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ORIGINAL PAPER

The effect of training and breed group on problem-solving behaviours in dogs

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Abstract Dogs have become the focus of cognitive studies looking at both their physical and social problem-solving abilities (Bensky et al. in Adv Stud Behav, 45:209–387, 2013), but very little is known about the environmental and inherited factors that may affect these abilities. In the current study, we presented a manipulation task (a puzzle box) and a spatial task (the detour) to 128 dogs belonging to four different breed groups: Herding, Mastiff-like, Working and Retrievers (von Holdt et al. in Nature 464:898–902, 2010). Within each group, we tested highly trained and non-trained dogs. Results showed that trained dogs were faster at obtaining the reward in the detour task. In the manipulation task, trained dogs approached the apparatus sooner in the first familiarization trial, but no effect of breed emerged on this variable. Furthermore, regardless of breed, dogs in the trained group spent proportionally more time interacting with the apparatus and were more likely to succeed in the test trial than dogs in the non-trained group, whereas regardless of training, dogs in the working breed group were more likely to succeed than dogs in the retriever and herding breed groups (but not the mastiff-like group). Finally, trained dogs were less likely to look at a person than non-trained dogs during testing, but dogs in the herding group more likely to do so than dogs in the retriever and working but not the mastiff-like breed groups. Overall, results reveal a strong influence of training experience but less consistent differences between breed groups on different components thought to affect problem solving.

Keywords Dogs · Problem solving · Breeds · Training · Inhibitory control · Neophobia · Communication

Introduction

Artificial selection for certain morphological and behavioural features has resulted in more than 400 dog breeds recognized today. Traditional breed groupings were created by major kennel clubs (e.g., Federation Cinologique International, American Kennel Club), based on morphological similarity and their 'working' function; however, more recently the relationship between breeds has been revealed on the basis of genetic closeness (Parker et al. 2004; von Holdt et al. 2010).

Since the pioneering work of Scott and Fuller (1965) on genetic and social behaviour on five dog breeds, relatively little work has been carried out comparing dogs of different breeds. Single breed (e.g., Duffy et al. 2008; van den Berg et al. 2010; Svartberg and Forkman 2002; Svartberg 2006;) and breed group (Ley et al. 2009; Seksel et al. 1999; Serpell and Hsu 2005; Turcsán et al. 2011; Starling et al. 2013) differences have, however been reported for many personality traits (e.g., Turcsán et al. 2011).

More recently, researchers have started to investigate whether there may be breed differences in socio-cognitive

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abilities. With regard to dogs' understanding of human social cues, breeds working under close visual guidance by humans (i.e., gundogs and sheepdogs) have been found to use human communicative gestures better than breeds working more independently (e.g., sled dogs and scent hounds) (Gácsi et al. 2009) and selection for heightened or inhibited predatory responses has also been suggested to affect dogs' performance in a pointing task (Udell et al. 2014).

A number of studies have also examined breed differences in dogs' communicative tendencies towards humans. Based on a self-report questionnaire study, herding dogs appear to use more eye contact and vocalization to communicate with humans, whilst retrievers seek more body contact (Lit et al. 2010). In a study measuring association learning of looking to a person to obtain food, retrievers took longer to extinguish this behaviour compared to other breeds (German shepherds and poodles), although no breed differences emerged in the acquisition phase (Jakovcevic et al. 2010). When measuring spontaneous looking behaviour in a detour task, dogs in the 'shepherds' group looked to the person more often than dogs in the 'hunting' group (Pongrácz et al. 2005). Finally, in an 'unsolvable task', where after repeated experience of being successful at obtaining treats from an overturned Tupperware box, the apparatus is locked so that the food becomes impossible to obtain, Passalacqua et al. (2011) found that although no breed group differences emerged between 2-month-old puppies, when testing 4-month-old puppies and even more so when comparing adults, dogs from hunting and herding breeds looked at a person more than dogs from Mastiff-like and ancient breeds.

