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What's the point? Golden and Labrador retrievers living in kennels do not understand human pointing gestures

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Abstract In many studies that have investigated whether dogs' capacities to understand human pointing gestures are aspects of evolutionary or developmental social competences, family-owned dogs have been compared to shelter dogs. However, for most of these studies, the origins of shelter dogs were unknown. Some shelter dogs may have lived with families before entering shelters, and from these past experiences, they may have learned to understand human gestures. Furthermore, there is substantial variation in the methodology and analytic approaches used in such studies (e.g. different pointing protocols, different treatment of trials with no-choice response and indoor vs. outdoor experimental arenas). Such differences in methodologies and analysis techniques used make it difficult to compare results obtained from different studies and may account for the divergent results obtained. We thus attempted to control for several parameters by carrying out a test on dynamic proximal and distal pointing. We studied eleven kennel dogs of known origin that were born and raised in a kennels with limited human interaction. This group was compared to a group of eleven dogs comparable in terms of breed, sex and age that had lived with human families since they were puppies. Our results demonstrate that pet dogs outperform kennel dogs in their comprehension of proximal and distal pointing, regardless of whether trials where no-choice was made were considered as errors or were excluded from statistical analysis, meaning that dogs living in kennels do not understand pointing gestures. Even if genetic effects of the domestication process on human–dog relationships cannot be considered as negligible, our data suggest that dogs need to learn human pointing gestures and thus underscore the importance of ontogenetic processes.

Keywords Cue following · Pointing · Dog · Ontogeny · Domestication · Kennel dogs

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Introduction

The "Domestication Hypothesis" proposes that the natural and artificial selection of the wild progenitor of dogs caused genetic changes that allowed these animals to understand human signals (Agnetta et al. 2000; Miklósi et al. 2003; Hare and Tomasello 2005; Hare et al. 2002, 2010; Kaminski and Nitzschner 2013). This theory is largely based on studies demonstrating that dogs outperform wolves raised by humans in certain cue-following tasks (Hare et al. 2002; Virányi et al. 2008; Gácsi et al. 2009). Alternatively, the "Two-Stage Hypothesis" suggests that the ability to follow human cues is acquired over a dog's lifespan after humans are accepted as companions in early ontogeny and when opportunities to learn from human are provided overtime (Udell and Wynne 2008, 2010; Wynne et al. 2008; Udell et al. 2010a). In fact, it has been found that when wolves are raised with intensive socialization with humans, they outperform dogs in following human social cues (Udell et al. 2008) and they are also able to understand a broad range of human gestures (Udell et al. 2012). These theories are not necessarily antagonists to each other. Indeed, the synergistic hypothesis suggests that the dog-wolf difference in the sensitivity for human gestural cues emerges both at the evolutionary and at the developmental level (Gácsi et al. 2009; Miklósi and Topál 2011).

To date, more than 50 papers have addressed human pointing gesture comprehension among dogs. In many cases, the specific goal was to determine whether dogs' capacities to understand human pointing gestures are an evolutionary or developmental social competency. To this end, family-owned dogs have been compared to shelter dogs and wolves. It is assumed that shelter dogs are less socialized by humans and have been given fewer opportunities to learn from human rather than family-owned dogs. They should therefore serve as a good model through which to explore ontogenetic acquisition. Hare et al. (2002) compared dog puppies living with human families with those hosted in shelters and found that both groups of dogs are able to understand human pointing gestures even at the youngest age (9–13 weeks) at above-chance levels. Accordingly, it was concluded that degrees of human socialization do not affect dogs' capacities to read and interpret human pointing gestures correctly, thus minimizing ontogenetic effects. On the other hand, opposing study results report that puppies from homes better understand pointing gestures (Zaine et al. 2015). For adult dogs, Udell et al. (2008) showed that while shelter dogs understand momentary distal pointing at chance levels, pet dogs perform above-chance levels; none of the shelter dogs followed pointing gestures successfully, and as a group, shelter dogs were significantly less successful at understanding human pointing gestures than pet dogs. This outcome was confirmed in follow-up studies by the same authors, underscoring that most shelter dogs learn to understand momentary distal pointing when subjected to additional training (Udell et al. 2010a, 2011). These findings, in sharp contrast with those of Hare et al. (2002), appear to demonstrate the opposite trend, in that for dogs domestication as such is not a predictor of sensitivity to human cues, highlighting the role of ontogenetic processes. Hare et al. (2010) repeated Udell and Wynne's experiments by studying a larger sample of shelter dogs to determine how skilful they were at using human pointing gestures. Twenty-three dogs hosted in a shelter were studied, of which 12 were suspected of having lived with families before their arrival at the shelter and with the other 11 dogs suspected of being feral with limited exposure to humans. The results showed that while both groups used pointing at above-chance levels, there was no significant difference in the performance of the two groups. More recently, Cunningham and Ramos (2014) used a different technical approach whereby dogs were not induced to move to a cued location, but instead had to follow pointing gestures by shifting their gaze towards a specific location. Food rewards were not given. They compared shelter dogs with trained and highly trained dogs and did not find any differences between the groups, once again emphasizing the importance of genetic acquisition for dog performance in heterospecific communicative skills.

