Journal of Veterinary Behavior 10 (2015) 307–314

Contents lists available at ScienceDirect

Journal of Veterinary Behavior

journal homepage: www.journalvetbehavior.com

Research

Effects of learning on social and nonsocial behaviors during a problem-solving task in shelter and pet dogs

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ARTICLE INFO

Article history:
Received 7 August 2014
Received in revised form
10 March 2015
Accepted 17 March 2015
Available online 26 March 2015

Keywords:
problem solving
social and nonsocial response
pet dogs
shelter dog

ABSTRACT

Many lines of evidence show differences between the communicative skills and social responses of dogs kept in shelters (SHDs) for long periods of time compared with pet dogs (PDs). The purpose of this work is to investigate whether there are also differences between these groups in a nonsocial problem-solving task consisting of dislodging nine plastic bones placed in a bowl to obtain the food hidden underneath it. The procedure comprised 3 phases: reinforcement, extinction, and reacquisition. In study 1, a second goal was to study whether, in the course of resolving the said task, the dogs exhibit different social responses in the presence of a stranger who remained seated near the apparatus in a passive attitude throughout the test. Results demonstrated that PDs spent longer time interacting with the apparatus throughout the 3 phases, which probably indicates greater persistence of reward-seeking behavior, compared with SHDs. This difference may relate to the fact that PDs have been more frequently exposed to partial reinforcement processes during their everyday life and have thus increased their resistance to extinction. On the other hand, during the extinction phase when no food was left, SHDs remained near for a longer time and gazed more at the person than PDs. This might indicate that the person was a stronger stimulus for SHDs as they are more deprived of social contact with people in their everyday life, which proves how the experiences during ontogeny shape the relationship between dogs and humans. The second study showed that PDs spent more time interacting with the apparatus compared with the SHDs, even in the absence of the person. These results indicate that PDs are more persistent in the reward searching response, whereas SHDs have a higher social motivation.

Introduction

The ability to solve problems has been studied in dogs using a wide variety of tasks (Scott and Fuller, 1965; Miklósi et al., 2003; Osthaus et al., 2005). Several pieces of evidence show that dogs frequently resort to human communication cues as tools to solve different problems, although the underlying mechanism is still under discussion (Miklósi et al., 2003; Bentosela et al., 2008; Udell et al., 2010a). One of the major debates regarding the remarkable communication skills displayed by dogs in their interactions with humans relate to how the development of such skills is contingent on the learning and experiences acquired during ontogeny. Some authors posit that they are the result of domestication and are somewhat independent of ontogeny (Hare et al., 2010), whereas others postulate that ontogeny would play a more significant role (Udell et al., 2010a).

A way of contributing evidence toward clarifying the debate is to assess dog populations with varying levels of everyday interaction with humans, such as those that occurs with shelter dogs (SHDs) compared with pet dogs (PDs) (Udell et al., 2010a). If ontogeny shapes communication skills, these skills would be somewhat

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http://dx.doi.org/10.1016/j.jveb.2015.03.005
1558-7878/

impaired by limited social contact with humans. In this sense, the evidence shows that SHDs and PDs were equally able to follow simple cues (point to correct, mark correct, shake correct, and shake empty) to find food (Hare et al., 2010). However, SHDs failed to follow a relatively complex human cue such as momentary distal pointing to a target location (Udell et al., 2008). Nevertheless, they were able to learn the task with additional training (Wynne et al., 2008; Udell et al., 2010b). Also, SHDs had poorer performance than PDs when discriminating some cues indicative of the attentional state of humans, such as differentiating between someone reading a book and someone looking straight ahead (Udell et al., 2011).

Gaze is one of the most important nonverbal communicative responses in the communication of several species (Emery, 2000). There is evidence showing that, when faced with an unsolvable task involving an inaccessible reward, dogs tend to gaze at the human face to gain access to the reinforcement (Miklósi et al., 2003; Marshall-Pescini et al., 2008, 2009). Barrera et al. (2012) demonstrated that there are no differences between SHDs and PDs regarding the duration of their spontaneous gaze at the human face to ask for food when it is visible but out of their reach. Furthermore, Barrera et al. (2011) observed that there were no differences in the acquisition of this response during the reinforcement phase. However, gaze duration in SHDs was shorter during extinction, that is, lower persistence of their communicative response when it no longer led to obtaining food. These results would indicate that both groups differ in their gaze response; however, the differences observed may likely be related to characteristics inherent to the extinction process rather than to the fact that it is a communicative response. In such case, SHDs should also be less persistent regarding the extinction of other types of nonsocial types of learning that do not involve communicative interaction with humans. As far as we know, there are no data comparing the resolution of nonsocial problems among SHDs and PDs.

Therefore, the purpose of this article is to first compare the acquisition, extinction and reacquisition phases in SHDs and PDs during a nonsocial problem-solving task. This would also contribute to clearing up the results obtained by Barrera et al. (2011), showing that PDs are more persistent than SHDs both in social and nonsocial tasks. Second, considering that dogs tend to ask for help when faced with an unsolvable problem (Miklósi et al., 2003; Marshall-Pescini et al., 2008, 2009), a person will remain near the apparatus in a passive and indifferent attitude toward the dog to evaluate if both groups differ in their social and communicative responses. Taking into account that several lines of evidence show that SHDs are strongly motivated to interact with people (Gácsi et al., 2001; Barrera et al., 2010) even more than PDs (Barrera et al., 2010), SHDs would seemingly exhibit more social contact-seeking responses and requesting behaviors than PDs. Finally, to evaluate if the presence of a person has any influence on dogs' performance in this problem solving-task, we ran a second study in which PDs and SHDs had to solve the same problem but in the absence of any person. The results of this study assess whether SHDs exhibit differences in problem-solving ability during a nonsocial task, compared with PDs.