Taken together these results suggest that breeds selected for tasks requiring a close collaborative working partnership with humans may both be more sensitive to human communicative cues, and more inclined to use cues such as gaze to communicate. Indeed a genetic component in such looking behaviour towards humans seems to be supported by a study by Hory et al. (2013), providing evidence for an association between owner-directed gazing behaviour in an unsolvable task and polymorphisms in the dog DRD4 gene. However, results from current studies on breed group differences in dogs' communication with humans are in some cases contradictory and in general difficult to interpret since breed groups may be composed of different breeds across studies. Furthermore, a number of studies (e.g., Lit et al. 2010; Turcsán et al. 2011; Duffy et al. 2008) rely on owner-reports of their dog's behaviour, which may be affected by the preconceived view of how certain breeds 'should' act with humans.

Breed group differences on other aspects of learning and/or independent problem solving have received less attention. In a recent study, Hall et al. (2015) investigated breed differences in odour discrimination and contrary to general expectations based on German shepherds being considered one of the best 'working breeds', the study found that pugs actually outperformed German shepherds in this task.

Pioneering work by Frank and Frank (1987) investigated spatial abilities using a detour-like task and found that wolves outperformed similarly raised dogs. Recent work by Smith and Litchfield (2010) reports dingoes solving the detour task considerably faster than dogs or wolves (Marshall-Pescini et al. 2015). However, when using the same task, no breed group differences emerged (Pongrácz et al. 2005). Hence overall, results so far appear to suggest that breed group differences may be more evident in tasks involving a communicative component towards humans, rather than independent problem solving, although the latter has been rarely tested directly.

Another important factor, which has been shown to affect both personality and socio-cognitive abilities, is dogs' life experiences. Shelter dogs with a more limited experience with people have been shown to perform more poorly than pet dogs in tasks requiring comprehension of human social cues tasks (Udell et al. 2008). However, this effect was not found in other studies (Hare et al. 2009). Training experience, on the other hand, has been shown to affect dogs' performance in a number of tasks. For example, dogs that regularly engage in high level training activities with their owners such as agility, search and rescue, or dog dancing (henceforth 'trained dogs') were shown to be more persistent in solving a puzzle box and showed less looking behaviour towards their owners than non-trained dogs (Marshall-Pescini et al. 2008; Range et al. 2009). Furthermore, training appears to modulate dogs' communicative signals towards humans. In an 'unsolvable' task, agility dogs show more looking behaviour towards the owner, whereas search and rescue dogs, combined looking with barking and preferentially direct their communication towards the researcher rather than the owner (Marshall-Pescini et al. 2009).

In the current study, we aimed to investigate both the potential effects of breed group and training on dogs' independent problem-solving abilities in a manipulative and in a spatial problem-solving task. To this aim, following von Holdt et al.'s (2010) classification based on the genetic similarities between groups, we tested breeds belonging to 4 different groups: Herding, Mastiff-like, Working and Retrievers. For each of these breed groups, we tested a population of highly trained dogs that regularly engaged in sport activity or working activities with their owner, and pet dogs with no or just basic training.

Because problem-solving itself may include a number of different components depending on the task, we presented two tasks to the dogs. In the manipulative task, which consisted of a 'puzzle box' containing food (see Marshall-

Pescini et al. 2008), we were able to assess both dogs' initial explorative, neophobic reaction during an open box familiarization trial and their persistence in attempting to open the box when it was presented to them closed. The spatial task employed principles from the classic detour fence (Frank and Frank 1987; Scott and Fuller 1965), which has been considered a good measure of an animal's inhibitory control skills, since it requires dogs to move away from focusing on the desired object/food, in order to successfully solve the task and obtain the reward. In both tasks the owner and researcher were present, allowing for the examination of the potential differences in human-directed gazing behaviour when confronted with a problem-solving situation, since the communicative component in both of these tasks has been shown to potentially differ between groups of dogs (Marshall-Pescini et al. 2008; Pongrácz et al. 2005).

