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The Role of Visual Cues in the Comprehension of the Human Pointing Signals in Dogs

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In this study we examined the effect of the visually emphasized pointing arm in the case of the "Cross-forward pointing" gesture in dogs which proved to be difficult for them in an earlier study (Lakatos, Soproni, Dóka, & Miklósi, 2008). Our hypothesis was that if we emphasize the directionality of the visual cue using different, more contrasting coloured clothes during the tests, the dogs will be able to enhance their performance in two-way choice tasks. Our results showed that the conspicuousness of the pointing signal can affect how dogs perceive it. In contrast to our initial hypothesis pointing in a long white sleeve on a black background did not increase the dogs' performance, while the black sleeves with nude ("white") hands had an enhancing effect. This suggests that dogs need to see a salient body part what overhangs the median of the body silhouette and when the whole body is covered by black colour then the nude (pointing) hand appears as a conspicuous asymmetrical feature on one side of the body. Making the pointing hand less conspicuous makes the effect invariably disappear. Thus in summary we assume that the key aspect of the pointing gesture is not the directionality but the visually asymmetric cue provided by the human informant.

Recently it has been established that dogs are able to rely on the human pointing cue in two-way object choice tasks. They are also able to generalize to a certain degree from familiar pointing gestures to unfamiliar ones, and thereby they perform well on the basis of partially novel or "strange" pointing gestures (Hare & Tomasello, 1999; Hare, Brown, Williamson, & Tomasello, 2002; Lakatos et al., 2008; Miklósi, Polgárdi, Topál, & Csányi, 1998; Miklósi, Pongrácz, Lakatos, Topál, & Csányi, 2005; Soproni, Miklósi, Topál, & Csányi, 2002).

According to Butterworth and Itakura (2000) pointing production is based on vector extrapolation, thus one can assume that a corresponding version of this mechanism may be involved in the comprehension of the pointing gesture. Butterworth and Itakura (2000) have examined whether human children and adult people utilize this mechanism when they comprehend the direction indicated by pointing or head and eye movements. It was found that comprehension of pointing is unlikely to depend on extrapolating precise linear vectors along the pointing arm even in adults. Nevertheless their results showed that children perceive the directionality of the gesture and follow the direction of the arm into the visual periphery. Their results also revealed that the type of the visual effect/signal is very important, the longer lever (like the arm) carries the children's attention further into the visual periphery than do cues based on shorter levers (head movements). In real life visual factors (i.e. the differential salience of the target) necessarily interact with these approximate cues in making definite reference (Butterworth & Itakura, 2000).

In a recent study relatively unfamiliar gestures were utilized to find the critical visual features of the pointing signal that guide the choice behaviour of

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dogs and children in different ages (Lakatos et al., 2008). By varying the pointing gesture systematically we have found that, first, the dogs' performance was above the chance level only if the gesture provided a visually protruding body part (from the point of view of the dog) on the side of the baited bowl (e.g. "Momentary distal pointing", "Long cross-pointing"), and their performance did not differ from the chance level if there was no protruding body part ("Cross-forward pointing"). Second, their performance was significantly below the chance level when the protruding body part was on the side of the incorrect bowl, and third, dogs showed some evidence of generalization in the presence of unfamiliar gestures when they responded correctly from the beginning to "gestures" made by the legs. Finally, dogs did not grasp the meaning of the pointing index finger. Taken together these results suggested that dogs relied on a common simple rule, that is, they follow the direction indicated by the protruding body part (Lakatos et al., 2008). This notion is also supported by findings that an elongated nose on a mask improved the performance of children (Butterworth & Itakura, 2000).

Agnetta, Hare, and Tomasello (2000) showed that dogs are able to use novel cues when the experimenter places an arbitrary marker in front of the target location with overt behaviour elements but they are not able to use a physical marker as a communicative cue in the absence of any overt human behaviour toward the location of the hidden food. These findings have been extended recently by Riedel, Buttelmann, Call, & Tomasello (2006) who reported that; actually, dogs attached more importance to the marker than to the hand that placed it, although the presence of the hand enhanced the dogs' performance if it appeared together with the marker. It is also possible that under such conditions dogs simply choose the side at which something happened (a visual effect: i.e. the experimenter's arm moved to that side or a marker has been placed there) in a communicative situation.

