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Communication between domestic dogs (*Canis familiaris*) and humans: Dogs are good learners

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ABSTRACT

Communication involves a wide range of behaviours that animals emit in their daily lives and can take place between different species, as is the case of domestic dogs (*Canis familiaris*) and humans. Dogs have shown to be successful at following human cues to solve the object choice task. The question is what are the mechanisms involved in these communicative abilities. This article presents a review of studies about the communicative capacities of domestic dogs emphasizing the ones that considered the effect of associative learning upon these skills. In addition, evidence about differences in dogs' performance in following physical or social cues is summarized and two studies where both signals compete are presented here. The obtained results suggest that the training of a colour cue reverses the dogs' preference for the social one. These results are discussed in light of the findings that gave importance to the learning effect, concluding that the dogs fundamentally follow those cues that allowed them to obtain reinforcers in their previous learning history.

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1. Introduction

According to a broad definition, communication takes place between two animals when an observer can detect predictable changes in the behaviour of one of them in response to certain signals from the other (Wilson, 1975). In this sense, communication would include an extensive range of behaviours, which are often emitted by animals in their daily lives to solve different problems like searching for food, mates, territory, and in some species, playing, cooperating, etc. Experimental learning psychology defines communication as a set of chained responses, where the signals act as discriminative stimuli that prompt the receiver to perform a certain response. This behaviour, as a consequence, leads to a reward for one or both animals (Skinner, 1953). For social species, learning through others is essential due to the fact that a great part of the interaction and social cohesion is determined by the correct identification of behavioural cues which facilitate adaptation to the environment.

Communication is not limited to members of the same species; it can take place between different species as is the case of domestic dogs (*Canis familiaris*) and humans. Dogs have several skills that allow them to respond to different signals given by humans (Miklósi et al., 2004; Hare and Tomasello, 2005). They can use human pointing, body posture, gaze direction, touching or marking as cues to find hidden food. Dogs may even solve this kind of situation at their first attempts (Hare and Tomasello, 1999; Soproni et al., 2001; Riedel et al., 2006) and from early stages of their development (Agnetta et al., 2000; Riedel et al., 2008). These findings led some authors to postulate that these skills may be independent from learning. Nevertheless, recent evidence suggests that associative learning may play a role in communicative behaviours (Bentosela et al., 2008, in press; Elgier et al., 2009).

Given the particular features of the natural habitat of dogs, communication with humans has a crucial importance. Evidence shows that this ability would be greater than that of other canids, such as wolves (Hare et al., 2002; Miklósi et al., 2003) and that of species genetically related to man but that did not coexist with him, such as primates (Anderson et al., 1995; Itakura et al., 1999). Virányi et al. (2008) presented a series of experiments where wolves and dogs socialized in similar ways, were compared in their performance to follow human cues. In the first study, they found that four-month-old puppies of both species responded in a different way to distal pointing (i.e., a cue where the human index finger is approximately 50 cm from the baited bowl). Only the dogs used these signals to find the hidden food. Generally, these differences in performance among species led to the hypothesis stating that dogs' communicative skills were developed during the domestication process (Miklósi et al., 2003; Hare and Tomasello, 2005). On the other hand, in the case of proximal pointing (i.e., the distance between the index finger and the container is 10 cm) and "touching" (i.e., the experi-

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menter kneels down and touches the baited bowl with his hand for 1 s), wolves and dogs performed above chance (Virányi et al., 2008). These results would indicate that, at least with very salient cues, wolves could behave like dogs if they had proper socialization during their ontogeny. The domestication process would not seem to be the only factor responsible for these skills.

Regarding the controversy about the role of ontogeny in the development of these skills, some evidence shows the importance of early experiences upon communication. For example, in another experiment of Virányi et al. (2008) the performance of the same wolves at 11 months of age, after intensive training, was compared with that of naive dogs of the same age in a task with momentary distal pointing (the distance between the top of the finger and the pointed object is greater than 50 cm, and the signal is in sight of the animal less than 2 s, returning to the initial position before the choice). They found significant differences not in the number of correct responses, nor in the latency or maintenance of the gaze to the experimenter who gives the cue. On the other hand, a recent study by Udell et al. (2008a) found that on average, socialized wolves can follow the distal pointing to the same degree as pet dogs tested indoors, and better than dogs tested outdoors and those from a shelter. In synthesis, the performance of dogs compared with that of wolves seems to depend, in part, on the experiences in communicative situations with humans that both species received during ontogeny and on suitable socialization. Still, the influence of the domestication process, in interaction with socialization, cannot be discarded.

