Agility and search and rescue training differently affects pet dogs' behaviour in socio-cognitive tasks

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ABSTRACT

Both genetic factors and life experiences appear to be important in shaping dogs' responses in a test situation. One potentially highly relevant life experience may be the dog's training history, however few studies have investigated this aspect so far. This paper briefly reviews studies focusing on the effects of training on dogs' performance in cognitive tasks, and presents new, preliminary evidence on trained and untrained pet dogs' performance in an 'unsolvable task'. Thirty-nine adult dogs: 13 trained for search and rescue activities (S&R group), 13 for agility competition (Agility group) and 13 untrained pets (Pet group) were tested. Three 'solvable' trials in which dogs could obtain the food by manipulating a plastic container were followed by an 'unsolvable' trial in which obtaining the food became impossible. The dogs' behaviours towards the apparatus and the people present (owner and researcher) were analysed. Both in the first 'solvable' and in the 'unsolvable' trial the groups were comparable on actions towards the apparatus, however differences emerged in their human-directed gazing behaviour. In fact, results in the 'solvable' trial, showed fewer S&R dogs looking back at a person compared to agility dogs, and the latter alternating their gaze between person and apparatus more frequently than pet dogs. In the unsolvable trial no difference between groups emerged in the latency to look at the person however agility dogs looked longer at the owner than both pet and S&R dogs; whereas S&R dogs exhibited significantly more barking (always occurring concurrently to looking at the person or the apparatus) than both other groups. Furthermore, S&R dogs alternated their gaze between person and apparatus more than untrained pet dogs, with agility dogs falling in between these two groups. Thus overall, it seems that the dogs' human-directed communicative behaviours are significantly influenced by their individual training experiences.

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1. Introduction

In the past 10 years there has been a considerable increase in the number of studies on dogs' cognitive (Collier-Baker et al., 2004; Cooper et al., 2003; Kubinyi et al., 2003; Osthaus et al., 2005; Pongrácz et al., 2001, 2005; Range et al., 2007; Topál et al., 2006) and communicative abilities (Call et al., 2003; Hare et al., 1998; Hare and Tomasello, 1999, 2005; Horowitz, 2009; Miklósi et al., 1998, 2000; Schwab and Huber, 2006). As noted by Miklósi et al. (2004) in a seminal paper, dogs are interesting study subjects for a number of reasons amongst which the possibility of looking at both the genetic influence on behaviour by, for example, studying breed differences, and the ontogenetic process i.e. taking into consideration various aspects of a dog's life history.

The genetic influence on dogs' behaviour has received a certain amount of attention, particularly in the applied field of problem behaviours where a number of studies have suggested a link between a breed and specific behavioural phenomena such as tail-chasing (Hartigan, 2000; Luescher, 2003) and others have indicated an increased manifestation of aggression in certain breeds (Duffy et al., 2008; Svartberg, 2006).

The genetic aspect has also been of interest in the more theoretical arena of social cognition (Miklósi et al., 2003; Virányi et al., 2008; Hare et al., 2002, 2005; Hare and Tomasello, 2005). More specifically, dogs have been compared to hand-reared wolves on a number of tasks involving reliance on human gestural communication and intriguingly dogs consistently outperformed their ancestors despite a common ontogenetic history (Hare et al., 2002; Miklósi et al., 2003; Virányi et al., 2008). Thus, for example dogs followed a human pointing gesture to obtain hidden food at an earlier age compared to wolves (Virányi et al., 2008) and when confronted with an unsolvable task they looked back at their human companion sooner than hand-reared wolves (Miklósi et al., 2003). These

results have lead various authors to suggest a powerful influence of the domestication process on the emergence of the dogs' socio-cognitive abilities (Miklósi et al., 2004; Hare and Tomasello, 2005; Miklósi and Soproni, 2006). This influence seems further supported by data showing (1) dog puppies as young as 6-week-old accurately following the human pointing gesture (Riedel et al., 2008), (2) no difference in the performance of 9–26-week-old puppies living in homes compared to those living in a kennelled environment (Hare et al., 2002) and (3) 'domesticated' foxes performing on a par with dogs of the same age in the comprehension of pointing (Hare et al., 2005).

