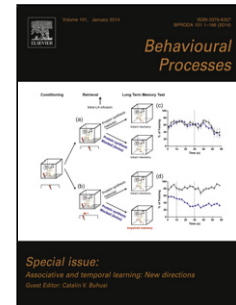


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Individual differences in social and non-social behaviors in domestic dogs (*Canis familiaris*) during the acquisition, extinction and reacquisition of a problem solving task

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Highlights

► ► We investigated a problem solving task in which dogs did not require humans help. ► Non-social behaviors increased during acquisition and social responses in extinction. ► Dogs searched more the reward when the owner was present compared to a stranger. ► Retrievers showed a greater social motivation than Shepherds in the reacquisition.

Abstract

Dogs are able to solve different problems by trial and error learning, but it seems that they cannot understand the means-end connection. Some studies suggest that dogs' performance is influenced by their breed and by the level of familiarity with the person they interact with. In our study, we assess individual differences in both social and non-social responses in a problem-solving task during the acquisition, extinction, and reacquisition phases. In order to investigate the effect of familiarity, in the first experiment, the human present during the task was either a familiar (the dog's owner) or unfamiliar person. In the second experiment, we compared breeds (Retrievers and Shepherds) that had previously shown differences in a communicative task. The results revealed that all groups learned the task and became more efficient in the acquisition trials. These non-social responses diminished during extinction, where an increase in social responses was observed. With regard to individual differences, dogs were more persistent in searching the reward during the second extinction trial when the owner was present (in contrast with a stranger), and also looked longer at the unfamiliar person at the beginning of the acquisition trial. On the other hand, Retrievers showed greater social motivation during reacquisition and Shepherds picked up more bones during the third acquisition trial, thus suggesting a more persistent search of the reward. These findings highlight the relevance of studying different learning schedules as well as individual differences in problem-solving ability so as to improve selection and training techniques.

Key words: breeds, owner-stranger, learning, social responses, problem solving.

1. Introduction

Problem solving can be defined as a subset of instrumental responses that appear when an animal cannot achieve a goal using a direct action. Therefore, the subject needs to perform a novel action or an innovative integration of available responses in order to solve the problem (Scheerer, 1963). This ability has been studied in dogs using a wide variety of tasks (e.g. Frank & Frank, 1985; Miklósi et al., 2003; Osthaus, Lea & Slater, 2005; Scott & Fuller, 1965). One of the most commonly used activities is the string-pulling task, designed by Koehler (1927), in which a piece of food is attached to a rope and put out of the dog's reach. The subject has to pull the rope to obtain the reward. Dogs are successful in solving this task but they cannot understand the means-end connection; hence, the mechanism to solve the problem is trial-and-error instrumental learning (Osthaus et al., 2005; Range, Möslinger & Virányi, 2012). Additionally, they had the ability to solve a cooperative version of this problem. In this task, the dog has to pull one end of the rope and, at the same time, another dog or human has to do the same at the other end in order to obtain the reward (Ostojic & Clayton, 2014).

However, some dogs appear able to learn to pay attention to connectivity using another task. In this problem, dogs have to choose between two boards, one with a reward (on) and another with the reward placed next to the board (off). The results showed that dogs chose the "on" board when both rewards were placed at the same distance from the dog or closer to the dog. They were able to solve the task even when the "off" board was closer to them (they did not commit the proximity error). (Range, Hentrup & Virányi, 2011). However, more recently, Müller, Riemer, Virányi, Huber & Range (2014) were unable to replicate these results, despite the fact that the dogs learned to solve the task

with training. Furthermore, they were only able to show transfer to two of the three new conditions in which some stimuli of the experimental setup had been changed. The authors concluded that dogs can learn to solve the support problem based on perceptual cues, but seemingly without developing an understanding of the underlying causal structure.

Dogs have demonstrated remarkable abilities to solve problems using human communicative cues, such as following a pointing gesture to find hidden food (e.g., Miklósi & Soproni, 2006). Likewise, several studies have revealed that when dogs are exposed to an unsolvable problem they tend to look at a person to ask for help (e.g. Marshall Pescini, Passalacqua, Barnard, Valsecchi & Prato Previde, 2009; Marshall Pescini, Valsecchi, Petak, Acorssi & Prato Previde, 2008; Miklosi et al., 2003). Regarding communicative abilities, some authors have stated that such skills are the result of domestication and are somewhat independent of ontogeny (e.g. Hare et al., 2010; Miklósi et al., 2003). However, several pieces of evidence support the idea that learning and experiences during ontogeny would play a significant role (e.g. Barrera, Giamal, Mustaca & Bentosela, 2012; Bentosela, Barrera, Jakovcevic, Elgier & Mustaca, 2008; Udell, Dorey & Wynne, 2010). For example, different associative learning procedures (reinforcement, extinction, and omission) modified the duration of the gaze at the human face when a reward was unavailable as well as the following of human pointing gestures to find hidden food (Bentosela et al., 2008).

In addition, some studies indicate that dogs' performance changes according to the level of familiarity (owner-stranger) with the person present during the task (Elgier, Jakovcevic, Barrera, Mustaca & Bentosela, 2009; Kerepesi, Dóka & Miklósi, 2014;

Marshall-Pescini, Passalacqua, Petrazzini, Valsecchi & Prato-Previde, 2012). For instance, Elgier et al. (2009) demonstrated that, in an object-choice task, the extinction of following pointing gestures took longer if the pointer was the dog's owner compared to a stranger. These studies showing differences in dogs' performance based on reinforcement or on the familiarity with humans (owner vs. stranger) attest to the importance of learning and experiences during ontogeny in the underlying mechanisms of dogs' social cognitive skills (e.g. Bentosela et al., 2008; Udell et al., 2010; Wynne, Udell & Lord, 2008). To our knowledge, there are no previous studies comparing the effect of the presence of the owner vs. a stranger during a non-social problem in which dogs can solve the task by themselves, without interaction with the human. The level of familiarity of the person who interacts with the dog can be an important source of individual differences in social and non-social tasks.