On the other hand, dogs are also capable of emitting signals towards humans, such as gaze direction. For example, if an obstacle is placed between the dog and a hidden-reward box, and the animal cannot open the box in the way it had been trained, dogs tend to initiate eye contact with their owners more rapidly and for longer periods of time than socialized wolves exposed to the same situation. In addition, wolves try to open the box themselves (Miklósi et al., 2003). In another study, dogs' ability to gaze towards the human face was compared with the performance of another domesticated species, cats (*Felis catus*) (Miklósi et al., 2005). In this experiment, these animals suddenly could not access the hidden food. Dogs initiated eye contact with the human faster and for longer than cats. In addition, there were significant differences in the number of gaze alternations between the human and the food: cats showed a lower frequency of alternation. These results may show that gaze to the human face as a communicative cue might have arisen as a result of the domestication process (Miklósi et al., 2003; Kubinyi et al., 2007).

In summary, these communicative behaviours generated two types of debate in the field of comparative psychology: on the one hand, whether these abilities can be considered innate or acquired and the importance that each of these factors has for the expression of these behaviours; on the other, whether these skills depend on some cognitive process like theory of the mind, which allows dogs to attribute intention or meaning to the human communicative intention, or can be explained by instrumental learning processes.

At present, there is evidence that gives some support to both positions but none of it is conclusive. To answer the first question about the origin of the communicative skill, it is necessary to carry out a crucial experiment about these skills with puppies raised in complete isolation from human contact, from birth up to the eighth week of life, where the sensitive period of socialization is usually completed and their sensory systems are totally developed (Scott and Marston, 1950; Scott, 1958; Freedman et al., 1961). However, for obvious ethical reasons this cannot be done.

The second controversy in the literature is about the mechanisms involved in interspecific communication. The problem is establishing whether the communicative skills of dogs should be regarded as an associative learning situation where the subject forms an association between a cue and the reward or if more complex mechanisms are involved. In the first case, the experimental results would be explained by conditioning processes (Shapiro et al., 2003), or the so-called "low level" hypothesis (Povinelli and Giambrone, 1999). The alternative explanation suggests that this is a communicative situation where subjects might learn about the meaning of the cue, requiring complex cognitive skills to understand the communicative intention of the emitter. This is known as the "high level" hypothesis (Miklósi et al., 1998; Soproni et al., 2002; Braüer et al., 2006; Riedel et al., 2006).

As a whole, evidence seems to indicate that the most suitable position is to hold an intermediate view of the first debate, where both genetic and environmental factors are involved in the development of communicative skills. Animals genetically capable of responding to social cues will still differ in their ability to use specific forms of signals depending on their individual histories and environments. Domestication alone cannot be responsible for an individual's untrained sensitivity to human cues (Wynne et al., 2008).

Regarding the controversy about the mechanisms, there are few systematic studies about the effect of learning on the performance in interspecific communicative tasks. If associative learning processes can modify the use of different communicative cues between dogs and humans, it would strengthen the idea that high level processes are not necessary to explain these capacities. Our research project focuses on the study of the role of associative learning on the mechanisms involved in interspecific communicative situations. Specifically, we evaluate two behaviours: the emission of the dog's gaze towards the human and the pointing following behaviour.

The aims of the present paper are: (1) to present a brief review of the studies about the effect of learning on communication, (2) to summarize studies performed in our laboratory and (3) to present two studies about the dogs' performance on the differential use of physical and social cues to find hidden food.

2. Associative learning and interspecific communication

Learning is a relatively permanent change in behaviour due to experience (Domjan, 1998) and allows an organism to adapt to variable and dynamic environmental contingencies (Alcock, 1975).

The major focus of research on instrumental conditioning is on the relationship between responses and their corresponding outcome (Thorndike, 1911; Skinner, 1953). First, behaviour can produce positive consequences (e.g., food) and the positive outcome should increase the likelihood that one engages in the behaviour in the future. This relation is known as "positive reinforcement" (Thorndike, 1911). Signals such as gazing at the owner's face, which produce the delivery of a reward (i.e., food, game or petting), would be repeated under similar conditions, mainly through the reinforcement processes. Second, if the behaviour does not produce appetitive consequences and other responses receive positive outcomes, the probability of the first behaviour decreases. This phenomenon is known as "omission". Third, when that behaviour no longer produces positive consequences (e.g., no food), that response decreases. This phenomenon is known as "extinction" (Thorndike, 1911; Skinner, 1953).