More recent results however have called into question these conclusions, since wolves with continued daily contact with humans have been shown to perform equally if not better than dogs in comprehension of pointing (Udell et al., 2008), and a re-analysis of data from Riedel et al.'s (2008) study appears to show improvement across age groups, suggesting a strong learning effect during development and, perhaps even more significantly, an improvement across trials in the youngest group (Wynne et al., 2008). Together, the latter results suggest that, at 6 weeks, dogs have not wholly acquired the capability of following the pointing gesture, but they are in fact learning within the testing phase itself (Wynne et al., 2008). Thus, both these studies point to the potential importance of dogs' (and wolves') life experiences in shaping their responses in a test situation.

One potentially highly relevant life experience may be the dog's training history. Dogs have historically been trained to perform a multitude of tasks from the more classic examples of hunting, herding and guarding to the more recent explosion of canine related sports and competitions such as agility (where dogs and their owners have to negotiate an obstacle course together as quickly as possible) and freestyle (where a choreography of complex movements is performed by dogs and their owners to music). In the last 10 years or so, Italy has seen a considerable increase in the number of pet owners choosing to take their dogs to training schools, mostly linked to a cultural change in the training world which has gone from the old style choke chain and physical punishment methods to the use of positive reinforcement methods involving toys, food and fun. Thus, at least for Northern Italian pet dogs, training is a potentially important aspect of their lives.

In the following pages we shall briefly review the relatively few scientific studies looking at the effects of training on dogs' performance in cognitive tasks and present results comparing trained and untrained pet dogs in an 'unsolvable task' similar to that presented to pet dogs and hand-reared wolves by Miklósi et al. (2003).

2. Trained vs untrained dogs' performance in cognitive tasks

Osthaus et al. (2003, 2005) presented dogs with a string-pulling task to test their comprehension of the means-end connection, i.e. that a desired outcome can only be achieved by utilizing some means to that end. Overall, dogs performed rather poorly in this task, however clicker trained dogs (i.e. dogs trained using an operant conditioning with secondary reinforcer method) were faster to learn the basic behaviour of pulling the string out of the box. Furthermore, when the string was laid out at an angle (thus no longer directly in line with the food source), compared to untrained dogs, clicker trained dogs performed significantly fewer so called 'proximity errors', i.e. attempts to dig their way into the box close to the food.

McKinley and Sambrook (2000) showed how pet gun-dogs were significantly worse than trained gun-dogs in the comprehension of pointing. This is not altogether surprising, since following an outstretched hand is part of a gun-dogs training experience in the field. However, the other interesting result reported by the authors is that

when head orientation was used as a communicative cue, which all dogs found considerably difficult to follow, trained gun-dogs significantly improved their performance across trials whereas untrained gun-dogs did not. The same effect, although it did not reach statistical significance, also occurred when gazing alone was used as a communicative cue. The study also reported a difference between untrained gun-dog pets and pets of other breeds, with gun-dogs following all communicative signals significantly better. This study thus suggests an interesting effect of both genetic factors (breeding for cooperative type work) and life experiences (gun-dog training) in the comprehension of human communicative signals.

In two previous studies by our group we investigated the potential effects of training on performance in socio-cognitive tasks. In Marshall-Pescini et al. (2008) pet dogs, trained in various disciplines (agility, search and rescue, schutzhund, freestyle, gun-dog working trials), and untrained pet dogs (with no or only basic training) were tested in a problem solving task involving a 'puzzle box' which could be opened pressing a paw pad, or nosing the lid to obtain a valued food item. Whether having observed the researcher open the lid or not, significantly more trained pet dogs opened the box compared to untrained pet dogs. Furthermore, a detailed behavioural analysis revealed that untrained pet dogs spent a significantly greater proportion of time orienting towards the owner compared to trained dogs, who conversely spent most of their time interacting with the box. We also compared the two most represented samples of trained dogs i.e. agility and schutzhund but no differences between them emerged in any of the behavioural categories analysed.

