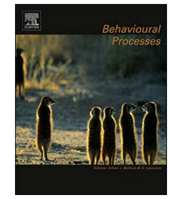
Behavioural Processes 146 (2018) 42–45

Contents lists available at ScienceDirect

Behavioural Processes

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




# Mouth-licking by dogs as a response to emotional stimuli

Natalia Albuquerque[a,b,*], Kun Guo[c], Anna Wilkinson[a], Briseida Resende[b], Daniel S. Mills[a]

[a] School of Life Sciences, University of Lincoln, Lincoln LN6 7DL, United Kingdom
[b] Department of Experimental Psychology, Institute of Psychology, University of São Paulo, São Paulo 05508-030, Brazil
[c] School of Psychology, University of Lincoln, Lincoln LN6 7TS, United Kingdom

ARTICLE INFO

*Keywords:*
Dog
Emotion
Ethology

ABSTRACT

Dogs are able to perceptually discriminate emotional displays of conspecifics and heterospecifics and possess the cognitive prototypes for emotional categorisation, however, it remains unclear whether dogs can respond appropriately to this information. One way to assess associations between specific behaviours and the perception of emotionally competent stimuli is to look at other reliable measures that are related to cognitive and physiological processing. Using a cross-modal preferential looking paradigm (Albuquerque et al., 2016), we presented dogs with pairs of facial expressions (positive and negative) combined with an emotionally charged vocalisation (positive or negative) or a control sound (neutral) and coded their mouth-licking behaviour. We found an effect of the valence of the face image dogs were seeing on the onset of the mouth-licking, with higher frequencies of this behaviour in response to the negative faces compared to images with positive valence. However, neither the sound being played nor the interaction between image valence and sound affected the behaviour. We also found an effect of species with mouth-licking occurring more often towards human stimuli. This spontaneous differential behavioural response, combined with previous evidence of cognitive emotional processing in these animals, suggests that dogs may have a functional understanding of emotional expressions.

## 1. Introduction

Appropriately responding to other's emotions is crucial for maintaining functional social interactions in complex social units. This is particularly challenging for mixed species groups, such as those in which most domestic dogs (*Canis familiaris*) live. Some recent studies have demonstrated that dogs can visually discriminate human smiling faces from blank faces (Nagasawa et al., 2011), show a different gaze bias when inspecting happy versus angry human or dog faces (Racca et al., 2012), and can match the top and bottom half of human faces sharing the same expression (Müller et al., 2015). There is thus little doubt that dogs can discriminate human and dog facial expressions of opposing emotional valence (for a review see Kujala, 2017). However, it is unclear whether dogs can use these cues to evaluate and respond appropriately to the emotionally transmitted information.

It has recently been demonstrated that adult dogs possess the cognitive prototypes for emotional categorisation (Albuquerque et al., 2016). Using a cross-modal preferential looking paradigm, we presented domestic dogs with unfamiliar human or dog faces of different emotional valences (happy/playful vs. angry/aggressive). These were presented side-by-side and combined with a single vocalisation (of either positive or negative valence) from the same individual. Dogs looked significantly longer at the face whose expression matched the emotion of the vocalisation played, regardless of the valence, gender or species presented. This demonstrates that dogs can match visual (facial expressions) cues with acoustic (vocalisations) cues sharing the same emotional valence. The existence of this perceptual capacity raises the question as to whether dogs can also respond differentially and functionally to emotional expressions.

One way to assess this is to identify behavioural displays which are reliably associated with the physiological and/or cognitive responses to emotional signals (*e.g.* Smith et al., 2016). Mouth-licking behaviour in dogs is believed to be an indicator of short-term (or acute) stress responses (Beerda et al., 1997). It has been used as a behavioural measure to infer dog welfare and a dog's ability to cope in response to physical or social stressors (*e.g.* Beerda et al., 1998; Frank et al., 2007; Horváth et al., 2007; Rooney et al., 2007; Palestrini et al., 2010; Deldalle and Gaunet, 2014) in much the same

* Corresponding author at: Department of Experimental Psychology, Institute of Psychology, University of São Paulo, São Paulo 05508-030, Brazil.
*E-mail addresses:* nsalbuquerque@usp.br (N. Albuquerque), kguo@lincoln.ac.uk (K. Guo), awilkinson@lincoln.ac.uk (A. Wilkinson), briseida@usp.br (B. Resende), dmills@lincoln.ac.uk (D.S. Mills).

https://doi.org/10.1016/j.beproc.2017.11.006
Received 28 June 2017; Received in revised form 6 October 2017; Accepted 8 November 2017
Available online 10 November 2017

way self-scratching behaviour is used in monkeys and apes (*e.g.* de Waal and Aureli, 1997; Castles et al., 1999; Fraser et al., 2008). Beerda et al. (1998) noted a variety of behaviours, including mouth-licking, which were displayed by dogs in response to aversive stimuli (*e.g.* pulling and pressing the animal to the floor, loud noises and electric shocks). More recently, studies such as those by Frank et al. (2007) and Palestrini et al. (2010) have used mouth-licking as a measure to assess stress when left alone in both puppies and dogs with separation-related problems (respectively). However, it has also been suggested that this display might simply be a spontaneous display of increased arousal or motivation (*e.g.* Miklósi et al., 2000) or a communicative cue in the absence of food when asking for a toy and for playing (Gaunet, 2010). Despite the widespread use of this response in behavioural studies, there are several controversies regarding its function, underlying mechanisms and even its validity as a stress indicator. Most importantly, until now, no study has sought to systematically identify its specific association with emotionally competent stimuli.