Unlike studies on puppies, the main problem associated with studies on adult shelter dogs is that stray and abandoned dogs can be of unknown origin as noted in the following quote: "*However, some caution is required as the histories of the shelter dogs were not known. It may be that these animals had lived for prolonged periods in a human home with sufficient ontogenetic experience to produce cue-following behaviour in line with levels demonstrated by pet dogs*" (Cunningham and Ramos 2014). Some shelter dogs examined in the above studies included purebred dogs that were not likely have been born as strays without human support. Such subjects, in experiencing life with a family for a period of time, may have had opportunities to learn pointing gestures to some extent. Their contributions may improve the number of correct responses given in shelter dog groups, lessening their differences with family-owned dogs and making it difficult to obtain significant differences between pet and shelter dogs. Lazarowski and Dorman (2015) attempted to settle this matter by comparing human pointing comprehension levels between dogs residing exclusively in kennel environments (i.e. never experiencing a life with a family) and pet dogs living in human homes. The authors found that the latter significantly outperformed the kennel dogs, thus reasserting once again the importance of ontogenetic effects. However, in this research study, the pet dogs studied were much older (mean = 4.75 years) than the kennel dogs examined (i.e. 13–17 months of age). Human pointing comprehension may increase as a function of age, as demonstrated through studies on puppies (Dorey et al. 2010), infant chimpanzees (Okamoto-Barth et al. 2008) and toddlers (Butterworth et al. 2002).

In addition to these problems, other variations make it difficult to obtain consistent study results, such as differences in the experimental areas where tests are conducted (e.g. outdoor vs. indoor), different pointing protocols used (e.g. type of pointing gestures and the number of trials), differing emotional states among subjects (e.g. Hennessy et al. 1998 have shown that shelter dogs have higher levels of stress-related hormones), potentially affecting behavioural outcomes and differing statistical analysis approaches used (e.g. coding an absence of choice as an incorrect choice or only considering choices as correct or incorrect through statistical comparisons). In the present study, we tried to control for these parameters by conducting a simple test based on dynamic proximal and distal pointing gestures. We studied adult dogs of known origin, which are referred to as kennel dogs following Lazarowski and Dorman (2015). Unlike shelter dogs, kennel dogs do not include dogs of unknown origin. All the dogs studied were born and had lived their entire lives in a kennels with limited human interaction and were compared to dogs comparable by breed, sex and age that had lived in family homes since they had been puppies. We investigated whether dogs' capacities to understand human pointing gestures are affected by the lack of extensive human influence. Due to several contradictions present in the literature, we cannot make specific predictions; however, from Udell et al.'s (2010b) results, we expect both groups of dogs to perform better at following easily understandable dynamic proximal pointing gestures compared to dynamic distal pointing.

Materials and methods

Subjects

Twenty-nine dogs were included in the study: thirteen kennel dogs and sixteen pet dogs. All kennel dogs came from the FOOF dog museum (Caserta, Italy; www.foof.it). This establishment breeds dogs and sells purebred puppies. Unsold puppies of many breeds are held for exhibition purposes. All of the dogs studied had never experienced mistreatment and were reared in very comfortable conditions. They live in kennels equipped with a floor cooling system in the summer and a heating system in the winter, with covered and open areas. Each kennel holds two or three dogs. The dogs have access to a recreational area where they can run and play freely in small groups for approximately 20 min per day. Social interactions between humans and dogs are very limited. Visitors are only allowed to observe the dogs, and interactions are forbidden. The dogs are fed and cleaned by the same caretaker once a day for 10–15 min. Periodically, the dogs are treated by a veterinarian. While we initially tried to select different breeds of dogs from the kennel, in several cases it was not possible to test the dogs because they showed fear of the experimenters. We thus re-oriented our focus to Labrador and Golden Retrievers for two reasons: first, they rank very high in sociability, curiosity, fearlessness (Svartberg 2006) and boldness, which measures the willingness to play and be approached and which has negative loadings for avoidance behaviour and behavioural indicators of fear (Starling et al. 2013), thus eliminating strong pre-selection requirements; second, they are among the most common breeds, making it easier to find a control group of the same breeds matched for sex and age. Pet dogs were recruited from personal contacts, Internet advertisements, parks and veterinary surgery clinics; all of these dogs had lived in houses with the same family since they had been puppies.

Two Golden Retrievers (both intact females) in the kennel group and 4 Golden Retrievers (all intact males) and 1 intact male Labrador Retriever in the pet group were not interested in food during the pretest and were fearful of the experimenters, so they were not studied. Thus, 11 dogs in the kennel group (mean age 2.8 ± 0.98) and 11 in the pet group (mean age 2.9 ± 1.99) were studied (Table 1). Three Labrador Retrievers of the kennel group had already been examined in a previous study on gazing behaviours based on the impossible task paradigm (D'Aniello and Scandurra 2016). Apart from the dogs excluded from the test, stress signals were only occasionally observed, in a few dogs of each group, so their frequency was not tested statistically. All selected dogs (of both groups) approached the experimenters in a friendly manner, without showing fear or avoiding behaviours.

Experimental setting

The tests were conducted indoors in two different locations: at the University of Naples "Federico II" in Naples (room 14 m^2) and at the FOOF dog museum (Caserta) in a delimited indoor space of approximately 15 m^2. The dogs had never been to either place (except for 3 Labrador Retriever of the kennel group). The kennel staff and owners were asked not to feed the dogs over the 4 h preceding the test. For the motivation test trials, we placed single bowls inside another bowl positioned roughly 40 cm in front of the signaller (see below) and spaced roughly 2 m apart (Fig. 1). Before the experimental phase, the dogs were allowed to move freely to explore and familiarize themselves with the room and with the research group for roughly 5 min. Three researchers were involved in the testing room: one (E1) for dog management and for holding the dogs, one who made pointing gestures (E2) and another (E3) who took notes and randomly assigned trials to the cue-giver. The same male E2 made pointing gestures throughout the entire experiment, while E3 was a female. Two different female students served as E1. Once each test was completed, the bowls and room were cleaned with a lightly perfumed non-toxic disinfectant.

