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Let me sniff! Nosework induces positive judgment bias in pet dogs

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ABSTRACT

When confronted with an ambiguous stimulus, an individual's perception of and behaviour towards the situation are affected by emotional states. In a new situation, positive emotional states lead to optimistic reactions; negative emotional states, to pessimistic reactions. This phenomenon is related to welfare and is well-studied in humans and other animals via the cognitive bias test. This test is often used in applied ethology, especially for captive animals, and assesses the emotional state of animals to evaluate their welfare. However, one species is often forgotten in that category of "captive animals": domestic dogs. Pet dogs can be considered "captive" insofar as they cannot choose their daily activities; nor do they generally have the opportunity to express the natural behaviors necessary for their welfare – such as olfactory foraging behaviour. In this study, we tested the effect of an olfaction-based activity on pet dogs' emotional states. Dogs were first given a cognitive bias test, then practiced a daily, specified activity for two weeks, and finally were given a cognitive bias test again. The activity conducted differed between the groups: dogs from the experimental group practiced nosework, and dogs from the control group practiced heelwork. Results show that the latency to approach the ambiguous stimulus declined significantly after treatment in the experimental group, whereas the latency did not change for dogs in the control group. We conclude that allowing dogs to spent more time using their olfaction through a regular nosework activity makes them more optimistic. By allowing dogs more "foraging" time, their welfare is improved. Applications for pet dogs in daily life are discussed.

1. Introduction

Emotional states are short-term mental states, with a positive or negative valence, that an individual experiences after the perception of important internal or external stimuli (Panksepp, 2010). They are adaptive as they are essential to an individual's fitness, by guiding her behavioral decisions relative to those perceived stimuli, and can affect her survival or reproductive success (Panksepp, 2010). It is known that emotional states modify cognitive processes such as attention, memory, and judgement of a perceived situation (Bishop, 2007; Mendl et al., 2009; Paul et al., 2005). Cognitive bias – also called judgment bias – is defined as the influence of emotional states on an individual's interpretation of any ambiguous stimulus, and thus on her decision-making as well as on her behavioral response (Bethell, 2015; Mendl et al., 2009). Tests of cognitive bias posit that a more positive judgment of the ambiguous stimulus reflects positive emotional states, whereas a more negative judgment of the ambiguous stimulus reflects negative emotional states (Bethell, 2015).

Cognitive bias has been extensively studied in adult humans. Individuals in positive emotional states better remember positive information, expect more positive events in the future, are more attentive to positive stimuli, and express more positive judgments when facing ambiguous stimuli (Paul et al., 2005). It has also been shown that people experiencing negative emotional states are more attentive to threatening stimuli, have more negative memories, and have a more negative judgment on future events or ambiguous stimuli compared to people in positive emotional states (MacLeod and Byrne, 1996; Mendl et al., 2009; Williams et al., 1996).

Estimation of an individual's cognitive bias is done via language in humans, with tested subjects able to directly provide a value of their subjective emotional state; such a method is not available with other, non-verbal species (Mendl et al., 2009). A specific test was thus designed by Mendl et al. (2009) to evaluate cognitive bias in non-human animals, and has since then been widely used, revised and amended. Generally, the Cognitive Bias Paradigm consists in training animals to discriminate between two stimuli: one is associated with a positive event (e.g. food reward), the other is associated with a negative event, such as disgusting food (Boleij et al., 2012), fear-eliciting object (Destrez et al., 2013; Douglas et al., 2012), or absence of reward (Carreras et al., 2015; Freymond et al., 2014). The tested individual is

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then presented with an ambiguous stimulus, and her behavior is observed. Speed and frequency of reaction towards the ambiguous stimulus provide an estimate of whether the subject judges it positively ("optimistic") or negatively ("pessimistic") (Bethell, 2015).

Various studies have validated the cognitive bias paradigm as an effective tool to determine the emotional states of captive non-human animals, and thus to evaluate the impact of their living environment on their welfare (Boissy and Erhard, 2014). For example, rats living in unpredictable living conditions evaluate ambiguous stimulus less positively than rats living in predictable living conditions (Harding et al., 2004). Numerous studies have demonstrated that judgment bias in a cognitive bias test reflects differing affective states correlated to living conditions in captive mammals (Mendl et al., 2010a,b; Doyle et al., 2010), birds (Matheson et al., 2008; Salmeto et al., 2011) or insects (Bateson et al., 2011).

