

Pointing following in dogs: are simple or complex cognitive mechanisms involved?

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Abstract Domestic dogs have proved to be extremely successful in finding hidden food following a series of human social cues such as pointing (an extended hand and index finger indicating the location of the reward), or body position, among many other variants. There is controversy about the mechanisms responsible for these communicative skills in dogs. On the one hand, a hypothesis states that dogs have complex cognitive processes such as a theory of mind, which allow them to attribute intent to the human pointing gesture. A second, more parsimonious, hypothesis proposes that these skills depend on associative learning processes. The purpose of this paper is to provide data that may shed some light on the discussion by looking into two learning processes by using an object choice task: the effect of interference between stimuli on the preference for human social cues and the effect of generalization of the response to novel human social stimuli. The first study revealed that previous training using a physical cue (container location) may hamper the learning of a novel human social cue (distal cross-pointing). The results of the second study indicated stimulus generalization. Dogs learnt a novel cue (distal cross-pointing) faster due to previous experience with a similar cue (proximal pointing), as compared to dogs confronted by a less similar cue (body

position) or dogs with no previous experience. In sum, these findings support the hypothesis about the important role of associative learning in interspecific communication mechanisms of domestic dogs.

Keywords Interspecific communication · Interference · Generalization · Learning · Domestic dogs

Introduction

At times, successful communication among different species is observed. This is the case of domestic dogs (*Canis familiaris*) and humans (e.g. Hare and Tomasello 2005). Dogs have learnt to ask humans for help on numerous occasions to reach different relevant resources like food or toys. Thus, humans become social tools (Cooper et al. 2003; Leavens et al. 2005). For instance, in an object choice task, where food is hidden in one of two possible containers, dogs manage to find it by following a series of human-given cues, such as pointing with an arm and an extended finger or the person's body position (e.g. Soproni et al. 2001). These skills seem to be basically expressed in cooperative situations where the human provides information so that the dog may find the relevant resource, but not in competitive situations (Pettersson et al. 2011). This remarkable dog performance was identified since early stages of development and after the first training trials, which led several authors to assert that these capacities were the outcome of a domestication process and were not hinged upon experiences received during ontogeny (e.g. Miklósi 2009; Hare et al. 2010).

On the other hand, there is some controversy about the mechanisms involved in these skills. Several authors have postulated that such skills would be related to complex

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cognitive processes like detecting attentional states and understanding humans' communicative intent. Dog–human communication would be referential in its nature as it involves triadic interactions with references to surrounding objects (e.g. Bräuer et al. 2004; Leavens 2004). An indicator that complex cognitive processes are involved is that following human social cues to locate food predominates over physical cues such as odour. This preference would imply that dogs understand the communicative meaning of the gesture used to point at the food location (Soproni et al. 2001; Erdőhegyi et al. 2007). Another indicator is the dogs' response to novel cues. Dogs are usually successful in performing communicative tasks without requiring explicit training; hence, these would not be learned behaviours. These responses to novel cues would be related to the dog's capacity to understand the referential value of communication (Soproni et al. 2002). However, there are more parsimonious interpretations that highlight the role of the subjects' experiences during ontogeny and award a key role to associative learning in interspecific communication mechanisms (e.g. Elgier et al. 2009; Petter et al. 2009; Udell and Wynne 2010).

A common characteristic in most previous studies is that they do not consider the way in which different learning processes may affect the outcome of a given behaviour. One of these refers to *cue competition effects*, namely, that cues trained in compound with the same outcome compete for behavioural control (Pineño and Matute 2005). Competition may also appear between separately trained stimuli, and the saliency and surprise of cues would be the key factors to determine how each association is to be learnt. This competition creates interference phenomena in learning different cues (e.g. Miller and Escobar 2002). One of the most studied phenomena in this respect is stimulus blocking. Kamin (1968) demonstrated that the surprise of the reinforcer influences stimulus-reinforcer association learning. If the reinforcer is predicted by other cues already present, then the new cue will be redundant and less will be learnt about it. This phenomenon would reflect one of the functions of learning: the anticipation of the events in the environment so that an organism can prepare for and modify them. If one cue already predicts an outcome, there is seemingly little utility in learning that a second cue that accompanies the first cue also predicts the same outcome (Miller and Escobar 2002).