On the basis of previous results, we predicted that non-trained dogs would be less likely to succeed and more likely to look at the human partners than trained dogs in the object manipulation task (see Marshall-Pescini et al. 2008). We further predicted that no breed group differences would emerge either in the likelihood to succeed during the detour task, nor in terms of latency to success (see Pongrácz et al. 2005). In both tasks we expected dogs in breed groups encompassing breeds selected for cooperative work with humans to be more likely to look at the human partners than dogs in other breed groups (see Gácsi et al. 2009; Pongrácz et al. 2005). As for the neophobic tendencies, since no studies have been carried out on the potential breed group and training effects on neophobia, no predictions were made.

Materials and methods

Subjects

Overall 128 dogs were tested; 123 dogs completed the detour task and 123 dogs completed the puzzle box task; however, these were not the same dogs. In fact, only 118 dogs completed both tasks. Analyses for each task were conducted separately on the total number of dogs that completed the test (i.e., in both cases 123 dogs). The correlation analyses across tasks were, however, conducted on the 118 dogs that completed both tasks (see Table 1 for a summary of groups and Table S1 in the supplementary material for the full list of participating subjects). Following von Holdt et al.'s (2010) classification, subjects were included in the following breed groups: (1) Herding group (border and Australian collies); (2) Mastiff-like group (boxer, Bernese and Rottweiler); (3) Working group (Doberman, German shepherd and large poodle); and (4) Retriever group (golden, Labrador and flat-coated retriever). von Holdt et al. (2010) note that following their genetic analyses, a number of breeds fall within categories not predicted/expected by their phenotypic or functional characteristics. Amongst which German shepherds are included in the 'working' rather than the 'herding' group.

Dogs within each breed group were sub-divided into two groups (see Table 1 for details): 1. trained (i.e., carried out a sport discipline at the competition level or were certified as working dogs such as police, search and rescue, agility or man-trailing) and 2. non-trained (i.e., had either no training at all, or had been trained by their owner or a dog trainer but only in general obedience, such as basic sit-down-stay commands and ball/toy fetching games). All dogs lived with their owner as pets except for the police dogs that lived in kennels (see Table 1; Table S1 in supplemental materials for further details).

Prior to participation in the study, dog owners were asked if their dogs had ever seen the testing apparatuses (detour and puzzle box) before and if so they were excluded from the studies. Tests were all carried out in an outdoor location familiar to the dogs, based on the owner's availability.

Apparatus

Detour task Following Pongrácz et al. (2001) we used a V-shaped fence 1 m high, with sides 3 m long placed at an angle of 80. The fence was made of wire mesh. The fence was set up by pushing the pegs protruding from the frame into the ground. The frame of the fence prevented the dogs digging under it.

Puzzle box Consisted of a commercially available yellow and blue plastic feeding box ('Slurp'- Mega srl, Bologna) 30 cm long (including the paw pad) 20 cm wide and 12 cm high, which could be opened by pressing a paw pad or nosing the lid; the box was securely fixed to a heavy wooden board (55 cm × 55 cm) and placed with the back against a wall or other obstacle (Marshall-Pescini et al. 2008).

Procedure

Spatial problem solving: detour task

A starting line was defined at 2 m from the intersecting angle of the fence, where both the dog and the owner had to stand at the start of the trial. The task of the dogs was to obtain a toy/ball by detouring along the fence.