Interestingly one species is less often considered when looking at the welfare of captive animals: domestic dogs. Pet dogs can be considered captive individuals, insofar as they cannot choose where to live, where or when to go outside, with whom to interact, or what activity to do and when to do it (Carlstead et al., 1993; Horowitz, 2016b). They are often alone and confined in a limited space during the daytime (Rehn and Keeling, 2011) and thus cannot engage in natural behaviors essential for their welfare, such as social interaction and foraging activity (see Dawkins (1989) for the importance of foraging behaviors in welfare; see Bracke and Hopster (2006), and Fraser (2008) for the importance of natural behaviors in welfare). While recent studies have investigated the effect of life experiences such as stress due to time spent alone (Mendl et al., 2010a,b; Müller et al., 2012), food satiation (Burman et al., 2011), and conspecific removal (Walker et al., 2014) on cognitive bias in dogs, the impact of a poorly enriched living environment is still unknown. It is reported that free-ranging dogs forage alone most of the time, using olfaction (they are opportunistic and look for human food leftovers or carrion), and spent at least 10 to 22% of their active time doing so (Daniels, 1983; Beck, 2002); there is still a lack of data on total budget time allocated to foraging in all dogs (Bradshaw, 2006; Matter and Daniels, 2000). Working dogs are one sub-group which does dedicate considerable time to use of olfaction, in their employ to detect explosives (Goldblatt et al., 2009), narcotics (Shoebotham, 2016), cancers (Jezierski, 2016), or other animals (Cablk et al., 2008; Gadbois and Reeves, 2014). Shelter dogs have been seen to benefit from olfactory enrichment in their environments, which leads to a decreases in the number of stress associated behaviors and an increase in their welfare (Binks et al., 2004; Graham et al., 2004). However, pet dogs have been overlooked in these studies. Given their living arrangements, pet dogs often have little opportunity to forage or explore their environment using olfaction. To our knowledge, the impact of olfactory enrichment on pet dogs' welfare has not yet been studied. We thus aimed to investigate the effect of a daily olfaction-based activity – nosework – on pet dogs' performance on the cognitive bias test. Nosework is defined as an activity in which dogs use their noses to find something hidden – the *Hide* (in the present study, a food reward) (Horowitz, 2016a). In nosework, dogs search for hidden treats or scents independent of their owners. We predicted that the experimental group practicing nosework with food reward would show higher levels of optimism on a post-intervention cognitive bias test than a control group of dogs practicing a food-reward based activity with the same physical activity as in nosework, but with no olfactory search component (heelwork).

2. Methods

2.1. Participants

20 dogs of unrestricted breeds (age at least one year; mean age 467 ± 0.50 years old, balanced sex ratio) were selected on a volunteer basis. They were all free of any health issue that could have modified their normal behavior or prevent them from moving, seeing, and sniffing correctly. Through a random number generator, dogs were pseudo-randomly assigned to control group or experimental group (controlled for sex ratio), as follow: *i.* experimental group: 5 Shepherds (2 Australian Shepherds, 1 Belgian Shepherd, 1 Shetland Shepherd, 1 Mix Schiperke Shepherd), 1 Spitz, 1 Spaniel (Cocker Spaniel), 1 Akita, 1 Jack Russel, 1 Dachshund; *ii.* control group: 5 Shepherds (2 Australian Shepherds, 2 mix Border Collie Shepherd, 1 Shetland Shepherd), 2 Spaniels (1 Cocker Spaniel, 1 Brittany Spaniel), 2 Huskies, 1 Dalmatian. No dog had previously participated in nosework or heelwork training.

2.2. Ethical note

The study was conducted in accordance to the legal requirements of the country for animal welfare, Rural Code Article R214-17, and of the official French Legal Code of Animals (2018). The study was observational and the dogs were neither physically nor psychologically harmed in the course of the study. The dogs did not undergo any physical intervention (e.g. blood or saliva sampling). The owners were informed of the steps of their participation, affirmed that they were voluntarily participating in the study, and knew that they could stop at any time. Each owner signed a consent form. Owners did not know the working hypothesis of the study and were randomly assigned to « *nosework group* » (experimental group) or « *heelwork group* » (control group). Both groups were told that we were investigating the (unspecified) effect of these exercises over time.