Another relevant learning process relates to stimulus generalization, which implies that animals can respond to certain stimuli on which they have never been explicitly trained thanks to their similarity to other stimuli already learnt (Pavlov 1927). Normally, the generalization phenomenon is studied experimentally by training a subject to respond to a stimulus associated with a reinforcer such as food. Generalization is measured based on the subject's

response to a second novel but similar stimulus, once the first trained stimulus is no longer present (Wisniewski et al. 2009). Pavlov was the first researcher to study this phenomenon and demonstrated that, if a 1,000 Hz tone was associated with food, many other tones would acquire similar properties to trigger a response and that these properties decreased as the difference between these tones and the 1,000 Hz tone increased (Pavlov 1927). Thus, it was also established that there is a generalization gradient whereby the number of responses decreases as the differences between the two stimuli increase (e.g. Guttman and Kalish 1956; Siegel et al. 1968).

Both processes, stimulus generalization and interference, are produced spontaneously by an individual's learning throughout his/her life. In view of this, when working with adult animals whose history is unknown to us, it is difficult to determine when behaviour is novel and the extent to which such behaviour is influenced by previous learning. Identifying novel behaviour is important because it involves complex cognitive processes that go beyond associative learning. Such a complex process can only be assumed if a sudden solution to a problem is observed, which is expressed as a proper response occurring since the first trials with no previous training (Premack 1995). This “insight” phenomenon would be accounted by means of the reorganization of experience (Thorpe 1964).

Based on these considerations regarding the implications of learning processes on the outcome of new behaviours, the purpose of this investigation is to assess the importance of associative learning and, particularly, of the interference (“Study 1”) and stimulus generalization (“Study 2”) phenomena in dogs' responses to human communicative cues. These studies will help shed some light on the mechanisms underlying communication between the two species.

Study 1

Several studies have revealed that dogs prefer to follow human social rather than physical cues to locate hidden food. This preference is noted even with an incorrect human social cue, which places the dog at a disadvantage as it cannot locate the food. For this reason, it has been considered to be a not learnt preference from human cues (Szetei et al. 2003; Bräuer et al. 2006; Erdőhegyi et al. 2007; Prato-Previde et al. 2008). However, these studies did not take into account the animals' previous experiences with each of those cues during their daily lives. The purpose of the next study was to investigate whether the interference of physical stimuli affected responsiveness to human social cues by manipulating the previous reward history with each of the stimuli. To this end, we assessed whether learning a physical cue, specifically the container's

position in a first phase, may interfere with the subsequent learning of a human social cue (distal cross-pointing) to locate hidden food. This interference would show that in an object choice task, dogs do not choose the cues to be followed based on their type (either social or physical) but based on their associative strength, that is, on the reward history that each cue had in that situation. As far as communication mechanisms are concerned, these data would indicate that responding to both types of cues depends at least partially on the same associative learning principles. In this sense, it is possible to predict that the control group will show a better performance with the human social cue.

Methods

Subjects and apparatus

The initial sample consisted of 27 dogs. However, 7 of them were discarded because they did not eat the liver or because they did not meet the learning criterion of the first phase (see procedure). The final sample consisted of 20 adult dogs, 11 males and 9 females (mean age: 3.7 years with a range from 1 to 8 years) and different breeds (4 German shepherds, 3 Labrador retrievers, 2 Cocker spaniels, 1 Golden retrievers, 1 Weimaraner, 1 Boxer, 1 Jack Russell, 1 Poodle, 1 Fox terrier, and 5 mixed breeds) who lived with humans as pets since puppies. The animals had free access to water, and the last meal before training sessions had been received approximately between 3 and 8 h earlier. They had no previous experience in object choice task experiments. The dogs that participated in the study were obtained from personal contacts and Canine School “GB”. The owner’s consent was obtained prior to participation in the study. The observations were made in a familiar environment for the dogs. For hiding the food (portions of 3 g of cooked liver), two opaque containers of 30 cm in diameter and 8 cm in height were used. In order to control the odour, both containers were greased with abundant liver before the experience and they had a false bottom containing eight food pieces. The containers were separated by 1 m from each other and the experimenter (E) stood 50 cm from each one. The starting point of the dog was 2 m in a straight line from the position of the E. The dog was always next to a handler, who carried it to the starting point with a leash. During the evaluation, only the E (a woman unknown for the animal), the handler, and the dog were present. Figure 1 shows an image of the set and the experimental design.