Study 1

Materials and methods

Subjects

The subjects comprised 26 adult dogs (*Canis familiaris*). Thirteen of them (4 males and 9 females), belonged to the "Esperanza" Shelter (SHD group), located in the province of Entre Ríos, Argentina. The rest (6 males and 7 females; mean age: 6 years, standard deviation [SD]: 2.63) were PDs (PD group). They were all mixed breeds and had received no previous training. The age of the SHDs was unknown, but they had lived in the shelter for at least 2 years before the test; and according to the veterinary staff, they were younger than 10 years. Their background history was not available. They were all in good health.

The SHDs were kept in kennels (2 m high × 4 m long × 2 m wide). Each kennel had 4-7 dogs. The shelter had a recreational area where dogs were allowed to walk for 15-20 minutes a day, taking turns with each kennel group. Their contact with shelter staff was limited to feeding and cleaning activities.

The selection criteria used for PDs was to choose dogs that had spent most of their lives in a household and had daily interaction with their owners inside the house. A total of 9 SHDs and 10 PDs had already been assessed in other tasks (socialization test and gaze at the human face task). None of the dogs had experience with problem-solving tasks.

Two additional dogs that did not eat any reward during the first trial were excluded from the sample.

Apparatus

The experiment was conducted at the location where the dogs lived. In the case of the SHDs, the observations were made in a 2 × 3-m enclosure situated some 10 m away from the kennels and with no visual contact with the facilities. On the other hand, the PDs were evaluated in one of the rooms of the house having a similar surface area to that used for the SHDs.

The apparatus used was a game for dogs from "Dog Magic, Nina Ottosson interactive toys" consisting of a round bowl, 36 cm in diameter, with 9 bone-shaped depressions containing nine plastic bones. Each bone has a small hole to release the smell of food. There are 8 bones arranged in a circle and a ninth one in the center. 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 (75 × 45 cm) to prevent slipping. A woman unknown to the dog (the experimenter, E) sat down on the floor 1 m away from the apparatus. A person was placed at a distance of 1 m in a straight line from the apparatus to tape the sessions. Figure 1 illustrates the experimental setting used. Sessions were all taped with a Sony DCR TRV 310 camera (Sony CO., China). Each session was attended by the dog, the E, and the person operating the camera.

Procedure

The dogs were exposed to a problem-solving task consisting of dislodging the bones from the apparatus to obtain the piece of liver hidden under each bone.

Both, the SHDs and the PDs, underwent a previous familiarization period of approximately 3 minutes at the trial site. The apparatus was not present in the room during the familiarization but the cameras.

The procedure comprised 3 phases, namely acquisition, extinction, and reacquisition.

Acquisition Phase. This phase consisted of 3 trials. The first trial was of continuous reinforcement, so that all bones contained food. The inter-trials intervals were of approximately 1 minute, the time it takes the E to refill the apparatus with food and smeared it with liver. In every inter-trial and inter-phase intervals, the E smeared the apparatus with abundant liver to control for olfactory clues.

At the start of the trial, a guide left the dog in the room, where the person in charge of taping, the E, and the apparatus were already present. If the dog did not spontaneously approach the apparatus for interaction within 1 minute, the E called it by its name and, while pointing at the apparatus, lifted the bone to show the hidden food and let the dog eat. A similar instigation was repeated

Figure 1. Image of the experimental setting.

at minutes 2 and 3 if the dog was still unable to pick any bone on its own. The trial ended after 5 minutes or when the dog had obtained all the pieces of food.

The second and third acquisition trials were of partial reinforcement, with 5 of 9 bones containing food semi-randomly placed and with no baits in more than two adjacent bones. During these 2 trials, there was no instigation. The E remained motionless gazing at the dog. The trial ended after 3 minutes or when the dog had obtained all the food.

Extinction Phase. There was a 2-minute interval between the acquisition and extinction phases. Two 3-minute extinction trials were conducted. There was a 1-minute inter-trial interval where the toy was baited out of sight from the subjects. In this trial, 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-minute interval between the extinction and reacquisition phases. This phase comprised 1 single trial. The conditions were similar to those in acquisition trials 2 and 3. If the animal did not pick a bone within the first minute, it was instigated to do so once only. The trial ended after 3 minutes or when the dog had obtained all the food.

Behavioral Observations. The behaviors observed were the following:

1. Latency of the first bone picked, measured as the time elapsed between the beginning of the trial and the first bone picked by the dog. If the dog did not pick any bone on its own, a maximum latency of 5 minutes was considered for trial 1 and of 3 minutes for the remaining trials.
2. Number of bones picked up in each trial.
3. Number of food items consumed in each trial.
4. Duration(s) of interaction with the apparatus: cumulative duration of the time elapsed while the dog interacted with the apparatus (including sniffing, licking, paw touching, and trying to dislodge the bones with the paw and the nose).
5. Frequency of behaviors aimed at the person: including barks or other vocalizations, giving the paw, and physical contact with the nose or the head.
6. Time spent near the person: the dog remained with its paws at a distance of up to 50 cm from the E.
7. Gaze duration(s) toward the human face.