One of the first researches about the effect of learning was a preliminary study performed with puppies (Gácsi et al., 2005). The authors used a situation of conflict that is frequent in the daily life of dogs. They placed food in sight but out of the animal's reach. In this situation, dogs tend to gaze at the human face to obtain the food (Miklósi et al., 2000). In the study of Gácsi et al. (2005), three puppies were reinforced with a clicker sound and food after making eye contact with the experimenter. Results showed that gaze duration towards the experimenter increased significantly during trials. The authors concluded that "there are two possible explanations

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for increased tendency to gaze at the human's face in dogs; either they learned the association between eye contact and food reward very quickly, or they might have not learned much, but in this moderately stressful situation, they looked more into the human's eyes only because 'solicitation' came more natural to them" (Gácsi et al., 2005, pp. 10–11). Unfortunately, the above-mentioned results could not be adequately interpreted because control groups were not included.

Another study that investigated the role of learning in the comprehension of communicative human signals is that of Riedel et al. (2008). They presented information about four groups of puppies, from 6 to 24 weeks, showing that there were no significant age differences between the animals in the point following behaviour. In this article they stated that the dog's ability to use human cues in an object choice task was independent from the experiences during ontogeny. In a statistical re-analysis of that data, Wynne et al. (2008) found that the oldest dogs performed better than the youngest ones, and that the latter learned to respond to the human cues during the experimental procedure. In turn, they argued that domestic dogs usually eat from the caregiver's hand from 4 weeks of life, so 6-week-old puppies already have 2 weeks of receiving associations between hand and food, and as a consequence, between the human and the access to the rewards. Thus human actions might be very salient for domestic dogs (Wynne et al., 2008).

The learning processes involved in communicative cues following during the object choice task might be similar to the ones used in multiple discrimination tasks (Mitchell et al., 1985). For example, Shapiro et al. (2003) tested a gray seal to determine if the generalization of instrumental conditioning has a role in the animal's performance in pointing tasks. It was expected that the subject, once trained in a choice task, might generalize its responses to other similar cues. The training consisted of touching a white square (target) following the direction of a long black stick. Then, across trials, the distance between the signal given with the stick and the target was increased. In the last step, the experimenter replaced the stick by his arms, both left and right, pointing to the target. This was the only training that the animal received: a simple conditioning, which does not indicate any type of understanding of the pointing as referential signal. Three months elapsed between the initial training and the beginning of the experiment. The results indicated that the seal successfully generalized the signals when they were given from a central position with regard to both options.

Many animal studies suggest that the following of directional cues, such as pointing, would indicate the comprehension of the referential nature of such gestures. Nevertheless, the above-mentioned experiment shows that the following of human signals can be trained by conditioning. For example, changing the type of signal (e.g., elbow pointing) or shifting the distance between the experimenter and the pointed object provides information about how the animal generalizes along several signals, but it does not suggest a comprehension of referential communication. The results obtained by Shapiro et al. (2003) indicated that a more cautious interpretation of the data would be appropriate, and that it would be parsimonious to study the implications of learning processes for this type of task.

There are different ways to evaluate the participation of associative learning processes on the mechanisms involved in the communication between dogs and humans. One of them is to modify the reinforcement contingencies of the communicative behaviours. With that purpose, in our laboratory, we studied the effect of acquisition, extinction, successive negative contrast and omission of the reinforcer on the comprehension and emission of the above-mentioned communicative responses. Another way is to compare the effect of learning upon social and non-social cue following. With this aim, two studies comparing the performance of dogs with both types of cues were performed.

2.1. Acquisition, extinction and successive negative contrast effect on the comprehension and emission of communicative responses in domestic dogs

Acquisition occurs when a response is reinforced, and increases its probability of occurrence in similar situations. In an extinction procedure an instrumental response that has been acquired stops being reinforced at a certain moment. In general a decrease of the response is observed (Skinner, 1953). If a communicative response of the animal changes during these phases, it may suggest that instrumental learning is one of the mechanisms playing a role in interspecific communication. In one study (Elgier et al., 2009), 13 dogs were evaluated in an object choice task; the choice of the bowl pointed by the human was rewarded with food. For one group of subjects, the cue was given by the owner, who was previously instructed on how to emit the cue. For the remaining animals, the cue was given by an unfamiliar person and in the absence of the owner. Once the response had been acquired, the extinction procedure began. If the animal did not choose any bowl during 15 s, it was considered as an extinction response. The extinction criterion was that dogs do not realize any choice during four consecutive trials. The results showed that both groups accomplished the criterion. For a binomial distribution, the probability of giving four consecutive extinction responses above chance was 0.0625. In addition, when the cue was given by the owner, the dogs took significantly more time to extinguish their responses of pointing following than when the cue was emitted by an unfamiliar person. These results suggest that the dogs' response of following the human pointing extinguished when that behaviour was not reinforced in the presence of the stimulus and that the extinction is slower when the owner gives the cue.

