Applied Animal Behaviour Science 236 (2021) 105242

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

Affect matters: Positive and negative social stimulation influences dogs' behaviour in a subsequent situation involving an out-of-reach object

Ágoston Galambos [a,b,*], Anna Gergely [a], Alexandra Barbara Kovács [c], Orsolya Kiss [a,d,e], József Topál [a]

[a] Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences, Budapest, Hungary
[b] Department of Cognitive Psychology, Eötvös Loránd University, Budapest, Hungary
[c] Institute of Biology, Eszterházy Károly University, Eger, Hungary
[d] Department of Cognitive Science, Budapest University of Technology and Economics, Budapest, Hungary
[e] Center for Health Sciences, SRI International, Menlo Park, CA, USA

ARTICLE INFO

Keywords:
Dog
Social interaction
Positive/negative affective state
Priming
out-of-reach task

ABSTRACT

There is ample evidence to suggest that dogs have highly developed, context-dependent social skills. Recent literature also indicates a human-like susceptibility to social influence in dogs. However, it is still unclear how the affective social context affects the way dogs behave in a situation involving an out-of-reach object. The experimental manipulation served to prime the dogs with positive and negative affect in the form of social interactions. Dogs (N = 20) participated in both a negative and a positive social interaction with an unfamiliar male experimenter. Having received pretreatment with different social stimuli, subjects were observed in an instrumental task with an unfamiliar female experimenter requesting an out-of-reach object. The analysis of the dogs' tendency to engage in the task revealed that although the type of pretreatment did not influence whether they retrieved the cued object or not, the social interactions had a facilitatory effect on other, more subtle aspects of their behaviour. The positive interaction resulted in longer duration of looking time at the experimenter; shorter latency of moving upon release and of approaching the experimenter. The priming effects of the negative social interaction manifested in longer duration of looking time at the owner after release while gazing more at the target object during the first trial. These behaviours, together with the finding that dogs were more hesitant to approach the experimenter after the negative social interaction, may indicate that a negative emotional stimulation (involving the owner's and the experimenter's unresponsive behaviour, separation and a threatening stranger) causes a temporary disruption in the dog-owner bond, motivating the dog to repair it afterwards. These findings suggest that the valence attributed to the social interaction during pretreatment has differential effects on dogs' subsequent behaviour. Possible parallels with and differences from human behaviour are discussed.

1. Introduction

Dogs are unmatched amongst non-human animals regarding their inter-species social skills. As opposed to how their physical cognition ranks them in the virtual hierarchy (primates or corvids outperform dogs in many aspects – Van Horik et al., 2012; on the intelligence of corvids, see e.g. Clayton and Emery, 2005), convergent evolution – thousands of years of domestication – enabled them to excel at reading of and responding to human social-communicative signals. Human-like forms of behaviour in dogs involve reacting to pointing gesture (e.g. Hare and Tomasello, 1999; Miklósi et al., 2005; Miklósi and Topál, 2013), understanding gaze alternation as referential communicative act (Miklósi et al., 2000; Oláh et al., 2017), processing of facial expressions (Racca et al., 2012), attributing attentional state ('seeing leads to knowing', i.e. recognizing that an observer has information about events, whereas ignorance is linked to lack of knowledge – e.g. Call et al., 2003), social play (Bauer and Smuts, 2007), sensitivity to inequity aversion (Range et al., 2008), ability to selectively imitate (Range et al., 2007), recognizing emotions (Albuquerque et al., 2016), contagious yawning (Joly-Mascheroni et al., 2008), jealous-like behaviour (Harris and Prouvost, 2014; Cook et al., 2018).

This spectacular level of social sensitivity of dogs goes hand in hand

* Corresponding author at: Department of Cognitive Psychology, Eötvös Loránd University, Budapest, Hungary.
E-mail address: agoston.galambos89@gmail.com (Á. Galambos).

https://doi.org/10.1016/j.applanim.2021.105242
Received 18 April 2020; Received in revised form 24 January 2021; Accepted 27 January 2021
Available online 1 February 2021
0168-1591/

with behavioural flexibility: dogs demonstrate a high degree of context-dependence when interacting with humans. Studies show that dogs may react differently to strangers and their owner (e.g. Győri et al., 2010; Hernádi et al., 2015; Scandurra et al., 2017), they use contextual information when following a pointing gesture (Scheider et al., 2011), and are willing to behave socially even with a remote controlled car if it shows social-like behaviour towards them (Gergely et al., 2013). Vas et al. (2005) found evidence for how the different behavioural cues of the same experimenter (friendly vs. threatening) change dogs' responses, whereas Bálint et al. (2016) reported that the gender of the experimenter and different experience with male and female humans affect dogs' vocalization in a situation involving a stranger approaching in a threatening manner. Moreover, Kiss et al. (2018) found evidence for a rudimentary sensitivity for social categories in dogs: in their study, the dogs' behaviour varied as a function of similarity between an interaction partner and their owner (i.e. subjects paid preferential attention to people exhibiting motion pattern- and language-based similarity to their owner).

In line with these findings, it has also been shown that the affective content of the social context (i.e. differently valenced interactions with humans) might impact physiological and behavioural reactions in dogs. For example, positive human-animal interactions have a beneficial influence on blood pressure, cortisol, dopamine and the oxytocinergic system (for a review see Pop et al., 2014). Moreover, Coppola et al. (2006) found that even a single 'human contact session' has the potential to decrease shelter dogs' salivary cortisol levels, pointing to how interaction with a human might attenuate the stress response in dogs. In addition, Lynch and McCarthy (1967) reported that being petted by an experimenter alleviated the negative effects of electric shocks, whereas Hennessy et al. (1998) found evidence that following a venipuncture procedure, dogs showed behaviours indicating a relaxed state after being petted (vs. not petted) by a human. Moreover, there is empirical evidence suggesting that positive influences can occur even in the absence of explicit interaction: the mere presence of the owner has the potential to reduce dogs' physiological responses in a stressful situation (Gácsi et al., 2013).

It has recently been shown that the perceived affective quality of the social interaction with an unfamiliar human affects subsequent sleep EEG patterns in dogs (Kis et al., 2017a). In this study, dogs of various breeds underwent a specific manipulation that was intended to induce either a positive or a negative emotional state. Afterwards, the subjects participated in a 3-h-long sleeping session while their sleep and bodily functions were systematically monitored (non-invasive polysomnography technique for dogs – Kis et al., 2014). The authors found that the positive vs. negative stimulation did indeed influence sleep macrostructure: affected variables included sleep onset latency and the relative duration of all sleep stages (drowsiness, non-REM, REM).

To sum up, these empirical results provide evidence for how affect-laden social experiences influence dogs' behaviour and its underlying mechanisms in a variety of ways, and raise the possibility that exposure to differently valenced interactions with humans would not only have an impact on physiological variables and sleep macrostructure but also on overt post-manipulation behaviour in dogs.

It is worth noting that such exposure has been shown to influence several social behaviours in humans including affiliation (Lakin and Chartrand, 2003), cooperation (Bargh et al., 2001), and ingroup/outgroup attitudes (Spears et al., 2004). For instance, it has been reported that after having made a 'joint commitment' to play together (i.e. an experimenter using a puppet attended to and coordinated her actions with the child), 3-year-olds were more likely to show prosocial behaviour than children in the 'no joint commitment' condition in which the puppet moved by the experimenter did not pay attention to and/or acted independently of the child (Gräfenhain et al., 2013).