Data analysis

Two independent observers analyzed all the measures in 65% of the videotaped material. To test interobserver reliability, Spearman's coefficients of correlation were calculated for all the measures ($r > 92$, $N = 17$, $P < 0.05$).

Considering that the dependent variables (latency to remove the first bone, total numbers of bones removed, time spent near the person, gaze duration toward the human face, and frequency of other social behaviors) did not show a normal distribution (Kolmogorov-Smirnov test, $P < 0.05$), nonparametric tests were used: Mann-Whitney *U* tests were used to compare the performance between groups, and Wilcoxon and Friedman analysis of variance (ANOVA) tests were used for repeated measures analyses. The variable "duration of the interaction with the apparatus" was the only one not differing from a normal distribution (Kolmogorov-Smirnov test, $P > 0.05$) and thus an ANOVA test was used in this case. The alpha value was set at 0.05. All analyses involved two-tailed tests.

Results

Acquisition phase

Repeated measures ANOVA comparing the duration of interaction with the apparatus during the 3 acquisition trials showed a significant effect of Group ($F_{(1,24)} = 13.93$, $P = 0.001$), but not for Trials and the interaction between Group and Trials ($P > 0.1$; Figure 2). Thus, SHD spent significantly less time interacting with the apparatus.

Comparisons during the acquisition phase indicated that the latency of the first bone picked up decreased across trials ($\chi^2_2 = 22.19$, $P < 0.001$; Table 1), whereas cumulative duration of time spent near the person increased during the phase (Comparisons during the acquisition (ADQ) 1: 5.81, SEM ± 9.95; ADQ 2: 1.86, SEM ± 4.16; ADQ 3: 0.69, SEM ± 2.16; $\chi^2_2 = 15.09$, $P = 0.001$). On the other hand, there were neither significant differences on cumulative duration of the gaze at the human face (ADQ 1: 1.40, SEM ± 4.26; ADQ 2: 0.29, SEM ± 1.10; ADQ 3: 1.33, SEM ± 5.06) nor on the frequency of other social behaviors and the number of bones picked ($P > 0.1$).

Mann-Whitney *U* test comparing both groups showed significant differences in the latency of the first bone picked in trial 1 ($Z = -2.38$, $P = 0.017$) and the number of bones picked in trial 3 ($Z = -2.88$, $P = 0.004$; Table 1). The remaining comparisons were not significant ($P > 0.1$). In all cases, the total number of SHD and PD was 13 each.

Overall, SHD picked up the first bone faster in the first trial and managed to pick a larger number of bones in the last test than PD, whereas the latter spent more time interacting with the apparatus throughout the acquisition phase. Finally, both groups picked the first bone faster throughout the acquisition trials and increased the time spent in contact with the person.

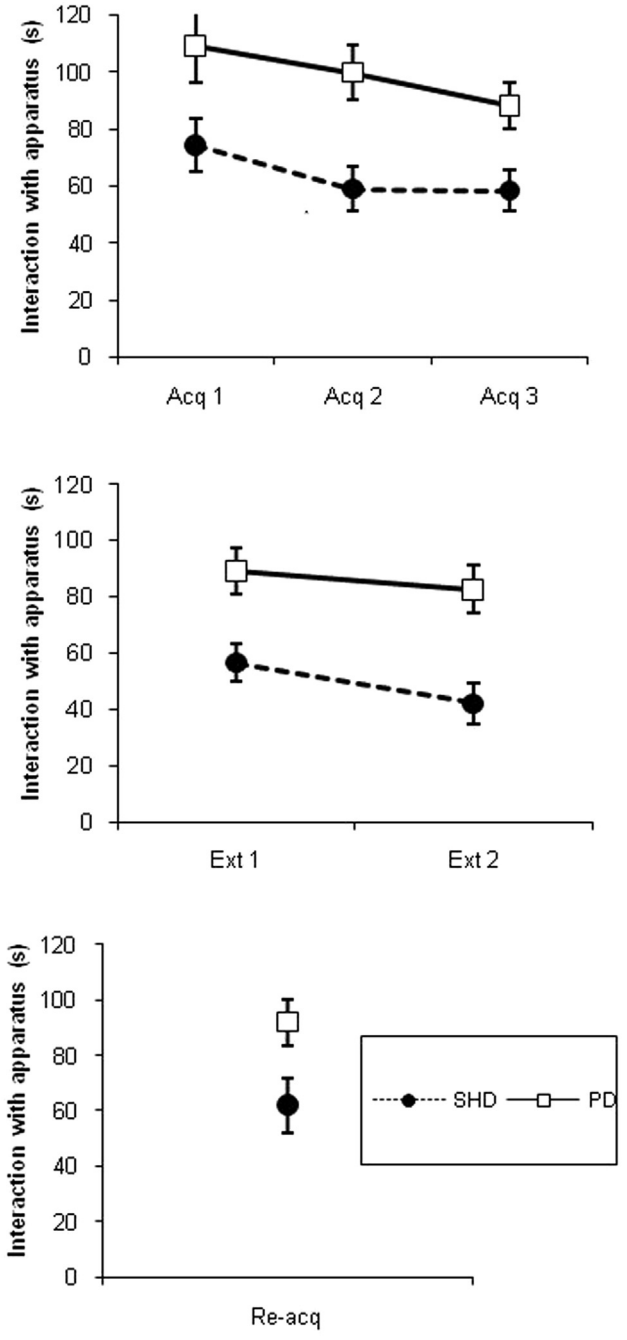

Figure 2. Duration (s) of the interaction with the apparatus in acquisition (acq), extinction (ext), and reacquisition (re-acq) trials for shelter (solid black squares) and pet dogs (empty squares; means ± 95% confidence intervals) of study 1. Two-tailed tests ($P < 0.05$).