Procedure

An object choice task was used. Dogs were randomly assigned to two groups: interference (IG; $n = 10$) and control (CG; $n = 10$) (see design in Fig. 1).

Pre-training The purpose of pre-training was to show dogs that containers had food in them. The guide led the animal up to each container, twice to each side randomly, and let it eat.

Phase 1 After pre-training, the IG received a first phase of 3 sessions comprising 10 trials each, where the cue used was the container’s location (left or right side regarding the dog position). This location was chosen at random; for half the dogs, the correct container was to the right and for the other half, to the left. The E remained between both containers, called the dog by its name until it makes visual contact but did not emit any cue. The animals that did not comply with the learning criterion of giving 8–10 correct responses in the last session of this phase were dismissed. The CG did not get any training on this cue but received the same amount of liver pieces matching those fed to the IG in order to control their degree of satiety.

Phase 2 In this phase, the IG received the previously trained cue (bowl location) concurrently with the human social cue (distal cross-pointing) during 2 sessions comprising 10 trials each. In this case, both the pointing and the previously trained bowl location indicated the correct place. Distal cross-pointing consisted in extending the contralateral arm towards the food location, so that only the hand appeared outside E’s body outline and also at a distance of more than 50 cm from the bowl. During the cue, only the arm was moved while the rest of the body remained still. Every trial began when the E called the dog by its name. When the animal made visual contact with her, she performed the cue. The CG underwent 20 trials involving only the human social cue (distal cross-pointing). For this group, food was randomly placed.

Phase 3 In phase 3, both groups underwent a test session with 10 trials where the only cue indicating the correct location was given by distal cross-pointing; rewards were placed at random across the two possible locations across trials.

Throughout all the phases, a response was considered correct when a dog touched the baited bowl or its head was within 10 cm of the bowl. In those cases, the dog was verbally reinforced and was allowed to get the food. If a dog walked up to an unbaited bowl, the guide would say “no” and show that it was empty, and then show the baited one, but the dog was not allowed to eat the reinforcer. If once E had given the cue, the dog remained 15 s at the starting point without choosing any of the containers, it was considered a non-choice response, and the trial ended. These trials were regarded as incorrect responses. The interval between trials was 30 s and 10 min between sessions and phases. In all cases, E continued to give the cue until the dog gave its choice response.