In Prato-Previde et al. (2008) we found that whereas there was no difference between trained and untrained dogs when they had to independently choose between a small and large quantity of food, highly trained dogs were less inclined than untrained dogs to follow their owners when the latter tried to convince them (vocally and by bodily orientation) that the visibly smaller quantity of food was better than the large quantity. Thus, considering the two previous studies together it appears that dogs with high levels of training, regardless of the specific type of trained activity/sport, are more pro-active in problem solving situations and less dependent on their owners for a solution, since compared to untrained pet dogs, in the first study they were more resilient in opening the box to obtain food, whereas in the second task they ignored their owner's misleading suggestions more than untrained dogs, thus obtaining a significantly greater food reward in the critical condition.

The tendency to look at the owner during the problem solving task (Marshall-Pescini et al., 2008) was found to be higher in untrained compared to trained pet dogs, furthermore untrained dogs were also significantly less successful in accessing the apparatus: thus it seems that they indeed looked at the owner when they could not solve the problem. However, trained dogs solved the task relatively easily so we could not truly compare their respective inclination to look at the owner.

Human-directed gazing behaviour has been considered a way to initialize communication with humans, and it has been observed in various situations in which the dog is confronted with an unsolvable problem, for example when unable to reach/obtain a desired object (Miklósi et al., 2000, 2003). It is considered a foundation on which dog–human communication developed (Miklósi et al., 2003) and, given the scarcity of this behaviour in hand-reared wolves, a product of domestication (Miklósi et al., 2003). Two previous studies have looked at the potential influence of life experience in human-directed gazing behaviour. Bentosela et al. (2008) found that human-directed gazing behaviour can be rapidly influenced by a the pattern of reinforcement and that schutzhund trained dogs (who undergo systematic "heeling" training, i.e. walking close to the heel gazing up at the owners face), looked at their owner/trainer significantly more than untrained dogs during an on leash walk outdoors.

Gaunet (2008) also looked at human-directed gazing behaviour but using the 'unsolvable task paradigm' and comparing pet and guide dogs for the blind. Results showed no differences in either the gazing or gaze alternation behaviour between the two groups, although guide dogs performed a noisy mouth-licking behaviour combined with gazing, which may have emerged as a supplementary attention-getting signal directed at their blind owners.

Considering the importance this behaviour has in theories of dog's socio-cognitive abilities, understanding whether and how this behaviour may be influenced by ontogenetic factors is potentially important. Thus, in the study presented below we used the 'unsolvable task' paradigm similar to that previously used by Miklòsi et al.'s (2003), but based on a different testing apparatus, to compare trained and untrained pet dogs. To assess the potential influence of training on the manifestation of this behaviour we considered untrained dogs and those trained in two substantially different training activities i.e. agility, which relies, almost exclusively on following human gestures and search and rescue training which is geared towards following the handlers commands but also developing the dog's independent abilities and encouraging work at considerable distance from the owner. Furthermore, differently from the previous study using this paradigm (Miklósi et al., 2003) we chose to look at human-directed gazing behaviour not just in the 'unsolvable task' but also in the first 'solvable' trial, since this would allow an assessment of the potential differences between groups in the spontaneous expression of gazing behaviour when first presented with a novel problem and not just when presented with an unsolvable one.

Given recent studies showing the influence of life experiences on dogs' and wolves' performance in human communication tasks (Udell et al., 2008; Wynne et al., 2008) and our own research suggesting that training significantly affects performance in socio-cognitive tasks (Marshall-Pescini et al., 2008; Prato-Previde et al., 2008) we expected to find differences in performance amongst groups. More specifically, mirroring results obtained in Marshall-Pescini et al. (2008), we expected trained dogs (especially the more independent S&R dogs) to look back at humans less than untrained dogs, at least in the 'solvable' trial. Hypotheses as regards the unsolvable task were left open since it was indeed the lack of information on this issue which spurred the current research.