Extinction phase

Regarding the duration of interaction with the apparatus, the repeated measures ANOVA indicated a significant effect of Group ($F_{(1,24)} = 12.95$, $P = 0.001$), Trials ($F_{(1,24)} = 4.42$, $P = 0.046$), but not the interaction between them ($P > 0.1$; Figure 2). The SHD spent less time interacting with the apparatus than PD and the PDs as a whole interacted more with the apparatus in the first extinction trial compared with the second.

No significant differences were observed in the comparison across trials during extinction ($P > 0.1$). We found a marginal difference in the number of bones picked ($P = 0.057$), suggesting that PD picked up more bones than SHD during extinction trials. The comparison between groups during extinction showed significant differences in: the time spent near the person in trial 1 ($Z = -2.29$, SHD = 13, PD = 13, $P = 0.022$) and trial 2 ($Z = -3.12$, SHD = 13, PD = 13, $P = 0.002$), and cumulative duration of the gaze at the human face in trial 2 ($Z = -2.45$, SHD = 13, PD = 13, $P = 0.014$; Figures 3 and 4).There were no significant differences in the other measures ($P > 0.1$).

In short, during the extinction phase, both groups of dogs decreased the time of contact with the apparatus throughout the trials, although PD exhibited longer contact time than SHD. On the other hand, SHD displayed longer time of contact and gaze duration at the person.

Reacquisition phase

An independent samples t test showed a significant difference between groups in the duration of interaction with the apparatus ($t_{24} = -2.25$, $P = 0.033$; Figure 2). No other significant differences were observed during this phase ($P > 0.05$). During the three phases, no behaviors aimed at the person were observed.

Comparison between the last acquisition and two extinction trials

The ANOVA repeated measures indicated that the amount of time interacting with the apparatus changed along the third acquisition and the two extinction trials ($F_{(2,48)} = 61.68$, $P < 0.001$). No significant effect of Group was found ($P > 0.05$); however, the Group by Trials interaction was significant ($F_{(2,48)} = 12.52$, $P < 0.001$). Post hoc analysis using Bonferroni correction showed that the comparison between the last acquisition trial and the two extinctions trials were significant ($P < 0.001$), but there were no significant difference in the two extinction trials ($P > 0.1$).

Friedman ANOVA indicated that there were significant differences in the number of bones picked up across trials (χ^2_2 16.82, $P < 0.001$). Post hoc comparisons showed that the last acquisition trials significantly differed with the first ($Z = -3.24$, $P = 0.001$) and second ($Z = -3.37$, $P = 0.001$) extinction trials. The analysis of each group separately revealed that only SHD group had significant differences between acquisition 3 and trial 1 ($Z = -2.68$, $P = 0.007$) and 2 ($Z = -2.81$, $P = 0.005$) of the extinction phase, showing a decrease in the number of bones picked up along trials. For PD group, P value higher than 0.05 was significant (Table 1).

Similarly, a difference was observed along trials in the duration of approach to the person ($\chi^2_2 = 11.88$, $P = 0.003$). The significant differences were between the last acquisition and the first ($Z = -2.80$, $P = 0.005$) and second ($Z = -3.06$, $P = 0.002$) extinction trials. However, only SHD group showed these differences with trial 1 ($Z = -2.57$, $P = 0.01$) and 2 ($Z = -2.90$, $P = 0.004$). For PD group, P value higher than 0.1 was significant.

Also, gaze duration toward the human face differed between these trials, $\chi^2_2 = 6.57$, $P = 0.037$. Only SHD group exhibited a significant difference between acquisition 3 and extinction 1 ($Z = -2.36$, $P = 0.018$) and 2 ($Z = -2.52$, $P = 0.012$). For the PD group, P value higher than 0.1 was significant.

There were no significant differences across these three trials either in the latency of the first bone picked or in the frequency of other social behaviors ($P > 0.05$).

Comparison between the last extinction and the reacquisition trials

Repeated measure ANOVA shows a significant effect of trial (extinction vs. reacquisition; $F_{(1,24)} = 89.24$, $P < 0.001$) and an effect of Group and Trial interaction ($F_{(1,24)} = 5.62$, $P = 0.26$) in the time

Table 1
Mean (SEM) latencies of the first bone picked (LFB), total number of removed bones (NB), gaze duration(s) towards the human face (GD); time spent (s) near the person (TP); frequency of behaviors aimed at the person (FBP) during acquisition (ACQ), extinction (EXT), and reacquisition (REACQ) phases in shelter (SHD) and pet dogs (PD)