Another important source of individual differences is the breed of the dog. There is a lot of anecdotal knowledge about breed differences. However, scientific studies are, unfortunately, scarce (Dorey et al., 2009) and are mainly related to social problem-solving skills. In this sense, Wobber, Hare, Koler-Matznick, Wrangham & Tomasello, (2009) demonstrated breed differences in an object-choice task by assessing the ability to follow different human cues to find hidden food. However, a meta-analysis involving different studies failed to find any significant differences between breeds in pointing tasks (Dorey, Udell & Wynne, 2009). Using another important communicative response, Jakovcevic, Elgier, Mustaca & Bentosela, (2010) showed that, when a reward was unavailable, Retrievers gazed longer toward the human face than Shepherds and Poodles. This difference was observed during a spontaneous test in which food was in sight but out

of the dogs' reach, as well as during an extinction procedure in which gaze behavior was no longer reinforced.

One of the most important weaknesses in the breed comparison studies is that there are hundreds of breeds and it is very difficult to select which will be compared. Today, less than one fourth of the existing breeds are represented in research studies on breed differences. Unfortunately, the main criterion often relates to a matter of availability (Mehrkam & Wynne, 2014). More recently and for the first time, Udell, Ewald, Dorey & Wynne (2014) have compared working breeds with a specific selection pressure during domestication and have demonstrated that breed-specific predatory motor patterns can serve as an important predictor of success in an object-choice task.

Furthermore, the empirical evidence of breed differences in non-social cognition is scanty. Scott & Fuller (1965) developed a broad program to compare the behaviors of various breeds and found differences in problem-solving ability, aggressiveness and emotionality. Plutchik (1971) detected differences in the tendency to approach and withdraw in novel situations. More recently, Svartberg (2006) compared a large number of breeds in their response to sudden stimuli.

In recent years, the experimental approach of behavior has become increasingly focused on studying individual differences (Gosling, 2001), probably because this knowledge could improve not only the comprehension of the mechanisms involved but also the selection of the most suitable dogs to perform different tasks. Considering that in many activities such as assisted therapy, rescue, guard, etc. dogs are selected by their breed, the knowledge of behavioral differences between breeds is relevant.

This work has several objectives. First, to assess if associative learning shapes social and communicative responses, even when dogs have to solve a non-social task in which they have to remove plastic bones from a plate to get the reward. This problem can be solved without any help from humans. The task comprises three learning procedures: acquisition, extinction and reacquisition. The evaluation of the effects of associative learning will provide information on how behaviors are modified in order to solve a problem. If these learning procedures also affect social behaviors during problem solving, we can support the hypothesis that learning is one of the mechanisms responsible for communicative responses to humans.

Second, to assess whether the familiarity of a person (owner-stranger), present during the task, shapes the social and non-social responses of the dogs (Experiment 1). It should be noted that in most studies the owner and the stranger are together at the same time. Therefore, the owner may be a relevant stimulus and can overshadow the presence of the stranger. Moreover, he can reduce fear or curiosity reactions toward him. Hence, we compare the presence of each person (owner-stranger) staying alone with the dog.

Third, to evaluate the individual differences in the problem-solving skills of Retrievers and Shepherds (Experiment 2). We have selected these breeds because they have already shown differences in gazing at the human face when a reward was unavailable, and this communicative behavior could be relevant to the task under analysis (Jakovcevic et al., 2010). However, in this case, the dogs have no need to interact with the person to use the food device and both, social and non-social responses, are evaluated at the same time. If Retrievers are more sociable than Shepherds, they will show more

social responses during the task and look longer at the person. In addition, these results could extend the differences found between these breeds to a new non-social task.

Finally, with regard to the potential scope of this approach, we can assess in both experiments which groups are more persistent in trying to solve the task during extinction when food is no longer available. The animal's level of persistence as a response to different reinforcement programs may indicate its adaptation to different types of training. High persistence may be optimal for certain tasks where no continuous reinforcement can be provided and the dog has to give a long response chain without obtaining any reward. In other cases, it may prevent the animal from having a more flexible behavior and searching other sources of reinforcement. Moreover, evaluating whether the presence of the owner during task learning may affect the dog's performance is indeed valuable for designing training situations where the owner may or may not be present, depending on the goals to be achieved. In addition, contributing to the scanty volume of empirical knowledge on breed characteristics will help make a better selection thereof for different types of training and tasks the dog may perform. In the long run, the dissemination of this knowledge will also help future owners make a better selection of their dogs. Unfortunately, given the little empirical evidence available on breed differences, owners base their dog choices on anecdotal information, which, in some cases, might increase incompatibility between the owners' and the dog's characteristics.

2. Study 1

Method

Thirty-nine subjects were assessed. Fifteen were discarded according to the exclusion criterion (see 2.3 Procedure). The final sample comprised 24 adult dogs (*Canis familiaris*), randomly assigned to two groups: Familiar Group (FG) and Unfamiliar Group (UG). The unfamiliar person was always a woman. FG consisted of 8 males and 4 females, mean age: 4.1, SD: 2.4 years, from various breeds (2 Labrador retrievers, 1 Golden retriever, 1 German Shepherd, 1 Poodle, 1 Cocker Spaniel, 1 Bull Terrier and 5 mixed breeds). The UG included 6 males and 6 females, mean age: 4.71, SD: 2 years, from various breeds (1 Brittany Spaniel, 1 Great Dane, 1 Rottweiler, 1 Bull Terrier, 1 Shar-pei, 1 Neapolitan Mastiff, 1 Pit Bull Terrier and 5 mixed breeds). All of them lived in family households as pets and had not received obedience training. Eight dogs had already been assessed in an object-choice task in which dogs had to follow a human pointing gesture to find hidden food in one out of two opaque bowls. They had no experience with the apparatus or the experimenter.

2.2 Apparatus

The experiment was conducted in a familiar room of the dogs' home. The apparatus used was Nina Ottosson© Dog Magic, consisting of a round plate, 36 cm in diameter, with nine bone-shaped depressions containing nine plastic bones. Eight bones are arranged in a circle and a ninth one is located in the center. Each bone had a small hole to release the smell of food. Small pieces of cooked liver were used as reinforcement and were hidden under each bone. In addition, the whole bowl surface was spread with large quantities of liver to distribute the smell evenly. The device was placed on a carpet (75x45 cm) to prevent slipping. A person (the experimenter, E) sat down on the floor 1 m

away from the apparatus. A helper, located 1 m in a straight line from the apparatus, recorded the sessions. Sessions were taped with a Sony DCR-SR 88 camera. During the session only the dog, the E, and the unknown person who operate the camera were present. Figure 1 shows an image of the experimental setting used.