3. Materials and methods

3.1. Subjects

39 dogs were tested (14 males and 25 females) age range between 1.5 and 11 years (mean age = 4 years, S.D. = 2.4), 38 pure breed and 1 mixed breed (see Appendix A for details). Dogs were allocated to 3 different groups according to their training experience: 13 dogs had been trained for search and rescue activities (S&R group, 5 males and 8 females), 13 dogs were trained for agility competition (Agility group, 2 males and 11 females) and 13 were pet dogs without a specific training experience (Pet group, 7 males and 6 females). Dogs were also balanced as far as possible for breed (see Appendix A). Agility dogs trained twice a week and regularly attended competitive events. S&R dogs trained once a week at different sites and were all certified and volunteering for the Italian Civil Protection Service.

3.2. Apparatus

The apparatus consisted of a transparent 15 cm × 15 cm lid-less plastic container (commercial tupperware) placed upside down over a few titbits of food on a 35 cm × 60 cm wooden board. The container could be either moved off the platform or overturned to

Fig. 1. Photo of the testing scenario.

obtain the food or it could be securely screwed to the board so the food could not be accessed.

3.2.1. Procedure

The testing was carried out in a secluded outdoor enclosure (approximately 10 m^2) either at the University of Milan or at the dogs' training field according to the dog owner's availability. Owners were asked not to feed their dogs for at least 4 h prior to testing. The test consisted of three 'solvable' trials in which dogs could obtain the food by manipulating the container, followed by an 'unsolvable' trial in which the container was fixed onto the wooden board. In all trials the owner and researcher maintained the same position i.e. at either side and one step back (20 cm) from the wooden board on which the container was placed. During the entire test period the owner and researcher looked straight ahead and ignored (i.e. neither spoke, looked at or touched) the dog (Fig. 1).

In the 'solvable' trials dogs, positioned between (or just in front of) the owners legs and held by their collars, witnessed the researcher squatting down and placing some food (4 pieces of large-sized Frolic®) under a transparent plastic Tupperware container with holes on the top. As soon as the researcher was in position the owner was instructed to leave the dog who was allowed to move freely around the apparatus and within the testing area. Each trial was interrupted after a maximum of 1 min or as soon as the dog obtained the food. Only dogs that succeeded at least twice in obtaining the food in the 'solvable' trials were tested in the 'unsolvable' one. Trials were presented one after the other with no interruption.

In the 'unsolvable' trial, an identical Tupperware container was fixed to the board with 4 pieces of large-sized Frolic® clearly visible inside. The researcher, placed the platform on the ground in front of the dog (held by its owner as above) and then squatted down next to the container, placing a hand over it and with the other hand pretended to place food under it. This was done to make the actions on the container as similar as possible to those carried out in the 'solvable' trials. In all other respects the same procedure was followed as in the 'solvable' trials with dogs been given a total of 1 min to attempt to overturn the container.

All trials were video-recorded using a wide angle video camera positioned on a tripod located in the testing area; thus the behaviour of the dogs towards the container, the owner and the experimenter could be analysed in detail. A moist commercial dog food with a very pungent smell (Frolic®) was used.

3.3. Data analysis

Digital video footage was taken for all trials and the Solomon Coder (beta 081122, Copyright 2006–2008 by András Péter) was used to record the dogs behaviour during testing. Marshall-Pescini, blind to the dogs' group allocation coded all trials based on the following behavioural categories: (1) interaction with the apparatus: any behaviour involving the dog being physically in contact with the container and with the board if within 5 cm from the container (duration); (2) interaction with the owner or researcher: the dog approaching and being in physical contact with the person e.g. rubbing, nosing, licking pawing a hand or leg or jumping up (duration); (3) gazing at the owner or researcher: the dog does not approach the person, but from a stationary position turns/lifts its head towards the person (duration, frequency and latency); (4) gazing at the container: the dog from a stationary position turns/lifts its head towards the apparatus (duration, frequency and latency); (5) barking bouts (frequency); (6) other: any other behaviour exhibited by the dog (duration). Observer reliability was assessed by means of double coding by Marshall-Pescini carried out at 30 days of interval on a sample of 9 dogs (23% of the total sample) and calculated as a percentage of agreement. The agreement exceeded 95%.

