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Dogs' (*Canis familiaris*) Responsiveness to Human Pointing Gestures

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In a series of 3 experiments, dogs (*Canis familiaris*) were presented with variations of the human pointing gesture: gestures with reversed direction of movement, cross-pointing, and different arm extensions. Dogs performed at above chance level if they could see the hand (and index finger) protruding from the human body contour. If these minimum requirements were not accessible, dogs still could rely on the body position of the signaler. The direction of movement of the pointing arm did not influence the performance. In summary, these observations suggest that dogs are able to rely on relatively novel gestural forms of the human communicative pointing gesture and that they are able to comprehend to some extent the referential nature of human pointing.

Dogs have been reported in many independent studies (Hare, Call, & Tomasello, 1998; Hare & Tomasello, 1999; McKinley & Sambrook, 2000; Miklósi, Polgárdi, Topál, & Csányi, 1998; Soproni, Miklósi, Topál, & Csányi, 2001) to be exceptionally good in responding to human pointing gestures, that is, finding food (or a toy) at a place that is indicated by a human. We are interested in extending the understanding of pointing in this species, which was domesticated at least 100,000 years ago to live in small human groups (Vilá et al., 1997). One could argue that learning about human communicative gestures is not exceptional in the dog but an everyday experience. Moreover many researchers suspect that dogs have been selected for being able to learn efficiently about human signals (Agnetta, Hare, & Tomasello, 2000; Miklósi et al., 1998; Soproni et al., 2001). Nevertheless, it is still not clear whether dogs understand the communicative intent of the signaling human or if they react only to some cuing that directs their attention to the hidden food.

To investigate this question experimentally, we presented dogs with pointing gestures that were varied systematically in important components of the pointing hand. This approach is in many respects similar to that applied to investigate components of so-called key stimuli, in which animals are tested with simplified stimuli or with only a few components of a complex key stimulus (i.e., Seitz, 1940; Tinbergen, 1960). Generally the aim of such an analysis is to find the key components that themselves have the capacity to release the appropriate behavior. In our case, we wanted to identify the key components and/or features of the human pointing gesture that contribute to the dog's understanding of it as a communicative action.

In human pointing, the action of the hand is usually accompanied with the gaze orientation and some utterances relevant to the situation (e.g., Leung & Rheingold, 1981). With regard to the role of the hand and body in this complex gesture, the following components may be deduced that can contribute to the understanding of it as a directional cue for finding food. Pointing is invariably done with the hand and is associated with some movement to the appropriate direction. The hand usually protrudes from the body contour, and the body of the pointer is usually closer to the indicated place than to other, potentially similar places. In Experiment 1, we tested for the role of the hand and the movement; in Experiments 2 and 3, we aimed to discover whether finger–arm extension from the body surface and body position itself during pointing had any effect on the dogs' choice behavior.

Experiment 1

Many animals, especially predators like the dog, are more sensitive to a moving object than to a stationary one. Although during human pointing, the arm–hand can assume a rigid stationary position, the usual form of the gesture involves the movement of the whole arm toward the goal. Therefore, one may argue that not the pointing gesture itself but the direction of the movement is the main indicator for a carnivore like the dog. Although Hare et al. (1998) reported that two dogs seemed to be good at finding food on the basis of stationary pointing gestures, we wanted to see whether backward movement of the hand would decrease the efficiency of the dog in finding the hidden reward. In other test

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trials, the pointing was done with a stick to examine the role of the arm and hand in this gesture.

Method

Subjects

Six male and 3 female dogs (*Canis familiaris*; $M = 4.7$ years, range = 2–7 years) took part in Experiment 1. Except for 3 dogs, all of them had lived with human families since they were puppies; the others (Baby, Szetti, Wasil) joined the family as adults. The dog–owner pairs were recruited from participants of our Family Dog Research Program. The dogs were of various breeds (see Table 1). Note that 1 year earlier, 4 dogs had participated in experiments involving pointing and gazing (Soproni et al., 2001), but dogs were naive with respect to all experimental pointing gestures presented in this study. Five owners were women, and one was a man; their ages were between 17 and 26 years. All dogs were fed by the owners once a day in the evening; nevertheless, owners were asked not to give any food to their dog for at least 2 hr before the trials.

Procedure

The observations were carried out during May 8–31, 2000, in the owners' apartments. Only the experimenter, the owner, and the dog were present during the training and testing. All trials had been conducted by the same experimenter (Krisztina Soproni). Two bowls (brown plastic flowerpots 15 cm in diameter, 15 cm in height) were used to hide the bait. Both bowls had double bottoms with one food pellet fixed under the separating panel. The bottom panels were covered with a piece of cloth to prevent any noise occuring during the baiting. Various brands of dry food were used as rewards. To accomplish the experiment, 3 consecutive days were necessary.