Procedure

The dogs' interest in the food given was measured by giving a limited amount of food to each dog before the test and by assessing whether each dog was willing to follow E2 (motivation pretest). The procedure was performed as follows. E1 brought each dog to the starting position in

Table 1 Selected pet and kennel dogs by name (when known), sex, sex status, age and breed

	Name	Sex	Sex status	Age (years)	Breed	Group
1	Luna	F	Neutered	3.3	Labrador Retriever	Pet
2	Aaron	M	Neutered	5.5	Labrador Retriever	Pet
3	Fluke	M	Intact	6.0	Labrador Retriever	Pet
4	Oliver	M	Intact	1.2	Golden Retriever	Pet
5	Maya	F	Intact	1.2	Labrador Retriever	Pet
6	Joey	F	Intact	1.1	Labrador Retriever	Pet
7	Aron	M	Intact	1.6	Labrador Retriever	Pet
8	Argo	M	Intact	2.5	Labrador Retriever	Pet
9	Lamù	F	Neutered	6.0	Labrador Retriever	Pet
10	Bill	M	Intact	2.0	Labrador Retriever	Pet
11	Kora	F	Intact	1.6	Labrador Retriever	Pet
12	Due	M	Intact	4.0	Labrador Retriever	Kennel
13	Lupa	F	Intact	3.0	Labrador Retriever	Kennel
14	Perla	F	Intact	4.0	Labrador Retriever	Kennel
15	Diva	F	Intact	4.0	Labrador Retriever	Kennel
16	Loh	M	Intact	1.5	Labrador Retriever	Kennel
17	Dog 1[a]	M	Intact	2.5	Golden Retriever	Kennel
18	Charlie	M	Intact	2.5	Golden Retriever	Kennel
19	Dog 2[a]	M	Intact	2.0	Labrador Retriever	Kennel
20	Dog 3[a]	F	Intact	1.2	Labrador Retriever	Kennel
21	Kate	F	Intact	3.0	Labrador Retriever	Kennel
22	Puma	F	Intact	3.0	Labrador Retriever	Kennel

[a] Dogs without names

front of E2, who stood 3 m from the midline between the bowls. E2 got each subject's attention and then placed a morsel of food in a pair of stacked bowls. The subject was released by E1 and was allowed to eat food and then was brought to the starting position by E1. This phase consisted of 8 trials. After 4 repetitions had been completed, the two stacked bowls were reversed so that the food odour was evenly distributed. The purpose of this phase was to assess each subject's level of motivation and to familiarize each subject with the experimental objects (pre-trial motivation) so as not to affect the test results.

The testing phase involved 16 trials in which E2 randomly made one of two types of signal and 8 control trials. Half the signal trials involved dynamic proximal pointing (i.e. E2 knelt with his finger placed 10–15 cm from the closest edge of the targeted container) and half involved dynamic distal pointing (i.e. E2 stood with his finger positioned 50–60 cm from the closest edge of the targeted container). The trial sequence was pseudo-random and was communicated to E2 by E3. The same point was not used more than twice consecutively. In the control trials, E2 remained in a neutral position (kneeling or standing) with his arms extended along his body looking forward; these were included to study the effect of missing signals in a comparative way between the two groups, even though in similar experiments it has been observed that a Clever Hans effect is unlikely to happen in pointing tasks (Hegedüs et al. 2013).

Although different pointing protocols can have different outcomes (Pongrácz et al. 2013), we chose to use dynamic pointing as it has been shown to induce the fewest no-choices in dogs (Zaine et al. 2015). Both proximal and distal conditions involved sustained pointing, so that E2's arm and hand were extended into a traditional point in the direction of the target container and then remained in place and motionless until the end of the trial. The dogs were released immediately after the point was made. The trial ended when the dogs choose one of the targets or, if no-choice was made, after 10 s. When a subject approached to the correct bowl, the E2 dropped a piece of food into the chosen container. When incorrect choices were made, no food was given.

To ensure the dogs' motivation and willingness to respond during the test, the bowls were stacked and positioned in the centre in front of the cue-giver every 2 trials and a morsel of food was placed inside the bowl placed in front of the dogs for a total of 16 trials (intertrial motivation). We also conducted this test to prevent the occurrence of unwanted learning effects during testing. When necessary, E2 refocused the dogs by making vocal sounds or by

