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SHORT COMMUNICATION

The order of ostensive and referential signals affects dogs' responsiveness when interacting with a human

Tibor Tauzin[1,2] · Andor Csík[2] · Anna Kis[3] · Krisztina Kovács[4] · József Topál[3]

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Abstract Ostensive signals preceding referential cues are crucial in communication-based human knowledge acquisition processes. Since dogs are sensitive to both human ostensive and referential signals, here we investigate whether they also take into account the order of these signals and, in an object-choice task, respond to human pointing more readily when it is preceded by an ostensive cue indicating communicative intent. Adult pet dogs ($n = 75$) of different breeds were presented with different sequences of a three-step human action. In the relevant sequence (RS) condition, subjects were presented with an ostensive attention getter (verbal addressing and eye contact), followed by referential pointing at one of two identical targets and then a non-ostensive attention getter (clapping of hands). In the irrelevant sequence (IS) condition, the order of attention getters was swapped. We found that dogs chose the target indicated by pointing more frequently in the RS as compared to the IS condition. While dogs selected randomly between the target locations in the IS condition, they performed significantly better than chance in the RS condition. Based on a further control experiment ($n = 22$), it seems that this effect is not driven by the aversive or irrelevant nature of the non-ostensive cue. This suggests that dogs are sensitive to the order of signal sequences, and the exploitation of human referential pointing depends on the behaviour pattern in which the informing cue is embedded.

Keywords Dog · Ostensive cues · Pointing · Signal sequence · Referential communication

Introduction

Humans encode a large amount of information in the form of ordered signal sequences where the order can affect the meaning of a communicative utterance. Signal structure is also of great importance in some cases of non-human communication (e.g. putty-nosed monkeys, *Cercopithecus nictitans*, Arnold and Zuberbühler 2008; rock hyraxes, *Procavia capensis*, Kershenbaum et al. 2012). In case of humans, the communicative intention and thus the relevance of referential signals are often determined by ostensive cues (such as mutual eye gaze) preceding the informative signals (Sperber and Wilson 1995). Therefore, the appropriate order of such signals is also crucial in the successful transmission of information to a given addressee. It has been shown, for example, that in infants looking at an object must be preceded by ostensive signals in order to trigger gaze-following (Senju and Csibra 2008). Such sequential connectedness of ostensive and referential signals is a key feature of human information exchange

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✉ Tibor Tauzin
tauzint@ceu.hu

[1] Cognitive Development Center, Central European University, Hattyú u.14, 1015 Budapest, Hungary

[2] Department of Cognitive Science, Budapest University of Technology and Economics, Műegyetem rkp. 3-9, 1111 Budapest, Hungary

[3] Research Centre for Natural Sciences, Institute of Cognitive Neuroscience and Psychology, Hungarian Academy of Sciences, Magyar Tudósok krt. 2, 1117 Budapest, Hungary

[4] Department of Ethology, Eötvös Loránd University, Pázmány P. s. 1/c, 1117 Budapest, Hungary

(Csibra 2010) which enables the addressee to identify the actor's communicative intention.

Although human and non-human communication systems share some common characteristics, the extent of this similarity is still a bone of contention (Owren et al. 2010). One of the likely candidates possessing human-like skills in communication is the domestic dog. Increasing evidence suggests that dogs show some understanding of human referential gestures. For instance, dogs are skilful at following various forms of human pointing gestures from a very early age on (Riedel et al. 2008), even if the pointing is momentary, when the signal can only be seen for a short time (Bräuer et al 2006; Hare et al 1998; Miklósi and Soproni 2006). Moreover, similar to human infants, dogs seem to be uniquely susceptible to ostensive cues such as making eye contact, naming the dog or talking in a high-pitched voice (for a review see Topál et al. 2014). For example, in a reinforced eye contact task, dog puppies, compared to wolves, show a stronger tendency to look into the human's eyes from 4 weeks of age onwards (Gácsi et al. 2005). Dogs are also willing to initiate eye contact with humans in different contexts (e.g. begging—Gácsi et al. 2004; food out-of-reach task—Miklósi et al. 2000). Verbal signals such as ostensive naming and the combination of different ostensive signals can also modulate dogs' responsiveness in an object-choice task (Kaminski et al. 2012), and they are more likely to gaze-follow a human actor's head-turning when accompanied by ostensive cues than the same referential gesture in a non-ostensive context (Téglás et al. 2012).