The present study therefore aims to investigate how the perceived affective quality of a social interaction with an unfamiliar experimenter (E1) affects subsequent behaviour of dogs in a situation in which another unfamiliar experimenter (E2) requests an out-of-reach object (by extending her arm and gazing toward it). Concerning the effect of pre-exposure to positive vs. negative interactions with humans on dogs' task-related behaviour, there are three possibilities.

First, we may assume that, just as in humans (e.g. Over and Carpenter, 2009), affiliative primes enhance prosocial (helping) behaviour in dogs as well. If so, pretreatment with positive social stimuli will have a positive impact on dogs' task engagement and motivation, and this may manifest itself in faster approach, faster object retrieval and longer looking times at the experimenter (or a combination of them) when compared to the negative social stimulation. Alternatively, one may expect that dogs show increased task-oriented behaviour in the negative pretreatment condition. That would mean that the behavioural effects of the negative interaction would outweigh those of the positive one. This could be the result of either the negative interaction leading to a temporary social exclusion effect (e.g. DeWall and Richman, 2011) that would increase the dogs' motivation to gain acceptance in subsequent interactions, or it might be related to negative affect-driven attentional processes. Taylor's mobilization-minimization theory (1991) on the role of negative affect suggests that negative states elicit an increase in attentional focus. This approach resonates with the well-established link between negative vs. positive emotional states and cognitive processes where positive moods are associated with assimilative strategies relying on intuitive thinking patterns, heuristics, stereotypes and schemas, whereas negative affect is tied to more accomodative, analytical, focused, effortful and complex cognitive processes (for an account of the historical and current approaches to affect and cognition, see Forgas, 2008). A third possibility would be that dogs, in terms of their task performance, do not respond differentially to the two, emotionally distinct pretreatments. This would either suggest that the way dogs are handled by the experimenter (positive/negative) is insufficient to influence their subsequent performance or that dogs separate their experiences with E1 from those with E2 (i.e. they do not generalize their positive/negative social experience from one human to another).

2. Methods

2.1. Ethical statement

This research was approved by the National Animal Experimentation Ethics Committee (Ref. No. PEI/001/1057–6/2015). Research was done in accordance with the Hungarian regulations on animal experimentation and the Guidelines for the use of animals in research described by the Association for the Study Animal Behaviour (ASAB).

2.2. Subjects

A total of 27 healthy adult pet dogs and their owners participated in the study. Some of them ($N = 7$) however, did not return for the second testing occasion, so a total of 20 dogs (12 females, 8 males; mean age ± SD: 4.25 ± 2.07 years, range: 1.5–8 years) were included in the data analysis. They were of various breeds: American Bulldog (2), Golden Retriever (1), Transylvanian Hound (1), Hungarian Vizsla (1), Russian Greyhound (1), Hungarian Greyhound (1), Pyrenean Mountain Dog (3), Husky (1), Mudi (1), American Staffordshire Terrier (1) and mongrels (7). We recruited owners through personal contact on a voluntary basis. All owners volunteered to participate in the experiments and gave informed consent. Along with the informed consent form, all owners were given written and oral description of the experiment prior to the pretreatment.

2.3. Procedure

The experiment consisted of two parts: a pretreatment, intended to elicit a particular (positive or negative) emotional state, and a test phase in which we measured the dogs' tendency to engage in a situation involving an out-of-reach object. We used a repeated measures design: all dogs participated in both the positive and the negative pretreatment conditions. The order of the conditions was counterbalanced across subjects: half of them started with the positive, the other half with the negative pretreatment, with 1–3 weeks between the two sessions (mean: 14.4 days; SD: 8.1). Both the pretreatment and the test phase were videotaped by four cameras (shooting from different angles), and the behaviour of the subjects was analyzed later.

2.3.1. Pretreatment phase

The pretreatment procedure was identical to that reported by Kis et al. (2017a). Both the negative and the positive pretreatment lasted for 6 min, and took place in the behavioural laboratory (5 × 4 m) of the Family Dog Project (Eötvös Loránd University, Budapest). Upon arrival at the laboratory, the female experimenter (E2) greeted the owner and their dog, and the owner signed the informed consent form.

2.3.1.1. Positive social interaction (PSI). During the 6 min of the positive social interaction, dogs had the opportunity to play with the owner and the male experimenter (E1). E1 and the owner petted the dog every time the dog approached them, played tug of war and/or throw and fetch depending on the dog's preference, and used dog-directed speech towards the subject. When the 6 min elapsed, E1 accompanied the owner and the dog to another room which was used for the test phase of the experiment.

2.3.1.2. Negative social interaction (NSI). The procedure consisted of three episodes lasting 6 min in total. First the owners were asked to leave the dog alone for 2 min in the behavioural laboratory on an approximately 1.5-meter-long leash that was fixed about 1 m away from the door (*Separation episode*, see e.g. Konok et al., 2011, for a similar situation). When the 2 min were off, the owner entered the room and stood right behind the fixation point of the leash, without greeting the leashed dog and avoiding eye contact with it. Then the male experimenter (E1) entered the room and approached the leashed dog from a distance of 5 m (as measured from the fixation point of the leash), moving slowly and haltingly (one step in every 4 s) with slightly bent upper body and looking steadily into the eyes of the dog without any verbal communication (*Threatening approach episode*, see Vas et al., 2005). This lasted for 1 min. E1 approached the leashed dog at a distance of 2 m, then for the remaining 3 min he sat on the ground at the place he stopped at the end of the threatening approach. He was looking at the dog with a neutral facial expression without talking to it, in a completely unresponsive state (*Still-face episode*, adapted from Haley and Stansbury, 2003). When the 3 min elapsed, E1 stood up and left the room. Then the female experimenter (E2) entered and accompanied the owner and the dog to another room for the test phase.

2.3.2. Test phase – out-of-reach task

E2 was seated in a chair, holding the dog on a leash next to her. The owner was standing at the other end of the room (about 4 m from E2). There were two identical plush animal toys (5 × 10 cm size) on the floor in front of the owner. The owner grabbed the two plush toys simultaneously (using both hands), and attracted the dog's attention by ostensive addressing (Name + 'Look!') and by moving the grasped objects. Then they turned around and placed the objects simultaneously on the ground, at their marked position, behind a physical obstacle (cuing episode). One of them was on the left, the other one on the right, approximately 1.5 m from each other. Note that both objects were visible to the dog, and were placed in an equal distance (4 m) from it. Then the owner and E2 switched places: the owner took over the leash, sat down on the chair, whereas E2 cued one of the objects (target) by approaching it, crouching down next to it, and indicating attempts to retrieve it. She did so for 30 s, using both verbal and nonverbal ostensive signals (e.g. Dog's name + 'Look!',' I can't seem to reach it') while alternating her gaze between the place of the object and the dog. Both objects were positioned in a way that it was apparently difficult for E2 to reach them (Fig. 1). After 30 s had passed, E1 knocked on the door to indicate the end of the cuing period. At that moment, the owner unleashed their dog and allowed them to move freely. E2 continued to address the dog in the above described ostensive way up until the trial's end, which was either when the dog retrieved the target object or the 90 s elapsed (which was signaled by E1 knocking on the door again). In case the dog retrieved the alternative object, the trial was not ended until the target was obtained or the time was up. (Note that at the end of the trials, the dog was allowed to play with the target and/or the alternative object only for a few seconds, then it was taken away). Afterwards, the owner and E2 switched places again and the whole procedure was repeated. All dogs participated in two sessions (NSI and PSI) placed 1–3 weeks apart. Each session consisted of 4 trials; E2 switched her position from trial to trial, thus cuing the left/right object as the target.