In another study, the aim was to assess the extinction effect on the emission of a communicative response: the gaze of the dog towards a human face (Bentosela et al., 2008). It was assessed when food was in sight but out of the dog's reach. The dogs had to make eye contact with the experimenter to access the reinforcer. The results showed that gaze duration increased over the three acquisition trials, while during the extinction phase the response gradually decreased. The gaze response showed a rapid change over trials as a function of the reinforcement contingencies, showing flexibility. In addition, during the extinction, the behavioural pattern was markedly different compared with the acquisition phase: dogs moved away and turned their backs to the experimenter, and also lay down. These results were also found using a surprising downshift of the reinforcer quality, in a successive negative contrast procedure (Bentosela et al., in press). In the first phase, the gaze response towards the experimenter's face led to a high quality reinforcer (liver), and in the second phase, led to a lower quality reward (dry pellets). When the dogs were suddenly downshifted from liver to dry pellets, the gaze duration fell below the level of a group that was always reinforced with dry pellets. In addition, downshifted dogs refused the food, moved away from the experimenter and assumed a lying-down posture more often than unshifted controls.

In summary, extinction and negative contrast cause a decrease in the point following behaviour and in the gazing to the human face. These results would seem to show that such behaviours are responsive to the contingencies of reinforcement. Associative learning would also appear to be implicated in the mechanisms of interspecific communication.

2.2. Omission effect on emission and comprehension of communicative responses in domestic dogs

In the omission procedure, every time the animal emits the target response (e.g., following the human pointing or gazing towards the human face), it does not receive the reinforcer. The positive

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outcome appears when another response is performed (i.e., when it chooses the not-pointed bowl or if it looks at a place other than the human face). In general, a decrease in the target response and an increase in alternative behaviours are observed. This procedure allows one to evaluate whether a response fundamentally depends on its instrumental consequences, that is to say, on reinforcement processes (Mackintosh, 1983).

In the first place, the omission effect upon the gaze towards a human face was evaluated, which led to the finding that the response decreased along trials (Bentosela et al., 2008). Secondly, in an object choice task, the dog's choice behaviour was studied when the reinforcer was not in the pointed bowl, but in the not-pointed one (Elgier et al., 2009). In this case, the task is equivalent to a reversal test since the animal must inhibit its learned response of going to the pointed-to place, and learn the opposite response. All the animals acquired the response of going to the not pointed-to place. Again in this case, for a binomial distribution, the probability of giving four consecutive reversal responses above chance was 0.0625. In addition, dogs learned the omission significantly faster when the cue was given by the owner, compared with the group that received the cue from the unfamiliar person.

These results together reveal that communicative abilities of domestic dogs are responsive to changes in environmental contingencies, and specifically to the consequences that come from humans in different situations. On the other hand, the differences found between owner and stranger groups suggest the importance of the previous learning history of communicative cues.

Another relevant feature in the study of learning effects is to compare the performance of the dogs in social and physical cues following. In the next section, studies that investigated the above-mentioned relationships are described.

3. Social and non-social cues following

Using an object choice task, it was found that dogs use odour cues to find hidden food. However, the mere presence of a human between the two bowls, without giving any cue, alters the performance leading to chance level (Szetei et al., 2003). When the cues were social (pointing) vs. physical (odour), dogs preferred the pointing cue. In another situation, where dogs had to choose between two transparent containers with different amounts of food, they chose the one with the higher amount. When the owner approached the container with the lower quantity of food and made verbal expressions of appetite for it, the dogs' preference for this option increased, compared to the owner absence group. Nevertheless, dogs did not show a significant preference for either of the two options. The preference for the bowl marked by the owner was only significant when the two containers had a similar amount of food (Prato-Previde et al., 2008). In another study, Erdöhegyi et al. (2007) found that dogs used direct visual information (i.e they can see where the reinforcer is) to choose between two possible locations of food, even when that information was competing with a social cue (e.g., gaze cues). When there was no direct information about the reinforcer location, dogs preferred the human marked container, compared to a group that received a movement cue (non-social).

In a social learning task in which animals had to make a detour to get the reinforcer, dogs that learned to solve the problem by imitating a human demonstrator continued imitating the person, even when there was a shorter route to access the reinforcer (Pongracz et al., 2003).

