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# Effect of reinforcement, reinforcer omission and extinction on a communicative response in domestic dogs (*Canis familiaris*)

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ABSTRACT

There is a controversy about the mechanisms involved in the interspecific communicative behaviour in domestic dogs. The main question is whether this behaviour is a result of instrumental learning or higher cognitive skills are required. The present investigations were undertaken to study the effect of learning processes upon the gaze towards the human's face as a communicative response. To such purpose, in Study 1, gaze response was subjected to three types of reinforcement schedules: differential reinforcement, reinforcer omission, and extinction in a situation of "asking for food". Results showed a significant increase in gaze duration in the differential reinforcement phase and a significant decrease in both the omission and extinction phases. These changes were quite rapid, since they occurred only after three training trials in each phase. Furthermore, extinction resulted in animal behaviour changes, such as an increase in the distance from the experimenter, the back position and lying behaviour. This is the first systematic evaluation of the behavioural changes caused by reward withdrawal (frustration) in dogs. In Study 2, the gaze response was studied in a situation where dogs walked along with their owners/trainers. These results show that learning plays an important role in this communicative response. The possible implications of these results for service dogs are discussed.



## 1. Introduction

There is evidence showing that domestic dogs have several skills that allow them to respond successfully to different signals given by humans (Miklósi et al., 2004; Hare and Tomasello, 2005). Dogs use human pointing, body posture, gaze direction, touching or marking as cues to find hidden food. They may even solve this kind of situation at their first attempt (Hare and Tomasello, 1999; Soproni et al., 2001).

Dogs use their own gaze towards humans as a communicative signal. 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, the dog tends to initiate eye contact with its owner 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). These results may show that gaze to a human face as a communicative signal might have arisen as a result of the domestication process (Miklósi et al., 2003; Kubinyi et al., 2007).

The main question is whether this communicative ability should be regarded as an associative learning situation where the subject forms an association between a cue and the place of reward, or whether this is a communicative situation where subjects might learn about the meaning of the cue, thus requiring higher cognitive skills (Miklósi et al., 1998; Soproni et al., 2002; Braüer et al., 2006; Riedel et al., 2006). Miklósi and Soproni (2006, pp. 91) stated that "results suggest the functioning of a more complex mental representational system behind such comprehension than one would assume on the basis of simple associative phenomena". However, Shapiro et al. (2003) argued that all experimental evidence of pointing comprehension could be explained by "simple conditioning processes". Also, Povinelli and Giambrone (1999) proposed the "low-level" hypothesis, which explains performance in such communicative situations by assuming that low-level associative learning is at work.

The major focus of research on instrumental conditioning is on the relation 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 probability that the subject will engage in the same behaviour in the future. Signals such as gazing at the owner's face, which produce the delivery of a reward, would be repeated

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under similar conditions, mainly through the reinforcement processes. Second, if the behaviour does not produce appetitive consequences while other responses receive positive outcomes, the first behaviour probability decreases. This phenomenon is known as “omission”. Third, when that behaviour no longer produces positive consequences, it gradually decreases. This phenomenon is known as “extinction” (Thorndike, 1911; Skinner, 1953). Gaze response would decrease in omission and extinction.

Despite the controversy about the mechanisms involved, systematic studies on the effect of environmental contingencies upon the emission of these communicative signals by dogs have not been performed yet. There is only one preliminary study in which three puppies were reinforced with a clicker sound and food after making eye contact with the experimenter (Gácsi et al., 2005). Results showed that gaze duration towards the experimenter increased significantly during trials. The authors concluded that “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 interpreted because control groups were not included.

The purpose of this work was to study how learning processes modulate communicative signal emissions in domestic dogs. Study 1 assessed the appetitive reinforcement, omission and extinction effect on the gaze to an unknown trainer’s face in domestic dogs. This response was measured when food was visible but out of its reach. In this situation dogs had to make eye contact with the human in order to have access to the food (Miklósi et al., 2000).

During the extinction phase two other aspects were studied. First, when response is no longer reinforced, said response decreases. However, if a period of time without training is inserted, a partial recovery of behaviour is observed, which has been called “spontaneous recovery” (Pavlov, 1927). Second, reward withdrawal produces an aversive emotional reaction called “frustrative nonreward” (Amsel, 1992). This effect includes a glucocorticoids release and an increase in locomotor activities, vocalizations, rearing and conditioned avoidance responses in rats (e.g., Papini and Dudley, 1997; Bentosela et al., 2006). To look for the presence of possible emotional reactions during extinction, frequency of being away from the experimenter, body postures, the presence of vocalizations, rearing and the body’s orientation with respect to the experimenter were assessed.

