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SHORT COMMUNICATION

Training improves inhibitory control in water rescue dogs

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Abstract

Inhibitory control is a collection of several processes that are aimed to refrain from any impulsive response in the subject during inappropriate situations. Evidence suggests that in dogs, the inhibitory control is affected by domestication process, but also experiences during ontogeny could be an important driver in acquiring inhibitory control. The aim of the study was to compare the performance of highly trained dogs (i.e., water rescue dogs) and pet dogs in the A-not-B task. In this procedure, the animals have to inhibit their urge of going to a previous reinforced place. The results showed that the trained dogs committed fewer errors in the task than the pet dogs suggesting a better inhibitory control. This result could indicate that inhibitory control is a flexible ability affected by ontogenetic processes such as the training experience.

Keywords Inhibitory control · A-not-B task · Water rescue dogs · Pet dogs.

Introduction

Dogs have adapted to live in human societies (Hare and Tomasello 2005) through a complex evolutionary process. In addition, this close contact, involving interactions with humans and depending on them throughout lives, has given the dogs an opportunity to learn how to predict people's behavior and respond accordingly (Udell and Wynne 2010). Under such circumstances, display of an appropriate behavior to adapt favorably to the human context for achieving a beneficial relationship with them is a clear advantage (Wright et al. 2011).

Inhibitory control is a complex construct that is comprised of a collection of processes aimed to refrain from an impulsive motor response during inappropriate situations (Marshall-Pescini et al. 2015; Roberts et al. 2011), resulting in a more advantageous alternative behavior (Brucks et al. 2017). Inhibitory control is measured by one of the most popular and standardized procedures, the "A-not-B" task (e.g., Bray et al. 2014; Topál et al. 2009), in which the subjects are requested to change their learned strategy. In this task, the subject needs to inhibit the motor response of going to the learned position (cup A) to choose the other position (cup B) to where the bait has been moved (MacLean et al. 2014). If the search is confined to the previous location, despite having witnessed the relocation of the bait to position B, it can be stated that the subject has committed an "A-not-B error" (Kis et al. 2012).

There are several explanations for the occurrence of "A-not-B error". Some authors contend that its underlying mechanism is related to attention deficits (Fiset 2010) or to local enhancement (Marshall-Pescini et al. 2010). This is seen specifically in dogs that have a tendency to follow human social cues where an "A-not-B error" is committed in communicative situations more often than in non-communicative ones (Kis et al. 2012; Sümegi et al. 2013).

The A-not-B task is part of reversal procedures, which include several components of the executive functions (Izquierdo and Jentsch 2012) such as inhibitory control and flexibility (Bari and Robbins 2013). The latter relates to the capacity of changing strategies or perspectives in spatial or interpersonal manner. To achieve such a change, the subject would have to inhibit the previous solution for activating a different solution in the working memory (Diamond 2013).

Many lines of evidence suggest that the inhibitory control in dogs has been affected by the domestication process

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(e.g., Sümegi et al. 2013; Topál et al. 2009), as well as by the ontogenesis (e.g., Fagnani et al. 2016b). In the latter study, shelter dogs, with limited human interaction, and family dogs were subjected to the A-not-B task for comparison. It was seen that the shelter dogs performed worse than family dogs, thus highlighting the effect of the socialization as an important driver for acquiring inhibitory control. Socialization has also been demonstrated to be important for other behaviors such as the understanding of human pointing gesture (D'Aniello and Scandurra 2016) and the use of the gazing behavior (D'Aniello et al. 2017).

A great variety of service dogs that perform specific tasks in society undergo complex training programs that involve inhibiting inappropriate behavioral responses in working contexts (Wright et al. 2011). This is a basic part of all dog's training programs (Fagnani et al. 2016a). However, Bray et al. (2015) found a difference between assistance and pet dogs in a detour inhibitory task, where exposure to excitement induced by an experimenter (by calling the dogs in an urgent and high-pitched tone) negatively affected inhibitory control in pets but improved the performance of assistance dogs. Moreover, since assistance dogs were specifically bred and trained for low arousal in this study, so a possible effect of the preselection on the inhibitory control can be implied.

The purpose of our study was to analyze whether or not training affects inhibitory control in an A-not-B task. This task differs from a detour inhibitory task (Bray et al. 2015) due to the presence of a reversal task that is included in the reversal learning paradigm. Water rescue dogs were found to be the ideal models for investigating the potential effects of training on the inhibitory control, due to many reasons. First, they do not have to undergo to any pre-selective procedure before their training program (i.e., failure of the program is mainly due to the handlers who are often not able to comply with the requested high swimming standards). Second, the training is carried out by the owner who follows the directives of a trainer (D'Aniello et al. 2016; Scadurra et al. 2017). Third, the dogs never experience a period in a kennel, thereby potentially affecting the inhibitory control (Fagnani et al. 2016b). Indeed, there are no breeding centers that select dogs for water rescue work. Most water rescue dogs start their training since as puppies and they have to learn the work without any preselection based on temperamental traits or attitude. The only selection that happens is based on the breed of the dog: Labrador and Golden retrievers are the fittest breeds, both physically and temperamentally, for working in the water. In summary, water rescue dogs are family dogs that learn a specific social work (see also D'Aniello et al. 2015; D'Aniello and Scandurra 2016), hence allowing the study of the effect of training as an isolated component.