Note that we used two pairs of plush animal toys: same in size but differing in shape and colour (one brown, one black and white with stripes). For the first occasion, dogs were presented with one pair, and

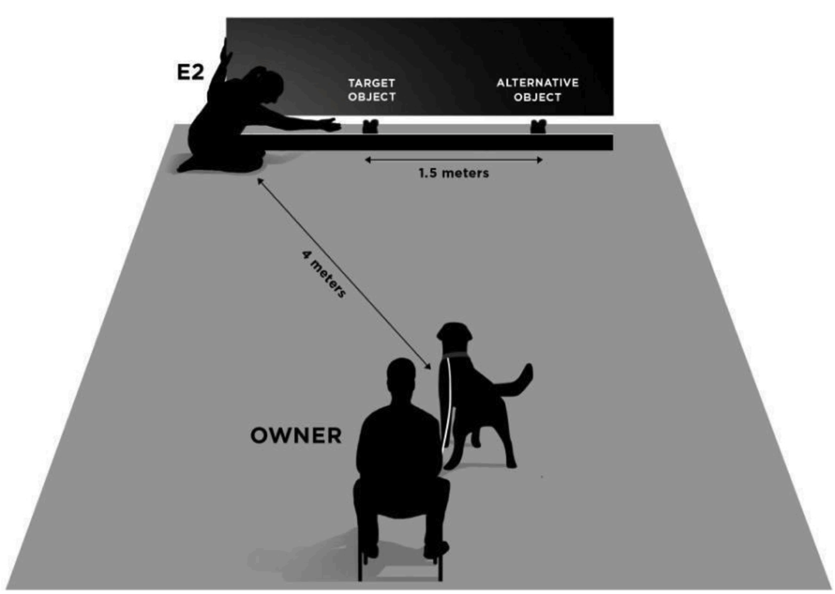

Fig. 1. Experimental arrangement of the instrumental helping situation.

with the other pair of plush toys for the second occasion. The identity of the first/second pair of toys was counterbalanced across subjects.

2.4. Behaviour coding and data analysis

The dogs' behaviour was analysed by frame-by-frame coding of all experimental recordings (with the 0.2-s resolution program Solomon Coder - beta 16.06.26, ©2006e 2008 by András Péter, http://solomoncoder.com/). In order to assess inter-observer reliability, a second trained observer scored a randomly selected sample of 25 %. Cohen's kappa coefficients (for categorical variables) and intraclass correlation coefficients (ICC – for continuous variables) are given below for each variable. The following behaviours were coded.

(1) Target object retrieval performance (score 0/1): the dog either retrieved the target object (grabbed it either by the paws or mouth) (score = 1) or it did not (score = 0) (Cohen's kappa coefficient: 1.0).
(2) Alternative object retrieval performance (score 0/1): the dog either retrieved the alternative object (grabbed it either by the paws or mouth) (score = 1) or it did not (score = 0) (Cohen's kappa coefficient: 0.85).
(3) Duration of looking (seconds) before release: (a) at the owner (ICC: 0.95); (b) towards the experimenter and/or target object (ICC: 0.91), (c) elsewhere (ICC: 0.86).

Note: the direction of gazing was recorded on the basis of head orientation of the dogs (while waiting to be unleashed) and thus looking at the experimenter could not be distinguished from looking at the target object.

(4) Duration of looking (seconds) after release (a) at the owner (ICC: 0.97); (b) at the experimenter (when looking was clearly directed at the experimenter) (ICC: 0.98); (c) at the target object (when looking was clearly directed at the target object) (ICC: 0.98); (d) at the alternative object (ICC: 0.90).
(5) Latency of starting to move (seconds): time elapsed between the moment when the owner released the dog and the moment when the dog started to move (ICC: 0.99).
(6) Latency of approaching the target object (seconds): time elapsed between the moment when the owner released the dog and the moment when the dog approached the target object within 10 cms (with its nose) (ICC: 0.99).
(7) Latency of retrieving the target object (seconds): time elapsed between the moment when the owner released the dog and the moment when the dog touched the target object – either by using its paw or mouth (ICC: 1.0).
(8) Latency of approaching the alternative object (seconds): time elapsed between the moment when the owner released the dog and the moment when the dog approached the alternative object within 10 cms (with its nose) (ICC: 1.0).
(9) Latency of approaching the experimenter (seconds): time elapsed between the moment when the owner released the dog and the moment when the dog approached E2 within 10 cms (with its nose) (ICC: 0.98).

For statistical analysis, we used multiple methods. First, we ran generalized linear mixed models (GLMM, SPSS software, version 23). The model included two fixed explanatory variables: pretreatment (PSI/NSI) and trial (1–4), as well as the two-way interaction of these main factors. Moreover, ID (subjects' identity) as a random factor was also included in the models. Non-significant effects were removed from the model in a stepwise manner (backward elimination technique). For binary variables, we used GLMM with binary logistic regression. For post hoc tests, Bonferroni corrections were used. Statistical tests were two-tailed, α value was set at 0.05. It has been reported, however, that latency data would be better analysed with survival models (Budaev, 1997) instead of GLMM. Therefore, we used Cox Model (R package' survival', Therneau, 2015) for latency measures that provides a powerful approach for analysis of the latency data. For Cox Models, hazard ratios (Exp[β]) between levels of a given fixed effect with 95 percent confidence interval are given.

3. Results

3.1. Dogs' behaviour before release

GLMM analyses of the durations of dogs' head orientation (*looking at the owner*; *looking towards the experimenter and/or target*; *looking elsewhere*) failed to show significant main effects of Trial and Pretreatment, and there were no significant Trial x Pretreatment interaction effects ($p > 0.05$ for all). This indicates that the dogs' looking behaviour did not change with repeated trials and there is no pretreatment effect during the first part of the test phase (while waiting to be unleashed).

3.2. Dogs' behaviour after release

Regarding the dogs' *retrieval performance* (obtaining the target object; obtaining the alternative object), neither the main effects (Pretreatment, Trial), nor their interactions were significant (GLMM, $p > 0.05$ for all). That is, the subjects demonstrated a fairly consequent object-retrieval behaviour during the instrumental task: they either did or did not retrieve the target, but they did so irrespective of pretreatment (10 dogs retrieved the target object at least 7 times, while the other 10 subjects retrieved the target maximum once out of 8). However, the GLMM analysis showed that pretreatment had a significant main effect on the duration of *looking at the owner* ($F_{1,157} = 7.200$, $p = 0.008$). The post hoc pairwise comparison showed that dogs, after NSI, looked more at their owners than after PSI (Fig. 2). The main effect of Trial, as well as the Trial x Pretreatment interaction were non-significant ($p > 0.05$ for both).

Concerning duration of *looking at the experimenter*, pretreatment had a marginally significant main effect ($F_{1,157} = 3.631$, $p = 0.059$). Dogs tended to gaze more at the experimenter after PSI than after NSI (mean ± SD: 4.14 ± 1.42 vs. 2.22 ± 60.77). The other main effect (Trial) and the Trial x Pretreatment interaction were non-significant ($p > 0.05$ for both).