Pretraining. The experimenter stood 0.5 m behind the middle line between the two bowls, which were 1 m apart and were on chairs. In front of the experimenter, at a distance of 2 m, the owner restrained the dog, which was facing the experimenter. The experimenter tried to make eye contact with the dog and called it by its name. While the dog was attentive, the experimenter showed the dog a food pellet and placed it into one of the containers. Then the owner allowed the dog to approach the bowls and choose one of them. If the dog chose the baited bowl, then it could eat the reward and was also praised verbally by the owner. If the dog made an incorrect choice and went to the empty bowl, then the experimenter took the pellet from the other bowl and showed it to the dog. In this case, the dog did not get the food. This trial was repeated four times; the position of the food reward was counterbalanced. The pretraining was necessary to ensure that the dogs knew that the bowls might contain food.

Testing. The position of the subjects was the same as above, but now the dog was prevented from observing the baiting; the owner guided the dog behind folding screens or furniture. The experimenter took a piece of food in each hand and put one in each bowl simultaneously, but one of the pellets was immediately removed. After the food was hidden, the owner stood behind the dog and made it sit facing the experimenter. The owner was asked to let the dog go after the cue. The experimenter made eye contact with the dog and gave the cue. She indicated the location of the food with various types of pointing gestures. In all experiments (1, 2, 3), three different pointing gestures (*probe* pointing gestures), which differed from each other in certain components, were combined with ordinary pointing gestures (P). For the latter gesture, the experimenter pointed briefly toward the baited bowl with extended arm and index finger. After signaling, she lowered her arm to the starting position beside her body. This experimental protocol was based on the study of Povinelli, Bierschwale, and Cech (1999) but see also Soproni et al. (2001). Each test session consisted of 12 trials. Trials 1, 3, 4, 6, 7, 9, 10, and 12 were control trials, and Trials 2, 5, 8, and 11 served as probe trials. In this experiment, three types of probe trials were used: (a) reverse pointing (RP), (b) stick pointing (SP), and (c) reverse stick pointing (RSP; see Figure 1).

The three types of probe trials were distributed within the sessions. Each dog participated in six sessions, with eight probe trials for each type of cue. The presentations of cues were in a planned order and were balanced for right and left side, with the restriction that one side could not be baited more than twice in a row.

In the case of RP trials, the dog was allowed to leave the cover only when the experimenter was already in the pointing position: She stood motionless with extended arm and index finger and then lowered her arm. The SP and RSP trials were the analogies of the P and the RP trials, respectively, but now the experimenter was using a wooden stick. During these trials, she held this stick (3 cm in diameter, 80 cm in length) hidden behind her back in both hands and swung it from this position to the right or left bowl. The experimenter remained in a stationary position when she was moving the stick. In the SP trials, she pointed the baited bowl with the stick and then lowered it behind herself. In the RSP trials, the experimenter was already in the pointing position, and when the dog was watching, she lowered the stick back to the starting position. For all trials, the experimenter was looking at the dog during and after the cuing. After the experimenter resumed her resting position, the dog was released. In all trials, as in other experiments (Miklósi et al. 1998; Soproni et al., 2001), dogs invariably made a choice by approaching one or the other bowl. They never approached the experimenter, and usually they took the shortest path to the bowls from their starting position, but sometimes they started off straight ahead before turning to one side or the other. Success was noted if the dog approached the bowl indicated by the experimenter, and in this case, it was allowed to eat the food. Approaching the nonindicated bowl was regarded as failure; dogs were prevented from getting to the food, but they were shown the place of the hidden food by the experimenter.

Table 1
Dogs and Their Breed, Sex, and Age and the Experiments in Which They Took Part

Dog	Breed	Sex	Age (years)	Experiment
Spuri	German shorthaired pointer	Male	2	1, 2, 3
Dome	German shorthaired pointer	Male	6	1, 2, 3
Philip	English cocker spaniel	Male	3	1, 2, 3
Axel	Belgian shepherd	Male	7	1
Mystic	Belgian shepherd	Male	3	1, 2, 3
Robin	Collie	Male	3	1, 2, 3
Szetti	Mongrel	Female	5	1, 2, 3
Baby	German shepherd	Female	7	1, 2
Wasil	Mongrel	Female	6	1, 2
Sally	English setter	Female	3	2, 3