At the start of the trial the experimenter placed the target behind the V-shaped fence next to the inner side of the intersecting angle, whilst the owner remained with the dog at the starting point and covered the dog's eyes with her/his

Table 1 Participants in the study subdivided by breed group, trained and non-trained dogs

Breed group	N. trained (M–F) (mean age and SD)	N. non-trained (M–F) (mean age and SD)	Total
Herding group	20 (5M–15F) (mean 4.5; SD 3.1)	13 (6M–7F) (mean 2.2; SD 2.0)	33
Mastiff-like group	14 (1M–13F) (mean 4.57; SD 2.8)	17 (6M–11F) (mean 2.4; SD 1.9)	31
Working group	13 (9M–4F) (mean 5.16; SD 2.6)	16 (7M–9F) (mean 4.4; SD 2.7)	29
Retriever group	16 (8M–8F) (mean 4; SD 2.9)	19 (9M–10F) (mean 2.7; SD 2)	35

The mean age and standard deviation (SD) are reported for each group

hands preventing it from seeing the experimenter's actions. Then the experimenter returned to the starting point, and the owner led the dog on the leash to the outer side of the intersecting angle of the fence and showed it the target through the wire mesh. After returning to the starting point, the owner unleashed the dog, starting the trial. If the dog obtained the target, the owner praised it verbally and played with it. If the dog was not able to obtain the target within 1 min, the trial was terminated. During the trial the owner was asked to encourage the dog to reach the target object but she/he had to stay on the starting line and was asked not to command the dog to go round verbally, or via gestures given by hand or other body parts.

Manipulative problem solving: puzzle box

The problem-solving test consisted of two phases: familiarization and test, carried out holding the dogs on a long leash (5 m).

Familiarization Phase: the owner held the dog close to him/her with a shortened leash 1 m in front of the apparatus. The researcher called the dog's name whilst showing it a piece of sausage and then dropping the food in the open box. Owners then slackened the leash and verbally encouraged their dogs to take the food, whilst the researcher remained crouched next to the apparatus holding the lid open. This was repeated three times. Dogs who did not take food from the open box were excluded from the study.

Test Phase: as with the familiarization phase, the owner held the dog close to him/her with a shortened leash 1 m in front of the apparatus. After seeing the researcher place a piece of sausage in the apparatus and closing the lid, the owners slackened the leash allowing dogs to freely move around and interact with the apparatus for a maximum of 1 min. During this phase, the two people present (researcher and owner) ignored the dog, standing quietly 1 m from the apparatus (the owner in the starting position and the experimenter to the side of the apparatus). The test phase was repeated three times, but for the purpose of the current study, only the first trial was taken into account. Order of presentation of the two tasks was counterbalanced across subjects.

Data collection and analysis

Based on previous studies, a number of behaviours were identified (see Table 2) and the occurrence (i.e., whether a dog exhibited the behaviour or not), latency (i.e., the time point from the start of the trial when the behaviour was exhibited), frequency (i.e., how many times that behaviour was exhibited) and duration (i.e., how long the exhibited behaviour lasted) of each were coded from video using Solomon Coder beta (© András Péter).

Latency to first contact in the first familiarization trial for the manipulation task was used as a measure of neophobia, whereas the latency to succeed in opening the apparatus and obtaining the food during the test trial (when the box was closed), and proportion of trial time spent interacting with the apparatus was used to evaluate dogs' persistence behaviour in the manipulative problem-solving task. As a measure of problem-solving ability (but also partly motivation, see discussion), the success and latency in obtaining the reward was used in the detour task. The occurrence of looking at a person regardless of identity (i.e., owner and experimenter) was used in both tasks as a measure of dogs' tendency to seek human intervention during problem solving.

To assess the potential effect of training and breed group, on these response variables generalized linear mixed models were conducted, using the program R (Version 0.98.1102 – © 2009–2014 RStudio) and the package 'lme4'. In all models, age of the subject was entered as a control factor, and the interaction of breed and training group was included.

If residuals were not normally distributed, response variables were transformed as follows: (a) inverse square-root transformation for latency to succeed in the detour task and proportion of time spent interacting with the apparatus in the manipulation task; (b) log transformation for latency to first contact in the familiarization trials and latency to succeed in the test trial for the manipulation task; (c) square-root transformation for latency to looking at the person in the manipulation task.