2.3. Procedure for behavioral treatment

For both groups, owners were asked to bring and use "high-value" food for their dogs: namely, their dogs' favorite treats. Please see Table 1 for an overview of the schedule of behavioral treatment.

Experimental Group: Half of the dogs (n = 10) were assigned to the Experimental group (counterbalanced for sex). Dogs and owners received a specific training, described below, in order to enable the dyads to practice nosework at home.

- *Group classes:* The training consisted of two group classes during which the experimenter trained the owners to practice nosework with their dogs. During the first class, the dog was shown a box (the Source) which contained a single small treat of the owner's selection inside (the Hide). The experimenter placed the source at least 1 m away from the dog, and the dog was encouraged, by a prompt from the owner (such as "Go find it"), to search for the Hide (Level 1). After three repetitions the experimenter placed the Source among two other non-baited boxes (Level 2). Each time the dogs found the Hide, they received praise and a sprinkling of more treats from the

Table 1
Planning for each dog participating in the study.

Day 1	Cognitive Bias Test before behavioral treatment
Day 2	1er group class
Day 3	Home exercises day 1
Day 4	Home exercises day 2
Day 5	Home exercises day 3
Day 6	Home exercises day 4
Day 7	Home exercises day 5
Day 8	Home exercises day 6
Day 9	Home exercises day 7
Day 10	2nd group class
Day 11	Home exercises day 8
Day 12	Home exercises day 9
Day 13	Home exercises day 10
Day 14	Home exercises day 11
Day 15	Home exercises day 12
Day 16	Home exercises day 13
Day 17	Home exercises day 14
Day 18	Cognitive Bias Test after behavioral treatment

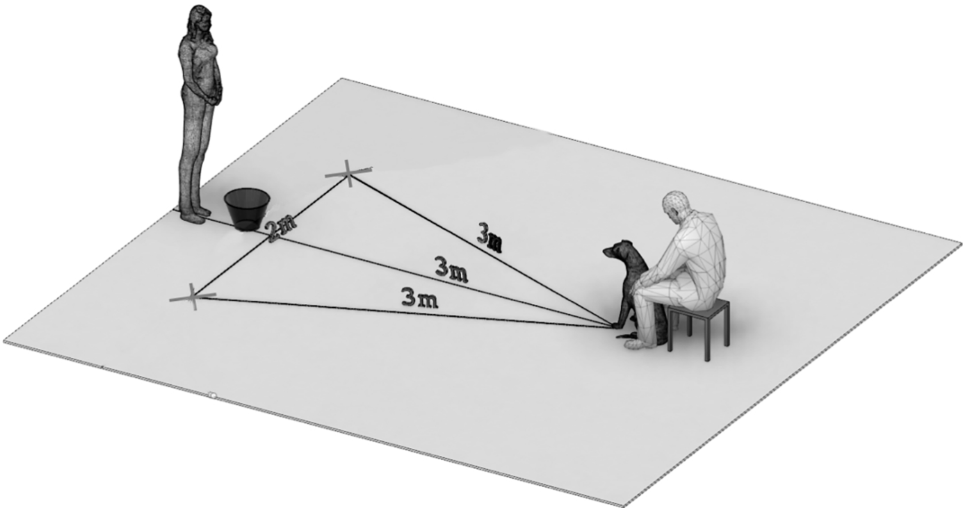

Fig. 1. Setting of the Cognitive Bias Paradigm. The dog sits between the owner's legs while the experimenter put the bowl at one of the three locations, 3 m away from the dog. The two bowls at the side represent positive and negative locations (side counterbalanced across dogs) and at the center is the ambiguous location (only for the test trial).

owner, regardless of the level. The Source was always the same box in order to avoid any odor contagion across boxes. At the end of the first group class, the dog had to be able to find the hide at Level 2.

- Subsequently, the owner practiced nosework exercises at Level 2 at home (see below) for one week. After the first week of home practice, a second group class was conducted. The experimenter started from Level 2, by letting the dog find the hide out of three boxes. After two repetitions, the experimenter placed the boxes in more complex locations (far away from each other, on the top of chairs, etc.) requiring the dog to search more actively to find the hide in the source among the other boxes (Level 3). When the dog succeeded three times in a row the group class concluded. During the following week the owners were asked to practice nosework exercises at Level 3 at home.
- *At home:* After each class, the experimenter explained the precise procedure of the behavioral treatment, and provided written as well as video instructions to owners to remind them of the procedure (written instructions are accessible in the online supplemental information file). During two consecutive weeks, owners engaged in one daily session of nosework with their dogs, respecting the procedure explained for Level 2 (first week) and Level 3 (second week), three consecutive times maximum (approximatively five minutes). Each owner was asked to note the time of the session and to film the whole session, which was then sent to the experimenter. The experimenter reviewed the videotapes to ensure that the home sessions were correctly performed.