GLMM analysis of dogs' *looking at the target object* showed a significant interaction effect (Trial x Pretreatment; $F_{1,151} = 11.388$, $p = 0.001$): dogs spent much longer time looking at the target object in the first trial after NSI than after PSI (mean ± SD: 8.05 ± 9.31 vs. 3.9 ± 3.54) (Fig. 3). The main effects (Trial, Pretreatment), however, were statistically not significant ($p > 0.05$ for all). Neither the main effects (Trial, Pretreatment), nor the Trial x Pretreatment interaction proved to be significant for the remaining two variables (duration of *looking towards the experimenter and/or target*; duration of *looking at the alternative object*, GLMM, $p > 0.05$ for all).

The survival analyses of the different latency variables also showed some effects of pretreatment on the dogs' behaviour. Positive vs. negative social interaction had a significant effect on *latency of the first move* (Expβ]h = 0.561 [0.397; 0.792]; $p = 0.001$), and a marginally significant effect on the *latency of approaching the experimenter* (Exp[β] = 0.546 [0.294; 1.012]; $p = 0.055$). That is, dogs in the PSI pretreatment condition started to move sooner after release and they also tended to approach the experimenter sooner (Figs. 4 & 5).

Moreover, Cox Model analyses showed significant repetition effects (main effect of Trial) on dogs' latency to approach the target and alternative objects. We found that dogs approached the target object sooner in the first trial as opposed to the second one (Exp[β] = 0.564 [0.327; 0.974]; $p = 0.04$) and in the third trial compared to the fourth (Exp[β] = 0.398 [0.228; 0.692]; $p = 0.0011$; Fig. 6).

A similar trial effect was found for the latency of approaching the

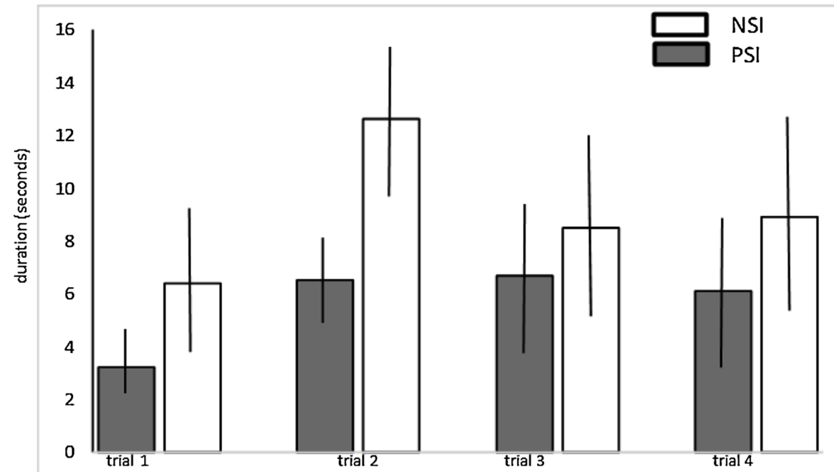

Fig. 2. Duration of looking at the owner (mean ± SD) in the out-of-reach situation after having received different pretreatments (PSI: positive social interaction, NSI: negative social interaction; N = 20).

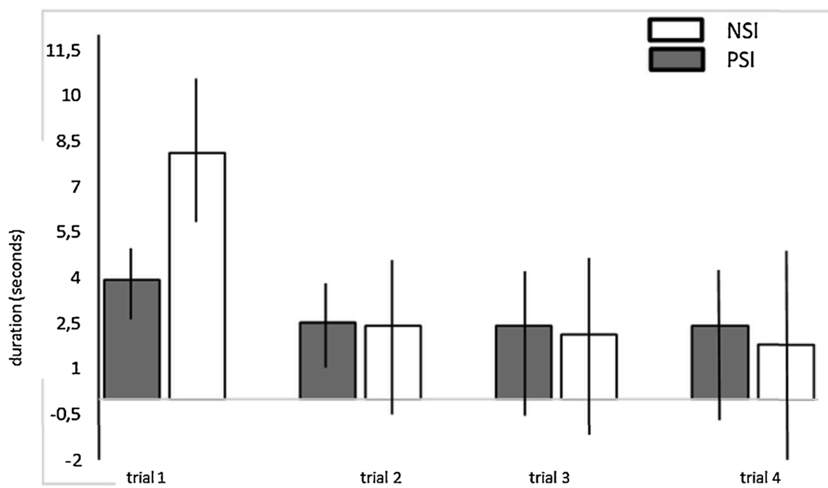

Fig. 3. Duration of looking at the target object (mean ± SD) in the out-of-reach situation after having received different pretreatments (PSI: positive social interaction, NSI: negative social interaction; N = 20).

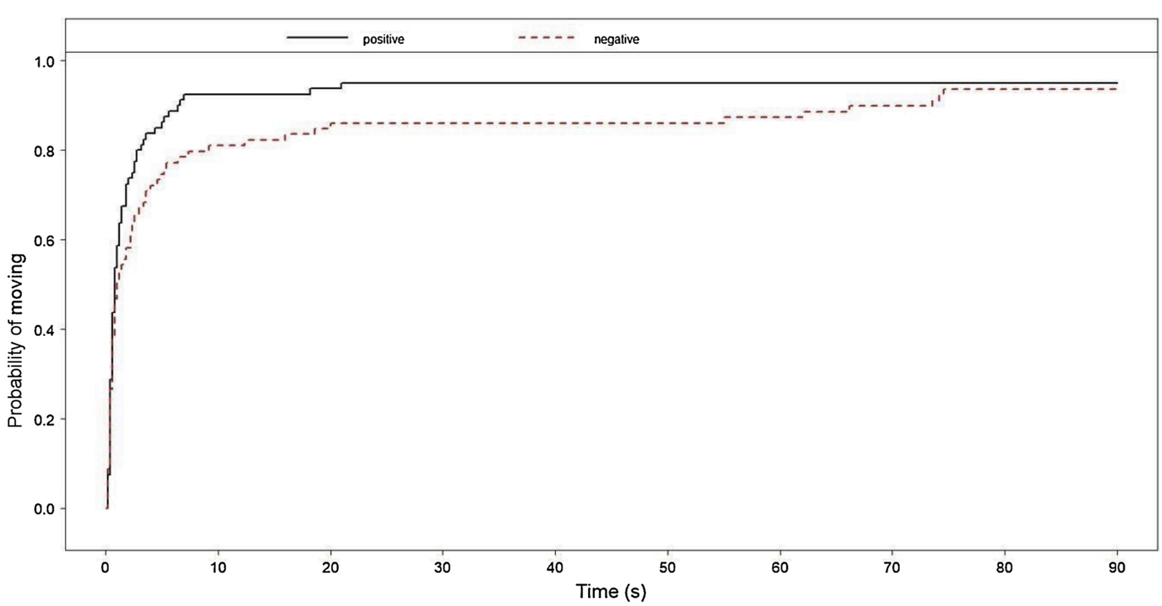

Fig. 4. Probability of moving in the different pretreatment conditions (positive social interaction – PSI, negative social interaction – NSI; N = 20).