Since we were interested both in the potential differences between the three groups in their initial problem solving abilities and their looking behaviour towards people we chose to consider both the first (of the three) solvable trials and the unsolvable trial. Thus, the duration of all the behavioural categories was measured for these trials. For gazing behaviour the frequency, duration and latency were calculated. Furthermore, in the unsolvable trial, the dogs' 2-way gaze alternation between person (i.e. regardless of identity) and container within 2 s (and vice versa), was calculated.

Non-parametric statistical analyses run on Statistica software package, were carried out to compare groups, i.e. two-tailed Kruskal–Wallis, post hoc multiple comparisons (corrected for group number) and Chi-square test to compare the number of dogs performing specific behaviours in each group. Mann–Whitney tests were also carried out to compare two groups where the third could not be included in the analysis. Friedman test was used to compare the dog's performance across the 'solvable trials'. The alpha value was set at 0.05.

4. Results

33 of the 39 subjects tested were successful in all three solvable trials, and all dogs were successful in at least two, thus they all went on to do the unsolvable task.

4.1. Within group comparison: trial one to three (solvable trials)

Significant differences emerged across trials in the frequency of gazing at the experiment, interacting with the experimenter, interacting with the bowl and 'other' behaviour ($N = 39$, df = 2 gaze experimenter: $\chi^2 = 10.5$, $p = 0.005$; interact experimenter: $\chi^2 = 7.11$, $p = 0.03$; interact bowl: $\chi^2 = 11.48$, $p = 0.003$; other: $\chi^2 = 11.04$, $p = 0.004$), with all the above behaviours being exhibited more often in Trial 1 compared to other trials. No other behaviour varied significantly across trials (gaze owner $\chi^2 = 3.7$, n.s.; gaze bowl $\chi^2 = 3.1$, n.s.; interact owner $\chi^2 = 0.5$ n.s.)

Duration of behaviours mirrored results described above with significant differences in gazing at the experiment, interacting
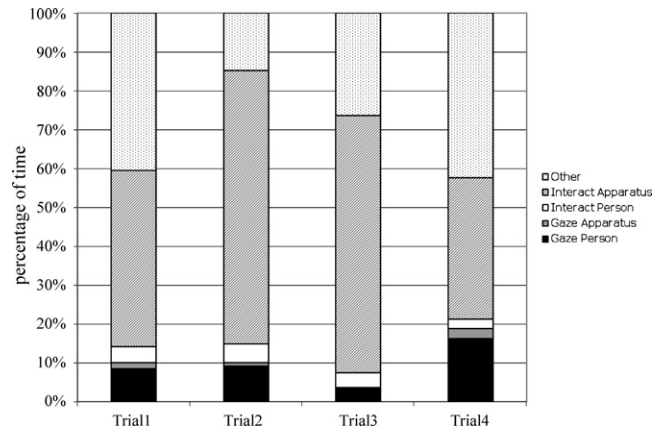

Fig. 2. The change in dog's behaviour across solvable (Trials 1–3) and unsolvable (Trial 4) trials.

with the experimenter, interacting with the bowl and 'other' behaviour ($N = 39$, df = 2, gaze experimenter: $\chi^2 = 12.02$, $p = 0.002$; interact experimenter: $\chi^2 = 9.03$, $p = 0.01$; interact bowl: $\chi^2 = 16.6$, $p = 0.0002$; other: $\chi^2 = 12.1$, $p = 0.002$). All the above behaviours being exhibited more often in Trial 1 compared to other trials (Fig. 2). No other behaviour varied significantly across trials (gaze owner $\chi^2 = 3.5$, n.s.; gaze bowl $\chi^2 = 4.7$, n.s.; interact owner $\chi^2 = 0.5$ n.s.).

4.2. Between group comparison: trial one (the solvable task)

Considering the first trial, only 5 dogs failed to access the food within the allotted time (1 min). Considering all dogs, mean latency to success was 19 s ($N = 39$; range 2.3–60 s; S.D. ± 18.48) excluding the 5 unsuccessful dogs mean latency to success was 14.17 s ($n = 39$; range 2.3–59. 8 s; S.D. ± 12.67). No significant difference emerged amongst groups in the latency to success ($N = 39$, $H = 2.2$, n.s.), in the time spent interacting with neither the apparatus ($N = 39$, $H = 0.8$, n.s.) nor the person ($N = 39$, $H = 1.3$, n.s.) and in the 'other behaviour category ($N = 39$, $H = 4$, n.s.).