Results and Discussion

During pretraining, each dog chose the baited bowl correctly at first in all trials, so additional trials were not necessary. There was no significant difference in the number of correct choices on the left and the right side for any gestures displayed; thus, this variable was removed from statistical analysis. Comparing the performance of dogs in Sessions 1 through 3 and 4 through 6 (Wilcoxon matched-paired signed-ranks test), we did not find any difference for any of the pointing gestures (so there was no change over time with practice). Because of similar results for Experiments 2 and 3, this variable was not taken into consideration in later analyses. For comparison, we included eight P trials that preceded the RP trials as a kind of baseline control trial, given that earlier experiments

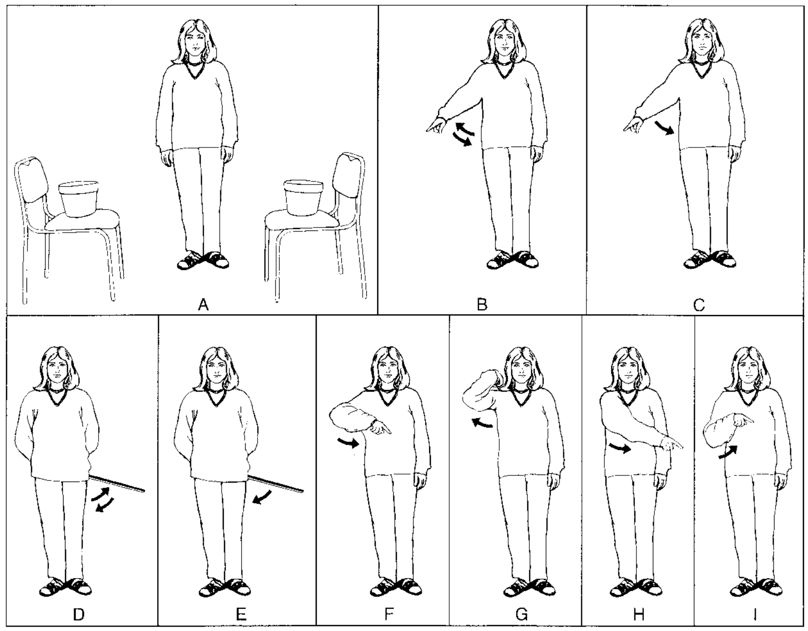

Figure 1. Different pointing gestures used in Experiments 1–3. A: The experimental setting. B: Pointing and far pointing. C: Reverse pointing. D: Stick pointing. E: Reverse stick pointing. F: Elbow cross-pointing and far elbow cross-pointing. G: Elbow pointing. H: Long cross-pointing. I: Short cross-pointing.

had shown that dogs usually respond at a level between 85% and 95% correct (Miklósi et al., 1998; Soproni et al., 2001). Regarding these four types (one control and three experimental) of trials, there was an overall difference in dogs' performance (Friedman analysis of variance [ANOVA]), $\chi^2(8, N = 9) = 13.68, p < .0034$. Dunn's post hoc multiple comparison test showed that there was a significant difference between P and RSP trials ($p < .01$) and between RP and RSP trials ($p < .05$). During the experiment, dogs performed significantly above chance on P trials (one-sample Wilcoxon signed-rank test); $T(8) = 36, p < .01$, and RP trials, $T(9) = 45, p < .01$, but they did not differ from random choice on SP trials, $T(4) = 10$, *ns*, and RSP trials, $T(4) = 10$, *ns*, (see Figure 2 and Table 2).

Our observations support that the direction of movement of the arm plays little role in indicating the direction for the dog. Dogs are able to choose well above chance if they witness an arm movement opposite to the direction of the hidden food. With similar findings of others (Hare et al., 1998), this suggests that the position of the lifted arm is a more important element of the pointing gesture than any directional movement. As far as we can tell (by asking the owners), pointing with the stick was a novel gesture for all of the dogs. However, whether dogs were able to generalize in this case is doubtful. Because there was also a significant difference between P and SP trials, we might conclude that the arm (as the favored part of the body) might contribute to the pointing signal. But this is not to say, of course, that (these)

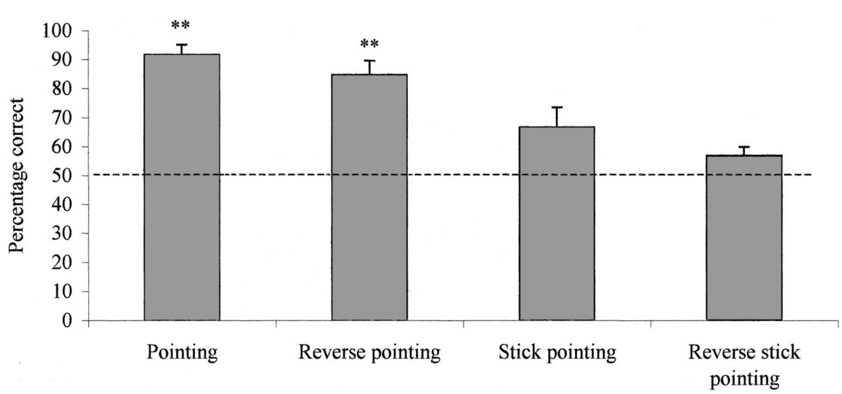

Figure 2. Means and standard errors of the performance (choice of the baited bowl) of dogs in response to pointing, reverse pointing, stick pointing, and reverse stick pointing. Dotted line represents chance performance level (50%). ** $p < .01$.