Inter-observer reliability on 20 % of the data was carried out for both the puzzle box, and the detour task agreement for latencies and duration were calculated using

Table 2 Behaviours coded for each task and measures used in the analyses

Detour task	Measure	Definition
Fence-object action	Duration	Any action directed towards the object exhibited with the fence between the dog and the object (e.g., pawing/nosing fence or ground adjacent to object)
Gaze person	Occurence	The dog looked at the owner or the researcher, orienting its head towards him/her
Success	Occurrence, latency	The time taken by a dog to obtain the object from the moment it was released
Puzzle box		
Object manipulation	Duration	Any form of interaction (e.g., pawing, nosing, biting) with the apparatus
Gaze person	Occurrence, latency	The dog looked at the owner or the researcher, orienting its head towards him/her
First contact	Latency	The time taken by a dog to touch the box from the moment it was released (first familiarization trial only)
Success	Occurrence, latency	The time taken by a dog to open the box from the moment it was released (test trial only)

Spearman's correlation and rho ranged from 0.71 to a 0.99. Agreement on occurrence of behaviour (success and gazing behaviour) was 100 %.

Results

Detour task

Overall 42 of 59 (71 %) trained dogs and 29 out of 64 (45 %) non-trained dogs succeeded in detouring the fence in the test trial (see Table 3).

Trained dogs were more likely to succeed than non-trained dogs in the detour task (glmm: Chi = 16.81, $p < 0.001$), but there was no effect of breed group (glmm: Chi = 3.06, $p = 0.38$), no breed group by training interaction (glmm: Chi = 3.88, $p = 0.27$) and no age effect (glmm: Chi = 0.0006, $p = 0.98$). Considering only dogs that succeeded, trained dogs were faster to obtain the reward than non-trained dogs (mean ± SE trained vs. non-trained: 25.89 ± 2.79 vs. 46 ± 2.66; glmm: $F_1 = 6.296$, $p = 0.015$) but there was no effect of breed group (glmm: $F_2 = 1.56$, $p = 0.21$), breed group by training interaction (glmm: $F_3 = 1.71$, $p = 0.18$) and age (glmm: $F_1 = 0.23$, $p = 0.64$). No significant effects emerged on the likelihood of looking at the person in relation to breed group and training group (glmm: age: Chi = 0.02, $p = 0.88$; breed by training: Chi = 1.17, $p = 0.76$; breed: Chi = 0.99, $p = 0.8$; training: Chi = 2.37, $p = 0.12$).

Puzzle box

In the first familiarization trial, latency to first contact was affected by training group (mean ± SE trained vs. non-trained: 0.88 ± 0.18 vs. 1.57 ± 1.8; glmm: $F_1 = 4.442$, $p = 0.037$) but neither breed group (glmm: $F_2 = 1.22$, $p = 0.3$) nor age (glmm: $F_1 = 0.48$, $p = 0.49$), and there was no interaction between breed group and training group (glmm: $F_2 = 0.99$, $p = 0.39$). Trained dogs were faster to contact the apparatus than non-trained dogs.

In the test trial, overall 2 out of 61 dogs in the trained group, and 32 of 62 non-trained dogs did not succeed in obtaining the reward (see Table 3). Indeed likelihood of success in the test trial was affected by both training (glmm: Chi = 42.92, $p < 0.001$) and breed group (glmm: Chi = 10.79, $p = 0.013$), although there was no effect of neither age (Chi = 0.05, $p = 0.82$) nor was there an interaction between breed group and training group (Chi = 6.29, $p = 0.098$). Regardless of breed group, trained dogs were more likely to be successful than non-trained dogs. Furthermore, regardless of training, dogs in the working breed group were more likely to succeed than dogs in the retriever (glmm: $z = 2.0$, $p = 0.045$) and herding (glmm: $z = 2.967$, $p = 0.003$) breed groups (no

Table 3 Percentage (and number/over total) of dogs in each group that successfully solved the detour and the puzzle box task

Breed group	Detour		Puzzle box	
	Trained	Non-trained	Trained	Non-trained
Herding	63 % (12/19)	38 % (5/13)	95 % (18/19)	15 % (2/13)
Mastiff-like	54 % (7/13)	29 % (5/17)	86 % (12/14)	59 % (10/17)
Retriever	80 % (12/15)	44 % (8/18)	100 % (15/15)	38 % (6/16)
Working	92 %(11/12)	25 % (4/16)	100 % (13/13)	75 % (12/16)

other differences emerged between breed groups, see Table S2 in the supplementary materials) (Fig. 1).