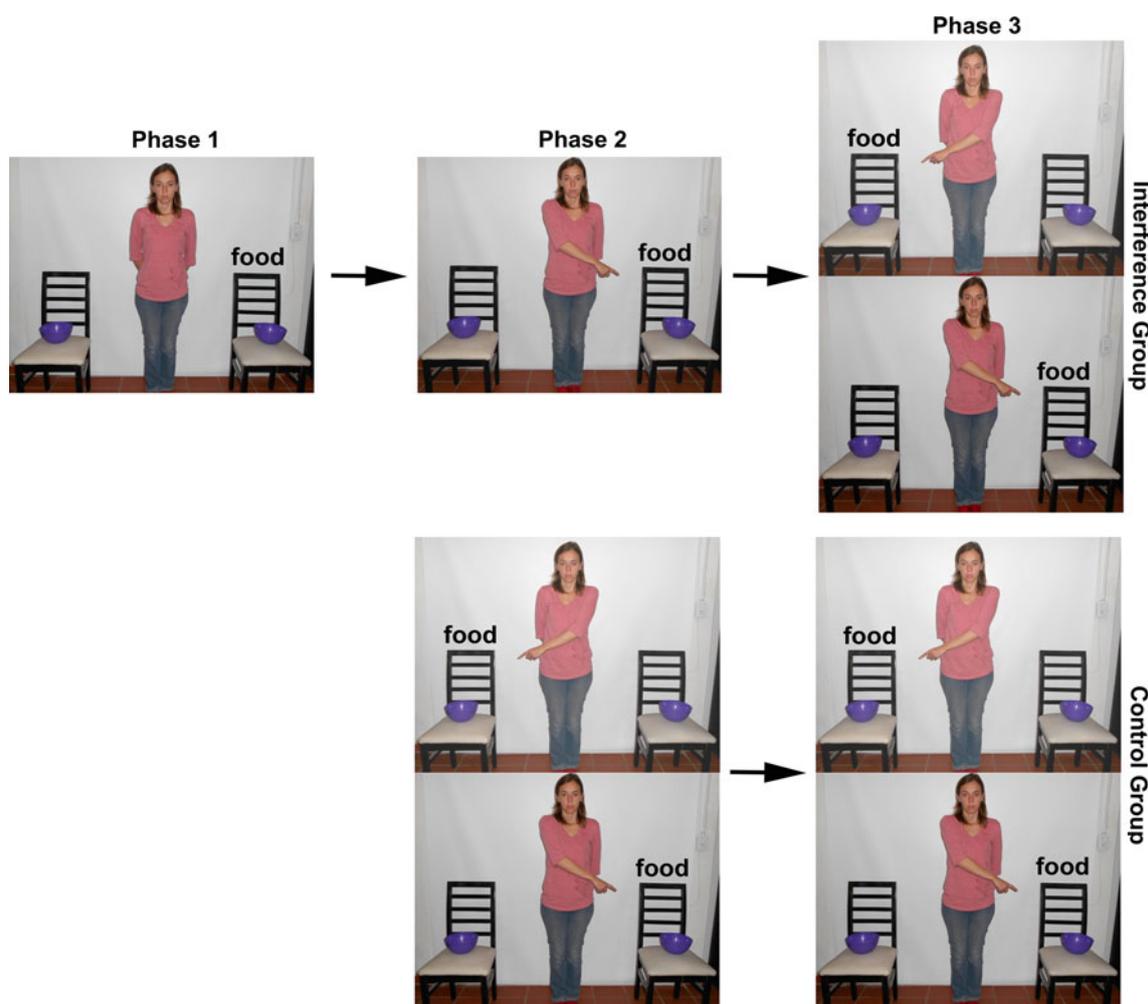


Fig. 1 Illustration of the setting and the experimental design of “Study 1”. During phase 1, the interference group (IG) received 30 trials with the physical cue (food position at the right/left side of the dog). In phase 2, IG received 2 sessions with the physical cue and the distal cross-pointing oriented to the same side, while the control group

(CG) only received the distal cross-pointing (the food was located randomly on the left or right side regarding the dog position). In phase 3, IG and CG received only one session with distal cross-pointing (the food was located randomly on the left or right side regarding the dog position)

Data analysis

Data analysis was performed using an independent samples *t* test to compare the number of correct responses between groups, and a one-sample *t* test to compare the performance of each group against chance. Furthermore, a binomial test was used to analyse the individual performance of each subject against chance. A 5 % alpha was stipulated to discriminate the significant effects. All tests were two-tailed.

Results and discussion

Figure 2 shows the number of correct choices of the IG and CG during sessions 1–5 and during the test in phase 3. According to the learning criterion set, the IG should have

at least eight out of ten correct responses in session 3 to be allowed to continue training.

The performance of each group during the test, measured as the number of times that the dogs chose the reinforced container during phase 3, was compared with an independent samples *t* test showing significant differences, $t_{18} = 4.961$, $P = 0.0001$. CG animals chose more often the correct container than IG. On the other hand, the analysis with the *t* test for one sample indicated that the IG performed at chance, $t_9 = -2.20$, $P = 0.055$ with a tendency to be significantly below chance, while the CG was significantly above chance, $t_9 = 5.62$, $P = 0.0001$. A binomial test showed that six out of the ten dogs of IG performed at chance ($P > 0.05$) and four below chance ($P < 0.04$), while seven of the ten dogs of CG performed above chance ($P < 0.04$) and three at chance ($P > 0.05$).