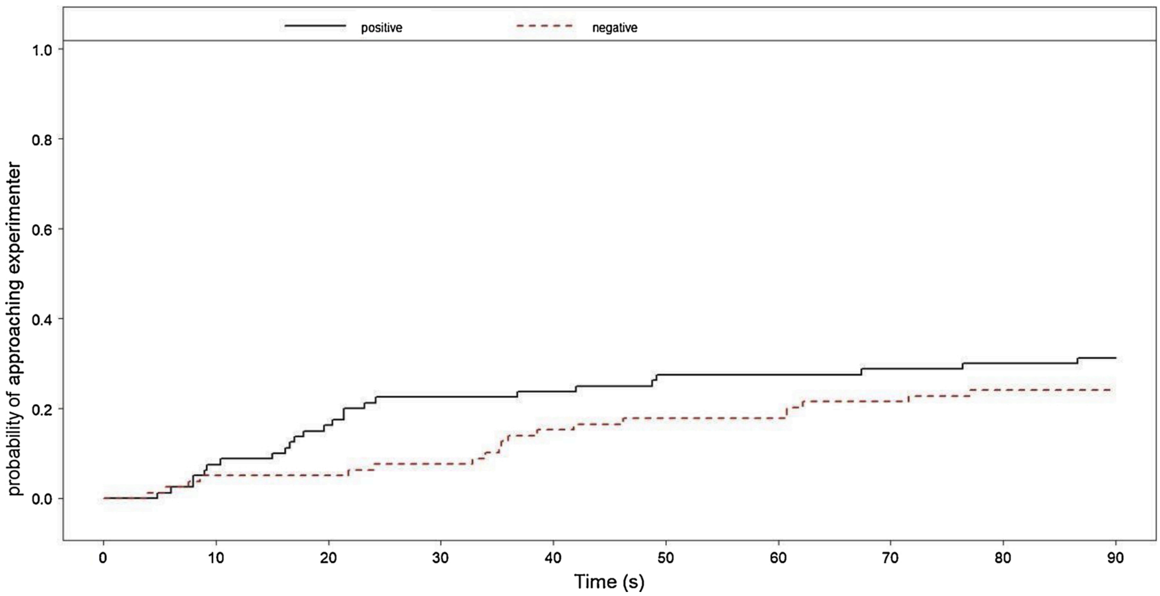

Fig. 5. Probability of approaching the experimenter in the different pretreatment conditions (positive social interaction – PSI, negative social interaction – NSI; N = 20).

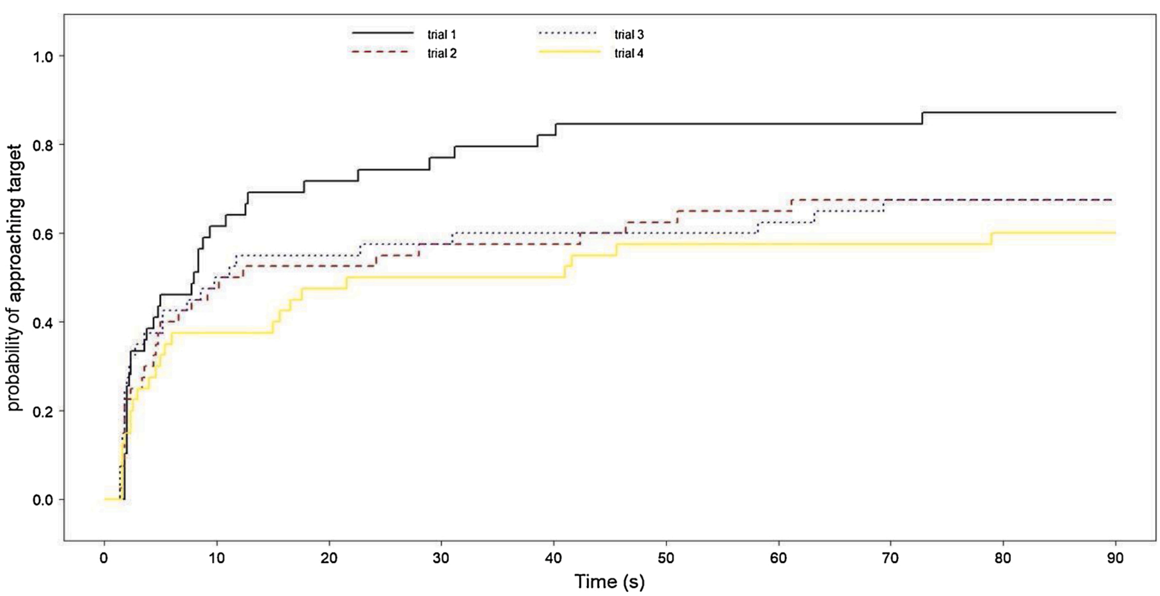

Fig. 6. Probability of approaching the target object in trials 1-4 (N = 20).

alternative object: dogs were less likely to approach the target object in the third trial as opposed to the second one (Exp[β] = 0.316 [0.152; 0.654; p = 0.0019); and in the fourth trial compared to the third one (Exp[β] = 0.381 [0.189; 0.771]; p = 0.0073; Fig. 7).

4. Discussion

In this study we investigated whether pretreatment with positive and negative social stimulation would affect subsequent behaviour of dogs in a situation where an unfamiliar human requests an out-of-reach object (by extending her arm and gazing toward it). Our results did not show any effects of different pretreatments on the dogs' behaviour during the first phase of the instrumental task (before release). More importantly, the dogs' object retrieval performance remained fairly stable across trials after both the positive and the negative social interaction (PSI & NSI): we did not find differences in the number of times the dogs retrieved the target object as a function of pretreatment. Like we delineated in our predictions, there are multiple potential explanations for such a lack of pretreatment effect. First, it is possible that dogs are not sensitive enough to the valence of the social interactions – or that our experimental manipulation was not efficient enough. However, this is not very likely, given that the exact same pretreatment procedure in an earlier study led to palpable post-manipulation differences in dogs' sleep macrostructure (Kis et al., 2017a). Also, Gácsi et al. (2013) used similar negative affect-evoking procedures (separation and threatening stranger) and found pronounced differences in heart rate and heart rate variability. Nevertheless, it is still possible that the affect-eliciting pretreatments were not strong enough to impact the dogs' willingness to retrieve the target object, only to influence more subtle aspects of their behaviour (see below).

The lack of pretreatment effect may also stem from switching the experimenters. Namely, the dogs possibly did not transfer their