In Study 2, the effect of reinforcement on the gaze towards the human’s face during a walk with its owner/trainer was assessed. The purpose was to compare gaze duration of dogs trained to look at the human’s face (sport dogs) to non-trained dogs for such performance.

These experiments could also give new insight concerning the processes involved in human–dog communication. If the response of looking at the human face can be modified through instrumental conditioning processes such as the ones used in the present paper, then it is possible to suppose that this communicative ability involves an associative learning mechanism.

Finally, our results could add some evidence concerning how flexible such communicative behaviours are. Flexibility is the ability to adapt ongoing behaviour to environmental changes. Several functions, including response selection, inhibition, extinction and reversal or omission learning, underlie this ability (Van der Plasse and Feenstra, 2008). We exposed the dogs to a brief experience in every reinforcement schedule. If the animals changed their behaviour after such brief training, we could assume that they were exhibiting flexible responses.

**Table 1**
Characteristics of the dogs used in the Study 1: breed, gender (M: male, F: female), age and experimental group of each dog

| Breed | Gender | Age (in years) | Group |
|---|---|---|---|
| Labrador | M | 1 | Omission |
| Braco | M | 6 | Omission |
| Cocker Spaniel | F | 1 | Omission |
| Samoyed | F | 3 | Omission |
| Rottweiler | F | 2 | Omission |
| Labrador | F | 2 | Omission |
| Labrador | M | 1 | Extinction |
| Labrador | M | 2 | Extinction |
| Beagle | F | 1 | Extinction |
| Weimaraner | M | 6 | Extinction |
| Labrador | F | 2 | Extinction |
| Labrador | M | 3 | Extinction |
| Labrador | M | 3 | Extinction |

## 2. Study 1

### *2.1. Materials and methods*

#### *2.1.1. Subjects*

Thirteen adult dogs of both sexes (seven males and six females), non-neutered, of different breeds, from family houses were used. The experimenter had no previous contact with the animals. The dogs had free access to water, and their last meal was between 12 and 14 h before the beginning of the study. Table 1 presents a detailed description of each dog and of the experimental treatment to which they were assigned.

#### *2.1.2. Experimental conditions and apparatus*

The observations were performed in a training/boarding establishment familiar to the dogs. The testing took place in an outdoor area. A 20 cm diameter food plate was placed on a cement wall, 1.30 m high. The food (liver) was visible to the dog but placed beside and below the experimenter’s face, to discriminate dog’s gaze direction. The dog was tied to a tree with a 3 m long leash, so that it had room to move but was unable to leave the experimental area.

Trials were recorded with a video camera (Sony DCR TRV 310, Japan). The video camera was placed behind the wall where the food receptacle was located. Small dried cow liver pieces (of approximately 0.3 g) were used as reinforcers.

#### *2.1.3. Procedure*

A within-subject design was used. Food was in sight but out of the dog’s reach. Solicitation for food was recorded: gaze response was defined as the dog looking at the experimenter’s face (directing both its head and gaze). In the first phase, the experimenter reinforced gaze direction towards the human face using a piece of food as a reinforcer. The effect of the reinforcing procedure was measured in terms of the duration and frequency of the dog’s gaze towards the trainer’s face. In the second phase, six animals received an omission procedure and the remaining animals (seven), an extinction procedure.

During all conditions, reinforcement, omission and extinction, the experimenter looked at the dog continuously and independently of its behaviour.

*2.1.3.1. Warm up trials.* During this phase, each dog was placed and tied in the experimental area. The experimenter actively approached the dog to pet, to play and to give it three pieces of food, irrespective of the dog’s behaviour. This period lasted approximately 3 min.

*2.1.3.2. Baseline.* Immediately after the warm up trials, the baseline of the gazing response was recorded. The objective of the baseline was to observe the basal gazing response before the acquisition phase, and then compare it with the animal's subsequent performance (Barlow and Hersen, 1984). Session started with calling the dog by its name. Animals that approached the experimenter were given a piece of liver. After this, the experimenter remained standing, without moving, 50 cm away from the food receptacle with the head and the gaze facing the animal. Independently of the dog's behaviour, the trainer delivered a piece of food every 30 s. The trial lasted for 2 min.