In sum, studies of the use of social vs. physical cues to guide dogs' choice behaviour tend to the conclusion that they have a preference for the social ones. Nevertheless, in these works the previous history that dogs have with physical cues was not controlled, which makes it difficult to explain this preference.

Table 1
Characteristics of dogs used in Studies 1 and 2. Trained Group: received a visual discrimination training. Untrained Group: did not receive that training.

Subject	Gender	Age	Breed	Group	Study
Goofy	M	3	Poodle	Trained	1
Julieta	F	6	Beagle	Trained	1
Lola	F	6	German Shepherd	Trained	1
Lost	M	3	Labrador	Trained	1
Astor	M	4	Mixed	Trained	1
Princesa	F	6	Mixed	Trained	1
Brisa	F	7	Mixed	Trained	1
Morena	F	7	German Shepherd	Untrained	1
Tina	F	9	Mixed	Untrained	1
Magui	F	9	Mixed	Untrained	1
Estrella	F	5	Mixed	Untrained	1
Homero	M	9	Boxer	Untrained	1
Esopo	M	3	Old English Sheepdog	Untrained	1
Chiara	F	7	Argentine Dogo	Trained	2
Pepe	M	7	Labrador	Trained	2
Reina	F	6	Mixed	Trained	2
Maggie	F	2	German Shepherd	Trained	2
Sandy	F	6	Mixed	Trained	2
Mendieta	M	3	Samoyed	Trained	2
Luna	F	4	Afghan	Untrained	2
Tucho	M	8	Mixed	Untrained	2
Lupé	F	5	Labrador	Untrained	2
Bosco	M	4	German Shepherd	Untrained	2
Juanita	F	8	Mixed	Untrained	2
Giorgio	M	4	Labrador	Untrained	2

One of the most-used arguments to explain dogs' preference for social cues, even when these do not give access to the reinforcer, is related again to the process of domestication to which they were submitted. According to several authors, dogs have lost several of their reasoning abilities during domestication, since human beings have solved many of their problems (Szetei et al., 2003; Bräuer et al., 2006; Erdöhegyi et al., 2007).

On the other hand, Prato-Previde et al. (2008) found that highly trained and older dogs were less inclined to follow their owners' choice in a quantity discrimination task. This would indicate that those animals are not blindly ruled by the human cue. In the Szetei et al. (2003) work, to see the human hiding the food had the same value that pointing did, so it could be suggested that it is the association of the food with the human and not only the communicative cue which guides dog behaviour. In this line, we developed two studies with the aim of studying the learning effect upon social vs. physical cues following, using the object choice task.

In the usual environment of dogs, food and other reinforcers are obtained through humans. But if in a certain context, access to the reward is indicated by a non-social stimulus, such as the colour of the bowl, then the animals' preference for social cues would be reversed. This would demonstrate that the decision rule is not always to follow the social cue, but to follow the most informative one, or that which was previously associated with the reinforcer. The dog would use the signal with more associative strength. The following studies were performed to test this hypothesis.

3.1. Studies on comparative performance on social and non-social cues

3.1.1. Study 1

3.1.1.1. Materials and methods.

3.1.1.1.1. Subjects. Thirteen adult dogs were used, 5 males and 8 females (*C. familiaris*; mean age = 6.08 years; range 3–9 years), that had lived with human families since they were puppies. Prior approval to participate in the study was given by the owners of all subjects. Dogs were food deprived 6 h on average before the beginning of the experiment. See Table 1 for a list of the subjects showing their breeds, sexes and ages.

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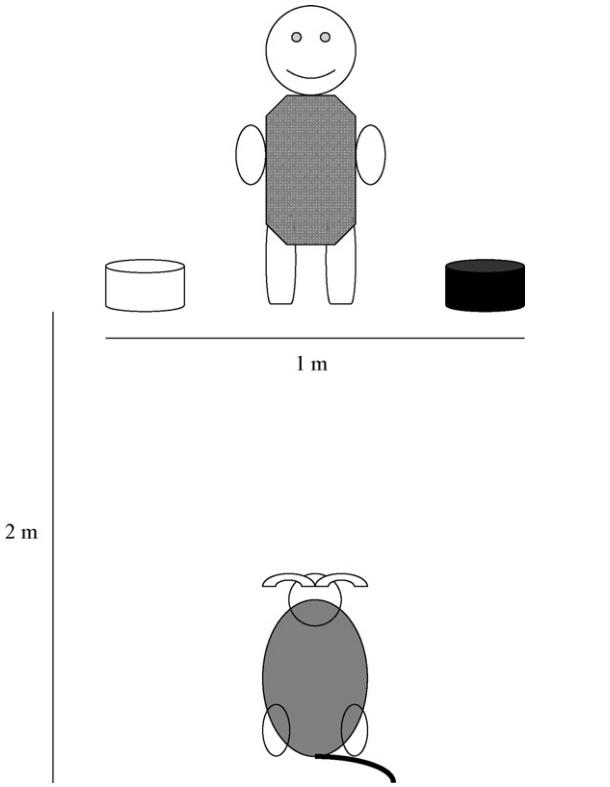