As regards gazing behaviour, a difference emerged between the number of dogs looking at a person during the first trial. In fact whereas only 2 out of 13 S&R dogs looked at a person, 8 out of 13 agility dogs and 7 out of 13 untrained pet dogs looked at the person. Comparing all three groups this difference was found to be significant ($\chi^2 = 6.47$, df = 2, $p = 0.04$) and more specifically a significantly greater number of agility dogs looked at a person compared to S&R dogs ($\chi^2 = 5.85$, df = 2, $p = 0.01$).

Given only two S&R dogs looked at the person in this trial, we excluded this group from further analysis regarding gazing behaviour and compared only agility and untrained pet dogs. Agility and untrained pet dogs did not differ neither in frequency (Mann–Whitney, N1 = 13, N2 = 13, $U = 58$, n.s) nor duration (Mann–Whitney, N1 = 13, N2 = 13, $U = 64.5$, n.s.) of gazing at the person, however agility dogs performed significantly more gaze alternations between person and apparatus than untrained pet dogs (Mann–Whitney, N1 = 13, N2 = 13, $U = 32.5$, $z = 3.05$, $p = 0.002$).

4.3. Between group comparison: trial four (the unsolvable task)

As regards gazing behaviour only six dogs did not look at the person (three in the untrained and three in the S&R group) thus whereas 17 out of 39 dogs (43.6%) gazed at a person in the first solvable trial a total of 33 out of 39 dogs (85%) did in the unsolvable trial. This difference was significant ($\chi^2 = 5.77$, df = 1, $p = 0.01$). Considering all dogs, the mean latency to look at the person in the unsolvable trial was 21 s ($N = 39$; range 0.4–60 s, S.D. ± 20.14), however no sig-
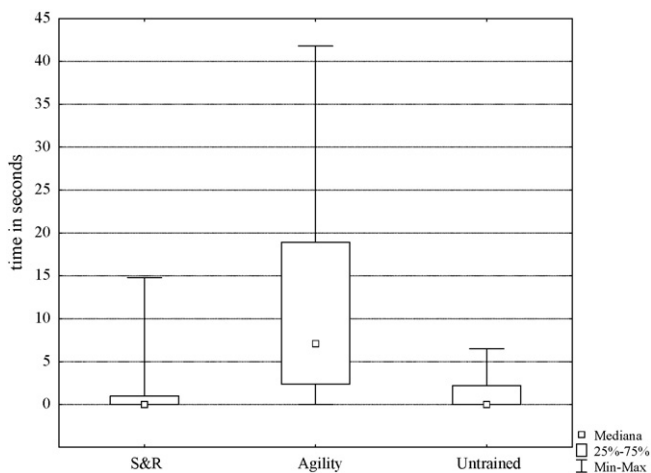
Fig. 3. Gazing towards the owner in the unsolvable trial (Trial 4). Agility dogs gazed at the owners significantly more than dogs in both the other groups (S&R and untrained).

nificant difference emerged amongst groups ($H = 1.7$, n.s.). Excluding those dogs that did not look at a person at all, the mean latency to gazing was 14 s ($N = 33$; range 0.4–41.6 s, S.D. $\pm$ 12.12) with no significant difference amongst groups ($H = 2.4$, n.s.).

There was a significant difference in the duration of gazing at the person ($N = 39$, $H = 12.88$, $p = 0.002$) with agility dogs gazing for significantly longer periods than pet dogs (post hoc $z = 3.57$, $p = 0.001$). A separate analysis for owner and researcher revealed that this difference was specific to the duration of gazing towards the owner ($N = 39$, $H = 13.35$, $p = 0.001$) but not the experimenter ($H = 4.33$, n.s.). Agility dogs gazed at the owner significantly more than S&R (post hoc $z = 2.99$, $p = 0.008$) and untrained (post hoc: $z = 3.15$; $p = 0.005$) dogs (Fig. 3).