Latency to succeed in the test trial (including only dogs that succeeded in obtaining the reward) was affected by neither age (glmm: $F_1 = 0.12$, $p = 0.72$), breed group (glmm: $F_3 = 0.67$, $p = 0.57$) nor training (glmm: $F_1 = 2.25$, $p = 0.14$), nor was there a breed group by training group interaction ($F_3 = 0.69$, $p = 0.56$).

Analyses of the proportion of time spent manipulating the apparatus showed no breed group by training group interaction (glmm: $F_3 = 1.5$, $p = 0.2$), no effect of age (glmm: $F_1 = 1.85$, $p = 0.18$) and no effect of breed group (glmm: $F_3 = 1.46$, $p = 0.23$). A main effect of training group emerged, with all trained dogs (regardless of breed group) spending a significantly larger proportion of trial time interacting with the apparatus than non-trained dogs (glmm: $F_1 = 28.74$, $p < 0.0001$) (see Fig. 2).

The likelihood that a dog looked at the person in the test trials was affected by both breed group (glmm: Chi = 8.634, $p = 0.035$) and training group (glmm: Chi = 10.259, $p = 0.001$), but not by age (glmm: Chi = 1.11, $p = 0.29$), and no interaction between breed group and training group emerged (glmm: Chi = 5.75, $p = 0.12$). Trained dog were less likely to look at the person than non-trained dogs. Furthermore, regardless of training, dogs in the herding group were more likely to look at the person than dogs in the retriever (glm: $z = 2.441$, $p = 0.015$), and working (glm: $z = 2.48$, $p = 0.013$) but not dogs in the mastiff-like (glm: $z = 1.508$, $p = 0.132$) breed groups. No other differences between breed groups emerged (see Table S3 in supplemental materials) (Fig. 3).

Latency to look at the person, when only including dogs that did in fact engage in this behaviour, was affected by neither age (glmm: $F_1 = 2.46$, $p = 0.12$), breed group (glmm: $F_3 = 0.57$, $p = 0.64$) nor training (glmm: $F_1 = 0.009$, $p = 0.93$), nor was there a breed group by training group interaction (glmm: $F_3 = 0.75$, $p = 0.53$).

Finally, no significant correlation emerged in the latency to succeed in the two tasks (r = 0.16, $p = 0.09$) and in the latency to look at the person during the tasks (r = −0.40, $p = 0.7$).

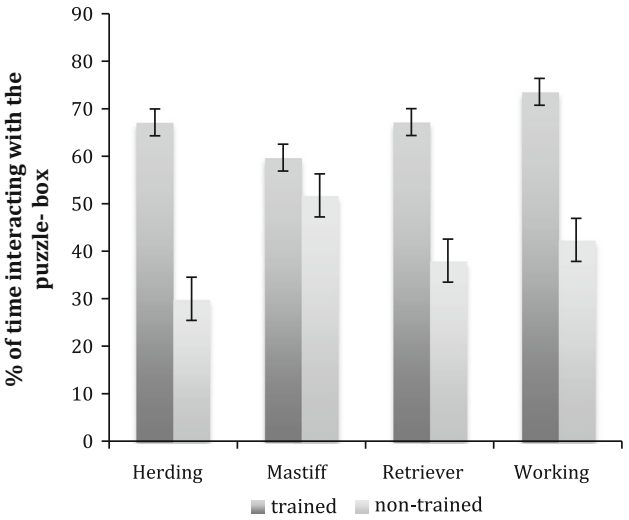

Fig. 2 Mean percentage of trial time (and standard error) spent interacting with the puzzle box for trained and non-trained dogs in each breed group

Discussion

The aim of the current study was to investigate the effect of breed group and training experience on dogs' independent problem-solving abilities, as well as their tendency to look towards humans when presented with a novel problem.