Fig. 1. Schematic situation of the testing scenario during choice trials in phase 2, and in phase 3.

3.1.1.1.2. Experimental conditions and apparatus. The observations were made in a familiar environment for the dogs. For hiding the food, two opaque containers were used, one white and the other black, of 45 cm in diameter and 15 cm in height. These containers were placed on two chairs. The height of the chairs varied based on the size of the subjects, in such a way that the dogs did not have visual access to the content of the containers. The containers were separated 1 m from each other. The human pointer was placed between the chairs, 50 cm from each one. The starting point of the dog was 2 m in a straight line from the position of the human pointer. The dog was always next to a handler, who guided it to the start point with a 1-m long leash. During the training phase, the person who pointed, the handler and the dog were present. As reinforcer, small pieces of dry liver of 3 g were used. Each bowl had a piece of liver under it, and they were previously smeared with the reinforcer, in order to control the odour. See Fig. 1 for the experimental setup.

3.1.1.2. Procedure. Animals were randomly assigned to two groups: a group with visual discrimination training (Trained Group, $n = 7$), and another without training (Untrained Group, $n = 6$). The whole procedure involved three phases: Pretraining, Visual Discrimination Training and Social vs. Visual Cues Competition.

Phase 1. Pretraining: Pretraining for both groups began after a familiarization of approximately 3 min, where the handler interacted with the dog, allowing it to freely explore the place. During this phase, only one bowl was placed: the one that contained a piece of liver. This bowl contained the food during the whole experiment. The pointer remained standing with the arms behind and looking at the animal during the whole trial. The handler gently led the dog to the baited container and left it to eat the reinforcer. Four consecutive trials were realized, randomly placing the baited bowl two times to each side. For half of the animals, the white bowl was used, and for the rest the black one.

Phase 2. Visual discrimination training: Immediately after the pretraining phase, the visual discrimination training began, only for the Trained Group. This phase had two stages. One consisted of two sessions of 10 forced trials with an interval between trials (ITI) of 30 s, and an interval between sessions of 10 min. Only one bowl was present. This one was the same as in phase 1, and had food inside. The dog was guided to the starting position by the handler; the experimenter between the chairs looked at the dog's eyes for 3 s, and called it by his name without giving any signal. The handler loosened the leash, so that the subject could approach the bowl and consume the food. The bowl was randomly placed to the right or to the left, and this location was not repeated in more than two consecutive trials.

After 10 min, the second stage began. This consisted of 5 sessions of 10 trials, with two bowls available (black and white). The ITI was 30 s, and the interval between sessions was 10 min. The training was exactly equal to the forced trials of the pretraining, except that now the two bowls were present, and the dog had to choose: the colour that had always been reinforced, or the other. If it chose the baited bowl (the same as in the pretraining and the first stage of the training), it was allowed to eat and this response was recorded as correct. If it went to the unbaited bowl, the handler said "no" and showed that this bowl was empty, and then showed the baited one, but the dog was not allowed to eat the reinforcer. In this case, the trial was repeated (the baited bowl was on the same side) until the subject gave a correct response. All trials were assessed independently if the response was correct or not or if it was a correction trial.

Phase 3. Social vs. visual cues competition: In this phase, the performance of the Trained Group was compared with that of the Untrained Group that did not receive any colour discrimination training. This phase started 10 min after the visual discrimination training for the Trained Group, and 10 min after the pretraining phase for the Untrained Group.

The cues competition phase for both groups consisted of a session of 10 trials with an ITI of 30 s. In each trial, both cues were given simultaneously to the dog: the colour of the baited bowl and the proximal pointing of the experimenter towards the empty bowl. When the dog was in the starting position, the experimenter called it by name, waited for 3 s and then pointed to the empty container. The handler loosened the leash and the dog was allowed to choose between both containers. A trial was considered as correct when the dog chose the baited bowl. If it chose the correct one (using as discriminative stimulus the previously reinforced colour), it was allowed to obtain to the reinforcer. If the dog made an incorrect choice and went to the pointed place, it was not allowed to eat. When the subject gave an incorrect response, the same side was repeated until the dog made a correct response.