In the present study we wanted to see whether there are alternatives to the comprehension that is based on protruding body parts. For this we utilized the so called "Cross-forward pointing" gesture in the case of which the experimenter points ahead of her (from the dogs point of view there are no extruding body parts), and, accordingly, Lakatos et al. (2008) found that dogs are not able to rely on this gesture in the two choice test. Our hypothesis was that if we emphasize the visual cue (the line of the pointing arm) using different, more contrasting coloured clothes during the tests then the dogs' performance increases. This was achieved by presenting the pointing signal in a white or black sleeved black T-shirt, which resulted in clearly directional visual cues (see Figure 1).

Methods

Subjects

Dogs (N=14): All individuals participated in both studies (see below), each of them participated in Study 1 for the first time, and after it was completed they participated in Study 2. Seven males, seven females; the mean age of the dogs was 4.5 years, SD was 3.6 years and the range was 1 - 13 years. Nine individuals were naive, five individuals have participated in other experiments recently, in which they had been exposed to some other kind of gestures (3 individuals: dynamic proximal and distal pointing, and momentary proximal and distal pointing gestures (Miklósi et al., 2005); two individuals: momentary long-cross pointing, momentary elbow-cross pointing; momentary cross-forward pointing and some kind of pointing performed by leg (Lakatos et al., 2008). The age of the owners was 25.07 + 7.43 years (mean + SD); range was 13 – 40; three men and eleven women.

Pretraining: familiarization with the situation

In the present experiments we used the same method as described in earlier studies (e.g. Lakatos et al., 2008; Soproni, Miklósi, Topál, & Csányi, 2001). The experimenter (G.L.) placed two bowls (brown plastic flower pots: 13 cm in diameter, 13 cm in height) 1.3-1.6 metres apart, in front of her on the floor. She put a piece of food (we used a small piece of frankfurter during the tests) into one of the bowls in the presence of the subject. The subjects could witness this hiding from a distance of 2-2.5 m with their owner standing behind them. After the experimenter put the food into the bowl, the owner allowed the dog to take the reward out from the bowl. One trial lasted about 30 seconds, and the procedure was repeated twice for each bowl to ensure that the subject knew that either bowl might contain some food.

Testing

The position of the participants was the same as above, but during the testing the subject was prevented from observing the hiding. The experimenter picked up the bowls, she put a piece of food into one of the bowls and after that she placed both bowls back onto the floor at the same time. During the pointing the experimenter was standing 0.5 m back from the middle line between the two bowls, facing the subject at a distance of 2-2.5 m. The owner was holding back the subject gently until the experimenter gave the cue. The experimenter drew the subject's attention to herself (any sounds, like clapping or/and the subject's name could be used) and presented the visual cue when the subject looked in the direction of her face. During the pointing the experimenter was looking at the subject. If the subject did not set out at the first cue, the experimenter repeated the pointing gesture again a maximum three times. The subject was allowed to choose only one bowl.

We used two types of pointing gestures in both studies. In the "Probe trial method" the experimental ("probe") trials were embedded into a background of the momentary distal pointing gestures ("control trials"); see below and see also Lakatos et al., 2008; Miklósi et al., 2005; Povinelli, Bierschwale, & Cech, 1999; Soproni et al., 2002). In the experimental trials we used the momentary Cross-forward pointing. During the m*omentary distal pointing* the experimenter pointed with extended arm and index finger in the direction of the correct location by her closer hand. After signalling, which lasted about 1 second, she lowered her arm to the starting position beside her body before the subject was allowed to approach the bowls.

During the *momentary cross-forward pointing* the experimenter stepped back about 0.5 metres from the bowls and she pointed with her contra-lateral hand in the direction of the correct location, but her extended index finger did not protrude from her silhouette. After signalling (1 sec), she lowered her arm to the starting position beside her body before the subject was allowed to approach the bowls (see Figure 1 and 2).

Each test session consisted of 20 trials, which contained 10 trials of momentary distal pointing gesture and 10 probe trials (momentary cross-forward pointing). The presentations of the cues were in predetermined semi random order and were balanced for right and left side. Neither the same gesture, nor the place of the reward was applied more than two times in a row. With each dog we did two studies one after the other within one month. There were two test sessions in both studies, depending on the clothes worn by the experimenter. There was a minimum of two weeks and a maximum of one month between the two test sessions in both studies. All experimental trials were recorded on video.