Table 2
Number of Correct Choices (Out of 8) by Each Dog in Experiment 1

Dog	Pointing	Reverse pointing	Stick pointing	Reverse stick Pointing
Spuri	6	6	8	4
Dome	8	8	4	4
Philip	8	7	4	4
Axél	8	5	4	5
Mystic	8	7	4	5
Robin	8	8	4	4
Szetti	8	7	7	6
Baby	4	5	7	4
Wasil	8	8	6	5
M	7.33	6.78	5.33	4.56
SE	0.47	0.40	0.55	0.24

dogs would not be able to learn pointing with a stick as a gesture. Note that children as young as 5 to 9 months old seem to be able to distinguish a rod from the human arm even if both objects perform seemingly similar actions (Woodward, 1998).

Experiment 2

In experiments with chimpanzees, it was found that they had problems finding food if the form of the usual pointing gesture was changed by bending the arm at the elbow and/or keeping the index finger in front of the body (Povinelli, Reaux, Bierschwale, Allain, & Simon, 1997). Similarly, both dogs had difficulties in following a similar gesture (belly pointing; Hare et al., 1998) under experimental conditions. If the signaling human was standing or sitting asymmetrically (nearer to one or the other bowl), it was often found that with some gestures the animals' incorrect choice was the result of approaching the signaling human and not following the direction indicated by the gesture. In this experiment, we varied the distance of the signaler to the bowl and presented the dogs with three different probe gestures. In addition to replicating and extending earlier experiments, we wanted to show that if, for some reason, the pointing gesture becomes incomprehensible for the subject, it chooses the place that is indicated by the position of the signaler's body.

Method

Subjects

The same 9 dogs used in Experiment 1 participated in this study, except 1 dog (Axel). Instead of him, a female English setter (Sally; 3 years old, with a female owner) was included (see Table 1). Six owners were women, and 1 was a man; their ages were between 17 and 26 years. Owners were asked not to feed the dogs for at least 2 hr before the trials.

Procedure

Observations for the present series were carried out between June 12, 2000 and July 5, 2000, in the owners' apartments. The experimental settings and the pretraining were the same as in Experiment 1. To accomplish the experiment, 2 consecutive days were necessary.

Testing

Apart from the P trials, three new types of probe trials were used (see Figure 1): (a) elbow cross-pointing (ECP), (b) far pointing (FP), and (c) far elbow cross-pointing (FECP). During the ECP trials, the experimenter was standing in the middle line of the two bowls and pointed to the baited bowl with her contralateral hand in front of her body. She raised her arm in such a way that her extended index finger was at the middle line of her body and her elbow protruded toward the empty bowl. The remaining two types of probe trials (FP and FECP) were identical to P and ECP trials, respectively, with one difference: In these cases, the experimenter stood next to the empty bowl (far from the baited bowl) and indicated the food location from this position. In FP trials, she pointed to the baited bowl with her closer hand, and in the FECP trials, she pointed to the baited bowl with her contralateral hand crossed in front of her body.

Results and Discussion

Eight P trials that preceded ECP trials were used for baseline comparison. Here, again, we found an overall difference among the different types of trials (Friedman ANOVA), $\chi^2(8, N = 9) = 26.17$, $p < .0001$, see Figure 3. Post hoc comparisons (Dunn's multiple comparison test) revealed that dogs performed

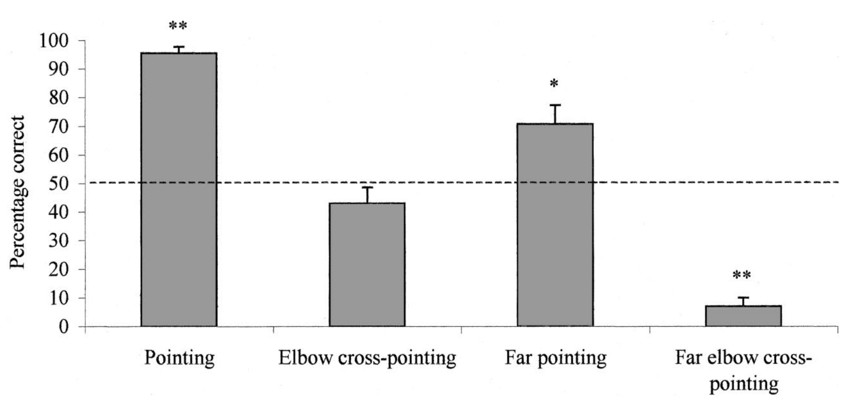

Figure 3. Means and standard errors of the performance (choice of the baited bowl) of dogs in response to pointing, elbow cross-pointing, far pointing, and far elbow cross-pointing. Dotted line represents chance performance level (50%). * $p < .05$. ** $p < .01$.