3.1.1.3. Data analysis. For the cues competition phase, an independent samples *t*-test was used, with Group as between-subject factor (Trained Group vs. Untrained Group) and number of correct trials as dependent variable. A binomial test was used to compare groups' performance with chance level.

3.1.1.3.1. Results. During the last visual discrimination training session, animals completed an average of 9.14 correct responses (going to the baited bowl).

Fig. 2 shows the average number of correct responses of Trained and Untrained animals during phase 3. The performance of each group, measured as the number of times that dogs chose the baited bowl during phase 3, was compared with an independent sample *t*-test showing significant differences, $t(11) = 4.741$, $P < 0.001$. The Trained Group in visual discrimination had an average of 6.43 correct responses, S.E.M. $\pm$ 2.37, while Untrained Group had an average of 1.33 correct responses, S.E.M. $\pm$ 1.21. This result suggests on one hand, that the animals of the Trained Group used the previously

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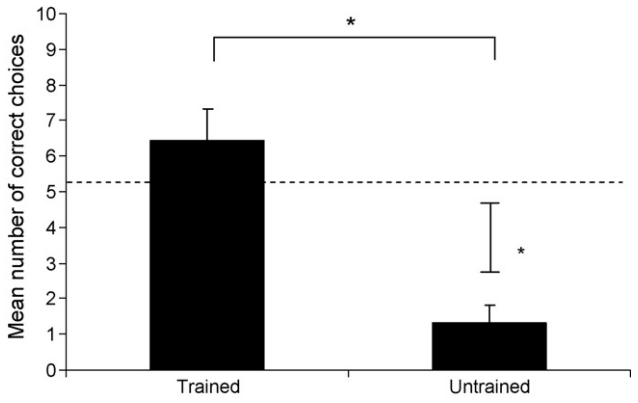

Fig. 2. Mean number (±S.E.M.) of correct choices in Trained vs. Untrained dogs during phase 3 of Study 1. Dotted line represents chance performance level (50%). Untrained Group is significantly below the chance level $^{*}P < 0.05$. Groups differ significantly between them $^{**}P < 0.01$. The social cue used was proximal pointing.

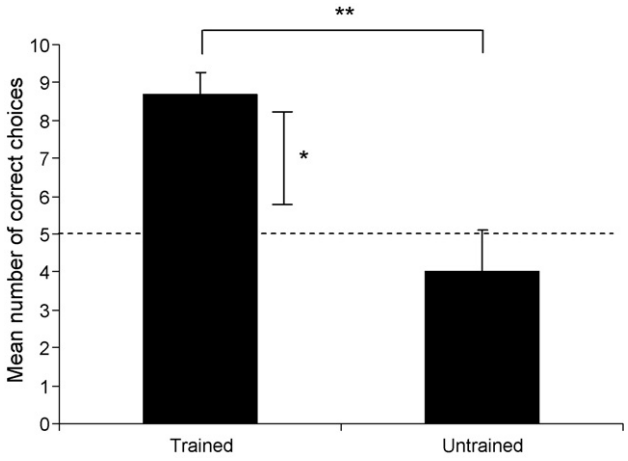

Fig. 3. Mean number (±S.E.M.) of correct choices in Trained vs. Untrained dogs during phase 3 of the Study 2. Dotted line represents chance performance level (50%). Trained Group is significantly above chance level $^{*}P < 0.05$. Groups differ significantly between them $^{**}P < 0.01$. The social cue used was elbow pointing.

learned colour cue significantly more than the Untrained Group to gain access to the reinforcer. Nevertheless, following a binomial distribution, the Trained Group performed at chance level ($P = 0.117$), whereas Untrained Group was significantly below the chance level ($P = 0.043$). These results suggest that pointing has a high informative value and interferes in the Trained Group performance. Moreover, the animals of the Untrained Group chose this signal even when it was not reinforced.

It is possible to conclude that training on a physical cue (colour of the bowl) was successful in reverting the dog's preference for the pointing cue but it was not effective enough to generate a preference for the colour in presence of the pointing. For this reason, we carried out a second study where a less salient social cue was used. In this case, we compared dogs' performance in the use of a colour cue vs. elbow pointing as a social cue.