It is still unclear, however, whether dogs are sensitive to the *order* of ostensive and referential signals when forming expectations about human pointing gestures, or alternatively, ostensive cues simply act as capturing a subject's attention when following pointing gestures.

To investigate this issue in experiment 1 (sequential-order experiment), adult pet dogs were presented with three consecutive signals in two different orders in a two-alternative forced-choice object search task. In the relevant sequence (RS) condition, ostensive cues were followed by momentary pointing gesture and then a non-ostensive attention getter, the clapping of hands. In the irrelevant sequence (IS) condition, the first and last signals were swapped in order to draw the attention of the dog without the expression of communicative intention before exhibiting a referential pointing. To rule out the possibility that the clapping of hands before pointing is aversive or simply irrelevant to the dogs in the control for clapping experiment, we investigated a new group of subjects' response to pointing gesture preceded by the clapping of hands (CH) and pointing without attention getter (wAG). We hypothesized that if dogs are sensitive to the sequential connectedness of ostensive and referential signals, then subjects will follow pointing gesture more readily in the RS compared to the IS condition. We also hypothesized that in the control experiment, dogs will show a better performance in the CH than the wAG pointing condition, since the clapping of hands can serve as a non-ostensive attention getter and not as a perceptual distractor.

Materials and methods

Subjects

Ninety-seven adult pet dogs were recruited for the sequential-order experiment. Three dogs did not meet the selection criteria of the warm-up phase (see "Procedure"), one dog was systematically influenced by its owner and another 18 dogs failed to search in more than two test trials; therefore, they were excluded. The final sample consisted of 75 dogs (40 males): 52 purebred (from 30 different breeds) and 23 mongrels (see supplementary data). Their mean age ± SD was 3.82 ± 2.44 years.

Twenty-five adult pet dogs were tested in the control for clapping experiment. Three dogs were excluded: One dog was systematically influenced by its owner and two dogs failed to search in more than two test trials. The final sample consisted of 22 dogs (14 males); 14 purebred (from 10 different breeds) and eight mongrels (see supplementary data). Their mean age ± SD was 4.30 ± 2.75 years.

All dogs were recruited from the volunteer database of Eötvös Loránd University.

Procedure

Before both the experiments, the owner sat down at a predetermined point in a testing room (5.0 × 3.0 m) and was asked to hold the dog by its collar facing Experimenter 1 (E1) at 2 m distance. E1 stood in the midline of the room, while another Experimenter (E2) stood on the left side of the subject.

Familiarization phase

E1 placed a brown plastic container (20 × 15 cm) on the floor 2 m away from the dog, looked at the dog, showing a tennis ball while simultaneously said: 'Listen, [dog's name]!'. This was done to avoid the sequential presentation of signals in the familiarization phase. Then, E1 puts the tennis ball into the container, stepped back and looked down. At this point, the dog was allowed to search for the ball. The familiarization trials were repeated until the dog had two successful trials. If a dog did not reach this criterion in a maximum of four trials, it was excluded from the test.

Test phase—sequential-order experiment

E2 placed a plastic occluder (1 × 0.75 m) in front of the dog to prevent witnessing further manipulations. E1, then, removed the container from the centre position and placed it and an identical plastic container equidistant from the dog and from each other (approximately 2.5 m). After that, E1 passed the ball to E2 unbeknownst to the dog and stood in the same place as in the familiarization trials. Then, E2 removed the occluder.

The RS trials consisted of three sequential signals: an ostensive attention getter (making eye contact with the dog, while saying 'Listen, [dog's name]!', in which the word 'listen' [in Hungarian 'figyelj'] was used to get the dogs attention); a referential cueing (momentary distal pointing gazing downwards to avoid eye contact with the dog); and a non-ostensive attention getter (hand clapping gazing downwards to avoid eye contact with the dog). In the IS condition, the first and third signals were swapped. The first signal in both conditions was repeated if the dog was not paying attention to E1. There were only nine RS and six IS trials in which the first signal was repeated. After giving the cues, E1 stepped backwards and looked down to avoid eye contact with the subject. The owner was allowed at that point to release the dog and encourage it to search for the ball without pointing. When the dog approached one of the containers, E2 threw the ball in front of the subject. This was done to prevent the dog to notice the ball from the distance. Dogs were presented with four trials: 1–1 to the left and right in both RS and IS conditions in a counterbalanced order.