INSERT FIGURE 1

2.3 Procedure

The problem-solving task consists of learning to remove nine bones from the apparatus in order to obtain the piece of liver hidden under each bone.

After a familiarization period of 3-5 min, the sessions began. During familiarization, dogs had no access to the device. The procedure comprised three phases: acquisition, extinction, and reacquisition. For half of the dogs the E was an unknown woman (Unfamiliar Group) and for the other half the E was the owner (Familiar Group), who was previously instructed on the procedure. The exclusion criterion was discarding the dogs that did not pick up a bone by themselves during acquisition 1 and 2. This criterion was used to ensure that the dogs had learnt the task before the extinction phase.

Acquisition Phase

This phase consisted of three trials with a 2-min inter-trial interval. In the first trial, we used a continuous reinforcement schedule so that all bones contained food. The trials began when the E entered the room and left the device on the carpet. Immediately after this, she sat on the marked point 1 m away from the toy. If the dog did not spontaneously remove any bone within 1 min, the E called it by its name and, while pointing at the device, lifted a bone to show the hidden food and let the dog eat. A similar instigation was repeated at minute 2 and 3 if the dog was still unable to pick up any bone on its own. Only three dogs from the owner group and one from the stranger group were instigated. The trial ended after 5 min or when the dog had obtained all the pieces of food.

In order to increase the persistence of the learned behaviors during extinction (Amsel, 1962) the second and third acquisition trials were of partial reinforcement, with 5 out of 9 bones containing food semi-randomly placed and with no baits in more than two adjacent bones. During these two trials there was no instigation and the E remained motionless gazing at the dog. The trial ended after 3 min or when the dog had obtained all the food. During the intervals, the dog remained in the room and the person filled the device in an adjacent room.

Extinction Phase

There was a 2-min interval between the acquisition and extinction phases. Two 3-min extinction trials were conducted. There was a 2-min inter-trial interval. In these trials, none of the bones were baited. The E remained motionless gazing at the dog, but did not interact with it.

Reacquisition

There was a 2-min interval between the extinction and reacquisition phases. This phase comprised one single trial. The conditions were similar to those in acquisition trials 2 and 3.

Behavioral Observations

We observed two categories of behaviors:

A. Non-Social behaviors:

1. Latency of the first bone picked up, measured as the time elapsed between the beginning of the trial and the first bone picked up by the dog. If the dog did not pick up any bone on its own, a maximum latency of 5 min was considered for trial 1 and 3 min for the remaining trials. We used a frame by frame (0.3 s) assessment.
2. Number of bones picked up in each trial.
3. Number of eaten rewards.
4. Time (s) interacting with the device: cumulative duration of the time spent interacting with the device or a bone (licking, smelling, chewing, etc.).

B. Social Behaviors

5. Time (s) spent near the E: cumulative duration of the time that the dogs stayed with both forelegs and head near the E (less than 75 cm).
6. Time (s) spent in physical contact with the person.
7. Gaze duration (s) towards the human face.

Variables 4 to 7 were assessed using the JWatcher behavioral observation software V 1.0.

2.4 Data Analysis

Two independent observers analyzed all the measures in 100% of the video-taped material. To test inter-observer reliability, Spearman's coefficients of correlation were calculated. For all the measures ($r_s > 0.95$, $N_s = 24$, $p_s < 0.05$).

Considering that the dependent variables did not achieve the criteria for parametric analysis, non-parametric tests were used: Mann–Whitney U-tests were used to compare the performance between groups. Wilcoxon and Friedman ANOVA tests were used for two or more repeated measures analysis respectively. The alpha value was set at 0.05. All analyses involved two-tailed tests.

For the variables time spent near the device, time near the person, time spent in contact with the experimenter and gaze duration towards the human face, given that the duration of trials was not fixed, a rate was conducted for each trial. The total duration time of a variable in one trial was divided by the total duration of this trial. For example, if the dog spent 15 s near the person and the trial lasted 65 s, we divided 15/65; therefore, the value was 0.23.

2.5 Results and Discussion

2.5.1 Comparisons between groups

Table 1 shows means (SD) of the variables along trials. The comparisons between groups using a Mann-Whitney U test showed that during the second extinction trial FG spent significantly more time near the device than UG, $Z = -2.11$, $p = 0.035$ $N_{FG} = 12$, $N_{UG} = 12$. These results indicate that the presence of the owner increased the duration of food searching behaviors during the second extinction trial. It is probable that the

reinforcement's history with the owner could increase motivation and persistence. The remaining trials did not show significant differences, ($Z_s < 1.809$, $p_s > 0.05$). (Figure 2).

INSERT FIGURE 2

In addition, Figure 3 showed that, dogs of the UG gazed longer to the human face than FG group during the first acquisition trial (Mann-Whitney U: $Z = -2.15$, $p = 0.031$, $N_{FG}=12$, $N_{UG}=12$). The remaining comparisons were non-significant, ($Z_s < 1.80$, $p_s > 0.05$).

As already said, when food is out of reach, dogs tend to look at the human experimenter as a communicative begging response. Although the first acquisition trial is not unsolvable, dogs have to learn how to solve it by trying different responses until they succeed in picking up the bones. Therefore, one possible explanation is that dogs are gazing at the human face asking for food, and they requested more food from the stranger compared to the owner. However, it is also possible that the presence of a stranger may increase their curiosity, and dogs show more exploratory behaviors toward him than toward the owner, which would lead to a longer gaze at the human face. The fact that this difference is not found in extinction, when the task becomes unsolvable, supports our second explanation.

INSERT FIGURE 3

The Mann-Whitney U analysis showed that there are no significant differences between UG and FG: latency to the first bone picked ($Z_s < -1.41, p_s > 0.05$), number of bones picked ($Z_s < -1.86, p_s > 0.05$) and eaten rewards ($Z_s < -1.80, p_s > 0.05$), time spent near the person ($Z_s < -1.72, p_s > 0.05$) and time spent in contact with the person during all trials ($Z_s < -1.44, p_s > 0.05$).