Control group: Half of the dogs ($n = 10$) were assigned to the Control group (counterbalanced for sex). They received no specific training to practice nosework with their owners; in other regards, though, the Control procedure was as similar as possible to that of the Experimental group in order to control for any effect linked to time spent with the owner, time being active, quantity of food ingested, and familiarity with the experimenter.

- *Group classes:* The training consisted of two group classes during which the experimenter trained the owners to practice heelwork with their dog. During the first class, the dog was encouraged to follow her owner for two steps, then received a food rewards (Level 1). After three repetitions the experimenter asked the owner to walk for a longer distance (Level 2). At the end of the first group class, the dog had to be able to follow the owner for ten steps. Then the owner practiced heelwork exercises at Level 2 at home (see below) for one week. After the first week of home practice, a second group class was conducted. The experimenter started from Level 2 by asking the owner to do the same exercise as the last one during the first group classes. After two repetitions the experimenter asked the owner to change walking direction (twice following a triangle-shaped path, then three times walking a square-shaped path: Level 3). When the dog succeeded three times in a row the group class concluded. During the following week the owners were asked to practice nosework exercises at Level 3 at home.
- *At home:* After each class, the experimenter explained the precise procedure of the behavioral treatment, and provided written as well as video instructions to owners to remind them of the procedure. During two consecutive weeks, owners performed one daily session of heelwork with their dogs, respecting the procedure explained for Level 2 (first week) and Level 3 (second week), three consecutive times maximum (approximatively five minutes). Each owner was asked to note the time of the session, and to film the whole session, which was then sent to the experimenter. The experimenter reviewed the videotapes to ensure that the home sessions were correctly performed.

2.4. Procedure for the cognitive bias test

Before the behavioral treatment, as well as one day after the end of the two weeks of behavioral treatment, all dogs were given a cognitive bias test. The training procedure was inspired by the procedure of Mend et al. (2010a,b), but was slightly modified, as we waited until the dogs did not go to the negative probe during the 10 s after they were released (see *discrimination criterion* section below) and as we confronted dogs with the ambiguous probe only once per cognitive test (see *test* section below).

Training: Dogs were trained to move from a starting position to a food bowl placed 3 m ahead (see Fig. 1). At the beginning of each trial the owner was seated on a chair with the owner's dog sitting between his or her legs. The experimenter, C.D., stood 4 m from the dog and baited (or did not bait, depending on trial type) the bowl with a piece of cooked chicken. She kept her back to the dogs, and made identical hand movements with or without placing the treat, according to the trial type, to ensure that dogs could not gain any information from bodily cues. The experimenter then placed the bowl at one of the pre--determined locations 3 m in front of the dog's fixed starting position. When the bowl was on the "positive" side it contained one piece of food; when placed on the opposite side, i.e. "negative" side, it was empty. After placing the bowl on the floor, the experimenter returned to her central position (see Fig. 1). The dog was then released and allowed to approach the bowl. Sides of the negative and positive locations were counterbalanced across dogs.

Initially, each dog received two consecutive positive trials (bowl placed in the positive location) followed by two negative trials (bowl

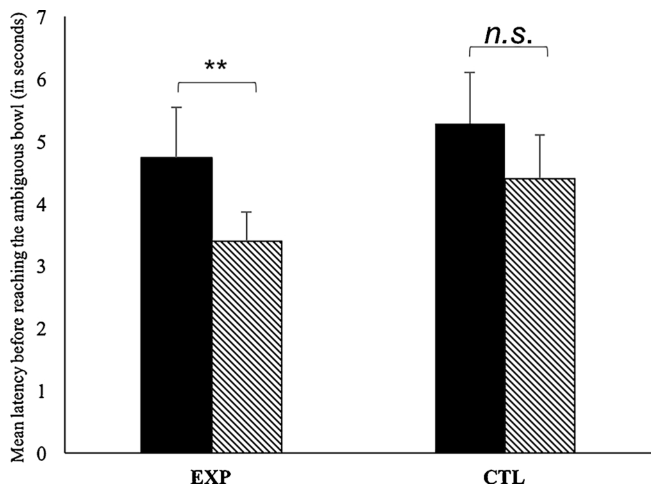

Fig. 2. Latency to reach the ambiguous bowl in the cognitive bias test before (black bars) and after (striped bars) behavioral treatment: nosework exercises for Experimental Group (EXP, $N = 10$) and heelwork exercises for Control Group (CTL, $N = 10$). **: p < 001. Standard Errors are on the graphic.