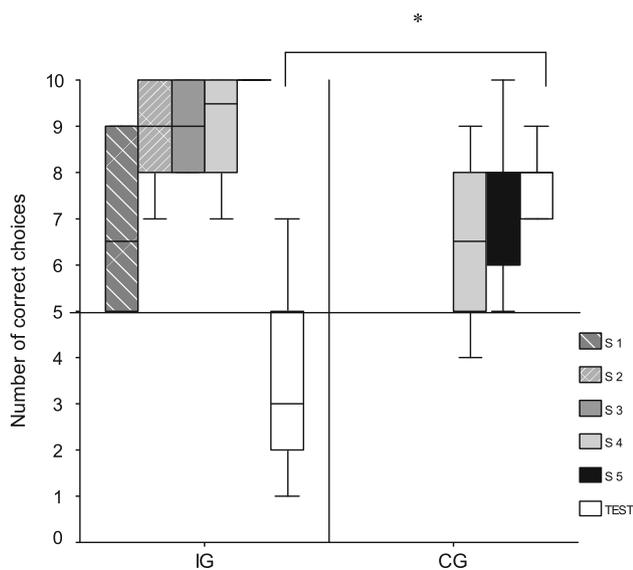


Fig. 2 Number of correct responses in phase 1 (sessions 1–3) for the interference group (IG), phase 2 (sessions 4 and 5) and phase 3 (test session) for IG and control group (CG). The *line* represents chance level. The CG significantly performed above chance and significantly outperformed the IG during the test, $*p < 0.05$, two-tailed tests. The *box* represents the interquartile range, containing 50 % of the values, and the *bold lines* indicate the median. The *error bars* extend from the *box* to the highest and lowest values

In sum, results indicated that the CG had a significantly higher number of correct responses than the IG group. Also, the CG's performance was above chance level while the IG behaved at chance level.

These findings reveal an effect of interference of the previous experience with a physical cue on the learning process with a human social cue. Probably, the reward location was no longer novel in the second phase; hence, the presence of a human social cue was redundant and barely informative. Thus, with proper training, physical stimuli can be predictors of resources that perform as well as the human social ones. The study would indicate that associative learning plays a role in following both cues. This statement could be strengthened in the future studying the interference effect of a human social cue over the learning of a physical one. Finally, although it is not possible to fully rule out the presence of complex cognitive processes, results support a more parsimonious explanation of interspecific communicative responses in domestic dogs.

Study 2

Commonly to analyse the response to novel human social cues, dog behaviour is evaluated through a series of consecutive trials with different signals of increasing difficulty or in several trials with similar cues in which correct

responses are reinforced and incorrect ones are not (e.g. Miklósi et al. 1998).

Another frequently used method (e.g. Soproni et al. 2002; Lakatos et al. 2009) relates to probe trial, where novel cues are interspersed with a familiar cue such as pointing. These procedures facilitate the development of stimulus generalization phenomena, so that a successful response to certain novel cues might in fact be due to previous experience with other similar cues.

The purpose of this second study was to assess how the experience with the communicative cue of proximal pointing may affect the subsequent learning of another similar human social cue, specifically distal cross-pointing. In order to evaluate the possible existence of a generalization gradient, animals were previously exposed to a cue very similar to distal cross-pointing, namely, proximal pointing, and to a less similar cue (body position), while a third group was not exposed to any cue. If there were a stimulus generalization effect, animals pre-exposed to proximal pointing will learn to follow distal cross-pointing faster than the others. Thus, the dogs' successful performance using this cue, as noted in previous works in literature (Hare et al. 1998; Soproni et al. 2002), could not be regarded as novel behaviour indicating complex cognitive processes but should be accounted for by associative learning mechanisms through stimulus generalization.