*2.1.3.3. First phase: acquisition.* Dogs were exposed to three 2 min trials of differential reinforcement. The intervals between baseline, the first acquisition trial, and the inter-trials interval (ITI) were about 2 min. Acquisition trials began when the experimenter was placed next to the food receptacle, called the dog by its name and delivered a reinforcer. During these trials, differential reinforcement of the gaze response was performed. We used a fixed ratio 1 schedule: the experimenter delivered a piece of food whenever the dog was directing its gaze toward the human face, with a minimum required response duration of 1 s. At the end of each trial, the experimenter left the experimental area.

*2.1.3.4. Second phase.* In the second phase, six dogs were randomly assigned to the Omission group and the remaining seven dogs to the Extinction group.

*2.1.3.5. Omission group.* The interval between acquisition and omission phases lasted for 2 min. Omission training was given during three 2-min-trials with a 2-min ITI. Whenever the animal was directing its gaze to the experimenter's face, no reinforcer was delivered. However, a piece of food was given to the dog whenever it was directing its gaze to any point in space other than the experimenter's body. At the end of each trial, the experimenter left the experimental area.

*2.1.3.6. Extinction group.* The interval between acquisition and extinction phases lasted for 2 min. This phase started by calling the dog by its name, but without giving it food. The experimenter remained in the same place as on previous trials. After 2 min, the trial ended and the experimenter left the area. Three extinction trials were performed with a 2-min ITI.

*2.1.4. Data analysis*

All trials were videotaped and two independent observers performed the behaviour recording. For all the measures recorded the reliability between observers was calculated using agreement percentage. For each behaviour, we obtained two measures belonging to each observer. Then we divided the lowest value by the highest and multiplied the result by 100. The minimum percentage of agreement tolerated was 90%.

Accumulated duration and frequency of gazes to the experimenter's face for each trial was measured. The results were analyzed using an Analysis of Variance (ANOVA) with trials as a repeated measure, after verifying that the distributions were normal (Kolmogorov–Smirnov Test). Post hoc comparisons were performed (Scheffé's Test). In addition, Pearson's correlation was made for consistency between both measures (duration and frequency). Accumulated gaze duration and frequency showed a significant positive correlation, $r = 0.7$, $p < 0.0001$. Given that both measures were consistent and the analysis of gaze duration and frequency were not different, only duration data are shown.

Baseline was analyzed dividing the trial into 4 blocks of 30 s each, and accumulated gaze duration in each block was measured to evaluate the intra-trial response development. The first block and the last block were compared, using ANOVA, with the variable block as a repeated measure.

On the other hand, during extinction phase two more measures were performed. In order to evaluate the existence of spontaneous recovery, each one of the three extinction trials was divided in 4 blocks of 30 s each. The accumulated gaze duration was measured in each block. Then, each trial last block was compared with the first block of the next trial using the Least Significant Difference (LSD) Test, for the study of the gaze response's spontaneous recovery after the ITI without training.

To assess the behavioural changes produced during extinction we compared the responses during extinction with the behaviours observed during the last acquisition trial. Accumulated frequency of the behaviours in every trial was measured by two independent observers through instantaneous sampling (every 5 s).

The behavioural categories recorded for each dog were:

1. Approach to the experimenter: (a) near (N), the dog remained within a range of 0.5 m from the experimenter; (b) far (F), the dog remained more than 0.5 m from the experimenter; in both cases disregarding body and head position.
2. Postures: (a) sitting (S); (b) standing (St); and (c) lying down (L).
3. Other behaviours: (a) rearing (R), standing on hind legs with front paws on person or object; (b) vocalizations (V), including barking, groaning, and howling; and (c) back (B), dog's whole body oriented to the opposite side of the experimenter.

## 2.2. Results

*2.2.1. Phase 1: baseline and acquisition*

Fig. 1 shows the results of the average accumulated duration(s) of the dogs' gaze as a function of baseline, acquisition (differential reinforcement), omission, and extinction trials. An intra-trial analysis as divided into four 30 s blocks, revealed a significant difference between the first and the fourth block (first baseline block, mean = 6.51, S.E.M. ± 5.55 s; last baseline block, mean = 3.31, S.E.M. ± 3.84 s) $F(1, 12) = 11.15$, $p < 0.005$. This result suggests that during baseline training, the animals significantly diminished the duration of the response towards the end of each trial, probably due to non-reinforcement. This result showed that the baseline negatively affected the animal's performance, so it did not yield an adequate comparative measure of the animal's behaviour before acquisition phase.