Test phase—control for clapping

The procedure was the same as in the sequential-order experiment, except that dogs were provided with different communicative cues. In the wAG trials, E1 stood in front of the dog while looking down to avoid eye contact with the dog. After E2 had slightly moved her foot up (signalling that the dog was currently looking at E1), E1 pointed at one of the two containers. After this cue, E1 stepped back, and the dog was allowed to choose between the containers. The CH trials were the same, except that E1 clapped his hands before he pointed at one of the containers. Dogs were presented with four trials: 1–1 to the left and right in both CH and wAG conditions in counterbalanced order.

Data analysis

Test events were videotaped, and dogs' behaviour was analysed later. A choice was coded if the dog approached a container to a distance of 20 cm within 60 s after being released. A second coder scored 100 % of the test videos of included dogs. Inter-rater reliability was almost perfect (sequential-order experiment: Cohen's kappa = 0.94; control for clapping: Cohen's kappa = 1). Generalized estimating equation analyses were run separately for the sequential order and the control for clapping experiments using a binary logistic model with three main factors (Condition, Side of pointing, Position of a trial: whether it was the first, second, third or the fourth), and Wilcoxon signed-rank tests were performed to test whether the experimental manipulations had an effect on the number of correct choices.

Results

A GEE analysis revealed that dogs followed the human pointing more frequently in the RS condition (proportion of correct choices: $M = 0.73$, SE = 0.03) than in the IS condition (proportion of correct choices: $M = 0.57$, SE = 0.04) in the sequential-order experiment. The main effect of Condition was significant ($\chi^2_{(1)} = 8.783$, $p = 0.003$, $r = 0.342$), while the Side of pointing ($\chi^2_{(1)} = 0.055$, $p = 0.814$, $r = 0.027$) and the relative Position of a trial had no significant effect ($\chi^2_{(1)} = 4.089$, $p = 0.252$, $r = 0.233$) on dogs' choice. There was no significant interaction between these factors (Condition × Side: $\chi^2_{(1)} = 0.042$, $p = 0.838$, $r = 0.024$; Condition × Position: $\chi^2_{(1)} = 0.662$, $p = 0.882$, $r = 0.094$; Position × Side: $\chi^2_{(1)} = 4.839$, $p = 0.184$, $r = 0.254$; Condition × Side × Position: $\chi^2_{(1)} = 1.336$, $p = 0.721$, $r = 0.133$). Dogs' performance in the RS condition was significantly above chance level ($Z = -5.337$, $p < 0.001$, $r = 0.616$); however, in the IS condition, it did not differ significantly from chance ($Z = -1.543$, $p = 0.164$, $r = 0.178$) (Fig. 1).

A further GEE analysis revealed that there were no significant main effects of Condition ($\chi^2_{(1)} = 0.53$, $p = 0.817$, $r = 0.155$), Side ($\chi^2_{(1)} = 0.448$, $p = 0.503$, $r = 0.143$) or Position ($\chi^2_{(1)} = 3.066$, $p = 0.382$, $r = 0.373$) in the Control for Clapping experiment. The interactions between these factors were also non-significant (Condition × Side: $\chi^2_{(1)} = 2.392$, $p = 0.122$, $r = 0.330$; Condition × Position: $\chi^2_{(1)} = 3.290$, $p = 0.349$, $r = 0.387$; Position × Side: $\chi^2_{(1)} = 2.707$, $p = 0.439$, $r = 0.351$). A Wilcoxon signed-rank test revealed that dogs' performance in the control for clapping experiment did not differ significantly from chance level if pointing was presented without attention getter (proportion of correct choices: $M = 0.63$, SE = 0.16; $Z = -2.138$, $p = 0.057$, $r = 0.322$). However, dogs chose the indicated container significantly above chance if pointing was preceded by a non-ostensive attention getter, the clapping of hands