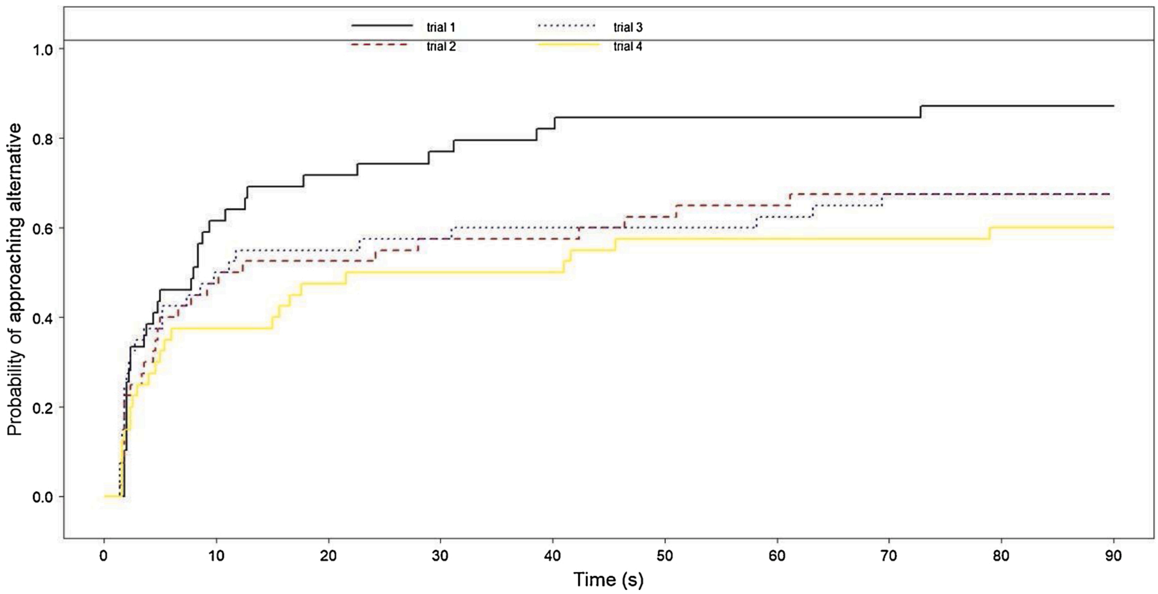

Fig. 7. Probability of approaching the alternative object in trials 1-4 (N = 20).

positively/negatively valenced experiences with the male experimenter to the task situation in which another (female) experimenter acted as a person trying but failing to reach an object. Dogs could potentially process the two situations (pretreatment and test phase) as functionally distinct, and thus they may not generalize their positive/negative experiences from pretreatment to the test situation. There is some evidence to support this notion: dogs, in an object hiding and finding task, perceive ostensive-communicative cues as imperatives that are relevant only to the particular context of 'here-and-now', and they do not generalize the communicative content to a modified task situation (Topál et al., 2009).

Another possible effect that needs to be taken into account is the gender difference between the two experimenters. There is ample evidence to show that the gender of the human partner alters dogs' behaviour. Wells and Hepper (1999), for example, showed that shelter dogs acted more aggressively toward a male as opposed to a female partner. In a similar vein, Hennessy et al. (1998) found that the gender of the person petting a dog affected dogs' response to stress: being petted by a woman elicited a more relaxed state (more frequent yawns, more time spent in a relaxed, head-up posture). Lore and Eisenberg (1986) reported a similar tendency, showing that dogs (males, specifically) were more likely to approach females compared to males. Bálint et al. (2016) found that male threatening strangers evoked higher arousal state in dogs as opposed to female strangers. Taking these results into consideration, our paradigm might have enabled dogs to show more affiliative behaviour toward the female experimenter, even after the negative social stimulation. This, in turn, might have led to the decreased efficiency of the negative pretreatment.

There is, however, rationale behind using two experimenters (of different genders). Had we used the same experimenter (or of the same gender) for pretreatment and testing, then behaviour in the test could have been a person-specific (or gender-specific) response – whereas we were interested in the putative affective impact of the pretreatments (that would carry over to the test phase). In addition, we used a similar design in a previous study (Kis et al., 2017b) with the same male experimenter (E1) doing some of the pretreatment (and a female experimenter doing the rest). In that study, pretreatment produced marked differences in the polisomnograms of the dogs, even though the experimenters were of different gender.

It is important to note that even though retrieval performance per se was unaffected by pretreatment, a more detailed analysis of the dogs' behaviour during the second phase of the object retrieval task (after release) indicated specific effects of the positive and the negative social pretreatment. On the one hand, we found that the dogs tended to look longer at the experimenter after PSI than after NSI – and the effect of differently valenced social pretreatments also manifested through changes in latency measures. That is, the dogs were more likely to start moving upon release and they were also more likely to approach the experimenter after the positive social interaction. These may indicate that PSI has the potential to increase task engagement in dogs; it is also possible that the positive social interaction has a more general facilitatory effect on subjects' behaviour (increased tendency to move and to approach the apparatus). Positive emotional states have been associated with approach behaviour (whereas negative ones with avoidance) – for example, Kis et al. (2015) found in their placebo-controlled experiment that dogs exhibited a cognitive bias (by forming positive expectations about an ambivalent stimulus) after being intranasally sprayed with oxytocin (they approached the target object sooner compared to a control condition). The finding that dogs in our study started to move sooner after the positive pretreatment resonates well with this result.

On the other hand, some behavioural effects of the negative social priming became apparent as well. That is, the effects of NSI manifested in longer duration of looking at the owner after release and in gazing more at the target object (at least in the first trial). This looking preference can be interpreted as a behavioural indicator of social referencing (using the owner as emotional referents in ambiguous situations – see e.g. Marshall-Pescini et al., 2013) – or it might be related to the motivational effect of social exclusion (e.g. DeWall and Richman, 2011). Although many assume that social exclusion decreases prosocial behaviour in humans (e.g. Twenge et al., 2007), it has also been shown that it has the potential to increase prosocial behaviour – through the process of invoking a 'desire to reconnect' (e.g. Chester et al., 2016). Kerr and Levin (2008) provide an evolutionary explanation for social exclusion: since being excluded from a group may have impeded chances of survival, a special mechanism (i.e. an increased sensitivity) to detect related signals may have evolved in the evolutionary past. Taking the convergent evolutionary history of dogs and humans into consideration (Miklósi and Topál, 2013), it is possible that dogs, too, have developed a heightened propensity to pick up on cues of social exclusion. Dogs readily form strong affiliative bonds with humans and they have a fundamental drive to affiliate with their heterospecific partners (Payne et al., 2015). Moreover, they are skilful at making social evaluations (Anderson et al., 2017), and any behaviour serving to reduce social exclusion would be highly beneficial. This might result in a motivational and/or attentional increase in dogs following social exclusion-related experiences. Accordingly, the finding that our dogs looked more at the owner after the negative pretreatment might be linked to this ‘desire to reconnect’. This latter idea seems even more plausible if we take into account the behaviour of the owner during the NSI: the owner was instructed to behave in a rather uncharacteristic way (i.e. not greeting or looking at the dog) – which may have caused the dog to be motivated to re-establish contact with or gain reassurance from the owner in the test phase. This notion is especially appealing because it would explain the higher amount of time spent looking at the owner, and the longer times taken to leave the owner to approach the experimenter (and the object). Within this framework, the findings of our study can be interpreted as having shown that temporarily disrupting the dog-owner bond (in an unfamiliar environment, with negative affect-induction) leads to enhanced activity by the dog: specifically, to re-establish that bond in the following minutes.

Our analyses also showed statistically significant effects of repeated trials, but only on one aspect of the dogs’ behaviour. Namely, dogs showed an increased latency of approaching both the target and the alternative objects over repeated trials. These changes might be easily attributed to a habituation effect reducing the dogs’ motivation to engage in the task.

When it comes to the dogs’ behaviour in the test phase, we caution against interpreting the findings in the context of ‘helping’. Very importantly, our design did not require the dogs to present the retrieved object to the experimenter. If that had been the case, we think at least two interpretations could be offered for that behaviour. First, it could be conceived as a ’true’ form of helping. To do so, the dog would require to infer the actor’s goal and then assist her in attaining that goal (i.e. presenting the reached for object to her). However, it could also be interpreted in terms of the dog responding to imperatives – which would not qualify as any form of helping. Even though there were no clear imperatives given in our study, there is evidence that ostensive-communicative signals prompt dogs to respond to them as if they were in the context of commands (see Topál et al., 2009). With these in mind, we do not think that our design was measuring pure helping – rather, it allowed us to examine a wide range of the dogs’ behaviour (e.g. mobilization, attention, proximity seeking).

