated between dog and baited cup. The adults were asked to tip their nose between pointing sequences. This was to ensure their gestures conformed to the children's gestures (see below).

Adult pointing Here the procedure was the same as that in the "Adult pointing + gaze alternation" condition except that now the experimenters retained eye contact with the dog throughout the trial until the dog made its choice.

Child pointing + gazing The procedure was identical to the adults' procedure. To help the children with the pointing procedure, children were asked to touch their nose with their finger between pointing sequences.

Child pointing Again the procedure was identical to the "Child pointing + gaze alternation" procedure except that now the experimenters kept eye contact with the dog throughout the trial until the dog made its choice.

Deceptive group

The conditions were administered in the same way as for the "Honest group" except that the experimenters pointed to the empty cup.

After each trial, the second experimenter and the dog left the room and the next trial was prepared. The intertrial interval was maximum 10 min. Most mother–child pairs tested two dogs, (though 6 dyads testing only one), and following a within-subjects design each dog received all four conditions appropriate to its group. Each dog received six trials in each condition, resulting in a total of 24 trials altogether. Some trials had to be repeated (7 % of total trials) because of experimenter errors. This was especially true when the experimenter was the child. 10 % of all child trials had to be repeated, for all adult trials it was 3 %. The experimenter type was blocked; that is half of the dogs started with the adult experimenter while the other half started with the child experimenter. Trials with and without gaze alternation were given in blocks with the stipulation that half of the children and half of the adults started with gaze alternation and the other two halves started without gaze alternation.

Scoring

We coded dogs' choice behavior. It was scored as a "correct" response, if a dog chose the cup to which the experimenter was pointing; if the dog chose the other cup, it was scored as an "incorrect" response. A choice was considered to have been made if the dog approached one of the cups to within a distance of at most 15 cm. If the dog chose correctly, it was allowed to eat the food. If the dog chose incorrectly, the helper showed the dog that the cup was empty, and it was not allowed to eat the food from the other cup. The dog was prevented from investigating the other cup by holding its collar and guiding it out of the room. If a dog did not choose at all it was scored as a "no choice"; those trials were excluded from the analysis, and therefore we had to report data as percentages. A second coder coded 20 % of the original video material for reliability purposes. Reliability was good (Cohen's Kappa = 0.87).

Results

Honest group

We looked at the mean percentage of the dogs' correct choices in the four different conditions (see Fig. 3). We conducted a repeated measurement ANOVA with the two within-subjects factors authority (mother vs. child) and gaze alternation (yes vs. no) and one between-subjects factor, mother–child dyads. The between-subjects factor mother–child dyads had no effect on any of the within-subjects factors and there was no main effect of dyad ($F(1,10) = 0.65$, $P = 0.75$).

We therefore collapsed all data and re-ran the ANOVA. Authority had no effect on the behavior of the dogs ($F(1,21) = 0.4$, $P = 0.53$), neither did the use of gaze alternation ($F(1,21) = 0.39$, $P = 0.54$), and there was no interaction between the two factors authority and gaze alternation ($F(1,21) = 0.98$, $P = 0.33$).

To see if order of blocks had an effect on the dogs' behavior, we conducted another ANOVA with the two within-subjects factors authority (mother vs. child) and gaze alternation (yes vs. no) and the between-subjects factor first experimenter (mother vs. child). This showed that dogs differed in their behavior with the child and the adult and that this depended on the order in which they received the trials as there was an interaction between the within-subjects factor authority and the between-subjects factor first experimenter ($F(1,20) = 0.008$, $P = 0.050$). A post-hoc pairwise comparison showed that dogs behaved differently with the child or the adult only in the group of dogs receiving trials with the adult first ($t(10) = -2.74$, $P = 0.021$).

To test whether dogs improved over trials, we compared the first half of trials with the second half irrespective of authority. We found that dogs are better at finding the hidden food in the second half of trials compared to the first half (paired sample t test; $t(21) = -2.07$, $P = 0.051$). The dogs chose the correct cup above chance level in all of the four conditions (one sample t test: *Child, no-gaze*:

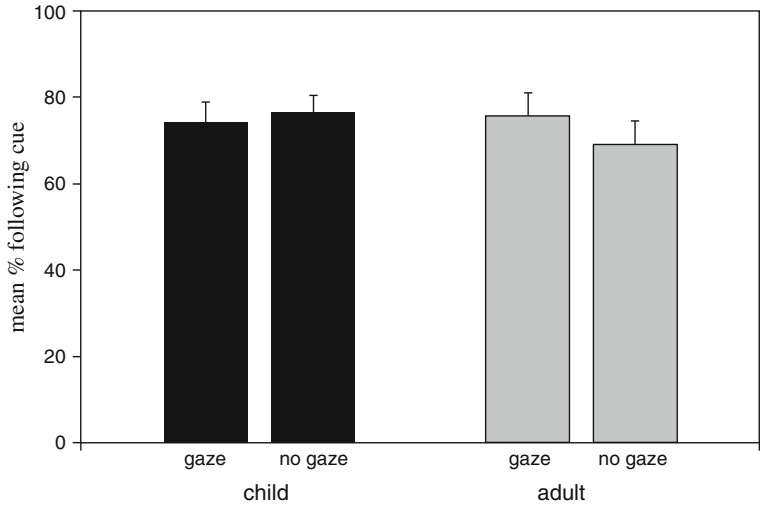

Fig. 3 Mean percentage of trials in which dogs ($N = 22$) followed the human pointing gesture in the different conditions in Study 2 ($+ga$ with gaze alternation; $-ga$ without gaze alternation) (n.s. $P > 0.05$) (+SE)

$t(21) = 19.25$, $P < 0.001$; *Child, gaze*: $t(21) = 15.94$, $P < 0.001$; *Adult, no-gaze*: $t(21) = 11.98$, $P < 0.001$; *Adult, gaze*: $t(21) = 14.18$, $P < 0.001$).

Deceptive group

We looked at the mean percentage of the dogs' correct choices in the four different conditions (see Fig. 3). We conducted a repeated measurement ANOVA with the two within-subjects factors authority (mother vs. child) and gaze alternation (yes vs. no) and the between-subjects factor mother–child dyads. The between-subjects factor mother–child dyads had no effect on any of the within-subjects factors and there was no main effect of dyad ($F(1,13) = 0.78$, $P = 0.67$).

We therefore collapsed all data and re-ran the ANOVA. Authority had no effect on the behavior of the dogs ($F(1,23) = 1.31$, $P = 0.27$), neither did the use of gaze alternation ($F(1,23) = 0.42$, $P = 0.53$) and there was no interaction between the two factors authority and gaze alternation ($F(1,23) = 0.6$, $P = 0.45$).

To see if order of blocks had an effect on the dogs' behavior we conducted another ANOVA with the two within-subjects factors authority (mother vs. child) and gaze alternation (yes vs. no) and the between-subjects factor first experimenter (mother vs. child). The between-subjects factor first experimenter had no interaction with any of the within-subjects factors and the factor dyad had no significant main effect (ANOVA, $F(1,23) = 0.52$, $P = 0.48$).

To test whether dogs improved over trials, we compared the first half of trials with the second half irrespective of authority. There was no significant difference in the dogs' behavior at finding the hidden food in the second half of trials compared to the first half (paired sample t test; $t(23) = 0.807$, $P = 0.428$).

Follow up

To ensure that the dogs did distinguish between commands coming from an adult or a child, we ran a follow-up study in which we tested the dogs' reaction to a command ("Sit") coming from a 4.5- to 5-year-old child or an adult.

Methods

Subjects and experimenters

Twelve dogs (6 males, 6 females) of various breeds (6 Mongrels, 1 Labrador Retriever, 1 Border Collie, 1 Golden Retriever, 1 Yorkshire Terrier, 1 Parson Jack Russel Terrier, 1 Airdale Terrier) and ages ($M = 6$, 25 years, range: 1,5–13 years) participated in this study. None of the dogs had participated in any of the other studies. Six naive pairs of experimenters (mother–child dyads) were recruited to participate in this study (children: 4 boys, 2 girls).

Procedure

The general experimental set-up was the same as in the main study, but there were no cups present. Instead, the experimenter (child or adult) gave a clear verbal command to the dog ("Sitz", German for "Sit"). Six adult-child pairs acted as experimenters, none of whom had participated in the main study. Each pair of experimenters tested 2 dogs. Each dog received 8 trials, 4 with the child as the experimenter, and 4 with the adult. Half of the dogs started with the adult as the experimenter and the other half started with the child as the experimenter. The maximum intertrial interval was 3 min. To ensure that dogs could hear the vocal command through the Plexiglas partition separating the experimenter from the dog, we cut 8 holes (diameter 5 cm) in the middle of the partition, in a vertical line.