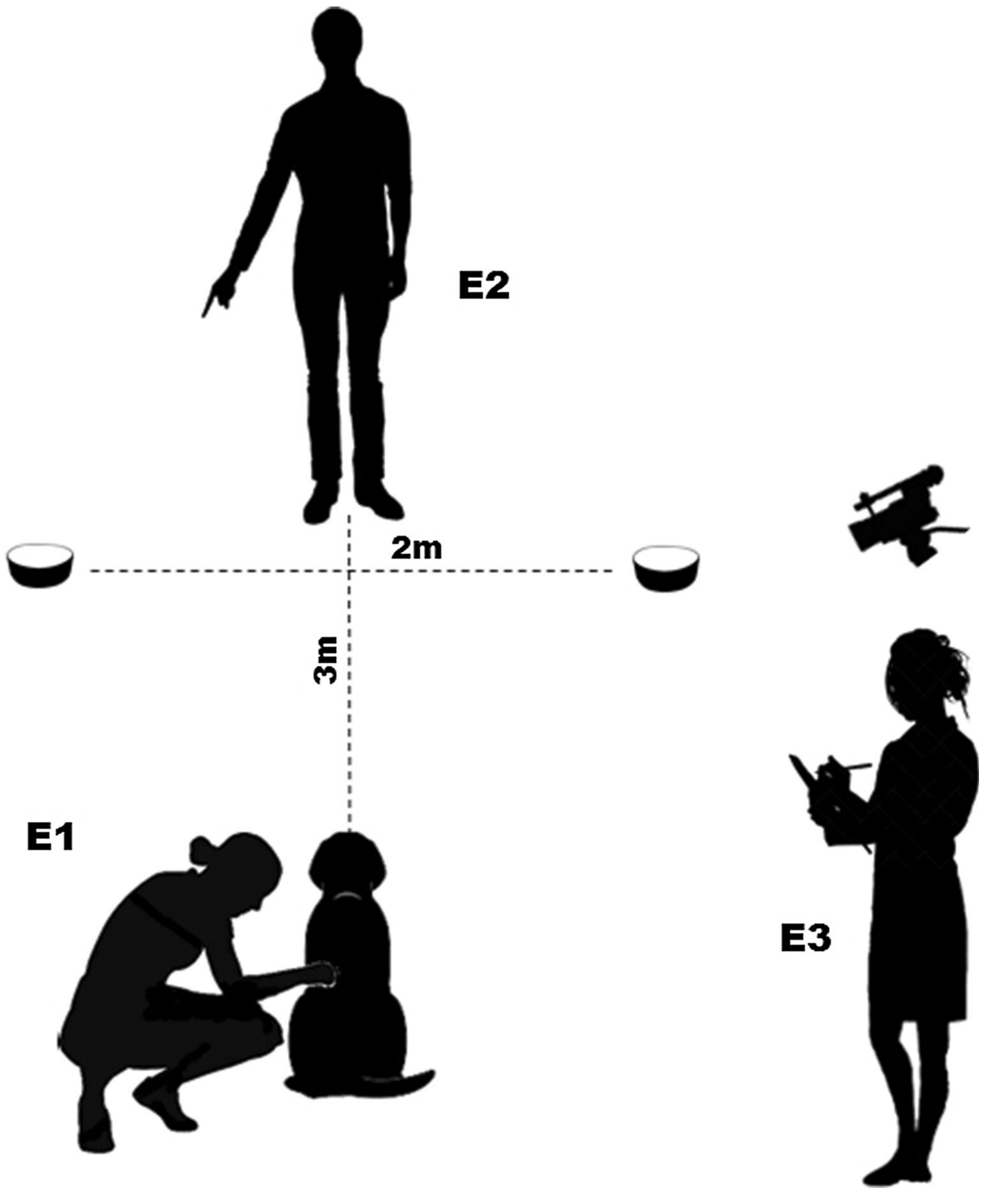

Fig. 1 Experimental setting of the distal pointing condition. One female experimenter managed and held the dogs (*E1*); one male experimenter served as the cue-giver (*E2*); the third experimenter was a female who took notes and randomly assigned trials to the cue-giver (*E3*)

calling the dogs by name, providing cues only when each dog was focused on him and establishing eye contact before signalling. When studying dogs, it is very important to maintain their attention in tests based on object choice tasks involving human pointing gestures (Carballo et al. 2016). While signalling, E2 looked away from the dogs.

Scoring and data analysis

We considered three possible responses: *correct*, when within 10 s a dog moved towards the target with his or her nose very close to (less than 10 cm) or in the bowl; *wrong*, when within 10 s a dog moved towards the wrong bowl with his or her nose in or very close to the bowl; and *no-choice*, when within 10 s a dog was unable to comply with the previous requirements (i.e. never approaching the bowl, remaining static, or walking towards the experimenters). To deal with these three possible responses, we adopted two different assumptions: A1: *treating no-choices as errors* and A2: *excluding no-choices from the analysis*. All analyses were carried out under both of these assumptions.

We first conducted an analysis at the individual dog level to identify which dogs performed above-chance levels using the Wilcoxon signed-rank test approach. Then, to compare response distributions between Pet and Kennel groups for each assumption, we performed a 2 × 2 contingency table exact Fisher's test considering the number of dogs performing above-chance levels in each condition. After verifying that the data were not normally distributed through a Kolmogorov–Smirnov test, a Wilcoxon signed-rank test for medians was conducted to verify whether the samples as groups had median percentages of correct choices greater than chance levels for both assumptions of each condition (i.e. control, proximal and distal). A Mann–Whitney *U* test was conducted to compute any difference in correct choices made under each condition between the two groups. Friedman's ANOVA was used to compare correct choices made under the three conditions between the two groups followed by a post hoc Wilcoxon signed-rank test with Bonferroni correction.