better in P trials than in ECP trials ($p < .05$) and FECP trials ($p < .001$), and there was also a difference between FP and FECP trials ($p < .01$). The performance of dogs was significantly above chance level on P trials (one-sample Wilcoxon test), $T(9) = 45$, $p < .01$, and FP trials, $T(8) = 32$, $p < .05$, and significantly below chance level on FECP trials, $T(9) = -45$, $p < .01$. In the case of ECP trials, there was no significant difference, $T(8) = -16$, *ns* (see Figure 3 and Table 3).

In contrast to chimpanzees (Povinelli et al., 1997) and in agreement with another study on dogs (Hare & Tomasello, 1999), our dogs were also able to respond correctly to pointing if the body position of the experimenter was asymmetrical in relation to the point. Although this situation was probably not novel to most of the dogs, it suggests some flexibility in their reaction to pointing. It is interesting to compare the dogs' reaction to elbow cross-pointing when it was signaled from the midpoint or from near the empty bowl. In the former case, dogs seemed to choose randomly, indicating possibly that they had no cue on which their choice could be based. Some dogs might have reacted to the protruding elbow and others to the cross-pointing lower arm (2 dogs performed at above-chance level and 6 under the chance level). However, if a further signal of the body position became available (when the experimenter was standing near the empty bowl), dogs invariably approached the empty container (behind which the signaler was standing), losing the reward on almost all of these trials! This suggests that if there are no other gestural cues at hand, dogs (and probably enculturated apes) use body position as a signal.

Experiment 3

The results of Experiment 2 suggested that dogs might be sensitive to pointing body parts that are protruding from the signaler's body contour. However, it is not clear whether any body parts (upper arm, hand, index finger) would have the same effect. We wanted to test experimentally whether dogs would still respond correctly if the pointing were done with different parts of the arm.

Method

Subjects

Five male (Spuri, Dome, Philip, Mystic, Robin) and 2 female (Szetti, Sally) dogs took part in Experiment 3 (see Table 1). Five owners were women, and one was a man; their ages were between 17 and 26 years. Owners were asked not to feed the dogs for at least 2 hr before the trials.

Table 3
Number of Correct Choices (Out of 8) by Each Dog in Experiment 2

Dog	Pointing	Elbow cross-pointing	Far pointing	Far elbow cross-pointing
Spuri	7	5	6	0
Dome	8	2	8	0
Philip	8	4	7	2
Sally	8	3	7	1
Mystic	6	2	5	0
Robin	8	3	3	0
Szetti	8	6	6	0
Baby	6	3	4	1
Wasil	8	3	5	1
M	7.44	3.44	5.67	0.56
SE	0.29	0.44	0.53	0.24

Procedure

This experiment took place during September 4–26, 2000, in the owners' apartments. The experimental settings and the pretraining were the same as in Experiment 1. To accomplish the experiment, 2 consecutive days were necessary.

Testing

In this experiment, three types of probe trials were embedded into P trials: (a) elbow pointing (EP), (b) long cross-pointing (LCP), and (c) short cross-pointing (SCP; see Figure 1). In the case of EP trials, the experimenter bent her arm, took her hand to her shoulder, and pointed at the baited bowl by raising her elbow. During the LCP trials, the experimenter pointed to the correct bowl with her opposite arm in front of her body in such a manner that her hand and extended index finger reached beyond her body. In the SCP trials, she also pointed with her opposite arm in front of her body, but in this case, she pressed her upper arm to her side (so her elbow did not raise), and her extended index finger was on the midline of her body (for further details, see Experiment 1).

Results and Discussion

In this experiment, eight P trials that preceded EP trials were used as controls. We found a significant difference among trials (Friedman ANOVA), $\chi^2(6, N = 7) = 13.21$, $p < .042$. A post hoc Dunn's multiple comparison test showed significant differences in P, EP ($p < .05$), and SCP ($p < .01$) trials. Dogs performed significantly above chance on P trials (one-sample Wilcoxon test), $T(7) = 28$, $p < .02$, and LCP trials, $T(6) = 21$, $p < .05$. The performance did not differ from the chance level on EP trials, $T(7) = 2$, *ns*, and SCP trials, $T(5) = -3$, *ns* (see Figure 4 and Table 4).