INSERT TABLE 1

2.5.2 Comparison between trials

During acquisition the latency of the first bone picked decreased along trials (Friedman test, $X^2(2) = 7.35, p = 0.025$). This indicates that animals learn to solve the task faster along trials. Nevertheless Wilcoxon analysis showed that there are no significant differences between both extinction trials and between the last acquisition and each extinction trials, $Z_s < 0.71, p_s > 0.05$. Regarding the number of bones picked up, there were no differences during acquisition $X^2(2) = 2.88, p = 0.236$, nor between extinction trials (Wilcoxon test: $Z_s = -0.285, p = 0.776$) but dogs picked up less bones during the first (Wilcoxon test: $Z_s = -2.88, p = 0.004$) and second extinction trials (Wilcoxon test: $Z_s = -2.84, p = 0.004$) compared to the last acquisition trial. This would

indicate that all dogs succeeded in solving the task during acquisition but their performance decreased during extinction, when they did not find any food under the plastic bones. For the remaining variables, the analysis revealed a significant decrement in the time spent interacting with the apparatus along the acquisition trials, $X^2(2) = 22.26, p = 0.0001$, probably associated with the effect of learning the task. However, Wilcoxon analysis revealed that there were no significant differences between extinction trials, $Z = -0.34, p = 0.732$. We also observed a significant decrement in the rates of time spent interacting with the device between: acquisition 3 and extinction 1, $Z = -4.14, p = 0.0001$, acquisition 3 and extinction 2, $Z = -3.94, p = 0.0001$ and extinction 2 and reacquisition, $Z = -4.10, p = 0.0001$. These results show that the dogs spent less time interacting with the apparatus during extinction, probably explained by the lack of food.

As for time spent near the E (see Figure 2), there are no differences during acquisition, $X^2(2) = 3.78, p = 0.151$. Wilcoxon analysis showed significant differences during extinction, the animals spent more time near the person in the first extinction trial than in the second, $Z = -2.17, p = 0.030$. The comparison between phases shows a significant increment between the last acquisition trial and the first extinction trial, $Z = -2.41, p = 0.016$ but not with the second one $Z = -1.71, p = 0.087$. This is probably due to the fact that during the first extinction trial the time spent near the experimenter was increased, and then decreased in the second trial. Still, time near the person was significantly longer in this second extinction trial compared with the reacquisition, $Z = -2.69, p = 0.007$.

These results are similar to those obtained with the variable time spent in physical contact with the experimenter. There were no differences during acquisition, $X^2(2) =$

3.15, $p = 0.207$, but a significant difference was found during extinction trials, $Z = -2.24$, $p = 0.025$. Again, comparison between phases using Wilcoxon test shows an increment in this variable between the last acquisition and the first extinction trials, $Z = -2.79$, $p = 0.005$ and between the extinction 2 and the reacquisition trial, $Z = -2.80$, $p = 0.005$. However, there were no significant differences between the acquisition 3 and the second extinction trial, $Z = -1.58$, $p = 0.114$.

Lastly, gaze duration toward the human face (Figure 3) significantly decreased throughout acquisition, $X^2(2) = 8.80$, $p = 0.012$. The comparisons between trials using Wilcoxon test showed no differences between extinction trials, $Z = -1.24$, $p = 0.212$. Gaze duration was significantly shorter in the last acquisition trial compared to the first ($Z = -3.21$, $p = 0.001$) and second extinction trials ($Z = -3.05$, $p = 0.002$). This second trial also showed longer gaze duration than the reacquisition, $Z = -2.35$, $p = 0.019$ according to the increment in the response observed during extinction. Even though gaze duration was longer when the task had not yet been solved on the first acquisition trial and when their responses had not been successful anymore in extinction, the rate of gaze duration was significantly higher on the first extinction trial compared to acquisition 1, $Z = -2.25$, $p = 0.024$. This would support the idea that gaze behavior increases when food is not directly available.

In sum, regarding non-social responses, dogs show an improvement in their problem-solving skills throughout acquisition and a decline in performance during extinction trials. As for social responses, there is an increment in social behaviors at the beginning of the task in the first acquisition trial as well as during extinction, which reflects the dog's difficulty to solve the problem and suggests that the person becomes relevant when

the dog is unable to get food by itself. These results imply, first, that dogs learn to solve the problem through a trial-and-error mechanism. Second and more importantly, that learning is able to modify social and communicative responses toward humans, even during a non-social task. At the same time, the familiarity with the person also modifies these social responses. Regarding the debate about communication mechanisms, this evidence highlights the relevance of associative learning and experiences during ontogeny to elicit social responses when dogs interact with humans.

Study 2

The aim of this study was to assess whether breeds, Shepherds and Retrievers, that had shown differences in an important communicative response such as gazing (Jakovcevic et al., 2010) also differed in social and non-social responses in a problem-solving task when the person present remained passive.

Method

3.1 Subjects

Thirty-six dogs were evaluated and according to the same exclusion criterion as Study 1, 13 had to be discarded. The final sample included 23 adult dogs (*Canis familiaris*), assigned to two groups according to the dog's breed: Retrievers Group (RG) and Shepherds Group (SHG). RG included 8 males and 4 females, mean age: 5.5, SD: 2.1 years, 5 Golden Retrievers and 7 Labrador Retrievers. SHG consisted in 6 males and 4 females, mean age: 5, SD: 3.1 years, 8 German Shepherds and 2 Belgium Shepherds. All

of them lived in family households as pets and had not received obedience training.

Seven dogs had already been assessed in pointing tasks.

3.2 Procedure

The apparatus and procedure were the same as in Study 1, except that in both groups the experimenter was an unknown woman. In this study only one Retriever and three Shepherds received instigation during the first acquisition trial.

Two independent raters coded all the measures in 100% of the video-taped material. The inter-observer reliability was high (Spearman's coefficients of correlation for all the measures ($r_s > 0.93$, $N_s = 23$, $p_s < 0.05$).

3.3 Results and Discussion

3.3.1 Comparison between groups

Table 2 shows means (SD) of the variables along trials. Mann-Whitney U analysis showed that SHG group picked up significantly more bones than RG in the third acquisition trial, when only 5 out of 9 bones had food ($Z = -2.05$, $p = 0.040$, $N_R = 12$, $N_{SH} = 11$). Figure 4 showed that RG group stayed more time near the person during reacquisition comparing to SHG ($Z = -2.24$, $p = 0.025$, $N_R = 12$, $N_{SH} = 11$).