It is important to note that the gestures used in this study were displayed in a "momentary" fashion, which means that the subjects could witness the emergence of the gesture but the pointing was terminated (the arm was lowered to the body side) before allowing the subjects to choose. Therefore for simplicity this characteristic will not be indicated in the names of the gestures in the following sections of the paper.

The statistical analysis was based on the number of correct choices and non-parametric procedures (One-sample Wilcoxon signed-rank test, Wilcoxon matched pairs test and Mann-Whitney test) were used.

Study 1

In this study we have investigated whether the visual accentuation of the whole arm (black shirt with white sleeves) enhances the performance of the

dogs in the two way choice task. We applied this modification in the case of the cross forward pointing gesture which was found to be incomprehensible by dogs (Lakatos et al., 2008) in the two-way choice test. We expected that if the dogs utilize visual cues based on the whole arm than this condition should increase their performance. As a control we camouflaged the pointing arm by dressing the whole upper body part of the experimenter in black.

Methods

Types of the clothes worn by the experimenter (see Figure 1):
1. "Black arm": The experimenter wore a black long-sleeved shirt, so this way the arms and the torso of the experimenter were also black, but her hands were nude (white).
2. "White arm": The experimenter wore a white long-sleeved shirt and a black waistcoat on it, so the arms of the experimenter were white, but her torso was black. Her hands were also nude.

So in one of the two test sessions the pointing cues were presented with "Black arm" for the dogs and in the other test session with "White arm". Half of the subjects participated in the "Black arm" session for the first time, while the other half of the subjects started the test with the "White arm" session.

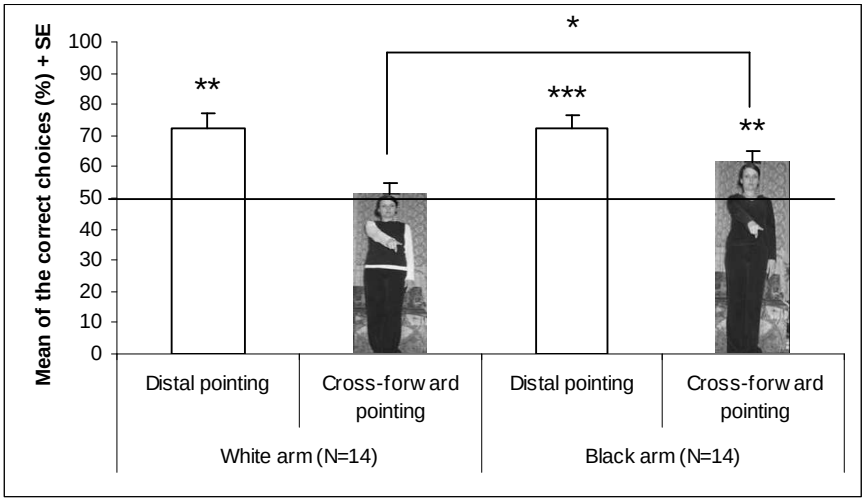

Figure 1. Dogs' performance in the Study 1 (Mean + SE). Dotted line represents chance level. The asterisks over the bars refer to the significant differences from the chance level (One-sample Wilcoxon signed-rank test) and to the results of the comparison of the "Black arm" and the "White arm" test (Wilcoxon matched pairs test) (* $p < .05$, ** $p < .01$, *** $p < .001$).

Results and Discussion

We compared the performance (mean of percentage) of the dogs to the chance level (50%) by one-sample Wilcoxon signed-rank test in both sessions in the case of both types of pointing gesture (see the results in Table 1). The dogs' performance with the "Distal pointing" gestures differed significantly from the chance level both in the case of the "Black arm" and "White arm" sessions. In the case of the "Cross-forward pointing" their performance was at chance level in the "White arm" session, but dogs chose significantly above the chance-level in the "Black arm" session (Figure 1).

Table 1
Results of the One-sample Wilcoxon signed-rank tests in Study 1.