Results

None of the dogs failed any of the motivational tests (i.e. pretest, pre-trial and intertrial tests). Results of the Wilcoxon signed-rank test for individual dogs based on different assumptions are reported in Table 2. Figure 2 shows that, under assumption A1, data from 8 trials were available for all dogs. No dog in either group performed above-chance levels in the control condition (Fisher's test $P = 1.000$). Ten dogs of the pet group versus 1 dog of kennel group for the proximal condition (Fisher's test $P < 0.001$) and 10 dogs of the pet group versus 0 dogs of the kennel group for the distal condition (Fisher's test $P < 0.001$) performed above-chance levels. Under assumption A2, some dogs were eliminated from the statistical analysis because they made *no-choice* responses in all trials. Furthermore, as *no-choices* were excluded from the analysis, the number of trials available was often less than 8. In this case, as shown in Fig. 2, 0 pet dog (out of 10) versus 0 kennel dogs (out of 8) performed above-chance levels in the control condition (Fisher's test $P = 1.000$). Ten pet dogs (out of 11) versus 1 kennel dog (out of 9) in the proximal condition (Fisher's test $P < 0.001$) and 10 pet dogs (out of 11) versus 0 kennel dogs (out of 10) in the distal condition (Fisher's test $P < 0.001$) performed above-chance levels.

The Wilcoxon signed-rank test results show that under A1 the pet group performed above-chance levels under the proximal ($z = 2.971$, $P = 0.003$) and distal conditions ($z = 2.465$, $P = 0.014$) while in all other cases, performance levels were below chance levels (pet: control $z = 2.831$, $P = 0.005$; kennel: control and distal $z = 3.002$, $P = 0.003$, proximal $z = 2.506$, $P = 0.012$). Under A2, excluding *no-choices* from the analysis, control conditions for both groups and the distal pointing condition for the kennel group led to chance performance, whereas performance in proximal conditions in both groups exceeded chance levels (pet: $z = 3.064$, $P = 0.002$; kennel: $z = 2.217$, $P = 0.027$), as did distal conditions for the pet group ($z = 3.064$, $P = 0.002$).

As shown in Fig. 3, intergroup comparison between correct-choices frequencies revealed a significant difference in the occurrence of signal understanding between the groups, showing that the pet dogs followed proximal and distal pointing cues significantly better than the kennel dogs (Mann–Whitney *U* test: $N_{Pet} = 11$, $N_{Kennel} = 11$; proximal: $U = 2.0$, $P < 0.001$; distal: $U = 2.5$, $P < 0.001$). No difference was found for the control condition ($N_{Pet} = 11$, $N_{Kennel} = 11$; control: $U = 50.0$, $P = 0.519$).

Our Friedman's ANOVA test results for within-group comparisons revealed significant differences between the three conditions for the pet group ($\chi^2 = 20.83$, $df = 2$, $P < 0.001$). The Wilcoxon signed-rank post hoc test showed that pet dogs understand dynamic proximal pointing better than dynamic distal pointing and control condition (control vs. proximal: $z = -2.944$, $P = 0.003$; control vs. distal $z = -2.947$, $P = 0.003$; proximal vs. distal: $z = -2.565$, $P = 0.010$). No significant differences were found for the kennel group between the three conditions ($\chi^2 = 5.07$, $df = 2$, $P = 0.079$).

Discussion

In this study, we compared the degrees to which two groups of dogs with differing levels of human socialization understand human pointing cues. None of the dogs failed any of the motivational tests (i.e. pretest, pre-trial and intertrial), and stress signals were only occasionally observed, ensuring that dogs of both groups were equally motivated and willing to approach the task throughout the entire test period. On the contrary, we found that Labrador Retrievers, the most common breed in our samples, cooperated well throughout the test regardless of their living conditions or specific training (Scandurra et al. 2015; D'Aniello et al. 2015) and while hosted in a kennel with limited human socialization (D'Aniello and Scandurra 2016).

We observed a very high percentage of no-choice trials, especially for the kennel group. Absence of choice has been interpreted several ways in the literature and has been the subject of debate (e.g. do they indicate a dog's lack of interest in a given task, a misinterpretation of signals or a lack of interest in food rewards? (Udell et al. 2008, 2010b; Wynne et al. 2008; Hare et al. 2010). We chose not to repeat the trial when a dog made no-choice, to avoid extending the study period, exhausting the dogs or creating a learning effect, but we performed two different analyses (i.e. considering absent choices as wrong choices and excluding absent choices). All of the results show that the pet dogs substantially outperformed the kennel dogs in object selection tasks regardless of whether a no-choice

Table 2 Binomial test results for the pet and kennel dogs for the control, proximal and distal conditions, according to Assumption 1, treating no-choices as errors, and Assumption 2, excluding no-choices from the analysis