The gaze duration gradually increased across acquisition trials in all animals. The analysis of the three acquisition trials revealed

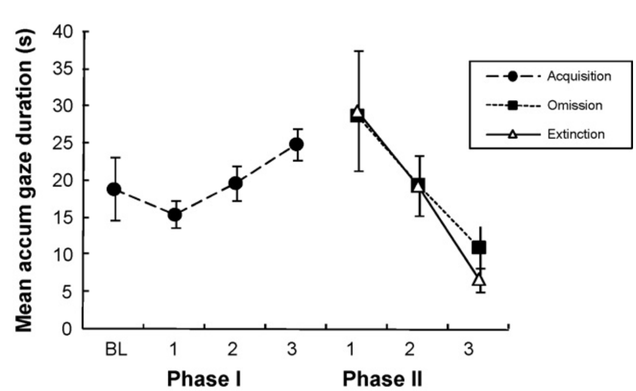


**Fig. 1.** Mean and standard error of accumulated gaze duration(s) of dogs towards the experimenter's face during baseline, Phase I (acquisition of the response, $n = 13$) and Phase II (omission, $n = 6$ and extinction, $n = 7$), Each phase consisted of three 2-min trials.

a main significant effect of Trial, $F(2, 24) = 7.31$, $p < 0.003$, indicating that the response increased with repeated reinforcement during acquisition training. Nevertheless, the comparison between the baseline and the last acquisition trial did not show any significant difference, $F(1, 12) = 2.05$, $p > 0.05$ (see Fig. 1, Phase I). Since during baseline training, the animals significantly diminished the duration of the response, it is possible that this result explains the decrease of the response observed in the first acquisition trial, compared to the baseline.

### *2.2.2. Omission group*

The average gaze duration during the three omission trials indicated that this response decreased over trials. An analysis with trials as repeated measure revealed that the decrease was significant, $F(2, 10) = 7$, $p < 0.01$. Post hoc comparisons showed a significant difference in the third trial, $p < 0.01$. An analysis comparing the last acquisition trial and the last omission trial showed a significant difference between them, $F(1, 5) = 16.53$, $p < 0.009$, indicating that gaze significantly diminished during the omission training (see Fig. 1, Phase II).

### *2.2.3. Extinction group*

Fig. 1 (Phase II) shows the average results of accumulated gaze duration during the three extinction trials. A gradual decrease of the response is observed according to our prediction. An ANOVA indicated a significant main effect of Trials, $F(2, 12) = 6.71$, $p < 0.01$, showing that the reinforcement withdrawal diminished the gaze duration. Pairwise Scheffe Test showed a significant difference in the third trial, $p < 0.01$. The statistical comparison of the last acquisition trial and the last extinction trial showed a significant difference, $F(1, 6) = 36.82$, $p < 0.001$, indicating that extinction training produced a significant decrease of gazing compared with the performance of the animals during acquisition.

### *2.2.4. Spontaneous recovery*

Fig. 2 shows extinction performance in terms of four 30 s blocks for each of the three trials. The within-trial pattern of responses suggests spontaneous recovery, a common property of behaviour during extinction (Pavlov, 1927).

The analysis of the four blocks of all three extinction trials showed a significant effect of Trial, $F(2, 12) = 4.51$, $p < 0.03$, of Block, $F(3, 18) = 13.83$, $p < 0.001$, and of the interaction Trial × Block, $F(6, 36) = 2.70$, $p < 0.03$. These results indicate a decrease of the response along trials and within each trial. In the last case (within-trials), this difference is larger for the first trial than for the last one. Moreover, the later comparison between the last block of the first trial of extinction, and the first block of the second trial, showed a significant difference ($p < 0.001$), reflecting spontaneous recovery of the response. Comparison between the last block of the second trial, and the first block of the third trial, did not show significant differences, $p > 0.05$. The spontaneous recovery effect was only evident in the second trial.