This experiment further supports an earlier observation (Hare et al., 1998) that dogs respond well above chance to cross-pointing gestures provided that the hand–index finger protrudes from one side of the body, a contrast that was shown clearly between long and short cross-pointing. These observations also suggest that the hand or the index finger might also be of special importance because the protruding (and moving) upper arm and elbow were not an effective signal.

Experiment 4

The cognitive approach to the understanding of the pointing gesture as a referential signal assumes that observers should be able to understand the directional nature of this gesture and therefore should be able to give adequate responses to slightly modified pointing or in novel contexts as well. However, the low-level associative theory suggests that human gestures (pointing) are regarded by dogs as discriminative stimuli that can be associated with reinforcing stimuli (e.g., food) and gain predictive but not communicative value as the result of repetitive experiences. In this case, dogs should react properly to those, and only those, types of pointing gestures that can be frequently observed in the gesture repertoire of their human caretakers. Therefore, in the present experiment, we wanted to see whether owners of the dogs tested would use any of our modified pointing gestures (i.e., cross-

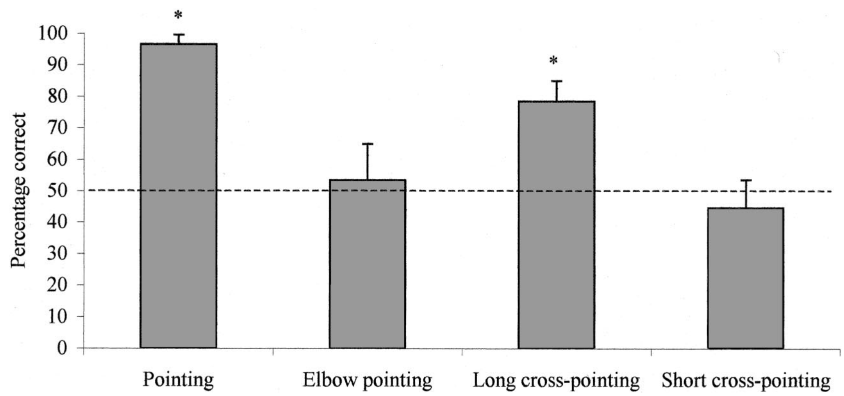

Figure 4. Means and standard errors of the performance (choice of the baited bowl) of dogs in response to pointing, elbow pointing, long cross-pointing, and short cross-pointing. Dotted line represents chance performance level (50%). * $p < .05$.

pointing) in everyday-life situations. Most of these gestures were really quite awkward to perform, and their usage was very unlikely; nevertheless, casual observations of humans revealed that some of them used the cross-pointing gesture. We are aware that negative results still would not exclude the possibility that owners might use novel forms of a pointing gesture occasionally. Nevertheless, this experiment might provide a background to which other findings could be compared. For this reason, without revealing the aim of this experiment, we visited dog owners of the previous experiment again and asked them to participate in a "pointing game."

Method

Participants

Owners of the dogs from the previous experiment were visited 4 weeks after the end of the testing.

Procedure

This experiment was carried out during November 6–14, 2000, in the owners' apartments. Only the owner and the experimenter were present during the tests. The experimenter asked the owner to stand facing her in the center of the room. The owner was asked to point to objects in three different test situations. Each situation consisted of 10 probes (pointings).

Table 4
Number of Correct Choices (Out of 8) by Each Dog in Experiment 3

Dog	Pointing	Elbow pointing	Long cross-pointing	Short cross-pointing
Spuri	8	3	7	4
Dome	8	2	8	4
Philip	8	8	7	5
Sally	8	3	6	3
Mystic	8	5	7	3
Robin	8	7	4	0
Szetti	7	2	5	6
M	7.86	4.29	6.29	3.57
SE	0.14	0.92	0.52	0.72

These test situations were continuously recorded, but the order of the tests was randomized among participants. The behavior of the owners was videotaped and analyzed later. Test situations were as follows:

1. The experimenter asked the owner to point spontaneously to objects in the room, as he or she liked. On the basis of the pointing, the experimenter tried to guess at what object he or she pointed.

2. The experimenter predetermined a list of 10 objects that were situated at various places in the room. The objects recorded subsequently in the list were in different directions. The experimenter told the order of the objects (from a prepared list) to the owner, who had to point at them. The way of pointing gestures was not restricted by the experimenter at all.

3. This situation was identical to the previous test except that the owner had to hold a tennis ball in his or her right hand (all participants were right handed). The order of the objects to be pointed at was determined by the experimenter.