placed in the negative location). Subsequently, positive and negative trials were presented in a pseudorandom order, with no more than two trials of the same type being presented consecutively. All dogs received a minimum of 15 training trials. On each trial, dogs were given a maximum of 10 s to visit the bowl. If they had not visited it by this time, the trial was terminated and after a 20 s interval, the next trial was initiated.

Discrimination criterion: Criterion to go to the test trial was when the dogs stopped going towards the negative bowl for at least six consecutives (3 positives and 3 negatives) trials (Mend et al. 2010). The final trial was always a negative one.

Test: When the dogs had discriminated the positive and the negative locations, the test trial was run. The test trial was identical to the training trials except that the bowl (empty) was placed at an ambiguous location, exactly in the middle between the positive and the negative positions, still 3 m from the dog (as done in Kiss et al. 2015) (see Fig. 1). To avoid any potential learning effects, dogs were only confronted once with the ambiguous test before the treatment, and once after the treatment.The dogs' behavior when facing the ambiguous bowl was observed.

2.5. Behavioral analysis

We coded the following behavioral elements: *i.* Latency to reach the ambiguous bowl. "Latency" was defined as time elapsed between release of the dog from the starting position and the dog putting her head into the bowl, or touching it with the nose (Mendl et al., 2010a,b). Difference in latency before and after treatment was then calculated. *Difference* was chosen, to control for any potential speed variation between individuals; *ii.* Total number of trials before reaching the test criterion. We also visually controlled for stress-related behaviors – body shaking, yawning, lips-licking, auto-grooming (Duranton et al., 2016) – with the rule that dogs exhibiting stress-related behaviors would be removed from the study. No dogs were excluded. To test the reliability of the behavioral coding done by coder M.D., a second coder (C.B.), who was blind to the study's aims and hypotheses, coded 100% of the data. The resulting Pearson correlation coefficients were satisfactory (latency before reaching the ambiguous pot: 99% agreement, $p < 0.001$; number of trials before reaching the test: 100% agreement, $p < 0.01$).

2.6. Statistical analysis

Statistical analysis was conducted using the software R version 3.5. Comparisons of means were conducted with Fisher-Pitman permutation tests (Ludbrook and Dudley, 1998). For between-groups comparisons, we conducted permutation tests for independent data, and for within-group comparisons, we conducted permutation tests for dependent data.

3. Results

3.1. Controlling for the population homogeneity before behavioral treatment

3.1.1. Latency before reaching the ambiguous bowl

There was no difference between latency to reach the ambiguous bowl in the Experimental Group ($M = 4.74 \pm 0.80$ s) and in the Control Group ($M = 5.28 \pm 0.81$ s; Fisher-Pitman: $Z = 0.48$; $P = 0.64$; Cohen's $d = 0.21$; 95% CI= [-1.84 – 2.92]) before behavioral treatments.

3.1.2. Total number of trials

There was no difference between total number to reach the test criterion in the Experimental Group ($M = 64.30 \pm 7.30$ trials) and in the Control Group ($M = 71.50 \pm 4.12$ trials; Fisher-Pitman: $Z = 0.87$; $P = 0.42$; Cohen's $d = 0.38$; 95% CI = [-5.31 – 19.71]) before behavioral treatments.

3.2. Effect of behavioral treatment

3.2.1. Latency to reach the ambiguous bowl

- *Experimental Group*: Latency to reach the ambiguous bowl after treatment ($M = 3.40 \pm 0.47$ s) was significantly shorter than latency to reach the ambiguous bowl before treatment ($M = 4.74 \pm 0.80$ s, Fisher-Pitman: $Z = 1.68$; $P < 0.01$; Cohen's $d = 0.64$; 95% CI= [0.27–2.95]; see Fig. 2).
- *Control Group*: Latency to reach the ambiguous bowl after treatment ($M = 440 \pm 0{,}70$ s) was not significantly different from latency to reach the ambiguous bowl before treatment ($M = 5.28 \pm 0.81$; Fisher-Pitman: $Z = 1.26$; $P = 0.15$; Cohen's $d = 0.37$; 95% CI = [-0,65 – 2,41]; see Fig. 2).