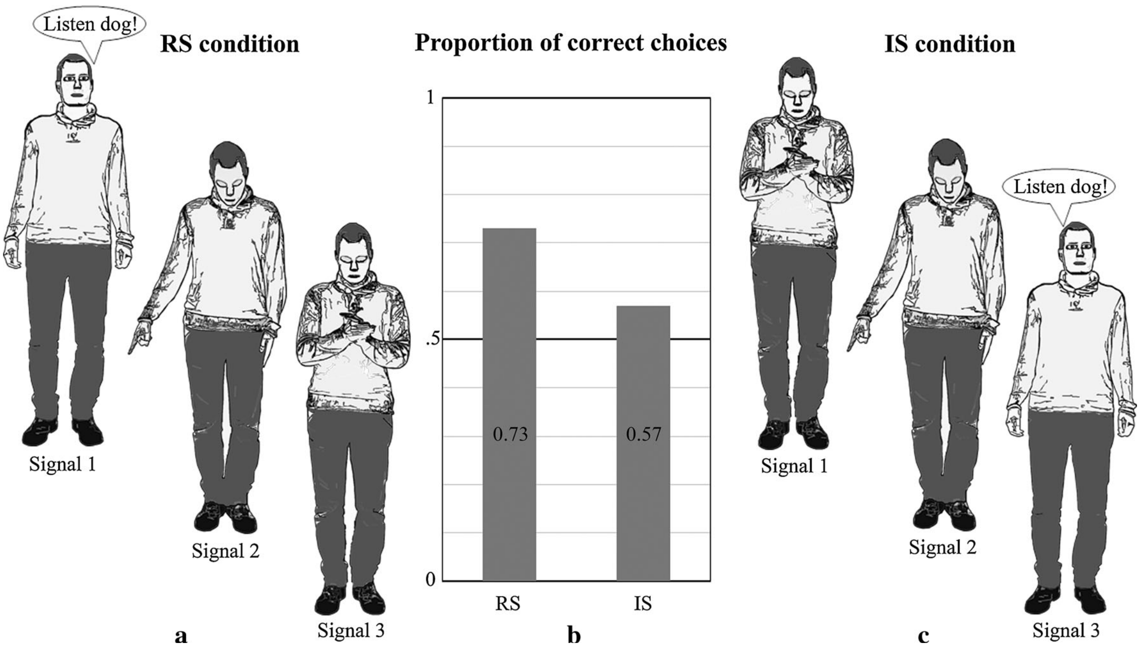

Fig. 1 **a** Signal sequence in the RS condition, **b** mean proportion of choosing the cued container and **c** signal sequence in the IS condition

(proportion of correct choices: $M = 0.80$, SE $= 0.13$; $Z = -3.000$, $p = 0.004$, $r = 0.452$).

Discussion

There is empirical evidence (e.g. Parise et al. 2010; Senju and Csibra 2008; Topál et al. 2009) to suggest that ostensive addressing signals do more than simply capturing preverbal infants' attention, since these signals have the potential to raise strong referential expectations about subsequent directional cues (see Csibra 2010). Although dogs seem to be especially attuned to human ostensive communication, there is an ongoing debate on whether human ostensive signals fulfil similar functions for dogs and human infants. Our findings might support the presence of such similarities and suggest that ostensive cues before a referential gesture indicate communicative intention for dogs, which is necessary to interpret the referential signal itself as communicative. Dogs were more ready to follow human pointing gestures when the referential signal was preceded—as opposed to followed—by ostensive cues indicating human's communicative intent. When the ostensive cues were swapped with the non-ostensive attention getter, dogs chose between the containers randomly despite the fact that the ostensive cue remained part of the tripartite signal sequence; thus, the whole utterance in the two conditions had the same saliency. Moreover, the results of the control experiment suggest that the clapping of hands could serve as an appropriate attractor sufficient for above chance following of pointing, but only if it was not embedded in an ill-formed signal sequence. This further supports the notion that dogs' performance in the IS condition was a result of the inappropriate order of signals and not due to the aversiveness or irrelevance of the attention getter at the beginning of the signal sequence.

This might mean that in dog–human interspecies communication, dogs are sensitive to the order of ostensive and referential signals. We may assume that such sensitivity is either fuelled by dogs' innate predisposition to learn about human communication (Riedel et al. 2008) or it is also possible that dogs acquire selective responsiveness to communicatively relevant signal sequences through life experience (Wynne et al. 2008). Importantly, these two alternatives would indicate fundamentally the same: the sensitivity to the sequential order of signals in the recognition of communicatively relevant utterances.

In summary, to our knowledge, this is the first study in which the behaviour of a non-human species was influenced by whether a heterospecific partner's ordered signal sequence is communicatively relevant or not. This suggests that in contrast to previous notions, the communication of certain non-human species might share more common properties with that of humans. However, it needs further investigation to determine whether this is a result of learning, domestication or homologous abilities in communication.

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Conflict of interest The authors declare that they have no conflict of interest.

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