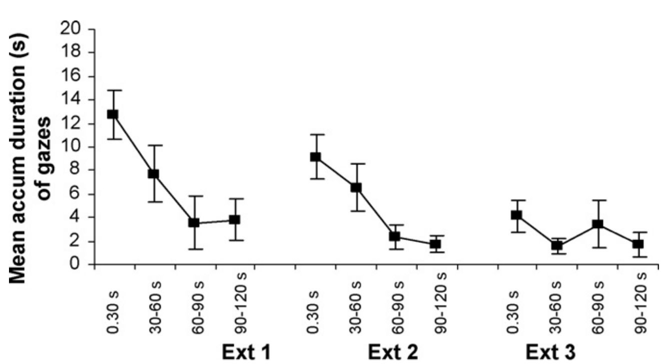


**Fig. 2.** Mean and standard error of accumulated gaze duration(s) of dogs towards the experimenter's face as counted on four 30-s blocks in each of the three extinction trials.

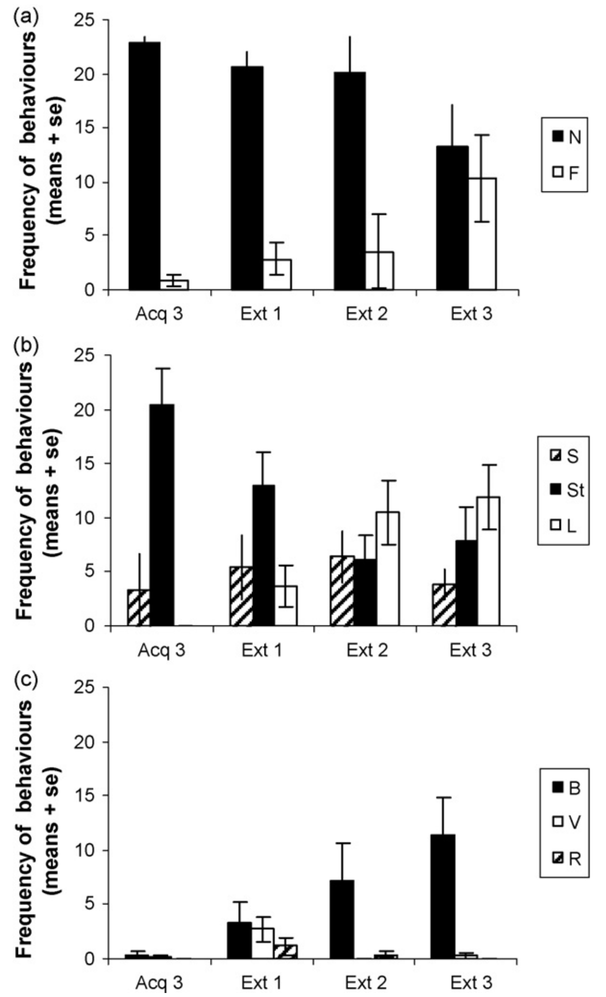


**Fig. 3.** Mean and standard error of accumulated frequency of behaviours in the last acquisition trial and three extinction trials. The following behaviours were recorded by instantaneous sampling method every 5-s. (a) Approach behaviours: near (N) and far (F) from the experimenter; (b) body postures: sitting (S), standing (St) and lying down (L); (c) others behaviours: backs to the experimenter (B), vocalizations (V) and rearing (R).

### *2.2.5. Extinction behaviours*

Fig. 3 shows the results of the responses measured during the last acquisition and extinction trials.

There was a significant decrease of the position of approach to the experimenter, $F(1, 6) = 6.33$, $p < 0.04$, and an increase of the distance, $F(1, 6) = 6.10$, $p < 0.04$ (see Fig. 3a). Fig. 3b shows an increase of both back position to the experimenter frequency, $F(1, 6) = 9.57$, $p < 0.02$, and lie downs, $F(1, 6) = 15.42$, $p < 0.02$. There was also a significant decrement of the standing position frequency, $F(1, 6) = 11.03$, $p < 0.01$. On the other hand, Fig. 3c shows no significant differences in vocalizations, $F(1, 6) = 0.17$, $p > 0.05$, and rearing.

In conclusion, these results indicate that the dog's behavioural pattern in the last acquisition trial mainly involved being near to the experimenter, standing, and with the body faced towards the person. During the extinction trials, dogs moved away and turned their back to the experimenter and also lay down.