The procedure was as follows: the dogs were allowed to move freely, with no other person present. Then the experimenter (child or adult) entered her side of the room, went to her designated location and remained there with her hands close to her body. She/he then looked at the dog, caught the dog's attention by calling its name and then commanded the dog to sit ("Sitz"/"Sit"). The command was given once after which the experimenter waited for a helper to enter the room and to guide the dog out. This occurred 7 s after giving the command. The dogs were not rewarded for any behavior.

Scoring

We coded the dogs' behavior after the experimenter gave the command with regard to whether the dog obeyed the command or not. The response was counted as "sit" if the dog's hind quarters rested on the ground keeping its forelegs straight. A second coder coded 20 % of the original video material for reliability purposes. Reliability was excellent (Cohen's Kappa = 1).

Results

We looked at the mean percentage of trials in which dogs followed the command to sit. Dogs followed the command significantly more often in the adult-condition ($M = 58.3$, $SD = 37.4$) than in the child-condition ($M = 20.8$, $SD = 20.9$) as demonstrated by a paired sample t test ($t(11) = 5.7$, $P < 0.001$).

Some children occasionally had difficulty following the instructions of the procedure, so it was dubious if one could count those as valid trials. For example, in some trials, children could not inhibit saying the command twice when the dog failed to obey the first time. Ignoring those trials and instead doing a more conservative analysis, a paired-samples t test shows the same pattern. Dogs followed the adult-given command significantly more often ($M = 62$, $SD = 40.8$) than the child-given command ($M = 21.3$, $SD = 24.3$), $t(8) = 5$, $P = 0.001$, $d = 1.7$).

Discussion

This study has three findings. First, we found clear experimental evidence that dogs react to commands from adults differently than to commands from children. The dogs largely ignored the command when it was given by a 4-year-old child. Whether dogs perceive children as lower authorities than adult humans can not be fully concluded from this behavioral difference, but these results favor this possibility. It is, however, also possible that because dogs are generally trained more by adult humans they might perceive commands coming from adults as more salient than those coming from children and therefore behave differently. Second, the dogs did not differentiate between children's and adults' pointing gestures. The dogs followed the pointing gesture and found the food irrespective of the authority level of the person pointing. This suggests again that dogs do not interpret pointing as a strong command comparable to a command like, e.g., "sit".

Dogs chose above chance level in all four conditions. They could solve the task from the beginning but they improved at finding the hidden food in the second half of the trials. Therefore, dogs improve over time and authority has no effect except in those trials in which the first experimenter is the adult. However, in that group, dogs performed against the hypothesis: they were significantly more successful at using the pointing gesture when it came from the child rather than the adult. One explanation for this could be that because the children occasionally found it difficult to perform the pointing gesture more trials had to be repeated. Another possible explanation is that the gesture of the adult was more salient than that of the child, and therefore dogs had more opportunity to learn to follow the cue given by the adults, which always resulted in a food reward, and kept following the cue when given by children afterward. If they started with children giving the cue, dogs did not have the same opportunity to learn to follow this cue and therefore, did not show enhanced performance in the second half of the trials. However, against this argument it must be recalled that dogs did not show any improvement over trials in the deceptive group, where the gesture was the same as in the honest group. However, it clearly shows that the level of authority of the person performing the pointing gesture does not affect dogs' performance.

Third, dogs did not differentiate between children and adults in situations when they pointed to the empty cup and dogs knew about the correct food location. They chose the cup containing the food in both situations. This result shows that even in a conflict situation they do not follow the gesture, which can be interpreted as showing that dogs do not consider the pointing gesture to have an imperative meaning for them.

Taken together, these three experiments argue against an imperative meaning of the pointing gesture in dogs in this kind of set-up.

General discussion

In the current studies, the dogs' strategies suggest that they do not see a human's pointing gesture as a command ordering them to walk in a certain direction. If dogs are

presented with cues signaling the location of food, they ignore the pointing gesture directing them to the wrong location, irrespective of the presence of the authority figure.

This shows that pointing is a gesture that dogs mainly choose to ignore in situations in which they have better knowledge. This result stands in contrast to the findings of Szetei et al. (2003) in which it was found that dogs would follow the pointing gesture irrespective of their own better knowledge. One reason for this difference could be that the Szetei et al. (2003) study and our study address different modalities. While Szetei et al. (2003) addressed the olfactory and the visual system ours exclusively addressed the visual modality. Seeing food and then following another visual stimulus (the gesture) to an alternative location may be more difficult than smelling the food and then following a cue based in another modality, i.e., visual.