Parameters	GR	ACQ 1	ACQ 2	ACQ 3	EXT 1	EXT 2	REACQ
LFB	SHD	58.10 (30.2)	21.6 (11.7)	14.01 (6.8)	7.19 (1.4)	19.13 (10.3)	11.06 (2.7)
	PD	106.28 (29.7)	26.44 (14.3)	12.39 (6)	12.45 (7.3)	7.42 (1.9)	6.93 (1.9)
NB	SHD	7.62 (0.9)	7.85 (0.7)	8.92 (0.1)	7.15 (0.5)	5.85 (0.8)	8.69 (0.2)
	PD	6.23 (1.1)	7.15 (0.7)	7.69 (0.5)	7.08 (0.5)	6.77 (0.5)	8.46 (0.3)
GD	SHD	0.3 (0.79)	0.4 (1.4)	0 (0)	2.7 (5.57)	1.8 (2.8)	0.66 (1.17)
	PD	2.5 (5.88)	0.19 (0.58)	2.6 (7.04)	2.07 (6.15)	0.12 (0.3)	0.03 (0.13)
TP	SHD	4.17 (8.18)	2.03 (4,64)	0.28 (1.02)	17.12 (19.95)	36.94 (44.13)	1.03 (2.44)
	PD	7.44 (11.55)	1.68 (3.8)	1.1 (2.89)	3.44 (7.76)	3.93 (8.9)	1.09 (3.83)
FBP	SHD	0.23 (0.83)	0 (0)	0 (0)	0.15 (0.37)	0.3 (1.1)	0 (0)
	PD	0.23 (0.83)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

interacting with the apparatus but no effect of Group ($P > 0.05$). Post hoc comparisons show that dogs spent significantly more time interacting with the apparatus in the reacquisition trial than in the last extinction trial ($P < 0.001$).

Dogs picked up significantly more bones during the reacquisition phase than during the last extinction trial ($Z = -3.8$, $P < 0.001$).

Finally, the amount of time spent near the person was significantly higher in the last extinction trial compared with the reacquisition phase ($Z = -3.46$, $P = 0.001$). A separated analysis of both groups shows that only SHD showed this difference ($Z = -3.05$, $P = 0.002$. For the PD group, P value higher than 0.1 was significant. Analysis of all the other measures shields no significant differences ($P > 0.1$).

Discussion

In summary, dogs picked up more bones and spent more time interacting with the apparatus in the reacquisition phase than in the last extinction trial. As a group, dogs spent more time near the person in the last extinction trial than in the reacquisition phase. But the analysis of each Group separately indicates that this difference was only evident in the SHD Group.

There were no significant differences across these three trials neither in the latency of the first bone picked nor in the frequency of other social behaviors.

There are two possible explanations to the findings that PD spent more time interacting with the apparatus and SHD spent more time near the E during the extinction phase. The partial reinforcement schedule during acquisition results in a major persistence of the learning response in several tasks (Amsel, 1962). Therefore, it is probable that PD have had a longer partial reinforcement history during their daily life, leading to a higher persistence in the extinction compared with SHD. For SHD, the food appears every day at the same time and they have no opportunities to beg for rewards. On the other hand, during the task, there was a competition between social and nonsocial responses. Considering that the person is a more salient stimulus to the SHD than to the PD (Barrera et al., 2010), it could be possible that SHD spent more time with the person, and as a consequence, they cannot interact with the apparatus the same time as PD. To evaluate this last explanation, we ran a second experiment in which the dogs had to solve the same task, but without the presence of the person. If in this study we found the same differences as in study 1, it would contribute to provide evidence supporting the second explanation. Although, if in the absence of the experimenter, we found no differences between groups, the results described in study 1 could be only owing to the higher social motivations of SHD.

Study 2

Materials and methods

Subjects

The subjects in the SHD group comprised 13 adult dogs (*Canis familiaris*; 6 males and 7 females), which belonged to the

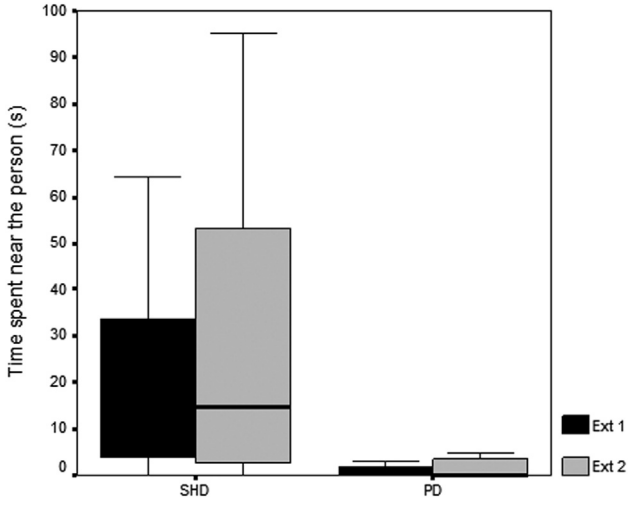

Figure 3. Time(s) spent near the person (less than 50 cm) during extinction (ext) trials for shelter and pet dogs (means ± 95% confidence intervals) of study 1. Two-tailed tests ($P < 0.05$).

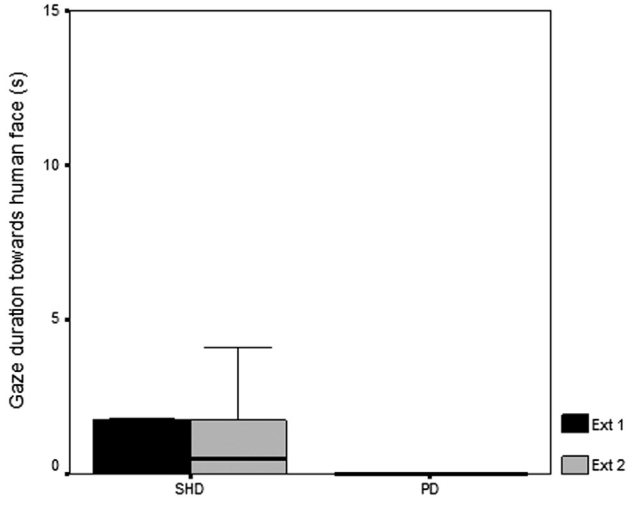

Figure 4. Gaze duration(s) towards the human face during extinction (ext) trials for shelter and pet dogs (means ± 95% confidence intervals) study 1. Two-tailed tests ($P < 0.05$).