Dog	Group	Condition	Assumption 1				Assumption 2			
			Total trials	Right choice	Observe value (%)	*P* value	Total trials	Right choice	Observe value (%)	*P* value
Aaron	Pet	Control	8	3	38	0.359	3	3	100	0.074
Aaron 2	Pet	Control	8	0	0	0.998	1	0	0	1.000
Argo	Pet	Control	8	1	13	0.943	3	1	33	0.607
Bill	Pet	Control	8	1	13	0.943	1	1	100	0.500
Fluke	Pet	Control	8	0	0	0.998	1	0	0	1.000
Joey	Pet	Control	8	1	13	0.943	1	1	100	0.500
KORA	Pet	Control	8	0	0	0.998	0	0	–	–
Lamu’	Pet	Control	8	2	25	0.696	2	2	100	0.173
Luna	Pet	Control	8	3	38	0.359	3	3	100	0.074
Maya	Pet	Control	8	0	0	0.998	3	0	0	0.978
Oliver	Pet	Control	8	4	50	0.141	6	4	67	0.065
Aaron	Pet	Proximal	8	7	88	**0.006**	7	7	100	**0.005**
Aaron 2	Pet	Proximal	8	8	100	**0.003**	8	8	100	**0.003**
Argo	Pet	Proximal	8	8	100	**0.003**	8	8	100	**0.003**
Bill	Pet	Proximal	8	7	88	**0.006**	8	7	88	**0.006**
Fluke	Pet	Proximal	8	3	38	0.359	4	3	75	0.093
Joey	Pet	Proximal	8	8	100	**0.003**	8	8	100	**0.003**
Kora	Pet	Proximal	8	8	100	**0.003**	8	8	100	**0.003**
Lamu’	Pet	Proximal	8	7	88	**0.006**	7	7	100	**0.005**
Luna	Pet	Proximal	8	8	100	**0.003**	8	8	100	**0.003**
Maya	Pet	Proximal	8	6	75	**0.017**	6	6	100	**0.010**
Oliver	Pet	Proximal	8	6	75	**0.017**	8	6	75	**0.017**
Aaron	Pet	Distal	8	5	63	**0.048**	7	5	71	**0.032**
Aaron 2	Pet	Distal	8	7	88	**0.006**	8	7	88	**0.006**
Argo	Pet	Distal	8	8	100	**0.003**	8	8	100	**0.003**
Bill	Pet	Distal	8	5	63	**0.048**	5	5	100	**0.018**
Fluke	Pet	Distal	8	2	25	0.696	2	2	100	0.173
Joey	Pet	Distal	8	7	88	**0.006**	7	7	100	**0.005**
Kora	Pet	Distal	8	7	88	**0.006**	7	7	100	**0.005**
Lamu’	Pet	Distal	8	5	63	**0.048**	5	5	100	**0.018**
Luna	Pet	Distal	8	8	100	**0.003**	8	8	100	**0.003**
Maya	Pet	Distal	8	5	63	**0.048**	6	5	83	**0.023**
Oliver	Pet	Distal	8	6	75	**0.017**	6	6	100	**0.010**
Charlie	Kennel	Control	8	1	13	0.943	3	1	33	0.607
Diva	Kennel	Control	8	1	13	0.943	1	1	100	0.500
Dog 1[a]	Kennel	Control	8	1	13	0.943	1	1	100	0.500
Dog 2[a]	Kennel	Control	8	0	0	0.998	0	0	–	–
Dog 3[a]	Kennel	Control	8	3	38	0.359	3	3	100	0.074
Due	Kennel	Control	8	1	13	0.943	1	1	100	0.500
Kate	Kennel	Control	8	0	0	0.998	0	0	–	–
Loh	Kennel	Control	8	1	13	0.943	1	1	100	0.500
Lupa	Kennel	Control	8	1	13	0.943	2	1	50	0.500
Perla	Kennel	Control	8	0	0	0.998	1	0	0	1.000
Puma	Kennel	Control	8	0	0	0.998	0	0	–	–
Charlie	Kennel	Proximal	8	1	13	0.943	2	1	50	0.500
Diva	Kennel	Proximal	8	3	38	0.359	3	3	100	0.074

Table 2 continued

Dog	Group	Condition	Assumption 1				Assumption 2			
			Total trials	Right choice	Observe value (%)	*P* value	Total trials	Right choice	Observe value (%)	*P* value
Dog 1[a]	Kennel	Proximal	8	0	0	0.998	0	0	–	–
Dog 2[a]	Kennel	Proximal	8	0	0	0.998	0	0	–	–
Dog 3[a]	Kennel	Proximal	8	3	38	0.359	4	3	75	0.093
Due	Kennel	Proximal	8	1	13	0.943	2	1	50	0.500
Kate	Kennel	Proximal	8	2	25	0.696	3	2	67	0.207
Loh	Kennel	Proximal	8	2	25	0.696	3	2	67	0.207
Lupa	Kennel	Proximal	8	3	38	0.359	3	3	100	0.074
Perla	Kennel	Proximal	8	1	13	0.943	3	1	33	0.607
Puma	Kennel	Proximal	8	6	75	**0.017**	6	6	100	**0.010**
Charlie	Kennel	Distal	8	1	13	0.943	2	1	50	0.500
Diva	Kennel	Distal	8	2	25	0.696	6	2	33	0.500
Dog 1[a]	Kennel	Distal	8	0	0	0.998	0	0	–	–
Dog 2[a]	Kennel	Distal	8	0	0	0.998	1	0	0	1.000
Dog 3[a]	Kennel	Distal	8	0	0	0.998	1	0	0	1.000
Due	Kennel	Distal	8	2	25	0.696	4	2	50	0.289
Kate	Kennel	Distal	8	0	0	0.998	1	0	0	1.000
Loh	Kennel	Distal	8	0	0	0.998	3	0	0	0.978
Lupa	Kennel	Distal	8	3	38	0.359	7	3	43	0.272
Perla	Kennel	Distal	8	0	0	0.998	3	0	0	0.978
Puma	Kennel	Distal	8	2	25	0.696	3	2	67	0.207