Type of the pointing gesture	One-sample Wilcoxon signed-rank test			
	White arm		Black arm	
	T	*p*	*T*	*p*
Distal pointing	87.5	0.01	66.0	0.001
Cross-forward pointing	12.5	0.68	62.0	0.01

Comparing the results in the two kinds of pointing gestures used we found that in the case of the "White arm" session dogs performed better in the "Distal pointing" trials than in the "Cross-forward pointing" trials (Mann-Whitney U-test; $U = 34.0$; $p < 0.01$) whilst there was no such difference in the "Black arm" session between the different types of pointing gestures (Mann-Whitney U-test; $U = 58.5$; $p = 0.07$).

There was no sign of learning during the testing for either of the pointing gestures. Comparing the performance on the first and the second session for both type of gestures we found no significant difference (Wilcoxon matched pairs test: "Distal pointing" (T (-) = -35.0; $p = 0.49$); "Cross-forward pointing" (T (-) = -46.0; $p = 0.62$)).

Thus contrary to our initial hypothesis dogs' performance was higher in the "Cross-forward pointing" trials if the experimenter wore a black long-sleeved shirt so her arms and the torso were also black than when she was pointing dressed in a white long-sleeved shirt and a black waistcoat, when the arms of the experimenter were contrastingly white on a black background of her torso (Figure 1). Although, in the case of the "White arm" gesture the sleeve provided a directional cue, its actual directionality was ambiguous, partially because the pointing arm seemed to be almost as if it would point straight forward. Contrarily in the case of the "Black arm" clothes the experimenter's nude pointing hand popped out conspicuously on black background on the baited side.

Study 2

Based on the results in Study I we modified our hypothesis suggesting that if the light hand skin ("white") provided a crucial (asymmetrical) visual cue for the dogs than pointing in black gloves should make this effect disappear. As a further control we applied the same gesture with nude ("white") arm using an everyday T-shirt which was supposed to replicate the effect of the white arm in Study 1 and the results of our recent experiment in Lakatos et al. (2008). Thus in both cases we hypothesised that the modification of the visual features would lead to a deterioration of the dogs' performance in the case of "cross pointing" gestures. The same group of dogs served as subjects.

Methods

Types of the clothes worn by the experimenter (see on Figure 2):

1. "Black arm with black gloves": The experimenter wore a black long-sleeved shirt and black gloves, so this way the arms, the torso and the hands of the experimenter were also black.

2. “Everyday T-shirt”: The experimenter wore a lightly coloured everyday T-shirt. It could be anything, which was not similar to the other 3 types of the used clothes. Her hands were uncovered (nude).

So in one of the two test sessions the pointing cues were presented by “Black arm with black gloves” gesture for the dogs, while in the other test session the experimenter wore “Everyday T-shirt”. Half of the subjects participated in the “Black arm and back gloves” session for the first time, while the other half of the subjects started the test with the “Everyday T-shirt” session.

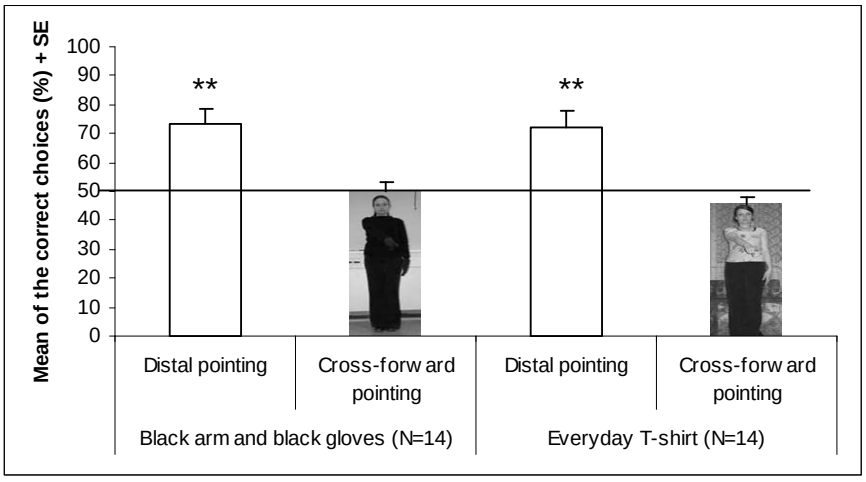

Figure 2. Dogs’ performance in the Study 1 (Mean + SE). Dotted line represents chance level. The asterisks over the bars refer to the significant differences from the chance level (One-sample Wilcoxon signed-rank test) and to the results of the comparison of the “Black arm and black gloves” and the “Everyday T-shirt” test (Wilcoxon matched pairs test) (* $p < .05$, ** $p < .01$, *** $p < .001$).