"Esperanza" Shelter, located in the province of Entre Ríos, Argentina. The exclusion criterion was the same as in study 1. Four dogs had to be discarded because they showed fear behaviors and 1 dog because it never touched the apparatus. All conditions were the same as in study 1.

For the PD group, we evaluated 16 dogs, 3 of them had to be discarded (1 because it showed signs of fear of the apparatus and 2 because they could not solve the task in the first acquisition trial). The final sample comprised 13 dogs (5 males and 8 females; mean age: 3.3 years, SD: 1.66). Three of the subjects in the PD group had participated in previous studies involving a pointing task. None of the SHDs or PDs had any previous experience with the apparatus. All other conditions were identical to study 1.

Procedure

The procedure was exactly the same as in study 1with the following exceptions: (1) Once the set was ready, the dog was left alone in the room and a female experimenter entered the room, put the apparatus on the floor and left the room, so the dog was alone during the trials. (2) In the first acquisition trial, the plastic bone in the middle of the apparatus was half dislodged from its position, thus letting the dog see the liver hidden inside. This modification was introduced to facilitate the task and as a way to instigate the dog to pick up the bones, given that there was no experimenter present during the study to encourage the animal. (3) Sessions were all taped with a Sony DCR TRV 310 camera on a tripod placed in a corner of the room far away from the apparatus. To know when the animals finished the task in acquisition and reacquisition phases and refill the apparatus, we added to the set a webcam (Genius, FaceCam 312, Taiwan) connected to a laptop computer from which we could see the behavior of the dog from an adjacent room. We used Debut Video Capture Software Professional to watch and record the trials. All other conditions and intervals were the same as in study 1.

Results

Acquisition phase

Repeated measures ANOVA comparing the duration of interaction with the apparatus during the acquisition trials showed a significant effect of Trials ($F_{(2,48)} = 10.27$, $P < 0.001$) but not for Group or interaction between Group and Trials ($P > 0.05$). Post hoc analysis (Bonferroni) showed that the animals spent significantly more time interacting with the apparatus in the first trial compared with the second ($P = 0.03$) and third ($P = 0.002$; Figure 5).

Comparisons during the acquisition phase indicated that the latency to picking up the first bone decreased across trials ($\chi^2_2 = 21.76$, $P < 0.001$). There were no significant differences in the other comparisons ($P > 0.05$). In all cases, the total number of SHDs and PDs was 13 each (Table 2).

Overall, dogs learnt to solve the problem through the acquisition phase and spent less time interacting with the apparatus in the final acquisition trial and the latency to pick up the first bone decreased across trials in both the groups.

Extinction phase

Regarding the duration of interaction with the apparatus, the repeated measures ANOVA indicated a significant effect of Group ($F_{(1,24)} = 8.02$, $P = 0.009$) but not of Trial or Trial and Group interaction. Dogs of the PD group spent significantly more time interacting with the apparatus than SHD (Figure 5).

There were no significant differences in the others measures ($P > 0.1$; Table 2). Overall, dogs of the PD groups spent more time interacting with the apparatus during the extinction phase.