3.3. Controlling for any learning/retention ability difference after treatment

3.3.1. Total number of trials

There was no significant difference between total number of trials needed to reach the test criterion after behavioral treatment in the Experimental Group ($M = 30.50 \pm 506$ trials) or in the Control Group ($M = 28.10 \pm 1.75$ trials; Fisher-Pitman: $Z = -0.46$; $P = 0.75$; Cohen's $d = 0.20$; 95% CI= [-14.25 – 9.45]). All dogs (in both groups) needed significantly fewer trials to reach the test criterion after behavioral treatment ($M = 29.30 \pm 11.72$ trials) than before treatment ($M = 67.90 \pm 18.61$ trials, Fisher-Pitman: $Z = 4.01$; $P < 0.001$; Cohen's $d = 2.55$; 95% CI = [24.97–52.23]).

4. Discussion

The present study demonstrates that practicing an olfaction-based activity with owners decreases subjects' latency to approach an ambiguous bowl. In a cognitive bias test, dogs were faster to go to the ambiguous bowl after practicing two weeks of nosework compared to two weeks of heelwork. Such a result has been described as a measure of "optimism" in the subjects; in this case, dogs who participated in the nosework treatment were "more optimistic" after treatment than before – a result which did not occur with the control (heelwork) treatment group.

It is important to note that, insofar as it was possible to determine, both Experimental Group and Control Group populations were similar before their respective behavioral treatments. The initial cognitive bias test before treatment confirmed that there was no initial difference on the test between the two groups: i.e. the lack of significant difference in latency to go to the ambiguous bowl demonstrated that dogs of one group were not more (or less) likely to approach the ambiguous bowl than those of the other. Similarly, the lack of significant difference between total number of trials before reaching the testing criterion allows us to say that dogs from both groups did not differ in their cognitive ability to understand the task. We thus suggest that the groups were correctly balanced and had similar physical and cognitive abilities on this task. Moreover, we ensured that the protocol for both groups were matched in length and number of collective classes, as well as individual exercises at home, to ensure that dogs of each group had the same amount of extra time spent with their owners. Certainly, though, there may have been individual differences over time that affected our result.

Owners had different progression levels to reach, through an errorless learning program, to ensure that they were all invested and satisfied of the progression of their dogs, whatever the group. They were also instructed to provide the same quantity of food during the exercises. Thus, we believe that the behavioral treatment received during the two weeks of the experiment was the relevant factor in dogs' performance on the cognitive bias test.

Though the individual subject differences were controlled for, it is useful to consider other explanations for the present findings. In particular, there is the question of interpretation of the latency difference. Though the cognitive bias test has been widely used and is considered as robust to demonstrate level of positive or negative affect in various non-verbal species (Baciadonna and McElligott, 2015; Bethell, 2015; Boissy and Erhard, 2014; Clegg, 2018; Paul et al., 2005; Verbeek and Lee, 2014), it is worth discussing other hypotheses for subjects' performance. In this study, for instance, one could argue that dogs who participated in the nosework practice were not more showing more positive judgment bias, but, instead, evinced improved cognitive abilities due to the use of their olfaction system. It is known that environmental enrichment and sensory stimulations promote the development of a larger cerebral cortex, with an increase of the number of synaptic connections (Diamond et al., 1964, 1966). So, it could be possible that participation in the nosework activity was more stimulating cognitively than the activity undertaken by control group, and that the seen difference in subsequent latency to reach the ambiguous bowl was only due to difference in cognitive abilities and not optimism. However, our results showed no difference in the total number of trials needed in the cognitive bias test after behavioral treatment: dogs from the experimental group did not remember the task more quickly than the dogs from the control group. We thus suggest that dogs retained the same cognitive abilities after treatment, and that the observed difference is more likely due to change in levels of affect.