Altogether, considering the particular ontogenetic pathway because of the type of training given to water rescue dogs, we expected that they would perform better than the pet dogs in the A-not-B task.

Methods

For performing this study, we selected 48 adult dogs (29 males and 19 females) with mean age of 48.19 ± 28.75 (in months), including 37 Labrador retrievers (77.1%) and 11 Golden retrievers (22.9%). Among them, 20 (17 Labrador and 3 Golden retrievers; 9 males and 11 females; mean age in months: 60.85 ± 30.52) were water rescue dogs (TD) from the Italian School and 28 (20 Labrador and 8 Golden retrievers; 20 males and 8 females; mean age in months: 39.14 ± 24.08) were pet dogs (PD) with no experience in any type of training. Both PD and TD lived in a human household as a companion animal.

The inhibitory control task known as A-not-B task was conducted at the University of Naples Federico II (Naples) and at the training center of the Italian School of Water Rescue Dogs (Velletri, Rome), in rooms with an area of 12 and 16 m^2, respectively. All of the 28 PDs and 7 TDs were tested in Naples, while 13 TDs were tested in Velletri. The experimenter was always kept as the same female person and handlers were four female experimenters who were kept in rotation.

The subjects were made to stare at three aligned cups (A, M and B) turned upside down with the opening toward the floor. A reward was placed in one of the cups, which was located at the far end of the array, while the cup in the middle (M) and the cup at the other end were empty. A distance of 1.20 m separated the aligned cups from each other and the start line (where the dog and handler were waiting) was at a distance of 2.10 m from the middle cup. The sausage was spread on all three cups to control the odor cues (Fig. 1). A recent study reported that human position influences a dog's behavior (Siniscalchi et al. 2014) and thus we handled the dogs in a random position.

The task was administered by following the protocol of Fagnani et al. (2016b). At "*Pre-training* phase", the

Fig. 1 Experimental setting

dogs were made to learn retrieval of food from the cups. The experimenter approached one of the cups, showed the reward in her hand to the dog, lifted up the cup to put the sausage on the floor, placed the cup on it and moved to the center of the array with her back to the dog. Immediately, the handler released the leash to allow the dog to choose freely from the cups. If the dog did not move forward, the handler encouraged it by saying words like "come on", a couple of times. If the dog touched the baited cup with its snout it was considered to be a correct response, in which case the handler allowed the dog to eat the reward by lifting the cup and also verbally reinforced the dog by saying "very good". When one of the two unbaited cups was selected, it was considered to be an incorrect response. In such a case the handler said "no" and walked the dog back to the starting line, and the experimenter also removed the reward from the baited cup out of the dog's view. The incorrect response was also recorded when the dog did not walk forward after 30 s, thus moving to the next trial. The same criterion was applied in the training and test phases. This procedure was repeated for all the three cups A, M, and B until the dogs managed to retrieve the reward from each container correctly at first choice. The location of cup A and B (right or left) from which the reinforcement was retrieved, was counterbalanced across the subjects.

The same procedure was followed in training phase, except that the experimenter always placed the reward in cup A. It was required that the subjects retrieve the reward in five trials, not necessarily consecutive, with a maximum of ten opportunities. The intervals between trials were of the 20 s each.

In the "test phase", the experimenter after baiting cup A, removed the bait and exposing the subject, placed it under the cup located at the other end of the array (cup B). If the subject was not paying attention during the moment of beginning the transfer of the food, the experimenter made a sound (e.g., joke, whistle, clap, etc.), so that animal could observe each movement. Dogs were required to retrieve the reward over 15 trials in total and the choice of cup B was considered to be the correct response. The location of cup A and B was counterbalanced across dogs, as in pre-training phase.

In accordance with the study by Fagnani et al. (2016b), we measured the number of trials required by the subjects, during training and test phases, to exhibit a correct response and the frequency of errors (incorrect and no-choice responses, coded from 0 to 15 in test phase).

Sessions were scored live by one of the experimenters, during the test, through a computer connected to the cameras that were located outside the test rooms while another experimenter corroborated the live score. The agreement between them was perfect.

Data were analyzed in SPSS 23.0 by the generalized linear model (GLM) utilizing a Poisson-type model. Group (TD, PD) was included as a fixed factor and age was included as a co-variable in the model and its respective interactions. We excluded the gender because statistical analysis with the Mann–Whitney *U* test did not reveal any difference between the two groups in any of the variables (Ps > 0.05). All tests were two tailed, $\alpha = 0.05$.