The following variables were recorded in each test situation: (a) direct pointing (DP)—objects were indicated with the closer hand; (b) cross-pointing (CP)—objects were indicated by the contralateral hand; (c) stationary pointing (SP)—the participant kept his or her arm pointing at the object for at least 3 s before lowering; (d) fast pointing (FP)—the participant pointed at the object for about 1 s, lowering his or her arm immediately after pointing; (e) change in body orientation—the owner oriented his or her body, face, or gaze toward the object he or she was pointing at; and (f) arm protrusion—the owner's arm protruded from the torso during pointing as observed from the experimenter's perspective.

Results and Discussion

In all three test situations, owners always preferred to use the arm closer to the object, that is, DP dominated over CP ($N = 6$, $T = 0$, $p = .027$ for all three cases). Because the number of objects on the left and the right were counterbalanced, this suggests that the right-hand preference in the participants did not bias the results. Results of Test 3 also support this conclusion because the ball in the right hand did not alter this preference; no left versus right differences were found ($N = 3$, $T = 0$, $p = .1088$).

In Test 1, participants performed more SPs than FPs ($N = 6$, $T = 1$, $p = .046$); this was not the case in the other two tests. This difference was also significant when we compared directly the numbers of fast pointings in different tests (Friedman ANOVA), $\chi^2(5, N = 6) = 7.58$, $p = .023$.

Owners predominantly changed their body orientation during the pointing gesture. In these tests, their body oriented toward the indicated objects on 98.3%, 96.7%, and 98.8% of the trials, respectively.

These experiments provide evidence that our dog owners rarely used CP as a visual gesture in various situations (i.e., the owners pointed at the object with the closer hand, and hand preference did not influence the use of the hand for pointing). Consequently, objects on the left were indicated by the left arm, thus decreasing chances for CP to occur. This tendency could not be reversed even if the participants had to hold a ball in their hand, making the pointing gesture less convenient. Interestingly, dogs belonging to owners performing CP occasionally did not perform better (75%, 50%, 62%) than the group average. This suggests that CP can be regarded as a relatively rare form of pointing for these dogs, which nevertheless were able to recognize and respond to it correctly.

Note that in the case of all owners, the pointing gestures were accompanied with spontaneous change in orientation of their body, head, and gaze toward the object. Therefore, these pointing gestures observed represented a more complex signal, compared with the communicative signals applied by the experimenter (in Experiments 1–3), who faced the dogs during the trials and used only her arm for signaling.

The movement of the arm was clearly influenced by the testing situation. In Test 1, the participants had to draw the experimenter's attention to an object (she had to name it). In this case, pointing was extended in time (participants waited with a straight, pointing arm for some seconds) because the participant waited for a response from the experimenter. No such difference was observed in tests in which the participant was only requested to point to a predetermined object. Here, participants used both static and fast pointing. This observation might partially explain why dogs have been less sensitive to the movement component of the pointing gesture.

These observations suggest that the pointing gestures displayed by the owners are invariable and are influenced only to a limited extent by the context. Assuming that our three different test situations represented everyday use of the pointing gesture, we would suggest that the dogs are exposed to a relatively rigid form of the pointing gesture. The dogs' responsiveness to the variations of the pointing gesture suggests that with some limitations, they seem to be able to understand the communicative intent of the experimenter.

General Discussion

In contrast to nonenculturated chimpanzees, dogs show a very reliable response to human pointing gestures, and they are able to find the indicated hidden food on almost all occasions. The robustness of this behavior was used to extend our knowledge of what components of this complex human gesture are informative for the dog. We hoped that by breaking up this gesture into smaller components, we can reveal invariant features of pointing that contribute to referential understanding in dogs. We should mention that there remain a fair amount of possible gestures that have not been tested, but apart from the technical problems of extensive testing, we believe that by combining the results of these three experiments, we can offer a clear explanation of how dogs perceive components of pointing.

It seems that dogs are sensitive to what body parts take part in the action and what their relationship to the torso is, and at the same time, they seem to ignore the direction of arm movement during the pointing gesture. Furthermore, if no other gestural information is available, dogs might make the choice on the basis of body position (if available). This was shown clearly in the ECP trials (Experiment 2) when the distance of the experimenter to the bowls was varied. This gesture, which shares only minor features with normal pointing, seemed not comprehendible to dogs, but they made a choice if the gesture was given near one (in this case nonrewarded) bowl. The uniform behavior of subjects suggests that they responded to a less complex aspect of pointing behavior (pointing with the body). Note that although the same phenomenon was found in dogs and apes, it was not discussed by Hare et al. (1998) and Hare and Tomasello (1999) and was probably misunderstood by Povinelli et al. (1997). In this testing arrangement, dogs had only little opportunity to learn (and they did not). Moreover, when choosing on the basis of the experimenter's position, they were never food rewarded. So it might be assumed that (as argued earlier by Miklósi et al., 1998) dogs did not use body position as a discriminative cue but as a signal for food. The situation in chimpanzees can be explained similarly. On another level, dogs seem to follow pointing only if some body parts protrude from the torso, but again, their response is specific to the hand (including the pointing finger) because pointing with the upper arm does not elicit the same high level of responding.