## 3. Study 2

We compared the responses of dogs which were involved in advanced training programs applied to sport with control dogs. In the Schutzhund sport, one of the exercises that the dogs must perform is "heeling", which involves walking near to their owner's or guide's left hand, while looking at the face of the human. Dogs in this sport are specifically trained to gaze at the face of the person, while they walk. Control dogs did not have specific training in gaze towards the owner's face during a walk. Animals trained in basic obedience usually walk next to their owners but do not have explicit gaze direction training. Comparison between experimental and control dogs will allow the evaluation of the effects of reinforcement on gazing towards humans in a different context using dogs trained by different persons, methods, and diverse training duration.

### *3.1. Materials and methods*

#### *3.1.1. Subjects*

We used 18 adult dogs of both sexes and different breeds, from family homes. The experimental group included nine sport-trained dogs (Schutzhund sport). They had been trained by different guides and with different training techniques involving the use of positive reinforcement (e.g., food, playing with a ball, petting, and verbal rewards) as well as aversive stimuli (e.g., mild electric shocks administered through an electric collar). The control group comprised nine dogs without any kind of training, although some of them had basic obedience training (simple commands like sit and lie). Dogs had free access to water and food. Table 2 shows a detailed description of the subjects.

#### *3.1.2. Experimental conditions and apparatus*

The observations were done outdoors in a street, garden, or park where these dogs were usually trained or walked. Each dog was led by a 1 m leash and handled by their respective owner/trainer.

#### *3.1.3. Procedure*

The trial began with the dog standing beside the human, both facing front. The walk started when the owner/trainer called the dog by its name and gave it the command to walk next to him/her. The walk lasted 30 s. During that time, the owner/trainer held the dog's leash, therefore, the dog could not go further than 50 cm away from the person. During this time, the owner/trainer looked ahead without directing his/her attention to the dog, and did not give any new commands, reinforcer or correction.

#### *3.1.4. Data analysis*

The walk was videotaped. Accumulated duration(s) of the dogs' gaze to the owner/trainer's face was measured during the entire 30 s walk. As in study 1, reliability between observers was above the 90%-criterion of minimal agreement. One factor ANOVA was performed comparing subjects from the sport-trained and untrained groups, after verifying that the distributions were normal (Kolmogorov–Smirnov Test).

### *3.2. Results*

The sport-trained animals looked at the human face during almost the full duration of the trial (mean = 24.4, S.E.M. ± 9.28 s), while non-trained animals did it to a lesser extent (mean = 1.85, S.E.M. ± 1.85 s). An analysis indicated that this difference was significant, $F(1, 16) = 51.6$, $p < 0.0001$.

**Table 2**
Characteristics of the dogs used in Study 2: breed, gender (M: male, F: female), age in years, training and months of training

| Breed | Gender | Age | Training | Training time (in months) |
|---|---|---|---|---|
| German Shepherd | F | 3 | Schutzhund | 6 |
| Rottweiler | F | 0.10 | Schutzhund | 2 |
| German Shepherd | F | 1 | Schutzhund | 10 |
| Dobermann | M | 2 | Schutzhund | 18 |
| German Shepherd | M | 4 | Schutzhund | 18 |
| Dobermann | M | 2 | Schutzhund | 6 |
| German Shepherd | M | 8 | Schutzhund | 36 |
| German Shepherd | M | 2 | Schutzhund | 12 |
| German Shepherd | F | 2 | Schutzhund | 18 |
| Cross-breed | F | 8 | None | – |
| Cross-breed | F | 9 | None | – |
| Labrador | M | 3 | Basic obedience | 2 |
| Rottweiler | F | 3 | None | – |
| Siberian husky | F | 7 | None | – |
| Labrador | F | 5 | None | – |
| Terranova Lanseer | M | 1 | None | – |
| Rottweiler | F | 4 | None | – |
| Napolitan Mastiff | M | 0.5 | Basic obedience | 1 |

## 4. General discussion

Domestic dogs show a series of behavioural skills that allow them to communicate with humans, at least on some level, and to solve different problems (Miklósi et al., 2004; Hare and Tomasello, 2005). Results suggest that dogs' gaze direction towards a human can be increased with reinforcement schedules and decreased with reinforcement withdrawal (Study 1). Our data shows that three 2-min-trials are long enough to observe a significant change in the dog's gaze to the face of an unknown human. This would suggest that it is a flexible response and that it can be modified by changes in the environmental contingencies with relative speed. In the second study, gaze duration of non-trained dogs during a walk was lower than the duration of sport-trained dogs taught for that particular purpose.