Second, one could argue that nosework trains dogs to physically search, resulting in faster trotting or running speeds post-treatment, only due to physical training, which could influence them – perhaps by encouraging them to run – in performance in the cognitive bias task. However, we think that such an explanation is unlikely as we measured latency, which is different of speed of running. Latency is a measure of response to a stimulus, implying motivation: if a dog is not motivated, she will not move fast, or take time before starting to move, or simply will not go to the ambiguous stimulus. On the contrary, if a dog is highly motivated, she will start to move immediately when freed and can have a shorter latency than a faster dog who is less motivated. Significantly, dogs practiced nosework in their homes, not in outdoor areas, and videos of their performance show that they mainly searched by walking or trotting, as they did not have enough space to run. Finally, nosework as an activity is not known to lead to faster dogs. Matching of general physical activity levels was done by the choice of heelwork for the control group.

Finally, it could be argued that as olfaction is the most important sense in dogs (Walker et al., 2006), pet dogs who practiced nosework learned to use their nose to search and to detect the presence or absence of food in containers, which could influence them during the cognitive bias task. There are two counter-arguments to this hypothesis: *i.* contrary to working dogs who are especially trained on purpose to use their olfaction, it is known that pet dogs do not spontaneously discriminate food quantity through olfaction only (Horowitz et al., 2013). Moreover, previous research in similar setups found that dogs are not able to used odour cues alone to find the baited pot (Lakatos et al., 2011; Kis et al., 2015). *ii.* Even more importantly, the ambiguous bowl was always presented empty. If dogs from the experimental group were able to better use olfaction to guide them in their approach, they could well have smelled the *absence* of food, in which case they may have reached the ambiguous bowl more slowly (or not at all) than dogs from the control group. As we found the opposite result – i.e. that dogs from the experimental group went more quickly to the ambiguous bowl than dogs from the control group – we suggest that they did not use olfaction to evaluate the pot, and that the shorter latency to reach the bowl was indeed due to a more positive judgment bias.

Even given the limitations of the present study concerning the underlying mechanisms of the change in dog's judgment bias, we can hypothesize why practicing nosework affects dogs' cognitive bias and makes them more "optimistic". De Jonge et al. (2008) suggest that foraging (including looking for and consuming food) is stimulating and intrinsically rewarding for non-human animals. By daily practice of nosework over two weeks, dogs increased their foraging time, thus increasing the time spent doing a natural and rewarding activity. It is also plausible that increasing foraging time plays an important role in dogs' welfare for the reason that it mimics the time that would naturally be allocated to the activity – such as is found in non-captive dogs (Beck, 2002; Daniels, 1983; Fraser, 2008). If so, a practical recommendation from this experimental result would be to encourage owners to increase their pet dog's foraging time through nosework or any other activity, such as natural sniffing during walks (Horowitz, 2009) or food-distributor toys (Rooney et al., 2009) to increase their dog's optimism and welfare –the impact of the latter on dog's optimism has, to our knowledge, not been studied yet, but see Schipper et al. (2008) on the positive impact on feeding enrichment toys on dogs' welfare.

Another explanation for the current result, not mutually exclusive from the above-mentioned hypothesis, is that nosework allows for dogs to act autonomously and by their own initiative. Owners were asked to follow their dogs, not to guide them; nor to intervene on their movements or choices. Nosework requires dogs to problem-solve, to correct and redirect themselves, to analyze their environement by themselves – in other words: to choose what to do (Horowitz, 2016a). Over the course of the nosework treatment, dogs learned to rely on their nose to find the Hide; they were autonomous agents acting on the environment, able to explore freely (Jackson et al., 2012). Dogs in the control group, practicing heelwork, did not have such autonomy, as the owners were leading the activity and movements of their dogs. In a captive environment such as experienced by most pet dogs, in which owners do not allow their dogs to take initiative (Greenebaum, 2010; Stafford, 2006), and in which dogs obey humans even if it is counterproductive for them (Marshall-Pescini et al., 2010), nosework clearly allows dogs to have more choice and autonomy in their environments (Horowitz, 2016a). It has previously been suggested that the ability to *have a choice* is essential in welfare, whatever the species (see for example Fraser, 2008; Fraser et al., 1997; Fraser and Matthews, 1997).

To conclude, the present study shows for the first time that practicing nosework increases positive judgement bias – levels of "optimism" – in pet dogs, suggesting that an olfaction-based activity may be a useful tool to improve welfare in owned dogs.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.applanim.2018.12.009.

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