Results and Discussion

We compared the performance of the dogs to the chance level by one-sample Wilcoxon signed-rank test in both sessions in the case of both types of pointing gesture (Table 2). We found that the dogs’ performance on “Distal pointing” trials differed significantly from the chance level both in the “Black arm and black gloves” session and in the “Everyday T-shirt” session. On the contrary, in the case of the “Cross-forward pointing” their performance was on the chance-level (50%) in the case of both sessions (Figure 2).

The comparison of the dogs’ performances in the different sessions in the case of each pointing gesture showed that using these kinds of clothes there were no significant difference in the dogs performance, neither in the case of the “Distal pointing” (Wilcoxon matched pairs test; $T(+) = 19.0$; $p = 0.94$) nor in the case of the “Cross-forward pointing” (Wilcoxon matched pairs test; $T(+) = 28.0$; $p = 0.19$) (Figure 2).

There was no sign of learning during the testing with either of the pointing gestures. Comparing the performance on the first and the second session for both types of gestures we found no significant difference (Wilcoxon matched pairs test; “Distal pointing” ($T(+) = 21.5$; $p = 0.64$); “Cross-forward pointing” ($T(+) = 32.0$; $p = 0.06$).

To test our new hypothesis we compared the dogs’ performance in the “Black arm and black gloves” session and in the “Everyday T-shirt” session with their performance in the “Black arm” session in Study 1. We found that

dogs performed significantly better in the case of the "Black arm" session than in either of the two sessions of Study 2 (Wilcoxon matched pairs test; "Black arm" – "Black arm with black gloves": T (+) = 57.0; $p < 0.05$; "Black arm" – "Everyday T-shirt": T (+) = 75.0; $p < 0.01$).

Taken together these findings suggest that dogs utilize the forward cross pointing gesture, which does not protrudes the body torso, only if it is visibly (and asymmetrically) emphasized by the pointing hand.

Table 2
Results of the One-sample Wilcoxon signed-rank tests in Study 2.

Type of the pointing gesture	One-sample Wilcoxon signed-rank test			
	Black arm and black gloves		Common clothes	
	T	*p*	*T*	*p*
Distal pointing	76.0	0.01	75.5	0.01
Cross-forward pointing	23.0	0.99	-36.0	0.13

General Discussion

In recent literature dogs have been often portrayed as being very skilful in comprehending the human pointing gestures in two way choice tasks (Hare, Call, & Tomasello, 1998; Hare et al., 2002; Miklósi et al., 1998; Miklósi et al., 2005; Soproni et al., 2002). In a recent comparative study we have found that in general the performance of the dogs is comparable to that of 1.5-2 years of children (Lakatos et al., 2008). However, we have also found that dogs were clearly inferior in the case of the forward cross pointing gesture in which from the observer's point of view the pointing arm and hand stays within the silhouette of the body. This finding led to the prediction that the protrusion of a body part of the body torso provides the key feature of the signal. Thus in contrast to children who by the age of 3 years attend the direction of the pointing index finger, dogs of all ages choose the "correct" side on the basis of a body part which "sticks out" from the silhouette of the body (Lakatos et al., 2008).

The present study shows that making the gesture visually more conspicuous can have an enhancing effect in cases where the gesture does not stick out from the body torso. In contrast to our expectations pointing in a long white sleeve (on a black background) did not improve the dogs' performance, however black sleeves with nude ("white") hands had an enhancing effect. This can be understood if one takes the observer's point of view. The important difference is that if the whole body is covered by black colour then the nude (pointing) hand appears as a conspicuous asymmetrical feature on one side of the body. Even if the forward cross pointing gesture does not protrude from the body silhouette, in this case the nude hand has visually the same effect as a body part sticking out from the body torso. It may be hypothesized that the actual colour is of less importance, and similar effect could be found using the two colours in opposite ways. Making the pointing hand less conspicuous (by using a lighter background and/or using black gloves on black background) makes the effect invariably disappear.