Bold indicates significant *P*-values from Wilcoxon sign rank test

[a] Dogs without names

was considered as a wrong choice (assumption A1) or was excluded from the statistical analysis (assumption A2). In particular, under A1, the pet dog group performed above-chance levels in the proximal and distal conditions and below chance levels in the control condition, whereas the kennel dog group performed below chance levels in all conditions. This outcome could be due to the prevalence of no-choice outcomes for all our dogs in the absence of signals (i.e. control conditions) and for the kennel group in the presence of signals (i.e. proximal and distal pointing), indicating that the kennel dogs as a group did not understand the pointing cues and that in the absence of cues, both groups appeared to be disoriented. Under A2, the control condition for both groups generated chance levels, as did the distal pointing condition for the kennel group, whereas performance under both proximal and distal conditions exceeded chance levels for the pet group, as it did under the proximal condition for the kennel group. The latter result is consistent with an interesting result observed in another study showing that some shelter dogs can understand simpler human pointing cues (Udell et al. 2010b). Although we cannot rule out effects of domestication on human pointing cue comprehension (Hare et al. 2002), it is unlikely that this process works only for some dogs and not for others; it is more probable that some dogs are able to learn proximal pointing gestures in a low socialization regime. We did not examine "Kaspar Hauser" dogs, and dog caretakers may use pointing gestures to refer to food bowls during feeding. On the other hand, it is known that dogs are able to understand human pointing cues very easily as puppies (Riedel et al. 2008; Virányi et al. 2008) even with a low level of human socialization (Hare et al. 2002; Zaine et al. 2015), prompting some researchers to suggest that dog uses of human communicative cues do not require extensive exposure to humans (Hare et al. 2002; Wynne et al. 2008).

Previous studies have shown that even when no-choices are included in the analysis, dogs living in shelters with few opportunities for human socialization perform pointing tasks at chance levels (Udell et al. 2008, 2010b). This discrepancy with our finding that kennel dogs perform below chance levels according to assumption A1 could be due to the fact that some shelter dogs studied in the papers cited were able to understand human pointing cues due to have been in substantial contact with humans before arriving at the shelters. A similar explanation could be applied for dogs performing at above-chance levels in similar studies (Hare et al. 2010). Our results also differ

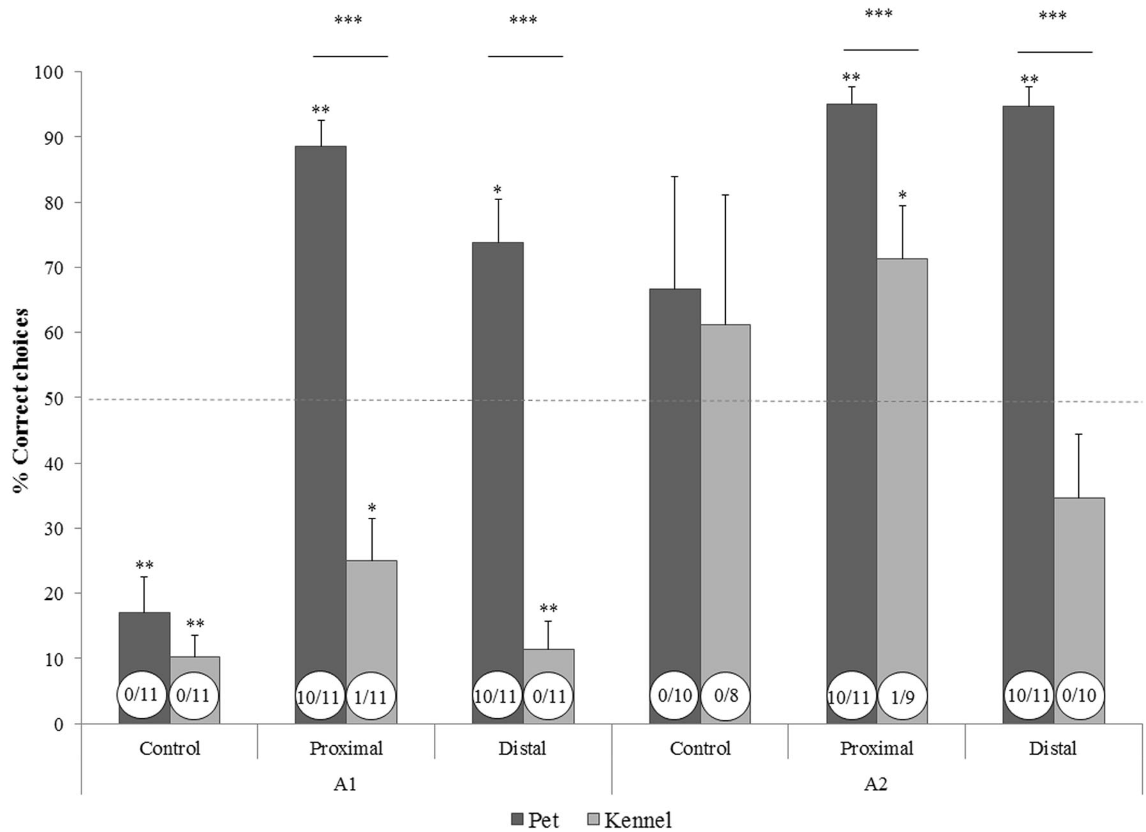

Fig. 2 Differences in the pointing gesture comprehension performance of pet and kennel dogs under Assumption 1 (A1) and Assumption 2 (A2) of the control, proximal and distal conditions with the chance level set at 0.50. *Bars* show the mean percentages of correct choices made. *White circles* denote the number of dogs performing above-chance levels from the total (see Table 2). *Asterisks over lines* denote significant differences between the number of dogs in each group exceeding chance levels according to the Fisher test; *asterisks over bars* denote group performance above and below chance levels. *$P < 0.05$; **$P < 0.01$; ***$P \leq 0.001$