Methods

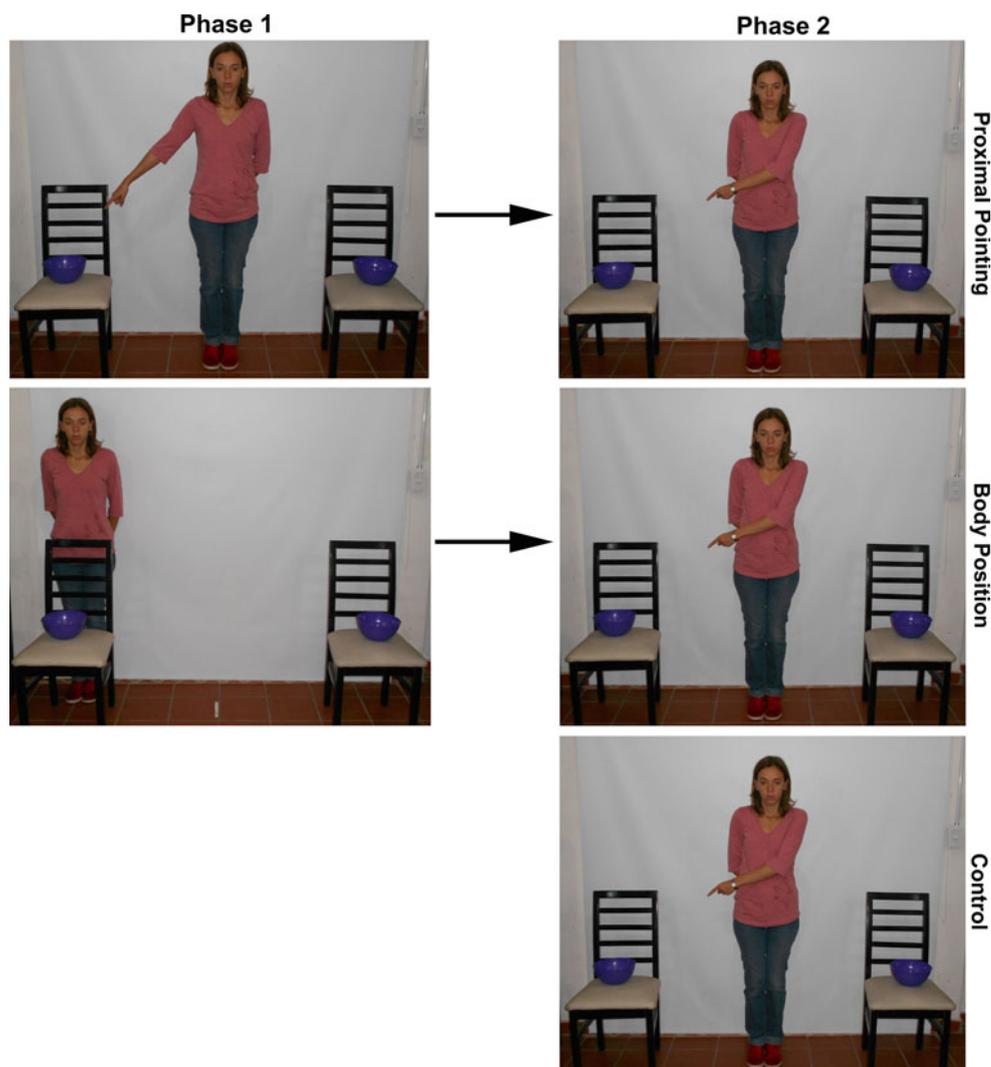
Subjects and apparatus

The subjects were 27 dogs. However, 4 of them were discarded in the pre-training due to lack of interest in the task. The final sample consisted of 23 dogs, 14 males and 9 females (mean age: 6.08 with a range from 1 to 9 years) of different breeds (1 American staffordshire terrier, 1 Great dane, 6 German shepherds, 4 Golden retrievers, 2 Schnauzers, 1 Boxer, 1 Breton, 2 Poodles, and 5 Mixed breeds) who lived with human families as pets since puppies. The subjects had no training or previous experience in experiments of object choice task. They were food deprived for 3–8 h before the study. The owner's consent was obtained prior to participation in the study. The experimental setting and apparatus were similar to "Study 1".

Procedure

Dogs were randomly assigned to 3 groups: proximal pointing group (PG; $n = 8$), body position group (BG; $n = 8$), and untrained control group (CG; $n = 7$). The difference in each group was its previous experience with a given human social cue (See design in Fig. 3).

Fig. 3 Illustration of the setting and the experimental design of “Study 2”. During phase 1 the proximal pointing group (PG) received one session of 10 trials with the proximal pointing cue and body position group (BG) received one session of body position cue. The control group (CG) had no experience in this phase. In phase 2 PG, BG and CG received one session of distal cross-pointing gesture



Pre-training The purpose of this phase was to show dogs that containers had food in them. First, the guide led the dog up to each container, showed the food, and let it eat. Subsequently, the animal was guided to the starting point, and E would call it by its name, while showing a piece of food in her hand. As the dog gazed, food was placed in one of the containers. Then, the dog was released and allowed to eat the reinforcer. This action was repeated twice on each side at random.

Training The procedure consisted of two phases, each having one single session with 10 trials. The interval between trials was 30 s, and 10 min between phases. Once the animal was guided to the starting point, E calls it by its name, trying to make visual contact with the dog. Subsequently, E gave the relevant cue, and the guide allowed the dog to choose one of the two bowls. A response was considered correct when the dog touched the bowl with its snout or stood within 10 cm of the bowl. If the dog chose

correctly, it was verbally reinforced and was allowed to consume the reward. If it chose the incorrect bowl, the guide said “no” and E would show that that container was empty and the other was baited, but would not let the dog eat. If the dog remained more than 15 s at the starting point after E had given the cue, it was considered a non-choice response and counted as incorrect. Figure 3 shows the cues used.