In conclusion, we believe that our findings add to the literature on the possible links between social-affective primes and subsequent behaviour in dogs. Although our controlled experimental setup can be viewed as being far from everyday human-dog interactions, the results confirm both the dissociation and some similarities between the impact of positive and negative affective states. A possible direction for future research, therefore, would target to disentangle the above interpretations.

Declaration of Competing Interest

The authors report no declarations of interest.

Acknowledgements

We thank the Family Dog Project (led by Ádám Miklósi) for providing laboratory space and materials, Ákos Pogány for his assistance in statistical analyses, and Péter Csúth for his help with illustrations. Financial support was provided by the Hungarian Scientific Research Fund (PD121038 & K128448).

References

Albuquerque, N.S., Guo, K., Wilkinson, A., Savalli, C., 2016. Dogs recognize dog and human emotions. Biol. Lett. 12, 20150883 https://doi.org/10.1098/rsbl.2015.0883.

Anderson, J.R., Bucher, B., Chijiiwa, H., Kuroshima, H., Takimoto, A., Fujita, K., 2017. Third-party social evaluations of humans by monkeys and dogs. Neurosci. Biobehav. Rev. 82, 95–109. https://doi.org/10.1016/j.neubiorev.2017.01.003.

Bálint, A., Faragó, T., Miklósi, Á., Pongrácz, P., 2016. Threat level dependent manipulation of signaled body size – dog growls’ indexical cues depend on the different levels of potential danger. Anim. Cogn. 19, 1115–1131. https://doi.org/10.1007/s10071-016-1019-9.

Bargh, J.A., Gollwitzer, P.M., Lee-Chai, A., Barndollar, K., Trötschel, R., 2001. The automated will: nonconscious activation and pursuit of behavioral goals. J. Pers. Soc. Psychol. 81, 1014–1027. https://doi.org/10.1037/0022-3514.81.6.1014.

Bauer, E.B., Smuts, B.B., 2007. Cooperation and competition during dyadic play in domestic dogs, Canis familiaris. Anim. Behav. 73, 489–499. https://doi.org/10.1016/j.anbehav.2006.09.006.

Budaev, S.V., 1997. The statistical analysis of behavioural latency measures. ISCP Newsletter 14, 1–4.

Call, J., Bräuer, J., Kaminski, J., Tomasello, M., 2003. Domestic dogs (Canis familiaris) are sensitive to the attentional state of humans. J. Comp. Psychol. 117, 257–263. https://doi.org/10.1037/0735-7036.117.3.257.

Chester, D.S., DeWall, C.N., Pond, R.S., 2016. The push of social pain: does rejection’s sting motivate subsequent social reconnection? Cogn. Affect. Behav. Neurosci. 16, 541–550. https://doi.org/10.3758/s13415-016-0412-9.

Clayton, N., Emery, N., 2005. Corvid cognition. Curr. Biol. 15 (3) https://doi.org/10.1016/j.cub.2005.01.020.

Cook, P., Prichard, A., Spivak, M., Berns, G., 2018. Jealousy in dogs? Evidence from brain imaging. ASent 22 (1), 117, 2018.

Coppola, C.L., Grandin, T., Enns, R.M., 2006. Human interaction and cortisol: can human contact reduce stress for shelter dogs? Physiol. Behav. 87 (3), 537–541. https://doi.org/10.1016/j.physbeh.2005.12.001.

DeWall, C.N., Richman, M., 2011. Social exclusion and the desire to reconnect. Soc. Pers. Psychol. Compass 5, 919–932. https://doi.org/10.1111/j.1751-9004.2011.00383.x.

Forgas, J.P., 2008. Affect and cognition. Perspect. Psychol. Sci. 3 (2), 94–101. https://doi.org/10.1111/j.1745-6916.2008.00067.x.

Gácsi, M., Maros, K., Sernkvist, S., Faragó, T., Miklósi, Á., 2013. Human analogue safe haven effect of the owner: behavioural and heart rate response to stressful social stimuli in dogs. PLoS One 8, e58475. https://doi.org/10.1371/journal.pone.0058475.

Gergely, A., Petró, E., Topál, J., Miklósi, Á., 2013. What are you or who are you? The emergence of social interaction between dog and Unidentified moving Object (UMO). PLoS One 8, e72727. https://doi.org/10.1371/journal.pone.0072727.

Gräfenhain, M., Carpenter, M., Tomasello, M., 2013. Three-year-olds’ understanding of the consequences of joint commitments. PLoS One 8, e73039. https://doi.org/10.1371/journal.pone.0073039.

Győri, B., Gácsi, M., Miklósi, Á., 2010. Friend or foe: Context dependent sensitivity to human behaviour in dogs. Appl. Anim. Behav. Sci. 128, 69–77. https://doi.org/10.1016/j.applanim.2010.10.005.

Haley, D.W., Stansbury, K., 2003. Infant stress and parent responsiveness: regulation of physiology and behavior during still-face and reunion. Child Dev. 74 (5), 1534–1546. https://doi.org/10.1111/1467-8624.00621.

Hare, B., Tomasello, M., 1999. Domestic dogs (Canis familiaris) use human and conspecific social clues to locate hidden food. J. Comp. Psychol. 113, 173–177. https://doi.org/10.1037/0735-7036.113.2.173.

Harris, Ch.R., Prouvost, C., 2014. Jealousy in dogs. PLoS One 9 (7), e94597 https://dx.doi.org/10.1371%2Fjournal.pone.0094597.

Hennessy, M.B., Williams, M.T., Miller, D.D., Douglas, Ch.W., Voith, V.L., 1998. Influence of male and female petters on plasma cortisol and behaviour: Can human interaction reduce the stress of dogs in a public animal shelter? Appl. Anim. Behav. Sci. 61 (1), 63–77. https://doi.org/10.1016/S0168-1591(98)00179-8.

Hernádi, A., Kis, A., Kanizsár, O., Tóth, K., Miklósi, B., Topál, J., 2015. Intranasally administered oxytocin affects how dogs (Canis familiaris) react to the threatening approach of their owner and an unfamiliar experimenter. Behav. Proc. 119, 1–5. https://doi.org/10.1016/j.beproc.2015.07.001.

Joly-Mascheroni, R.M., Senju, A., Shepherd, A.J., 2008. Dogs catch human yawns. Biol. Lett. 4, 446–448. https://doi.org/10.1098/rsbl.2008.0333.

Kerr, N.L., Levin, J.M., 2008. The detection of social exclusion: evolution and beyond. Group Dyn. Theory Res. Pract. 12 (1), 39–52. https://doi.org/10.1037/1089-2699.12.1.39.

Kis, A., Szakadát, S., Kovács, E., Gácsi, M., Simor, P., Gombos, F., Topál, J., Miklósi, Á., Bódizs, R., 2014. Development of a non-invasive polysomnography technique for dogs (Canis familiaris). Phys. Behav. 130, 149–156. https://doi.org/10.1016/j.physbeh.2014.04.004.