Most authors would agree that referential understanding of the pointing gesture is dependent on the ability to generalize it to novel situations (i.e., Herman et al., 1999). The relative novelty of these pointing gestures was assessed by analyzing natural pointing behavior of the owners. The results showed that some forms of pointing (i.e., CP) occur only rarely and that the pointing gestures used in the experiments are performed in a very different context of body position. Because the spontaneous pointing gesture was accompanied with other significant changes in body orientation, our "artificial" pointing gestures assumed some generalization from the dog's point of view. Therefore, we would argue that dogs are able to use human pointing as a referential gesture because we identified key components of these gestures that the dogs were attending to, independent from presence or absence of other components and contextual changes: The dogs performed above chance level, even when the movement direction of the hand was changed, even when only the hand and finger protruded from the torso, and even when the whole body was dispositioned asymmetrically. In contrast, substituting the hand with a stick, or preventing the dog from seeing the hand protruding from the body contour, decreased performance.

The species-specific differences should be also mentioned here. Although it might be true that referentiality could be supposed if observers were responding invariably to some aspects of a pointing gesture, it does not follow that these components should be the same for different species. So human children might be predisposed for associating different significance to the position of the index finger or other components of the pointing gesture (Povinelli et al., 1997), and they might be able to show an even more generalized response to pointing (e.g., by only observing the position of the index finger). In contrast, apes, dogs, or dolphins (Herman et al., 1999) might be attracted to other components of the gesture and still able to benefit from its referential nature. In summary, on the basis of the results of this study, we would strongly argue for the dogs' ability to rely on pointing as a referential gesture.

References

Agnetta, B., Hare, B., & Tomasello, M. (2000). Cues to food locations that domestic dogs *(Canis familiaris)* of different ages do and do not use. *Animal Cognition, 3,* 107–112.

Hare, B., Call, J., & Tomasello, M. (1998). Communication of food location between human and dog *(Canis familiaris). Evolution of Communication, 2,* 137–159.

Hare, B., & Tomasello, M. (1999). Domestic dogs *(Canis familiaris)* use human and conspecific social cues to locate hidden food. *Journal of Comparative Psychology, 113,* 173–177.

Herman, L. M., Abichandani, S. L., Elhajj, A. N., Herman, E. Y. K., Sanchez, J. L., & Pack, A. A. (1999). Dolphins *(Tursiops truncatus)* comprehend the referential character of the human pointing gesture. *Journal of Comparative Psychology. 113,* 347–364.

Leung, E. H. L., & Rheingold, H. L. (1981). Development of pointing as a social gesture. *Developmental Psychology, 17,* 215–220.

McKinley, J., & Sambrook, T. D. (2000). Use of human-given cues by domestic dogs *(Canis familiaris)* and horses *(Equus caballus). Animal Cognition, 3,* 13–22.

Miklósi, Á., Polgárdi, R., Topál, J., & Csányi, V. (1998). Use of experimenter-given cues in dogs. *Animal Cognition, 1,* 113–121.

Povinelli, D. J., Bierschwale, D. T., & Cech, C. G. (1999). Comprehension of seeing as a referential act in young children, but not juvenile chimpanzees. *British Journal of Developmental Psychology, 17,* 37–60.

Povinelli, D. J., Reaux, J. E., Bierschwale, D. T., Allain, A. D., & Simon, B. B. (1997). Exploitation of pointing as a referential gesture in young children, but not adolescent chimpanzees. *Cognitive Development, 12,* 423–461.

Seitz, A. (1940). Paarbildung bei einigen Cichliden [Pair formation in Cichlids]. *Zeitschrift für Tierpsychologie, 4,* 40–84.

Soproni, K., Miklósi, Á., Topál, J., & Csányi, V. (2001). Comprehension of human communicative signs in pet dogs. *Journal of Comparative Psychology, 115,* 122–126.

Tinbergen, N. (1960). *The herring gull's world.* New York: Harper & Row.

Vilá, C., Savolainen, P., Maldonado, J. E., Amorim, I. E., Rice, J. E., Honeycutt, R. L., et al. (1997, June 13). Multiple and ancient origins of the domestic dog. *Science, 276,* 1687–1689.

Woodward, L. A. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition, 69,* 1–34.

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