These results could indicate that after the extinction phase, when the device has food again under a partial reinforcement schedule, RG shows a greater social motivation as well as less persistence searching the reward.

The remaining comparisons were non-significant: latency to the first bone picked ($Z_s < -1.44$, $p_s > 0.05$), number of bones picked ($Z_s < -2.05$, $p_s > 0.05$) and eaten rewards (Z_s

< -1.38 $ps > 0.05$), time spent near the device ($Zs < -1.60$, $ps > 0.05$) time spent near the person ($Zs < -2.24$, $ps > 0.05$) and time spent in contact with the person in the remaining trials ($Zs < -1.40$, $ps > 0.05$) (see Table 2).

INSERT FIGURE 4

INSERT TABLE 2

3.3.2 Comparison between trials

Regarding the latency to the first bone picked, there was a significant decrease across acquisition trials, ($X^2(2) = 12.96$, $p = 0.002$). Also a decrease in the time spent near the device was observed, ($X^2(2) = 16.76$, $p = 0.0001$). The remaining comparisons were performed using Wilcoxon test. There was a significant decrement between acquisition 3 and both extinction 1 ($Z = -3.80$, $p = 0.001$) and 2 ($Z = -3.92$, $p = 0.001$) as well as between extinction 2 and reacquisition ($Z = -3.10$, $p = 0.002$). These findings suggest that animals learnt to solve the task along trials.

There were significant increases on time spent near the person between acquisition 3 and extinction 1 ($Z = -3.21$, $p = 0.001$) when the reward was no longer available. However, this time rate decreased between extinction 1 and 2 ($Z = -2.16$, $p = 0.030$).

Probably, at the beginning of the extinction phase dogs solicited help from the person, but considering that she was passive, the approaching behavior rapidly diminished.

Regarding the rate of time spent in contact with the person, there a significant decrement between acquisition 3 and extinction 1 ($Z = -2.60, p = 0.009$) and between the two extinction trials ($Z = -2.58, p = 0.010$).

Finally, and also according to the previous results, gaze duration towards the human face significantly increased between last acquisition trial compared to extinction 1 ($Z = -3.18, p = 0.001$) and 2 ($Z = -2.34, p = 0.019$). Also there was a difference between the two extinction trials ($Z = -2.10, p = 0.036$). The other comparisons were non-significant, ($Zs < 1.782, ps > 0.05$) (see Table 2).

In short, taking into account all the dogs, we have observed a pattern of non-social responses similar to Study 1, which shows that dogs are able to learn the task. Considering their social responses, there was an increase both in the time spent near and in contact with the person and in the duration of the gaze toward the human face during extinction. Again, this increment was also similar to that observed in the previous study. As some authors have stated (e.g. Miklósi, 2003), these social responses, especially the gaze at the human face when the reward is unavailable, can be interpreted as begging behaviors. In this sense, the present findings could suggest that dogs ask for help when they do not get the food. Another possibility is that the device was less salient during extinction, which caused an increase in other alternative responses such as social behaviors. According to unpublished data from our laboratory, during extinction, dogs spent less time interacting with the apparatus, both in the presence or absence of a person. This would indicate that the apparatus becomes less relevant during extinction (due to the

absence of food), so that alternative behaviors increase. However, social responses in the presence of a person may also represent begging behaviors.

In this task, breed differences were identified in social and non-social behaviors. Retrievers showed a greater social motivation, while Shepherds exhibited higher persistence in searching the reward. Possibly, each breed paid more attention to one of the two relevant stimuli (the device and the person). Strikingly, dogs were reinforced by behaviors oriented toward the device but not by social responses toward the person. We may conclude that the mere presence of a human, even if a passive observer, has a reinforcement value for retrievers.

4. General Discussion

A wide variety of evidence has demonstrated that dogs are capable of solving different problems by trial-and-error instrumental learning, but they seem unable to understand the means-end connection (e.g. Osthaus et al., 2005; Range et al., 2012). It has been observed in some cases that, when a reward becomes an unsolvable task, dogs tend to gaze toward the human face “to ask for help” (e.g. Marshall Pescini et al., 2009; Miklosi et al., 2003). On the other hand, some studies have shown that the presence of humans as well as the breed of the dogs influence the way in which dogs solve a problem.

The present studies provide relevant information about the individual differences noted both in social and non-social responses during a problem-solving task in which a person is present but playing a passive role. Our findings show, for the first time, that communicative behaviors are sensitive to learning, even when dogs are exposed to a task that they can solve by themselves. Different reinforcement schedules (acquisition,

extinction and reacquisition) modified not only the non-social responses but also the social ones. These results could suggest that associative learning is at least one of the communication mechanisms between dogs and humans, and could also increase the number of situations in which this effect may be observed. Additionally, they agree with previous results in communicative tasks (e.g. Bentosela et al., 2008; Elgier et al., 2012; Udell et al., 2010).

Specifically, during extinction, compared to the last acquisition trial, there is an increase in the length of time the dog is close to and in contact with the person, as well as in the duration of the gaze at the human face. In general, during this phase, non-social behaviors toward the device decrease and social behaviors increase. As seen in previous works (Gaunet, 2009; Marshall Pescini et al., 2009; Miklosi et al., 2003), this change might indicate the presence of begging behaviors toward the person when food is no longer available. Also, the fact of approaching the person might lower stress responses during extinction. Previous literature has shown that the human presence reduces stress in dogs. For instance, Pettijohn et al. (1977) found that the presence of a person compared to the presence of conspecifics, toys, or food was the stimulus that most reduced distress vocalizations in puppies when separated from their mother. Finally, the increase in exploratory responses in the absence of food may probably facilitate an increase in social responses.

On the other hand, regarding non-social responses, in Study 1, dogs show an improvement in their problem-solving ability throughout acquisition and a decline in performance during extinction trials. Dogs exhibit a shorter latency to pick the first bone and a decrease in the time spent near the device, which would indicate that they are able

to solve the task with increased efficiency. During extinction, the time spent near the device decreases together with the number of bones picked, i.e. the dogs' food-seeking behavior decreases because the response is no longer successful. The same pattern was observed in the second study, indicating that dogs learned to solve the task by a trial-and-error process and their behaviors were modified according to the reinforcement schedule.