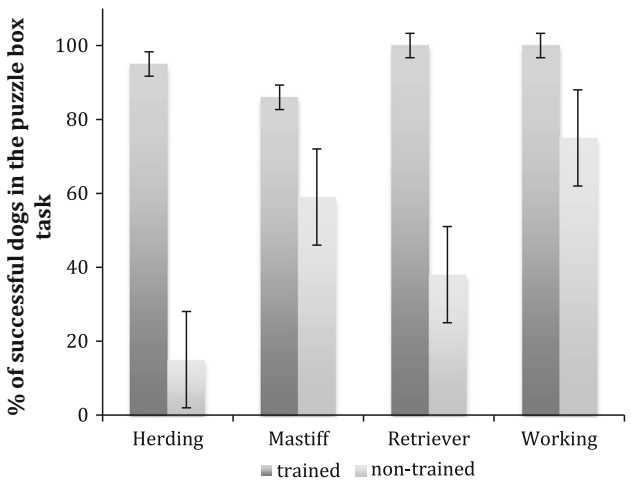

Fig. 1 Percentage (and standard error) of trained and non-trained dogs in each breed group that successfully accessed the puzzle box in the test trial

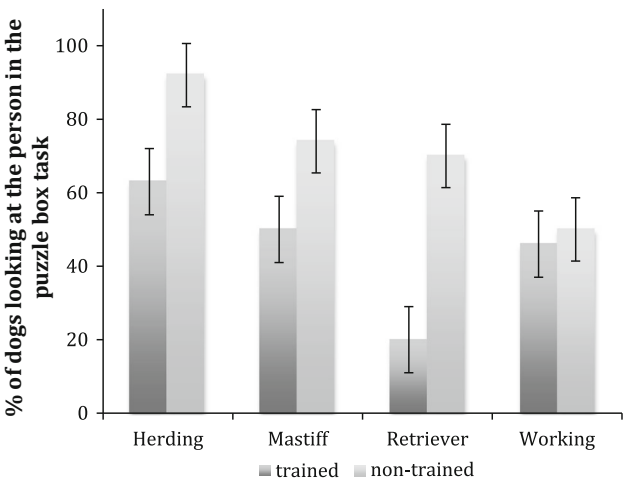

Fig. 3 Percentage (and standard error) of trained and non-trained dogs in each breed group that looked at the person in the test trial of the puzzle box task

Overall, we found that in both tasks dogs that had training experiences (e.g., search and rescue, agility etc.) showed a higher performance level as measured by the likelihood of success compared to dogs in the non-trained group. Furthermore, in the detour task, considering only dogs that had succeeded in obtaining the reward, we found that trained dogs were also faster to obtain the reward than non-trained dogs.

In the manipulation task regardless of breed, all trained dogs spent a higher proportion of trial time interacting with the apparatus suggesting that trained dogs were more persistent than non-trained dogs in their attempts to solve the task. However, in the manipulation task, trained dogs were also significantly faster at touching the new apparatus in the first familiarization trial. Dogs have been shown to be neophilic, in that they prefer a novel object to a known one (Kaulfuss and Mills 2008); however, there are no studies to our knowledge that explored the potential factors affecting neophobic or neophilic tendencies in dogs. Current results suggest that dogs that regularly engage in training activities may be less neophobic than non-trained dogs, when confronted with a novel object. However, differing motivation between trained and non-trained dogs cannot be excluded as a potentially important variable affecting performance in these tasks. In particular in the detour task, trained dogs may have had a higher motivation to obtain the toy/ball shown by their greater speed in obtaining the reward. Training often involves toys/balls as rewards, which may acquire a greater 'value' for trained compared to non-trained dogs. Further studies teasing apart the potential role of neophobia, neophilia and motivation will be necessary to assess the relative weight of these factors on trained dogs' performance.