3.1.2. Study 2

3.1.2.1. Materials and methods.

3.1.2.1.1. Subjects, experimental conditions and apparatus. Twelve adult dogs were used, 5 males and 7 females (*C. familiaris*; mean age = 5.33 years; range 2–8 years). See Table 1 for a list of the subjects showing their breeds, sexes and ages.

The experimental conditions and apparatus were identical to those utilized in Study 1. See Fig. 1 for the experimental setup.

3.1.2.2. Procedure. The procedure was identical to Study 1; the only difference was that in the phase of social vs. visual cues competition, the social cue used was elbow pointing (Soproni et al., 2002) instead of proximal pointing.

3.1.2.3. Data analysis. For the cues competition phase, an independent samples *t*-test was used, with Group as between-subject factor (Trained Group vs. Untrained Group) and number of correct trials as dependent variable. A binomial test was used to compare groups' performance to chance level.

3.1.2.4. Results. During the last visual discrimination training session, animals realized an average of 8.66 correct responses (going to the baited bowl).

Fig. 3 shows the average of the correct responses of Trained and Untrained animals during phase 3. The performance of each group, measured as the number of times that dogs chose the baited bowl during that phase, was compared with an independent sample *t*-test showing significant differences, $t(10) = 3.639$, $P < 0.005$. The Trained Group in visual discrimination had an average of 8.67 correct responses, S.E.M. ± 1.50, while Untrained Group had an average of 4 correct responses, S.E.M. ± 2.75. This result suggests that the animals of the Trained Group used the previously learned colour cue significantly more than the Untrained Group to gain access to the reinforcer. Following a binomial distribution, the Trained Group performed significantly above chance level ($P = 0.009$), whereas Untrained Group performed at chance level ($P = 0.205$). These results would indicate that the training in discrimination was effective in developing a preference for the physical cue (colour), in comparison to a lesser salient social cue like elbow pointing. The Untrained Group, on the other hand, did not show a preference for any type of cue.

4. General discussion

The results showed that training in the use of a non-social stimulus to obtain food changed the dogs' preference for social cues in a specific situation. These findings support the hypothesis that instrumental learning has a role in human–dog communication. Nevertheless, in Study 1 dogs did not show a preference to the colour since their performance did not differ from chance level. It is probable that proximal pointing is a signal with a high informative value for the dogs and with a long history of learning. This, in turn, could explain why the pointing interfered with the performance of the dogs related to the colour cue. Bearing this hypothesis in mind, we carried out a second study with an unusual social cue (elbow pointing) which is less salient for the dogs. In this case, dogs showed a significant preference for the non-social cue. In addition, the subjects of the Untrained Group behaved at chance level when responding to elbow pointing. This result would indicate that the animals had less previous experience with this cue.

As a whole, previous data from our laboratory showed that dogs' gaze towards a human face, and following a human point, could be modified by environmental contingencies (Bentosela et al., 2008, in press; Elgier et al., 2009). That is to say, these responses increased when they were reinforced, and decreased when they did not lead to a reinforcer, or to a reinforcer of lower quality. Therefore, it seems that dogs' behaviour depends, in part, on the expected outcomes in each situation.

Furthermore, dogs are not only capable of following and emitting communicative responses towards a human, but are also able to learn to ignore human cues and not to emit communicative cues when these responses are no longer successful (Bentosela et al., 2008, in press; Elgier et al., 2009).

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Udell et al. (2008a) found that wolves with an appropriate socialization and with daily contact with humans, are not only capable of following human cues like domestic dogs, but also under certain conditions, can outperform them. Keeping this in mind, the domestication process alone is not enough to explain the high sensibility of an untrained subject to follow human cues. Moreover, domestic dogs with different life histories (pet dogs vs. shelter dogs) perform differently during interspecific communicative tasks.

In spite of the scientific literature giving a major role to domestication process and to complex cognitive skills in dogs, the studies reviewed in this article show the importance of ontogenetic development in the performance of communicative interactions between dogs and humans, and particularly support the influence of associative learning.

Pet dogs share a lot of time with humans, so they have more opportunities to learn social cues than any other species. Interaction with humans becomes essential, because they manage the access to the reinforcers; therefore, dogs learn that some social stimuli predict the location of food (Udell et al., 2008b). This would explain the preference of these animals for social cues, instead of the physical ones. Nevertheless, when the relevant cues are non-social, such as the ones used in our studies, animals do not blindly follow the social signals.

In synthesis, dogs seem to make decisions based on the optimal strategies to gain access to reinforcers; frequently this strategy consists in following human communicative cues.

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