Phase 1 In the first phase, the PG received one single session comprising 10 proximal pointing trials, where E call the dog by its name, trying to make visual contact with the dog, and then extend her ipsilateral arm and her index finger pointing at the baited container while the rest of the body remained still. Her finger was within 50 cm of the bowl. In the BG, before the dog reached the starting position, E would stand behind the baited bowl. When the dog arrived at the starting point, E would call it by its name, and upon making eye contact, the dog was released

to make a choice. Finally, the CG did not go through this first phase but started training straightaway in phase 2.

Phase 2 All the dogs received a session comprising 10 distal cross-pointing trials, where E, standing between both containers, would call the dog by its name. Once the dog made visual contact, she crossed her contralateral arm in front of her body and with her extended index finger point at the correct location. The E only moved her arm while the rest of the body remained still. Thus, only the hand appeared outside E's body outline. In all cases, E remained in the same position and continued to give the cue until the dog made its choice response.

Data analysis

A one way ANOVA was used to compare the number of correct responses between groups. A *t* test for one sample was used to compare the performance of subjects against chance. A binomial test was used to compare individual performance against chance. A 5 % alpha was stipulated to discriminate the significant effects. All tests were two-tailed.

Results and discussion

In phase 1, the two groups evaluated behaved above the chance level, PG (9.62, DS \pm 0.51) and BG (9, DS \pm 0.92). This indicates that dogs were able to follow both: proximal pointing, $t_7 = 25.27$, $P = 0.0001$, and body position as cues, $t_7 = 12.22$, $P = 0.000$, to find the hidden food. In phase 2, where all the dogs were first exposed to distal cross-pointing, the ANOVA showed that there were no significant differences between the three groups ($F_{2, 22} = 2.979$, $P = 0.074$). However, considering the performance against chance, only the PG group was successful, (8.12, DS \pm 0.99; $t_7 = 8.919$, $P = 0.0001$), while BG (6.42, DS \pm 2.22) and CG (6, DS \pm 2.3) behaved at chance level, $P > 0.05$ (see Fig. 4). This shows that only those dogs that were exposed to proximal pointing in phase 1 could successfully use the distal cross-pointing from the beginning. Measuring the individual performance, the binomial test showed that in the PG, seven dogs performed above chance, while in the other two groups, only two dogs were successful ($P < 0.04$).

The results obtained indicated that previous experience with proximal pointing enabled the PG to perform above chance level using distal cross-pointing. Instead the BG, which had been confronted by a less similar cue like body position, and the untrained CG performed at chance level when a novel cue was used. These findings are consistent with those by Hare et al. (1998) and Soproni et al. (2002), who noted that dogs performed above chance level using

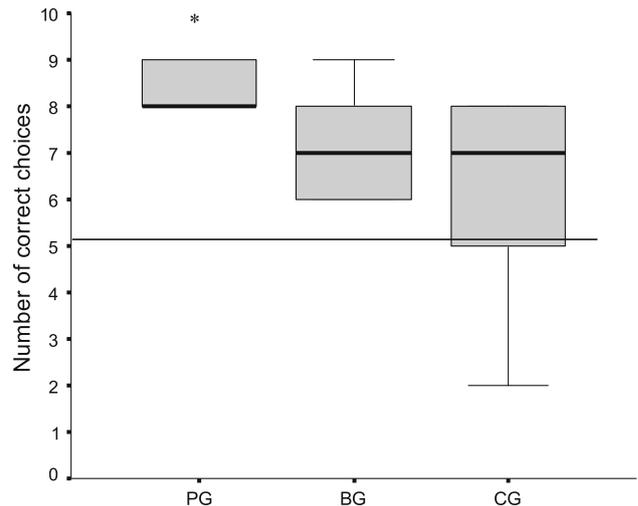


Fig. 4 Number of correct responses upon presentation of distal cross-pointing in the groups that had previous experience with proximal pointing (PG), body position (BG) and the control group (CG) with no experience (CG). The *line* represents chance level. The PG group performed significantly above chance, $*p < 0.05$, two-tailed tests. The *box* represents the interquartile range, containing 50 % of the values, and the *bold lines* indicate the median. The *error bars* extend from the *box* to the highest and lowest values

distal cross-pointing, but with a different design (hierarchical order according to degree of difficulty in cue presentation and trial probe method). It may be concluded that those results are due to a stimulus generalization process, as suggested by the data in this study. The fact that the group exposed to body position performed at chance level in the second phase allows us to rule out the possibility that the performance of PG may be simply due to the number of trials received by that group.