The second objective was to assess the effect of familiarity with the human present (owner vs. stranger). The results showed that dogs spend more time near the toy in the second extinction trial, when there is no more food available, if the human present is the owner than if it is a stranger. This fact might indicate that the mere presence of the owner, given the long-term partial reinforcement, increases the dogs' persistence to search for food. Usually a partial reinforcement procedure leads to a longer persistence of the learned behavior (Amsel, 1962). Considering that there are no differences in the length of time spent near the person, the hypothesis that dogs tend to ask for more help in the presence of a stranger may be discarded. Data seem to indicate that the presence of a stranger will lead to faster extinction. These results agree with those obtained by Elgier et al. (2009), who demonstrated that the extinction of following pointing gestures to find hidden food took longer if the pointer is the dog's owner compared to a stranger.

In short, the most important differences observed depending on the familiarity with the person present during the task occurred in the extinction phase when there is no more food available. It is possible that food is a salient stimulus for the dogs that overshadows any difference between the owner and the stranger during acquisition. Also, dogs spent most of the time interacting with the apparatus and did not pay attention to the human. During extinction, when the non-social responses decreased, the presence of the owner

facilitated the persistence of the non-social response (interaction with the device), which probably indicates that in everyday life the owner is a cue that anticipates the presence of food.

Second, regarding social responses, these findings surprisingly indicate that, in the first acquisition phase, dogs gaze more at the stranger than at the familiar person. Probably, dogs gaze longer at the stranger as an exploratory behavior because it is an unfamiliar person and also because the experimenter is sitting close to the food. Furthermore, this would explain why such difference is not replicated during extinction when the animals no longer find food and also when the person was the owner. In addition, we have to consider that these exploratory behaviors could interfere in the problem-solving responses. However, even when they looked longer at the stranger, dogs managed to resolve the problem in the first acquisition trial. These interference effects, if any, may have a minor impact on the dogs' ability to solve the task.

We may therefore conclude that a previous history with people shapes social responses during a problem-solving task. This evidence shows that the experiences during ontogeny are relevant to the expression of social and communicative responses. These behaviors can appear during both social and non-social tasks, reflecting a relatively stable effect. Such findings agree with previous results regarding the effect of different reinforcement schedules.

Finally, with regard to the difference between breeds, Shepherds picked a larger number of bones during the third acquisition trial, despite consuming the same number of reinforcements as Retrievers. However, it is striking to note that this difference is not seen in extinction, when they no longer receive food. These results might suggest an

increased persistence in Shepherds to search for reinforcements, but only when subject to a partial reinforcement program in which at least some behaviors lead to a successful response. However this difference cannot be explained by a change in the social responses of the dogs.

Retrievers spend more time close to the person than Shepherds during reacquisition, which would indicate greater social motivation after the extinction phase, when the food is available again. This might be related to the fact that Retrievers have a bigger interest in humans than Shepherds. This greater social motivation coincides with the findings by Jakovcevic et al. (2010). However, in our study, the difference in the duration of the gaze toward the human face was not replicated. Another difference is that Retrievers gaze longer at the human face only during extinction (Jakovcevic et al., 2010). This may likely be due to procedure differences, as in the study by Jakovcevic et al. (2010) the person was hand-feeding, while in our study the person remained passive and the dog had to pick the food on its own.

It is important to state that, in general terms, Retrievers show a greater social motivation, while Shepherds display a longer search of the reward during a partial reinforcement schedule. This may be related to selection along the evolution of each breed based on the activities usually performed with humans. On one hand, Retrievers are generally employed in social activities like helping disabled people, in animal assisted therapy, and they live as pets. The original functions of this breed have almost disappeared. On the other hand, Shepherds are mostly used for guarding and searching activities in which they have to work without any social or food reward for a long time. However, this hypothesis needs to be tested with additional studies. In this sense, these

differences are relevant for dog selection and training. Many times a more sociable and attentive dog is necessary. In other situations, dogs cannot be rewarded all the time during a task and they have to persist.

At present, there is very limited empirical evidence concerning individual differences in behavior. Trainers, breeders, potential adopters, and owners need this information to choose the right dog. Also, the conditions in which learning can be improved or facilitated are relevant. For example, the presence of a person (owner or stranger) could help or hinder the training of dogs to perform, during extended periods of time, such actions as detecting odors and continuing the pursuit by themselves. Our work is a humble attempt to increase the amount of information available.

In sum, all the groups assessed were able to solve a novel task and underwent learning during acquisition. Also, a decrease in certain behaviors was observed during extinction. Dogs showed a more intense social behavior in the absence of food during extinction. However, this difference may not only be due to a request for help from the human but also to typical diversified responses during extinction (e.g. Skinner, 1953) and to an increase in exploratory food search behaviors. Finally, individual differences were found both regarding the familiarity of the person who was present during the task and the breeds assessed. This would imply that the factors related to the dogs' past history and their relationship with the owner shape problem resolution. Likewise, certain specific breed characteristics may generate differences in this respect. Such differences may contribute to designing better strategies for dog selection and training, and also highlight the importance of studying individual differences regarding how dogs solve problems similar to those found in their everyday lives where people are usually present.

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Figure captions

Figure 1. Image of the experimental setting. A: an example of non-social behavior, B: an example of social behavior.

Figure 2. Duration ratio (cumulative duration of the behavior / total duration of the trial) of the time interacting with the device in the unfamiliar and familiar groups during the three acquisition trials (A1, A2, A3), extinction (e1, E2) and reacquisition (RA) in Study 1. The box represents the interquartile range, which contains 50% of the values, and the bold lines indicate the median. The error bars extend from the box to the highest and lowest values.

Figure 3. Duration ratio (cumulative duration of the behavior / total duration of the trial) of gaze towards the unfamiliar and familiar person during the three acquisition trials (A1, A2, A3), extinction (e1, E2) and reacquisition (RA) in Study 1. The box represents the interquartile range, which contains 50% of the values, and the bold lines indicate the median. The error bars extend from the box to the highest and lowest values.