There was also a significant difference between groups in the frequency of gazing at the person ($N = 39$, $H = 8.19$, $p = 0.02$) and separate analyses for owner and researcher revealed a significant difference for the former ($H = 11.87$, $p = 0.003$), although not for the latter ($H = 4.13$, n.s.). Agility dogs looked at the owner more frequently than both S&R (post hoc $z = 2.77$, $p = 0.02$) and untrained pet dogs (post hoc $z = 2.98$, $p = 0.009$).

A preference index for gazing was computed (i.e. owner-gazing/owner + researcher gazing $\times$ 100), to allow a comparison among groups on this measure. A significant difference emerged ($N = 39$, $H = 5.9$, $p = 0.05$) with agility dogs expressing a preference (although not significant $z = 2.2$, $p = 0.09$) for the owner compared to S&R dogs.

A highly significant difference also emerged in the duration of barking behaviour ($N = 39$, $H = 14.76$, $p = 0.0006$) due to the fact that 8 out of 13 S&R (61.5%) dogs carried out this behaviour whereas only 1 dog in the agility group and 1 in the untrained pet group did. Barking always occurred concurrently to gazing at a person or at the bowl. No significant difference between groups emerged in the time spent interacting with the apparatus ($H = 4.9$, n.s.) or doing 'other' behaviour ($H = 2.9$, n.s.).

Finally, groups differed significantly in the frequency of gaze alternations between the person (whether owner or researcher) and the apparatus ($N = 39$, $H = 8.8$, $p = 0.01$) with S&R dogs gaze alternating significantly more frequently than untrained pet dogs (post hoc $z = 2.55$, $p = 0.03$) and agility dogs in between.

5. Discussion

The aim of the current paper was twofold: to provide a brief review of the literature on the effects of training on dogs' cogni-

tive performance and to present new findings on whether dog's human-directed gazing behaviour may be affected by previous life experiences, such as a specific training regime (agility, S&R).

Overall results suggest this is indeed the case, although our predictions as regards the dogs' behaviour in the solvable trial were only partially confirmed. In fact, although we expected S&R dogs to be the least inclined to look at a person, we had not expected agility dogs to be at the opposite extreme. Results in the 'solvable' trial, showed fewer S&R dogs looking back at a person compared to agility dogs, and the latter alternating their gaze between person and apparatus more frequently than pet dogs. Furthermore, there were no differences between groups in time spent interacting with the apparatus and latency to success, which is probably due to a ceiling effect since only four dogs failed to access the food in the solvable trial and most did so within 20 s. Thus taken together, these results suggest that although the task was very simple and well within the dogs capabilities, almost half (44%) of the tested dogs looked back at the person anyway, and this was particularly true for agility and pet dogs.

Both gazing and interacting with the experimenter decreased across the three 'solvable' trials as did interaction with the apparatus and 'other' behaviours, which seems to suggest dogs learned to focus their actions so as to obtain the desired results, and thus looked less to humans for guidance.

In the unsolvable task, 85% of dogs looked at the person and only six did not, and the mean latency to looking was approximately 20 s (i.e. the same mean time it took dogs to obtain food in the solvable trial). Latency to look at the person did not differ between groups in the unsolvable task, however duration did, with agility dogs looking longer at the person, and more specifically at the owner, than pet and S&R dogs. Furthermore, a significant difference emerged in barking behaviour, with S&R dogs exhibiting the vast majority of this behaviour (only two other dogs, an untrained pet and an agility dog, barked and did so only once during the test). Interestingly, barking always occurred concurrently to looking either at the person or the apparatus. Finally, S&R dogs alternated their gaze between person and apparatus more than untrained pet dogs, with agility dogs falling in between these two groups.

Taken together results point to a strong effect of training on the dogs' human-directed gazing behaviour, although not in all circumstances. Agility dogs, trained to follow their conductor's every move, were much more inclined to look at a person than the more independent working S&R dogs, doing so even when the task was easy to solve and no 'problem situation' was encountered. Conversely, S&R dogs only looked at the person in the 'unsolvable' task, and when they did, they quickly added barking to their gazing behaviour. This would appear to be a direct result of their training regime, since the final step of the search and rescue procedure is to alert the handler by standing next to and barking at the missing person. The choice of person also varied between the two trained groups, with S&R dogs distributing their attention more or less equally between owner and researcher (stranger), whereas agility dogs focused significantly more on the owner. This may also be shaped by their respective training experiences since whereas agility dogs work exclusively with their owners, S&R dogs need to attend to their owner's signals but also focus on looking for a stranger.