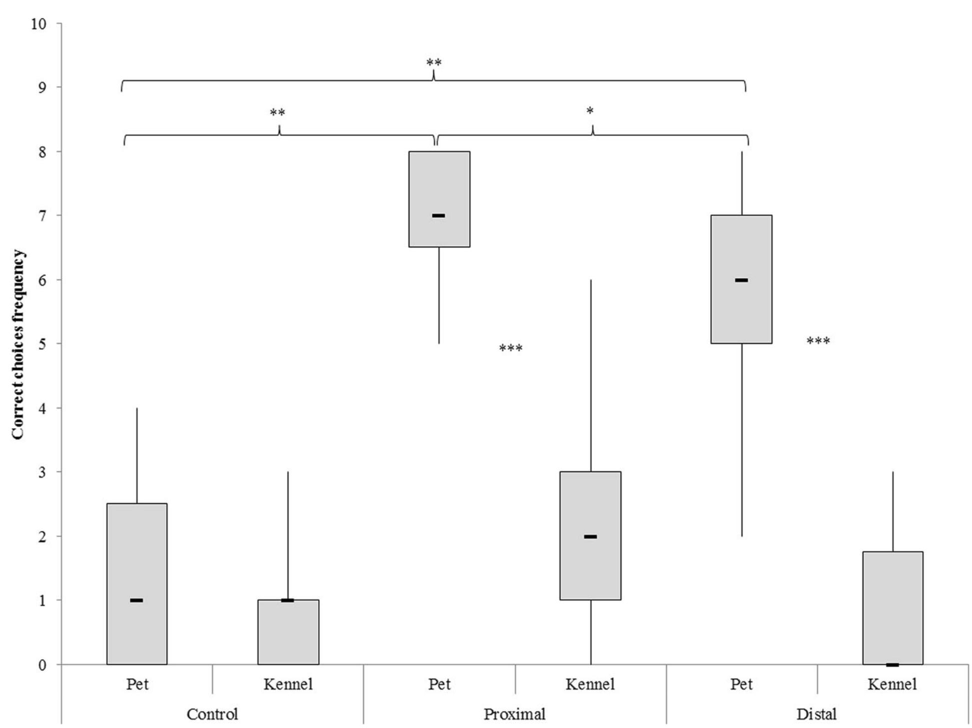

Fig. 3 Intergroup and within-group comparisons. The *box plots* show the frequency of correct choices made under control, proximal and distal conditions among the pet and kennel dogs. *Asterisks over the boxes* denote significant differences in the same group as shown by the Wilcoxon post hoc test; *asterisks* between *boxes* denote differences between the two groups in proximal and distal conditions as shown by the Mann–Whitney *U* test. *Bold horizontal lines*: medians; *grey boxes*: quartiles; *thin vertical lines*: minimum and maximum values. *$P < 0.05$; **$P < 0.01$; ***$P \leq 0.001$

from those of Lazarowski and Dorman (2015), who studied kennel dogs that had never lived with human families. However, unlike the dogs examined in our study, the kennel dogs examined in Lazarowski and Dorman's (2015) study were purpose-bred research dogs that had undergone human socialization, potentially explaining higher levels of human pointing comprehension compared with the dogs examined in the present study.

Our statistical tests on individual dogs showed that significantly more pet dogs than kennel dogs performed above-chance levels; furthermore, the pet dogs as a group understood proximal and distal pointing cues significantly better than the kennel dogs according to our intergroup comparison of correct choice frequency levels. Taken together, these results suggest a clear difference between pet and kennel dogs, with the former being more skilful at understanding human pointing cues for both conditions and assumptions. Thus, our data, in accordance with other studies (Udell and Wynne 2008; Udell et al. 2008, 2010b; Lazarowski and Dorman 2015), support the notion that socialization is essential to suitable responses to human pointing gestures.

Within-group comparisons of correct choice frequency show that pet dogs performed better with proximal pointing cues than with dynamic pointing cues or under the control condition, whereas no significant differences were found in the kennel group between the two pointing cues or the control conditions. This latter result shows that as predicted, proximal pointing is generally easier for dogs to understand (Reid 2009; Udell et al. 2010a; Lazarowski and Dorman 2015). The lack of difference between the two point conditions for the kennel dogs may well be a floor effect, since numbers of correct responses were generally very low.

In conclusion, in this paper we show that pet dogs substantially outperform kennel dogs at understanding proximal and distal pointing cues in regards to making correct choices, meaning that regardless of whether dogs interpret pointing as a directional of referential signal (see Tauzin et al. 2015; Scheider et al. 2013), most dogs with a low degrees of human socialization do not understand pointing gestures. Thus, our results are in agreement with the synergetic model on the emergence of interspecific social skills in dogs (Gácsi et al. 2009; Miklósi and Topál 2011), which predicts that dogs require social experiences with humans to master social skills. Therefore, while the effects of domestication on dogs' social relationships with humans are not negligible, we stress the importance of ontogenetic processes.

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Compliance with ethical standards

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

Ethical approval This study was approved by the Ethical Animal Care and Use Committee of the University of Naples "Federico II" (protocol number 2017/0025509). All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Informed consent Informed consent was obtained from the owners of all dogs included in the study.

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