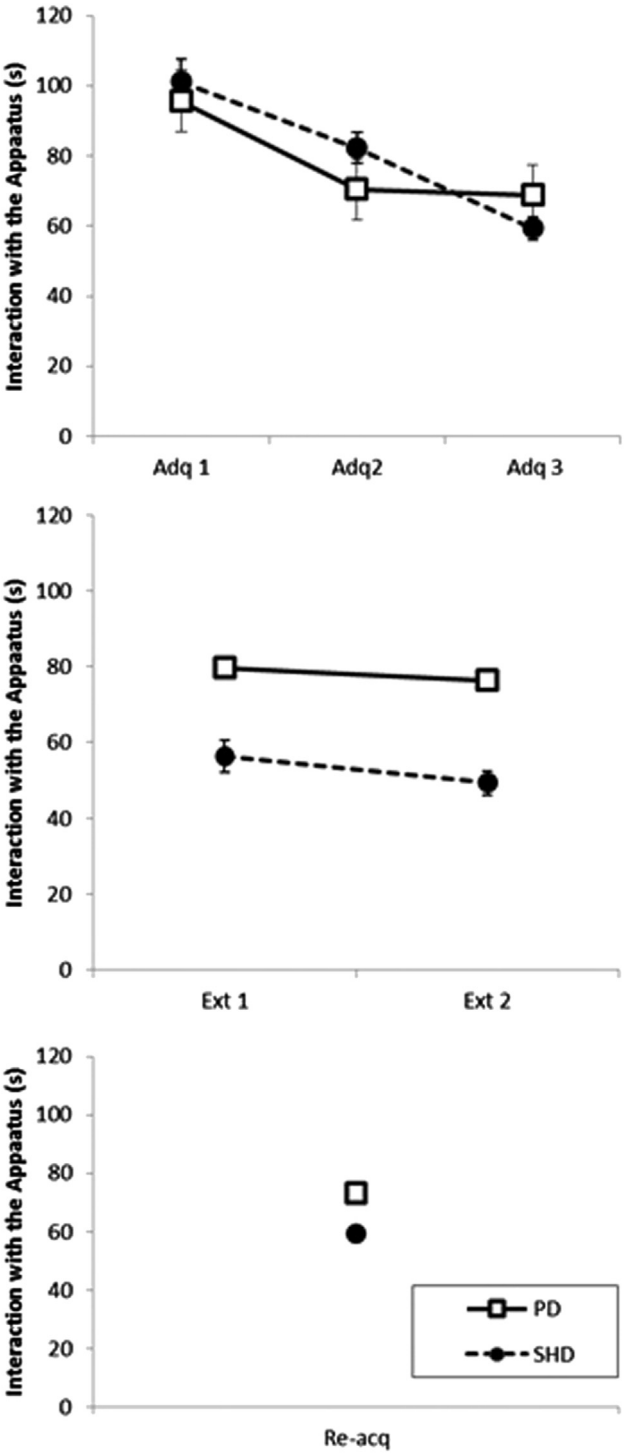

Figure 5. Duration(s) of the interaction with the apparatus in acquisition (adq), extinction (ext), and reacquisition (re-adq) trials for shelter (solid black squares) and pet dogs (empty squares; means ± 95% confidence intervals) of study 2. Two-tailed tests ($P < 0.05$).

Reacquisition phase

Figure 5 shows that there were no significant differences in the time interacting with the apparatus between groups ($t_{24} = -1.46$, $P = 0.15$). And no other significant differences between groups were observed during this phase ($P > 0.1$).

Table 2
Mean (SEM) latencies of the first bone picked (LFB); total number of removed bones (NB); and number of vocalizations (VOC) during acquisition (ACQ), extinction (EXT), and re-acquisition (REACQ) phases in shelter (SHD) and pet dogs (PD)

Parameters	GR	ACQ 1	ACQ 2	ACQ 3	EXT 1	EXT 2	REACQ
LFB	SHD	14 (7.24)	8.59 (5.72)	4.3 (1.89)	5.03 (4.05)	5.24 (2.85)	6.16 (3.73)
	PD	15.05 (14.41)	4.33 (2.95)	4.58 (3.16)	4.52 (6.14)	7.1 (8.69)	4.5 (3.21)
NB	SHD	9 (0)	8.61 (0.65)	8.38 (1.66)	7.61 (1.93)	7.15 (2.4)	8.53 (1.39)
	PD	9 (0)	8.92 (0.27)	8.84 (0.37)	8.15 (1.28)	7.69 (0.85)	8.61 (0.96)
FBP	SHD	0.07 (0.27)	0 (0)	0 (0)	1.38 (3.59)	0.76 (1.36)	0.3 (0.75)
	PD	0 (0)	0 (0)	0.07 (0.27)	1.38 (2.95)	2.15 (3.89)	0.23 (0.83)

Comparisons between the last acquisition and the two extinction trials

The ANOVA repeated measures indicated that the rate of time spent interacting with the apparatus changed along the third acquisition and the two extinction trials ($F_{(2,48)} = 53.89$, $P < 0.001$). No significant effect of Group or interaction was found ($P > 0.1$). Post hoc analysis shows that animals spent significantly less time interacting with the apparatus in the extinction phase compared with the last acquisition phase ($P < 0.001$), but there were no differences in this measure in the two extinction trials ($P > 0.1$; Figure 5).

With regard to the number of bones picked up across trials, Friedman ANOVA indicates that there were significant differences ($\chi^2_2 = 21.54$, $P < 0.001$). Post hoc comparisons showed that the last acquisition trials significantly differed with the first ($Z = -2.38$, $P = 0.019$) and second ($Z = -3.71$, $P < 0.001$) extinction trials. The analysis of each group separately revealed that only PD group had significant differences between the third acquisition trial and extinction trials 1 ($Z = -2.26$, $P = 0.024$) and 2 ($Z = -2.87$, $P = 0.004$), although SHD showed significant differences only between the third acquisition trial and the second extinction trial ($Z = -2.41$, $P = 0.016$; Table 2).

There were no significant differences across these three trials neither in the latency of the first bone picked up ($P > 0.1$) or in any other measure.

Comparison between the last extinction and the reacquisition trials

Repeated measure ANOVA shows a significant effect of Trial (extinction vs. reacquisition) on the rate of time spent interacting with the apparatus ($F_{(1,24)} = 118.32$, $P < 0.001$), a marginal effect of Group ($F_{(1,24)} = 4.15$, $P = 0.053$), and no effect of interaction. Dogs spent more time interacting with the apparatus in the reacquisition phase (Figure 5).

Dogs picked up significantly more bones during the reacquisition phase than during the last extinction trial ($Z = -3.4$, $P = 0.001$; Table 2).

Finally, regarding the other behaviors, the number of vocalizations during the last extinction trial was significantly higher than during the reacquisition phase ($Z = -2.39$, $P = 0.017$). All other measures show no significant differences ($P > 0.1$).

Discussion

Dogs picked up more bones and spent more time interacting with the apparatus in the reacquisition phase than in the last extinction trial. Also more vocalizations during the second extinction trial were observed compared with the reacquisition (Table 2). These results showed that PDs persist more in searching for the reward, compared with SHDs, even when there is no human present during the task. Therefore, the higher social behaviors of SHDs during the first experiment cannot be explained by the competition of stimuli between the person and the apparatus. In conclusion, both groups can solve the nonsocial problem, but PDs are more persistent in looking for the reward, whereas SHDs have a stronger social motivation.