Results and discussion

No significant differences were found during the training phase between TD and PD in any of the two measures (the number of trials required to perform a correct response (TD: $M = 1.18$, SE = 0.25; PD: $M = 1.08$, SE = 0.20) and frequency of errors (TD: $M = 0.49$, SE = 0.16; PD: $M = 0.29$, SE = 0.10), Ps > 0.05).

In the test phase, no significant differences were observed between TD and PD in the number of trials required to perform a correct response (TD: $M = 1.53$, SE = 0.29; PD: $M = 1.45$, SE = 0.23) $P > 0.05$. Moreover, this model yielded a significant main effect of groups in the variable frequency of errors ($\chi^2(1) = 13.41$, $P = 0.0002$): PD ($M = 4.10$, SE = 0.40) had significantly more frequency of errors than TD ($M = 2.00$, SE = 0.32) in the test phase (Fig. 2), and age had no significant effect in any of these comparisons (Ps > 0.05).

The results showed that water rescue dogs committed lower frequency of "A-not-B errors" throughout the test than

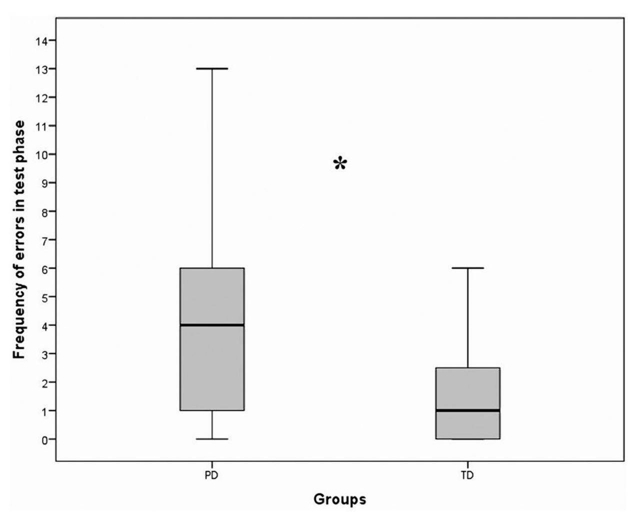

Fig. 2 Grey boxes represent averages of the frequency of errors (incorrect and no-choice responses) during a test of PD (pet dogs) and TD (trained dogs) groups. The bars represent the interquartile range containing 50% of values, and the lines indicate the mean in the case of frequency of errors. The error bars extend from the box for the maximum and minimum values. *$P < 0.05$, two-tailed tests

pet dogs with no previous training. This is in line with other studies showing that training improves the performance in the dogs in various socio-cognitive tasks (Bray et al. 2015; Marshall-Pescini et al. 2008). It is probable that dogs with complex training had more opportunities to learn advanced inhibitory control skills (Fagnani et al. 2016a), suggesting that inhibitory control might be affected by ontogenetic experiences. Indeed, shelter dogs with low human socialization level were seen to committed more "A-not-B errors" than pet dogs (Fagnani et al. 2016b).

The A-not-B task is a part of reversal procedures that include several components of the executive functions (Izquierdo and Jentsch 2012) such as inhibitory control and flexibility (Bari and Robbins 2013). The latter relates to the capacity for changing strategies or perspectives either spatially or interpersonally. To achieve such a change, the subject needs to inhibit the previous solution and activate a different solution in the working memory (Diamond 2013). Several studies have shown that the most flexible individuals possess better inhibitory control abilities (e.g., Izquierdo and Jentsch 2012). Our results suggest that the water rescue training improves the inhibitory control and the flexibility in dogs, which represent very important requirements for them in a working context. As pointed out earlier, this training involved several advanced and specific types of training tasks that required the dogs to inhibit their responses to achieve the expected objective. Moreover, it was demonstrated that this kind of training also affected other dogs' social responses. For example, in a study on the impossible task paradigm, water rescue dogs gazed at humans more than pet dogs (D'Aniello et al. 2015), thereby proving that water rescue dogs are less inclined to act independently from their owners than untrained dogs, as it has also been found in studies concerning the attachment behavior (Scandurra et al. 2016) and the social referencing paradigm (Merola et al. 2013).

In conclusion, the results from the study highlight that ontogenetic processes have a significant impact on the acquisition of socio-cognitive skills in dogs, indicating that the inhibitory control is a flexible trait that could be improved life long. These results are in agreement with the two-stage hypothesis about the main role of experiences and learning during life in the development of socio-cognitive skills in dogs (Udell and Wynne 2010).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest to declare.

Ethical statement This study was approved by the Ethical Animal Care and Use Committee of the University of Naples "Federico II" (protocol number 2017/0025509). All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All owners expressed their verbal consent for the participation of the dogs in this protocol.

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