These results serve as further confirmation for our earlier assumption (Lakatos et al., 2008) that the pointing index finger is not informative for the

dogs. Now it seems that the most informative aspect of the gesture is not the line of the pointing arm but a clearly visible patch, which appears conspicuously at one side of the body torso. It is not relevant which body part composes this patch as Lakatos et al. (2008) demonstrated i.e. dogs go to the wrong direction because of the protruding elbow in the case of the "Elbow cross pointing". Presumably, the most important aspect is the resulting visual asymmetry represented by the signal which will guide the dog to the appropriate direction.

These results provide a simple explanation to the ability to generalize in dogs (see also Hare et al., 1998; 2002; Hare & Tomasello, 1999; Soproni et al., 2001; 2002), even in situations when the animal is naïve. Thus by this relatively simple rule dogs are able to obtain a flexible understanding of bodily gestures which, actually, are often not points but other cues including head or eye movements. Such sensitivity could also explain why dogs can learn very rapidly to attend minute directional eye movements (Miklósi et al., 1998).

We also have to emphasize that in this study both pointing gestures were distal and momentary and hereby very difficult to process. In these cases the subjects need to remember the pointing signal until they are allowed to make their choice. In addition the gesture is relatively far from the signalled bowl, thus the signal could not be "mistaken" for a manipulation of the baited bowl (local enhancement, to find a definition see Heyes, 1994 and Fritz, Bisenberger, & Kotrschal, 2000). In the comparative perspective it is important to see that various species have difficulties to find the place of a hidden reward on the basis of human cues if the cue appears in a distance. Both chimpanzees and rhesus monkeys are not able to find the hidden food in a Wisconsin task if the signalling marker object ("beacon") is placed more than 20 cm away from the actual location (Jenkins, 1943; Murphy & Miller, 1955). Similar observations were reported for dogs in asocial situations (Milgram et al., 1999). Further, many other species tested are able to learn easily in delayed matching-to-sample tasks but still cannot learn to choose correctly in an object choice task if they have to choose on the basis of a momentary pointing gesture (i.e. capuchin monkeys or rhesus monkeys, see Anderson, Sallaberry, & Barbier, 1995; D'Amato & Worsham, 1972; Emery, Lorincz, Perrett, Oram, & Baker, 1997; Hampton & Hampstead, 2006; Tavares & Tomaz, 2002; Washburn, Hopkins, & Rumbaugh, 1989).

The observations of the present study also point to the importance of taking into account the visual abilities of the species in comparative work, apart from the possible differences or similarities of the underlying cognitive architecture. Although there is relatively little knowledge on dogs' visual abilities (see Miller & Murphy, 1995, for the only comprehensive review on the subject; Miklósi, 2007) we know that having only two types of cones in the retina (in comparison to the tricromatic humans) their visual world is less rich in colours. Further, recent experiments have shown that dogs are inferior (in comparison to humans) in distinguishing among shades of grey (Pretterer, Bubna-Littitz, Windischbauer, Gabler, & Griebel, 2004). However, in contrast to humans dogs are more sensitive to movement in the visual domain. Coile, Pollitz, and Smith (1987) have shown that their flicker fusion frequency occurs at higher values in comparison to humans. The ability to perceive rapid movements together with a restricted grey and colour vision might have

"forced" dogs to attend to different aspects of human communicative gesturing than is utilized by our species.

Thus, in everyday situations dogs might experience problems in comprehending the pointing signal because their restricted visual abilities, and not because they are not in the position to "comprehend" the signal. In this sense the results of this study should caution others not to jump to rash conclusions on species differences in communicative skills if there is little knowledge available on the perceptual abilities of the species under study. Given the differences in the visual processing apparatus between humans and dogs, it is less surprising to find differences at the level of performance which may or may not, in addition, be the outcome of differences in the cognitive skills.

In conclusion this study demonstrated that the most informative cue for the dogs is a clearly visible patch (irrespectively of the body part what makes this patch), which appears conspicuously at one side of the body torso. It seems that the most important feature of the pointing gesture for the dogs is the visual asymmetry represented by the signal which guides their attention to the appropriate direction.

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