General discussion

The purpose of these investigations was to analyse the role of associative learning in dog's mechanisms to respond to human social cues. The results of the first study show that learning a physical cue as an indication of hidden food location hampers the learning of a human social cue. This interference phenomenon would reveal the importance of the unexpected events in the learning of new behaviours (Kamin 1968).

These data are consistent with those previously obtained by Elgier et al. (2009), who found that in an object choice task dogs choose the cues to be followed based on the history of reinforcement that each cue had in that situation. It was noted that training on a physical cue (colour) was successful in reversing the dogs' preference for proximal pointing and elbow pointing cues. Overall, these data would show that the choice rule is not to systematically

respond to a human social cue but to follow a more informative reward-related cue. On the other hand, it could be suggested that the preference usually observed for a human social cue would depend, at least in part, on repeated associations with reinforcers in the past rather than on an innate tendency to respond to cues of this kind.

One of the most-used arguments to explain dogs' preference for human social cues, even when these do not give access to the reinforcer, is related to the process of domestication to which they were submitted (Erdőhegyi et al. 2007). Another possible explanation is that, given their social nature, dogs may put aside their self-interests in search of the group's cohesion with humans, as it also happens with wolf packs (Prato-Previde et al. 2008). These results, however, show that a very relevant factor to be considered is the previous experience dogs had in their daily lives, where reinforcers like food are frequently associated with humans, so that human social cues become extremely relevant and may prevent a dog from learning physical cues.

The results obtained in the second study indicate that the dogs' previous experience with certain human social cues affects their response to other novel signals. The group receiving training in proximal pointing had a successful performance when using distal cross-pointing, while those trained with body position and those with no previous experience performed at chance level with a novel cue. These results indicate a learning generalization effect from the first phase to the second. Also, a generalization gradient was observed as proximal pointing instead of body position facilitated the learning of a novel cue.

These findings show that, when a successful performance is observed during the first trials, it does not necessarily imply a novel behaviour. Although it may be asserted that distal cross-pointing is not frequently used by owners, it does not necessarily mean that, to solve the problem, the animal should not be using information from its previous experience through generalization processes. Thus, the postulate of complex cognitive mechanisms is challenged since these responses may be accounted for by simpler associative learning mechanisms. In this sense, a dog may respond to a novel human communicative cue not because it understands the person's communicative intent but basically because that cue is similar to others received in the past that allowed it to get different reinforcers.

On the other hand, both studies clearly underscore the importance of controlling the subjects' previous experience, both regarding evaluation methods and the possible experiences developed during their ontogeny. Procedures involving cue presentation of increasing degree of difficulty as well as probe trials create optimal conditions to produce stimulus generalization processes. The stimulus generalization process might help follow different human

social cues in interspecific communication, hence stressing not only the importance of experience during ontogeny but also the role of associative learning in interspecific communication mechanisms. An extended hand offering food, topographically similar to pointing, becomes a very salient stimulus in a dog that depends on humans to get resources (Udell and Wynne 2010). The generalization process might explain, at least in part, dogs' successful performance with human social cues since the first trials.

In sum, both studies provide evidence favouring the role of associative learning processes in domestic dogs' responses to human communicative cues. The two mechanisms, stimulus generalization and interference, have been thoroughly studied and evaluated using different cues and on different species. But, as far as we know, it is the first time they are studied in connection with dog-human interspecific communication. It should be noted that these findings do not allow us to definitely rule out the presence of complex cognitive factors, either attributable to a theory of mind or to some intermediate level between a theory of behaviour (learning that certain behaviours lead to certain outcomes) and a theory of mind, where the animal uses certain mediating behavioural elements that Horowitz (2011) defined as rudimentary theory of mind. Despite the lack of proper key designs (Heyes 1998), the alternative approach would be to try to understand the specific stimuli controlling the animals' behaviour under different conditions (Udell and Wynne 2011). In this sense, the old prejudice that associative learning can only account for very simple animal behaviours should be eradicated. The processes shown here allow us to identify associative processes related to complex communicative behaviours in dogs.

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