Figure 4. Duration ratio (cumulative duration of the behavior / total duration of the trial) of the time spent near the person in Retrievers and Shepherds during the three acquisition trials (A1, A2, A3), extinction (e1, E2) and reacquisition (RA) in Study 2. The box represents the interquartile range, which contains 50% of the values, and the bold lines indicate the median. The error bars extend from the box to the highest and lowest values.

Table 1: Means (SDs) of Familiar and Unfamiliar Groups of the Experiment 1

	Gr	Acq 1	Acq 2	Acq 3	Ext 1	Ext 2	Re-acq
Latency of the first picked bone	F	33.85 (36.91)	8.27 (6.13)	7.09 (5.21)	6.27 (4.20)	5.11 (4.05)	7.64 (8.62)
	U	25.5 (28,28)	9.27 (8)	8.53 (6.48)	8.44 (9.94)	10.18 (8.72)	9.98 (8.58)
Number of picked bones	F	8.08 (2.60)	8.33 (0.98)	9 (0)	7.66 (1.77)	8.33 (1.43)	8.91 (0.28)
	U	8.33 (2.3)	8.66 (0.77)	8.66 (0.65)	7.75 (1.71)	6.91 (2.19)	8.75 (0.62)
Number of eaten rewards	F	8.33 (1.77)	4.91 (0.28)	5 (0)	-	-	5 (0)
	U	8.25 (2.59)	5 (0)	5 (0)	-	-	5 (0)
Time (rates) spent near the person	F	.06 (.07)	.03 (.04)	.05 (.10)	.12 (.13)	.10 (.12)	0 (0)
	U	.04 (.07)	.04 (.05)	.01 (.03)	.12 (.13)	.04 (.08)	.01 (.03)
Time (rates) spent in contact with the person	F	.19 (.39)	.04 (.09)	0 (0)	.57 (.01)	.36 (.84)	0 (0)
	U	.11 (.18)	.33 (.78)	.24 (.67)	.53 (.82)	.23 (.55)	.02 (.10)

Note: F=Familiar Group; U= Unfamiliar Group; M= mean; SD= standard deviation, GR= group; Acq= acquisition, Ext= extinction and Re-acq= reacquisition.

Table 2: Means (SDs) of Retrievers and Shepherds Groups of Experiment 2

	Gr	Acq1	Acq2	Acq3	Ext1	Ext2	Reacq
Latency (s) of the first bone picked up	R	19.09 (31.79)	7.1 (4)	6.77 (5.25)	4.4 (3.24)	5.23 (4.13)	12.98 (23.92)
	S	33.33 (39.54)	5.94 (3.04)	5.28 (5.29)	7.62 (6.94)	8.4 (6.25)	7.32 (6.14)
Number of bones picked up	R	8.75 (0.62)	8.25 (1.71)	8.42 (1.16)*	8.08 (1.16)	7.67 (1.78)	8.58 (0.9)
	S	8.55 (1.21)	8.82 (0.6)	9 (0)*	8.27 (1.01)	6.91 (2.43)	8.73 (0.9)
Number of eaten rewards	R	8.91 (0.29)	4.75 (0.62)	4.83 (0.58)	-	-	5 (0)
	S	8.45 (1.21)	5 (0)	5 (0)	-	-	5 (0)
Time (rates) spent interacting with the device	R	.82 (.24)	.89 (.24)	.81 (.31)	.51 (.22)	.58 (.28)	.77 (.28)
	S	.86 (.19)	.95 (.08)	.89 (.22)	.55 (.20)	.42 (.28)	.95 (.17)

Time (rates) spent in contact with the person	R	.02 (.03)	.02 (.05)	0 (.01)	.1 (.23)	.02 (.05)	.03 (.11)
	S	.02 (0.3)	.01 (.01)	0 (.01)	.03 (.03)	.01 (.01)	0 (.01)
Gaze (rates) toward the human face	R	0 (.01)	0 (0)	0 (0)	.01 (.01)	0 (.01)	0 (.01)
	S	.01 (.02)	0 (.01)	0 (0)	.02 (.02)	.01 (.01)	0 (.01)

Note: R = Retrievers Group; S = Shepherds Group; M = mean; SD = standard deviation GR= group; Acq= acquisition, Ext= extinction and Re-acq= reacquisition.



Fig 1 .

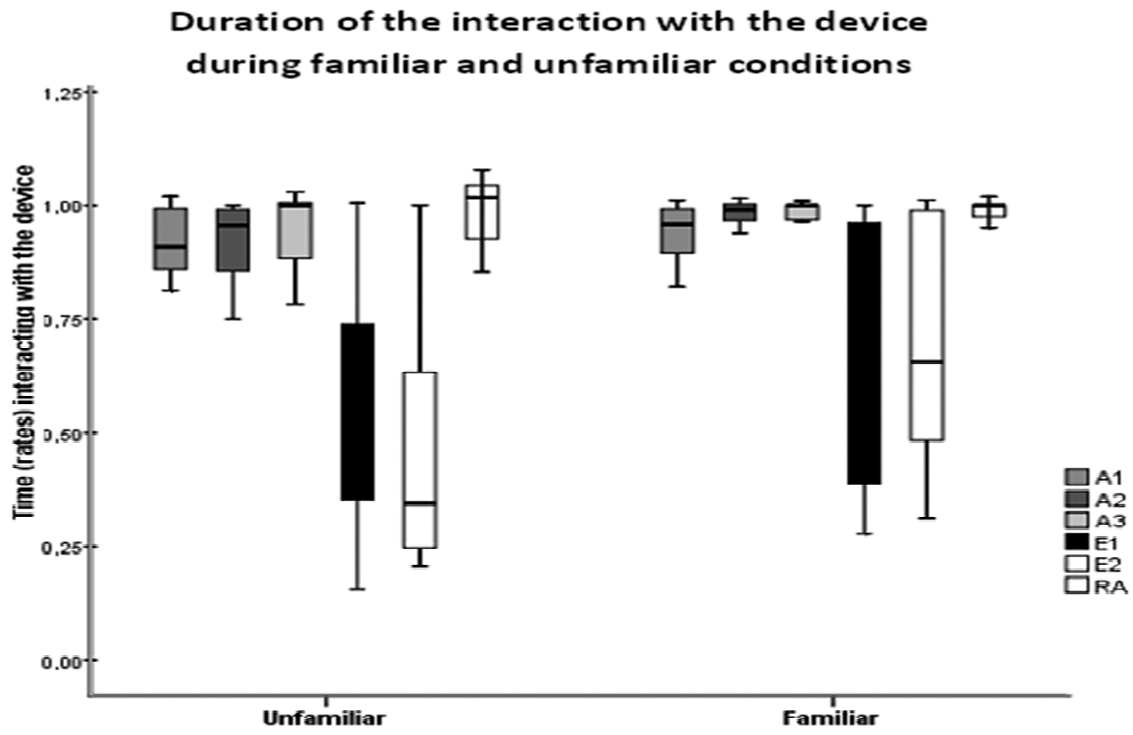


Figure 2 .