Kis, A., Hernádi, A., Kanizsár, O., Gácsi, M., Topál, J., 2015. Oxytocin induces an ‘optimistic’ cognitive bias in dogs (Canis familiaris). Horm. Behav. 69, 1–7. https://doi.org/10.1016/j.yhbeh.2014.12.004.

Kis, A., Gergely, A., Galambos, Á., Abdai, J., Gombos, F., Bódizs, R., Topál, J., 2017a. Sleep macrostructure is modulated by positive and negative social experience in adult pet dogs. Proc. Roy. Soc. B 284, 20171883. https://doi.org/10.1098/rspb.2017.1883.

Kis, A., Ciobica, A., Topál, J., 2017b. The effect of oxytocin on human-directed social behaviour in dogs (Canis familiaris). Horm. Behav. 94, 40–52. https://doi.org/10.1016/j.yhbeh.2017.06.001.

Kiss, O., Kovács, K., Szántó, F., Topál, J., 2018. Similarity between an unfamiliar human and the owner affects dogs’ preference for human partner when responding to an unsolvable problem. Learn. Behav. 46, 430–441. https://doi.org/10.3758/s13420-018-0337-y.

Konok, V., Dóka, A., Miklósi, Á., 2011. The behavior of the domestic dog (Canis familiaris) during separation from and reunion with the owner: A questionnaire and an experimental study. Appl. Anim. Behav. Sci. 135, 300–308. https://doi.org/10.1016/j.applanim.2011.10.011.

Lakin, J.L., Chartrand, T.L., 2003. Using nonconscious behavioral mimicry to create affiliation and rapport. Psychol. Sci. 14, 334–339. https://doi.org/10.1111/1467-9280.14481.

Lore, R.K., Eisenberg, F.B., 1986. Avoidance reactions of domestic dogs to unfamiliar male and female humans in a kennel setting. Appl. Anim. Behav. Sci. 15 (3), 261–266. https://doi.org/10.1016/0168-1591(86)90096-1.

Lynch, J.J., McCarthy, J.F., 1967. The effect of petting on classically conditioned emotional response. Behav. Res. Ther. 5 (1), 55–62. https://doi.org/10.1016/0005-7967(67)90056-3.

Marshall-Pescini, S., Colombo, E., Passalacqua, C., Merola, I., Prato-Previde, E., 2013. Gaze alternation in dogs and toddlers in an unsolvable task: evidence of an audience effect. Anim. Cogn. 16, 933–943. https://doi.org/10.1007/s10071-013-0627-x.

Miklósi, Á., Topál, J., 2013. What does it take to become 'best friends'? Evolutionary changes in canine social competence. Trends Cogn. Sci. 17, 287–294. https://doi.org/10.1016/j.tics.2013.04.005.

Miklósi, Á., Polgárdi, R., Topál, J., Csányi, V., 2000. Intentional behavior in dog–human communication: an experimental analysis of „showing" behavior in the dog. Anim. Cogn. 3, 159–166. https://doi.org/10.1007/s100710000072.

Miklósi, Á., Pongrácz, P., Lakatos, G., Topál, J., Csányi, V., 2005. A comparative study of the use of visual communicative signals in interactions between dogs (Canis familiaris) and humans and cats (Felis catus) and humans. J. Comp. Psychol. 119, 179–186. https://doi.org/10.1037/0735-7036.119.2.179.

Oláh, K., Topál, J., Kovács, K., Kis, A., Koller, D., Park, S.Y., Virányi, Zs., 2017. Gaze-following and reaction to an aversive social interaction have corresponding associations with variation in the OXTR gene in dogs but not in human infants. Front. Psychol. 8, 2156. https://doi.org/10.3389/fpsyg.2017.02156.

Over, H., Carpenter, M., 2009. Eighteen-month-old infants show increased helping following priming with affiliation. Psychol. Sci. 20, 1189–1193.

Payne, E., Bennett, P.C., McGreevy, P.D., 2015. Current perspectives on attachment and bonding in the dog–human dyad. Psychol. Res. Behav. Manag. 8, 71–79. https://doi.org/10.2147/PRBM.S74972.

Pop, D.A., Rusu, A.S., Pop-Vancea, V., Papuc, I., Contantinescu, R., Miresan, V., 2014. Physiological effects of human-animal positive interaction in dogs – review of the literature. Bull. UASVM Anim. Sci. Biotechnol. 71, 250–255. https://doi.org/10.15835/buasvmcn-asb:10398.

Racca, A., Guo, K., Meints, K., Mills, D.S., 2012. Reading faces: differential lateral gaze bias in processing canine and human facial expressions in dogs and 4-year-old children. PLoS One 7, e36076. https://doi.org/10.1371/journal.pone.0036076.

Range, F., Virányi, Zs., Huber, L., 2007. Selective imitation in domestic dogs. Curr. Biol. 17, 868–872. https://doi.org/10.1016/j.cub.2007.04.026.

Range, F., Horn, L., Virányi, Z., Huber, L., 2008. The absence of reward induces inequity aversion in dogs. PNAS 106, 340–345. https://doi.org/10.1073/pnas.0810957105.

Scandurra, A., Alterisio, A., Marinelli, L., Mongillo, P., Semin, G.R., D'Aniello, B., 2017. Effectiveness of verbal and gestural signals and familiarity with signal-senders on the performance of working dogs. Appl. Anim. Behav. Sci. 191, 78–83. https://doi.org/10.1016/j.applanim.2017.02.003.

Scheider, L., Grassmann, S., Kaminski, J., Tomasello, M., 2011. Domestic dogs use contextual information and tone of voice when following a human pointing gesture. PLoS One 6 (7), e21676 https://dx.doi.org/10.1371%2Fjournal.pone.0021676.

Spears, R., Gordijn, E.H., Dijksterhuis, A., Stapel, D.A., 2004. Reaction in action: intergroup contrast in automatic behavior. Pers. Soc. Psychol. Bull. 30, 605–616. https://doi.org/10.1177/0146167203262087.

Taylor, S.h.E., 1991. Asymmetrical effects of positive and negative events: the mobilization-minimization hypothesis. Psychol. Bull. 110 (1), 67–85.

Topál, J., Gergely, G., Erdőhegyi, Á., Csibra, G., Miklósi, Á., 2009. Differential sensitivity to human communication in dogs, wolves and human infants. Science 325, 1269–1272. https://doi.org/10.1126/science.1176960.

Twenge, J.M., Baumeister, R.F., DeWall, C.N., Ciarocco, N.J., Bartels, J.M., 2007. Social exclusion decreases prosocial behavior. J. Pers. Soc. Psychol. 92, 56–66. https://doi.org/10.1037/0022-3514.92.1.56.

Van Horik, J.O., Clayton, N.S., Emery, N.J., 2012. Convergent evolution of cognition in corvids, apes and other animals. In: Vonk, J., Shackelford, T. (Eds.), The Oxford Handbook of Comparative Evolutionary Psychology. Oxford University Press, New York, pp. 80–101.

Vas, J., Topál, J., Gácsi, M., Miklósi, Á., 2005. Friend or enemy? Dogs' reaction to an unfamiliar person is influenced by the way of approaching. Appl. Anim. Behav. Sci. 94, 99–115. https://doi.org/10.1016/j.applanim.2005.02.001.

Wells, D.L., Hepper, P.G., 1999. Male and female dogs respond differently to men and women. Appl. Anim. Behav. Sci. 61 (4), 341–349. https://doi.org/10.1016/S0168-1591(98)00202-0.