Our results indicate that dogs are not only capable of giving communicative responses towards a human, but also would be able to learn to ignore human cues and not to emit communicative signals when these responses are no longer successful. In other words, if the gaze towards a human in a specific context does not allow the dog to have access to a significant stimulus such as food, then the dog will probably stop emitting this signal. Results suggest that the gaze response as a communicative cue, at least in the situation here assessed, involves instrumental learning processes and it does not seem to require complex cognitive explanations. However, our data is not enough to completely exclude that explanation, so more research in this area is required.

Some authors (e.g., Miklósi et al., 1998; Virányi et al., 2004) stated that communicative skills are related to complex cognitive processes, rather than being a case of instrumental learning. Furthermore, they consider that these skills are relatively independent of learning. For example, Braüer et al. (2006) in a study of the pointing gesture stated that "Their performance cannot be explained by the use of olfactory cues (various control conditions ruled these out), by learning during the experiment (they were skilful from the very first trials), or by familiarity or past learning (they were skilful in many novel variations)... These facts suggest that dogs' ability to read human communicative cues is independent of their individual history" (Braüer et al., 2006; pp. 38–39). Also, their argument includes the fact that very young puppies having little experience with humans are able to use these communicative signals (Hare et al., 2002; Riedel et al., 2008). Nevertheless, this evidence does not necessarily imply that these communicative capacities are independent of learning. Accordingly, Shapiro et al. (2003) stressed the fact that experiments in which subjects have unrecorded interactions with humans, are difficult to interpret since learning might have taken place inadvertently at an earlier stage.

On the other hand, comparative studies with other species (Miklósi et al., 2003; Hare and Tomasello, 2005; Virányi et al., 2007) suggest that dogs have an enhanced ability to learn interspecific communicative responses. This rate of learning would be a species-specific skill.

Moreover, decrease in gaze duration in extinction trials may account for the preliminary results of Gácsi et al. (2005) since the dogs' response decreased even in a situation known to be stressful for the animals. The increase in gaze duration observed by Gácsi et al. (2005) could be explained as a result of an instrumental gaze-food association.

Also, this is the first systematic evaluation of changes in the behavioural pattern of the dog when an expected reward is withdrawn. Dogs did not only change their instrumental response (gaze direction towards the human face), but also showed a series of responses such as moving away and back from the experimenter and lying down. These responses are similar to the ones observed in rats which avoid and escape from stimulus associated with non-reward frustration (Daly, 1974). Nevertheless, it is not possible to discard alternative explanations (as satiety or fatigue) not linked to emotional reactions. However, preliminary data of our laboratory suggests that if reinforcers are delivered again after downshift reward, the gaze response and the behavioural pattern return to the acquisition phase levels (Bentosela et al., submitted). On the other hand, other behaviours that typically increase during stress such as vocalizations (e.g., Elliot and Scott, 1961; Hetts et al., 1992) were not observed. This is probably due to the previous experience of dogs with frustrations during their lives.

Finally, these findings have an important applied value, because they could lead to an optimization of techniques for directing dog attention. Taking into consideration these results, it is relevant to use the known training effects to increase and improve the interspecific communication in different applied fields which rely on dogs, such as dogs' assistance to disabled people and animal assisted therapy, explosives and drugs detection, rescue procedures, herding, and others. Moreover, the dog could learn to ignore communicative cues from other people, for example, not to look at unknown humans while working with its trainer.