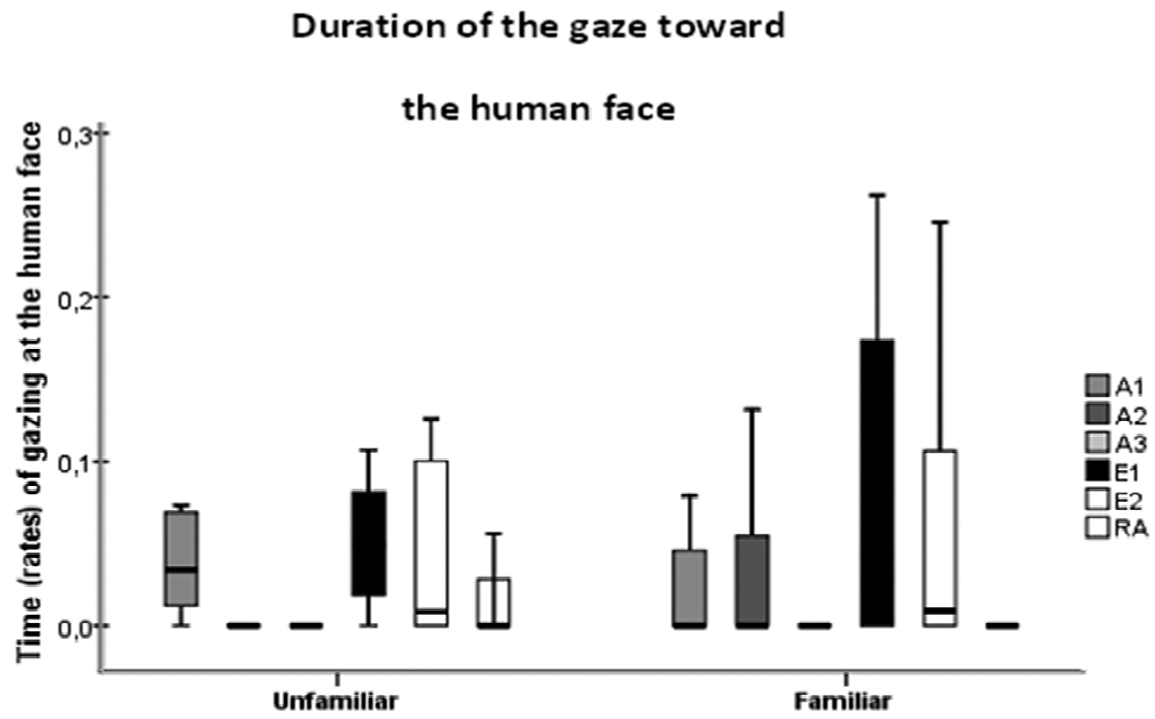


Figure 3 .

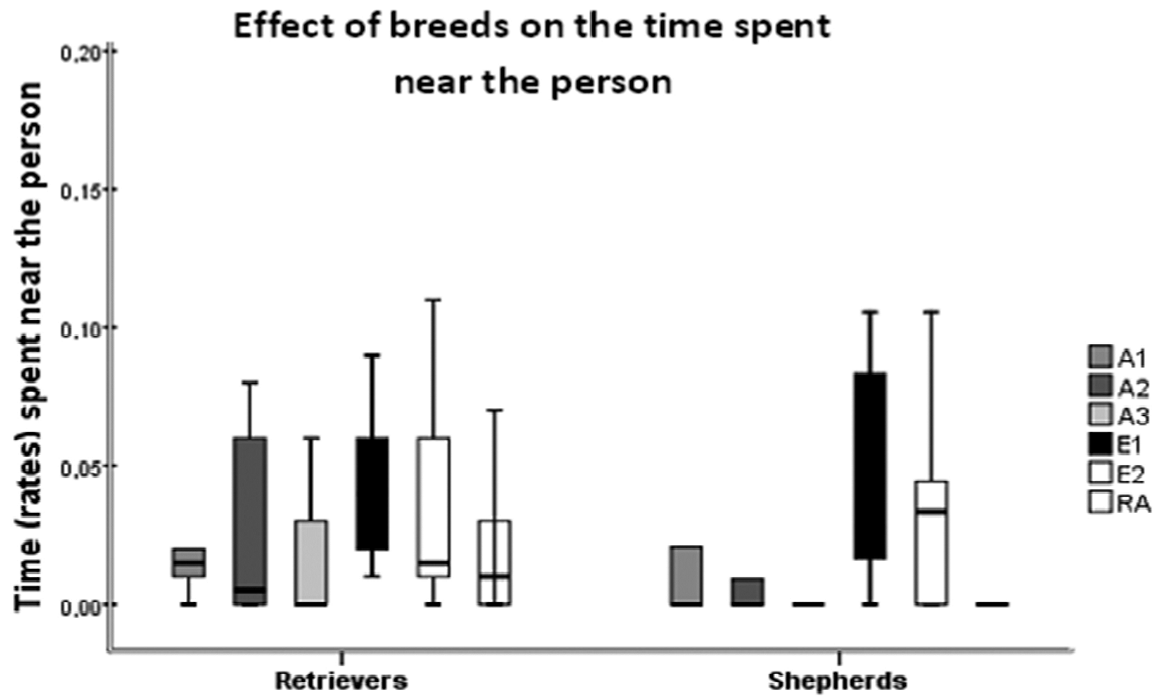


Figure 4 .