Nonetheless, taken together our results confirm those of previous studies (Marshall-Pescini et al. 2008; Range et al. 2009), showing that dogs with training experience are more persistent and willing to engage in a novel task and hence overall more successful at problem solving, conversely non-trained dogs appear to be less interested in engaging with the apparatus and turn to their human partner sooner when confronted with a novel situation, potentially seeking for intervention (Miklósi et al. 2000, 2003; Merola et al. 2012; Gaunet 2008, 2009).

As for the effect of breed group on problem-solving skills, as expected from previous studies no differences emerged in the detour task (see Pongrácz et al. 2005). However, in the manipulation task, a breed group effect emerged with dogs in the working breed group, regardless of training experience, being more likely to succeed than dogs in the retriever and herding (but not the mastiff-like) breed groups.

Considering dogs in the working breed groups did not show a heightened performance in the detour task, this difference seems to be task specific. Interestingly, dogs in this group were as fast as dogs in other breed groups to approach the apparatus in the familiarization trial, suggesting that differences in performance are not due to differences in neophobic reactions to the novel object. Previous studies, if at all, have found breed group differences only in relation to socio-cognitive aspects (Gácsi et al. 2009; Udell et al. 2014; Jakovcevic et al. 2010; Pongrácz et al. 2005; Hory et al. 2013); current results suggest there may also be some effects on individual problem-solving abilities. However, effects appear relatively inconsistent and task-specific; hence, a more thorough investigation potentially using a battery of tests would be necessary to confirm such preliminary findings.

Finally, in the current study contrary to expectations, no effect of breed group emerged on the likelihood of looking to the human in the detour task (Pongrácz et al. 2005). However, although Pongrácz et al. (2005) found that dogs in the shepherd group, looked to the human more frequently than dogs in the hunting group, the group composition across studies is not comparable. Indeed, although border collies were represented in both (as 'shepherd' in the former and 'herding' dogs in the current study), the breed composition of the other groups was noticeably different.

In the manipulation task, regardless of training, dogs in the herding group were more likely to look at the person than dogs in the retriever and working (but not mastiff-like) breed groups. Results are partially in line with a number of studies showing that herding dogs perform above other breed groups on tasks involving the understanding and use of signals between dog and human (Gácsi et al. 2009; Passalacqua et al. 2011). However, whereas in the current study dogs in the herding group did not differ from those in the mastiff-like group, in Passalacqua et al.'s (2011) study both 4.5-month-old puppies and adult dogs in the herding group carried out significantly more human-directed gazing behaviours than dogs in the mastiff-like group. Considering the inconsistencies in such results, it would appear that breed group differences also in social behaviours such as looking to humans are also highly task-dependant. Overall, direct comparisons between results from different studies are difficult, since breed group composition often varies (e.g., huskies being placed in the cooperative-breed group by Wobber et al. 2009, but in the independent-breed group by Gácsi et al. 2009).

Other variables such as the relationship with the humans present during testing (Horn et al. 2013) and the type of training methods (e.g., clicker training) used may also affect dogs' problem-solving behaviours (Osthaus et al. 2003). Future large-scale studies simultaneously taking into account these multiple variables will allow us to assess the relative weight of life experiences and breed group on dogs' performance in cognitive tasks.

In conclusion, the current study shows that training experiences strongly affects aspects of independent problem solving as well as the more frequently investigated human-directed communicative abilities. Some breed group difference also emerged; however, results were less consistent and require further investigation standardizing as much as possible breed group composition to allow direct comparisons across studies.

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Compliance with ethical standards

Conflicts of interest There are no known conflicts of interest with sponsors.

Ethical statement This research complies with the current Italian laws on animal welfare and guidelines for research with animals as outlined by the Association for the Study of Animal Behaviour.

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