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## References

Amsel, A., 1992. Frustration Theory: An Analysis of Dispositional Learning and Memory. Cambridge University Press, New York, pp. 34–60.
Barlow, D., Hersen, M., 1984. Single Case Experimental Designs: Strategies for Studying Behavior Change, second ed. Pergamon, New York.
Bentosela, M., Ruetti, E., Muzio, R.N., Mustaca, A.E., Papini, M.R., 2006. Administration of corticosterone after the first downshift trial enhances consummatory successive negative contrast. Behav. Neurosci. 120 (2), 371–376.
Braüer, J., Kaminski, J., Riedel, J., Call, J., Tomasello, M., 2006. Making inferences about the location of hidden food: social dog, causal ape. J. Comp. Psychol. 120 (1), 38–47.
Daly, H.B., 1974. Reinforcing properties of escape from frustration aroused in various learning situations. Learn. Motiv. 8, 187–231.
Elliot, O., Scott, J.P., 1961. The development of emotional distress reactions to separation in puppies. J. Genet. Psychol. 99, 3–22.
Gácsi, M., Győri, B., Miklósi, Á., Virányi, Z., Kubinyi, E., Topál, J., Csányi, V., 2005. Species-specific differences and similarities in the behaviour of hand raised dog and wolf puppies in social situations with humans. Dev. Psychob. 47, 111–122.
Hare, B., Tomasello, M., 1999. Domestic dogs (*Canis familiaris*) use human and conspecific social cues to locate hidden food. J. Comp. Psychol. 113, 1–5.
Hare, B., Tomasello, M., 2005. Human-like social skills in dogs? Trends Cogn. Sci. 9 (9), 439–444.
Hare, B., Brown, M., Williamson, C., Tomasello, M., 2002. The domestication of social cognition in dogs. Science. 298, 1634–1636.
Hetts, S., Clark, J.D., Calpin, J.P., Arnold, C.E., Mateo, J.M., 1992. Influence of housing conditions on beagle behaviour. Appl. Anim. Behav. Sci. 34, 137–155.
Kubinyi, E., Virányi, Z., Miklósi, A., 2007. Comparative social cognition: from wolf and dog to humans. Comp. Cogn. Behav. Rev. 2, 26–46.
Miklósi, A., Polgárdi, R., Topál, J., Csányi, V., 1998. Use of experimenter-given cues in dogs. Anim. Cogn. 1, 113–121.
Miklósi, A., Polgárdi, R., Topál, J., Csányi, V., 2000. Intentional behavior in dog–human communication: an experimental analysis of 'showing' behavior in the dog. Anim. Cogn. 3, 159–166.
Miklósi, A., Kubinyi, E., Topál, J., Gácsi, M., Virányi, Z., Csányi, V., 2003. A simple reason for a big difference: wolves do not gaze back at humans but dogs do. Curr. Biol. 13, 763–767.
Miklósi, A., Topál, J., Csányi, V., 2004. Comparative social cognition: what can dogs teach us? Anim. Behav. 67, 995–1004.
Miklósi, A., Soproni, K., 2006. A comparative analysis of animals' understanding of the human pointing gesture. Anim. Cogn. 9, 81–93.
Papini, M.R., Dudley, R.T., 1997. Consequences of surprising reward omissions. Rev. Gen. Psychol. 1, 175–197.
Pavlov, I.P., 1927. Conditioned Reflexes. Dover, New York, pp. 63–76.
Povinelli, D.J., Giambrone, S., 1999. Inferring other minds: failure of the argument by analogy. Philos. Top. 27, 167–201.
Riedel, J., Buttelmann, D., Call, J., Tomasello, M., 2006. Domestic dogs (*Canis familiaris*) use a physical marker to locate hidden food. Anim. Cogn. 9 (1), 27–35.
Riedel, J., Schumann, K., Kaminski, J., Call, J., Tomasello, M., 2008. The early ontogeny of human–dog communication. Anim. Behav. 75 (3), 1003–1014.
Skinner, B.F., 1953. Science and Human Behavior. MacMillan, New York, pp. 90–100.
Soproni, K., Miklósi, A., Topál, J., Csányi, V., 2001. Comprehension of human communicative signs in pet dogs. J. Comp. Psychol. 115, 122–126.
Soproni, K., Miklósi, A., Topál, J., Csányi, V., 2002. Dogs' responsiveness to human pointing gestures. J. Comp. Psychol. 116, 27–34.
Shapiro, A.D., Janik, V.M., Slater, P.J.B., 2003. Gray seal (*Halichoerus grypus*) pup responses to experimental-given pointing and directional cues. J. Comp. Psychol. 117, 355–362.
Thorndike, E.L., 1911. Animal intelligence. Am. Psychol. 53 (10), 1125–1127.
Van der Plasse, G., Feenstra, M.G.P., 2008. Serial reversal learning and acute tryptophan depletion. Behav. Brain Res. 186, 23–31.
Virányi, Z., Topál, J., Gácsi, M., Miklósi, A., Csányi, V., 2004. Dogs respond appropriately to cues of humans' attentional focus. Behav. Proc. 66, 161–172.
Virányi, Z., Gácsi, M., Kubinyi, E., Topál, J., Belényi, B., Ujfalussy, D., Miklósi, A., 2007. Comprehension of human pointing gestures in young human reared wolves (*Canis lupus*) and dogs (*Canis familiaris*). Anim. Cogn., doi:10.1007/s10071-007-0127-y.