Furthermore, dogs distinguished the experimental trials from the control trials in which the experimenter did not use any communicative gesture. In general, they followed the pointing gesture of the human (=choosing the non-baited cup) in the experimental trials more than they chose the non-baited cup in the control trials. This indicated that it was clearly the pointing gesture and not any other cue of the human which influenced dog's behavior here. However, they did follow the pointing gesture to some extent even in cases in which they knew better. This may indicate that the pointing gesture is interpreted to some extent as a directive ordering them where to go (Kaminski et al. 2012).

Previous studies have shown that the presence or absence of an authority has a strong effect on dogs' obedience. Call et al. (2003) showed that dogs ignore a human's command forbidding them to eat a piece of food as soon as the human leaves the room. However, if the human remains in the room after giving the command, dogs obey and steal significantly less food, especially if the human is fully attentive and looking at the dog, just as in this study (see also Schwab and Huber 2006). The fact that dogs in this study did not differentiate between situations in which the authority was present or absent may suggest that for them following the pointing gesture was different from following a command, where the presence of the authority matters. In addition, dogs responded to human pointing in a situation in which they did not have knowledge about the food location irrespective of whether the person pointing was an adult or a child with less authority. This is especially interesting because in a situation where dogs were given the command to "sit", they followed that command significantly more often if it came from an adult than if it came from a child. This suggests that indeed the two groups are perceived differently in terms of their authority, but that this is not a factor during pointing. One could argue that dogs would have followed the command "sit" irrespective of whether it was coming from the child or the adult, if they were rewarded with food after each trial, as in the pointing situation. It is, however, noteworthy that they clearly follow the adults' command to sit, even if no food is available, suggesting that commands from adults are more relevant.

In the situation in which dogs had knowledge about the food location and either an adult or a child was pointing to the empty cup, dogs ignored the gesture of either kind of experimenter and chose the baited cup. If dogs had perceived the pointing gesture as a strong command, they should have differentiated in both situations and followed the (deceptive) gesture of the adult more than that of the child, just as they did in the situations where a clear verbal command ("sit") was given. Therefore, the most plausible conclusion is that dogs do not perceive pointing as a command.

But this conclusion does not necessarily mean that dogs interpret pointing as an informative gesture, informing them about the location of the reward. Dogs' understanding of others' psychological processes seems to be limited. Dogs are sensitive to a human's attention (Call et al. 2003; Gácsi et al. 2004; Schwab and Huber 2006). Also, there is evidence that dogs may be sensitive to a human's perspective in a fetching situation (Kaminski et al. 2009). However, dogs do not seem to interpret past events as affecting a human's knowledge (Kaminski et al. 2009), which suggests that dogs are limited to only interpreting present events (see also Topál et al. 2009). Therefore, instead of interpreting pointing as a means of sharing information, dogs may interpret pointing as an imperative, telling them where to go. However, the current studies show that they do not do so in a command-like structure: however, imperatives can have different levels of authority. An imperative can also be meant as a suggestion, which, in some situations, can be ignored, e.g., when one's own knowledge is in conflict with this suggestion.

Another alternative hypothesis is that dogs follow human pointing based on associative learning mechanisms (e.g., Dorey et al. 2010; Wynne et al. 2008). This means dogs have learned in their individual ontogeny that the human's hand is always connected to a reward, in this case food, and therefore dogs would follow this gesture. But we have evidence that even 6-weeks-old puppies which had not much experience with the human hand in their lives do follow the pointing gesture of a human and there is no evidence of learning in the first few weeks of their lives (Riedel et al. 2008). The puppies in this study were successful in using the gesture even though they had to actively move *away* from the hand in order to find the food. We also have evidence that dogs do not simply follow a pointing gesture 'blindly' without having experienced any context prior to the communicative situation (Scheider et al. 2011).

Scheider et al. (2011) compared two groups of dogs in a situation in which a human pointed to an empty spot in a room. One group had experienced a context prior to the communicative situation, namely finding food on the ground. Another group had not experienced such a context, and had not found food at all. If the human then points to a predetermined empty spot on the ground, dogs in the context group showed more searching behavior in the direction of the pointing gesture, compared with the dogs in the no context group. These findings cannot simply be explained by an associative account as it is proposed by some authors (e.g. Elgier et al. 2009; Wynne et al. 2008). If the point-following behavior is explained by associative mechanisms alone, the dogs would have been expected to search in the direction of the gesture even if they had not experienced any context prior to this situation.

However, further studies will need to be conducted to explain in more detail how dogs understand the human pointing gesture, and in particular whether this ability shows an understanding of the human intention behind their communication.

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