Of course the sample size for this initial study was rather limited and although all efforts were made to match dogs for breed, the number of border collies in the sample is, to some extent over-represented compared to other breeds, thus results should be viewed with some caution until further testing of differently trained dogs has been carried out.

Gazing has been considered an attention-getting behaviour and gaze-alternation a form of directional communication, which dogs are capable of using flexibly to communicate with humans (Miklósi et al., 2000; Hare et al., 1998). The fact that the vast majority of dogs

in our study looked at the person during the unsolvable task is in line with Gaunet's (2008) study comparing pet and guide dogs and seems to confirm that gazing is an important factor in the dogs' interaction with humans (Miklósi et al., 2000, 2003). Furthermore, the fact that most human-directed behaviour (gazing and interacting) in our study occurred in the first trial and in the unsolvable trial, seems to suggest it is indeed used as a communicative act in 'difficult' or 'unclear' situations.

However our results also suggest that training shapes the dogs' communicative behaviour in two ways: (1) in terms of their inclination to communicate, with agility dogs doing so more frequently, for longer and in potentially unnecessary/redundant situations, and (2) in the dogs' communicative style, with S&R dogs using both vocalization and gazing to get attention where agility dogs use only the latter. Gaze alternation, which is considered by some authors as the basis for joint attention and cooperation (Tomasello, 1995), was also significantly affected by the dogs' training experience. This is perhaps not surprising since both in agility and S&R dogs need to look at the owner to both follow and give directions, and their relative success is based on a high level of communication within the dog–human team.

Thus a question which may arise is what aspect of dog training may influence the dogs communicative abilities with humans? Pongrácz et al. (2004) showed that in a spatial social learning task dogs who observed their owners carrying out the target behaviour whilst talking to them, were faster at solving the task than dogs whose owner was silent during the demonstration and in a more recent study Virányi et al. (2008) identified both talking and eye contact with the dog as important factors in facilitating social learning. Similarly Horn et al. (2009) found that dogs who were encouraged to access the food in the 'solvable trials' looked at the owner for longer in the unsolvable task, although, as in our own study, latency did not differ between groups. Considering these results together it appears that ostensive communication can affect a dog's performance in socio-cognitive tasks, although the exact mechanisms are as yet unknown. It may be that the relevant element in the training experience is in fact the dogs' more frequent exposure to ostensive communication by humans, since both forms of training (especially agility) require humans to maintain continuous contact with the dog both verbally and visually. This kind of communication may not be such a common experience for pet dogs, or at the very least, it may be substantially more variable and less systematic in the pet population. If this were indeed the case we may for example also expect trained dogs to show a higher performance in social learning tasks, an aspect which is currently being investigated by our group.

A final more general consideration regards the need to investigate the dog's socio-cognitive abilities from an ontogenetic as well as a phylogenetic perspective. Across all our studies trained pet dogs consistently performed differently from untrained pet dogs and results from another research by our group have also shown rescue-shelter dogs exhibiting their own specific pattern of behaviours in socio-cognitive tasks (unpublished data). Thus, although the domestication process may well have had a strong influence on the emergence of specific socio-cognitive abilities in dogs, it will only be possible to comprehend the magnitude of this effect when also ontogenetic aspects are more fully understood.

Acknowledgements

Appendix A

Pure-bred dogs included in the study were: Group 1 (S&R): 1 Boxer, 1 Boxer-cross, 2 Australian shepherds, 2 Border collies, 4 Retrievers, 1 Schnauzer, 1 German shepherd, 1 Cec wolfdog; Group 2 (Agility): 3 Australian shepherd, 8 Border collies, 1 Schnauzer 1 Retriever; Group 3 (Pet): 2 Australian shepherds, 5 Border collies, 5 Retrievers, 1 Beagle.

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