General discussion

This study compared the problem-solving ability of the SHDs with the PDs living in households. The dogs learned to dislodge plastic bones placed in a bowl, using the nose and paws, to obtain the hidden food. This capacity was not seemingly affected by a long period of time spent in shelters. The SHDs and PDs were capable of learning the task, and both groups picked up the first bone faster throughout the acquisition trials, which would suggest an operant learning curve. This pattern was observed both when an unknown person was present or absent during the task.

It is interesting to note that, in the first study, during the first trial, dogs in the SHD group picked the first bone faster than dogs in the PD group. This difference might show greater food motivation as well as higher levels of deprivation in SHDs, which very rarely have access to highly appetitive food such as liver. However, such difference disappeared in the remaining trials and also this difference was not observed during the second study. Bearing this in mind and the fact that all animals ate the rewards in all the trials, it might be assumed that both groups were similarly motivated by food throughout the trial phases.

On the other hand, the PDs spent more time interacting with the apparatus. Although it is not possible to determine the reasons for this behavior, one possibility is that PDs are more persistent in their reward-seeking behavior by licking and sniffing at the apparatus. This difference would indicate that the previous history of each group affects their performance. In this sense, as we previously mentioned, usually some of the PDs' responses lead to obtaining the rewards, whereas others do not. Partial reinforcement produces persistence of learned responses (Amsel, 1962) and this might be reflected in the activity here in evaluated, as was previously observed in the communicative task of gazing at the human face (Barrera et al., 2011).

Finally, both groups increased the time in contact with the person throughout the acquisition trials. During the first trials, the dogs were focused on solving the task. In the course of the trials, they not only became more efficient but also switched from a continuous reinforcement program to a partial reinforcement program, where only 4 of the 9 bones were baited. A closer approach to the person during these trials may likely be related to their reaction to change in the reinforcement schedule, because they are within a partial reinforcement program.

Some of these assumptions have been confirmed by the results obtained in the extinction phase. During this phase, both groups decreased the time of contact with the apparatus as no reinforcement was delivered. However, PDs showed a longer time interacting with the apparatus than SHDs, again evidencing greater persistence of their learned response, whether the person was present or absent. This agrees with the findings of Barrera et al. (2011) who demonstrated that PDs gazed more at the human

than SHDs to ask for food during the extinction phase. Considered as a whole, it might be concluded that PDs have greater resistance to extinction, both regarding social and nonsocial learning. It would be important to test this idea on a larger number of tasks.

This persistence difference may be related to a variety of factors. First, PDs, compared with SHDs, are subject to partial reinforcement processes occurring spontaneously and more frequently in their everyday life.

Second, the differences found might be owing to a paradoxical phenomenon known as the magnitude reinforcement extinction effect, that is, larger reinforcer magnitudes during acquisition result in lower persistence during extinction compared with lower magnitudes (Amsel, 1962). Although both groups in this study received the same magnitude, the reinforcement incentive value might have been greater for SHDs because, unlike what usually occurs with PDs, they do not have access to highly appetitive food, as liver, in their everyday life. Notwithstanding this, our hypothesis requires further analysis to control, for instance, the frequency of high-magnitude reinforcers in the everyday life of PDs.

Third, the SHDs are normally affected by higher levels of chronic stress associated with poor living conditions, little contact with humans, and social isolation (Hennessy et al., 1997). Stress could have caused a faster extinction of the learned responses. However, this explanation does not seem too reasonable given that the various lines of evidence in the literature regarding rat studies show that chronic stress led to impaired extinction recall and thus to greater persistence of the previously learned response (Miracle et al., 2006; Baran et al., 2009; Wilber et al., 2011).

Finally, SHD exhibited longer time of contact and gaze duration at the person than PD during extinction. The same behaviors observed during the sociability test conducted, when SHDs sought greater approach to a stranger (Barrera et al., 2010), is also noted here because, instead of persisting in trying to find food in the apparatus, SHDs prefer to seek the social reinforcer provided by the person at hand. Probably, as they are deprived of human social contact in their everyday life, the person represents for this group a more salient stimulus that might be acting as an alternative reinforcer when food is no longer present. These results also showed that associative learning modulates the social responses, even during a nonsocial problem when the dogs can solve the task by themselves and do not require the help from humans. This modulation was also observed during the learning of communicative responses (Bentosela et al., 2008; Elgier et al., 2009), suggesting that learning is one of the mechanisms involved in the relationship between dogs and humans.

Conclusions

In conclusion, these results showed that long-term shelter stays affect some aspects of nonsocial problem resolution and generates shorter persistence in seeking rewards. Additionally, it increases the approach to a person at hand even when in a passive attitude. These differences are similar to those observed in problem solving involving social and communicative cues, which probably shows a typical pattern for SHDs.

Acknowledgments

This research was supported by CONICET (grant number: 11220090100169) and AGENCIA (PICT 2010, number 0350). The authors express their special gratitude to Nydia Schmidt and to all the staff of the “Esperanza” Animal Shelter in Crespo, Entre Ríos, Argentina. They are deeply thankful to all dog owners, and Gustavo Bianco and Canine School GB for their collaboration. Also, they would like to thank Caterina Barisón, Luciana Crespi, Guillermo Ursini, and Juan Manuel Fernández for helping in data collection. Furthermore, they appreciate the valuable comments on a preliminary version of this manuscript of Esteban Freidin.

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