Although there is currently an increasing body of literature on emotions in dogs, little attention has been given to analysing the potential communicative value of behavioural responses associated with the perception of emotionally relevant information. Therefore, we revisited the data from our previous emotion categorisation study (Albuquerque et al., 2016) and undertook a detailed examination of mouth-licking behaviour, investigating when it occurred and whether its occurrence was differentially associated with the perception of negative emotional stimuli. We predicted that if mouth-licking has communicative value as an emotional response, then it should correlate with the dog's affective state and would occur more often upon the presentation of negatively charged stimuli. We also investigated whether the species and the gender of the stimulus influenced the occurrence of this behaviour.

## 2. Methods

The responses of 17 healthy adult family dogs of various breeds (9 males and 8 females, 2–7.5 years old) from Albuquerque et al. (2016) were analysed. All dogs were owned and had no auditory, visual or chronic health problems. Dogs were not food deprived before taking part in this experiment. Each subject was tested individually. All dogs had the opportunity to explore the room with the owners and habituate to the environment and experimenters prior to testing. There was no training or familiarisation phase. The procedures used caused no physical or psychological harm and the behaviour of all subjects was monitored throughout the experiment to ensure the animals were comfortable (dogs were free to move if they wanted to). Ethical approval was granted by the delegated authority of the Ethics Committee of the School of Life Sciences of the University of Lincoln. Owners provided written informed consent, with the right to withdraw without giving a reason, for each dog.

Dogs were presented with a pair of grey-scale face images of unfamiliar humans or dogs with positive (happy/playful) and negative (angry/aggressive) facial expressions (Fig. 1). The images were paired with a sound from the same individual (positive or negative vocalisation) or a neutral sound (Brownian noise) in a cross-modal preferential looking set up (see Albuquerque et al., 2016 for full details).

Trials were five seconds long and consisted of the simultaneous presentation of images paired with a sound. During testing, dogs stood in front of two screens and a digital video camera recorded their looking as well as mouth-licking behaviour (towards the happy face, the angry face or away from the screens). Each dog was tested in two separate experimental sessions (two weeks apart from each other) and undertook 20 trials in total. Each dog saw all combinations, only once. The order of presentation of the stimulus combinations was randomised.

Only spontaneous behaviour was recorded and no behaviour was reinforced at any time. The absence of reinforcement ensured that mouth-licking behaviour in this study could not be associated with the presence or anticipation of food or other rewards.

### *2.1. Data analysis*

The behaviour of each subject was analysed continuously for the five seconds of each trial. Mouth-licking displays were blind coded frame-by-frame and real time speed using Solomon Coder Beta (www.solomoncoder.com). For each experimental trial, the direction of the dog's gaze at the onset of the display and number of mouth-licks were calculated. A second experimenter blind-coded 25% of the data. Good correlation and agreement between coders was found for both looking behaviour (Pearson correlation 0.95, $p < 0.0001$ and Kendall's concordance coefficient 0.88, $p < 0.0001$) and mouth-licking (Spearman correlation: 0.771, $p < 0.0001$ and Kendall's concordance coefficient: 0.767, $p < 0.0001$).

Since dogs may have displayed mouth-licking more than once and towards different images in the same trial, we created a standardised metric (index) for mouth-licking frequency ($I_{ML}$). This was the number of "mouth-licks" displayed in a given condition divided by the total number of "mouth-licks" displayed by that dog. For each dog, $I_{ML}$ was calculated in each of the following conditions: (i) looking at negative

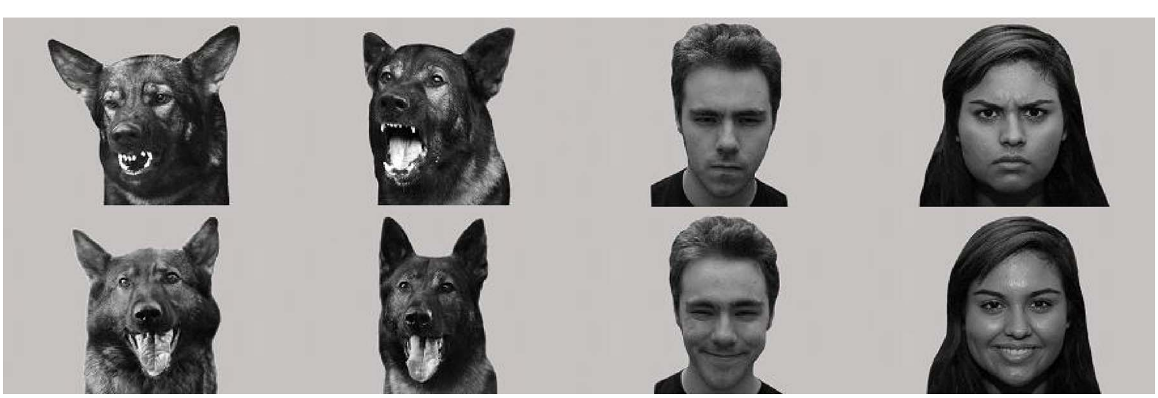


**Fig. 1.** Visual stimuli used in the study.

face with a negative vocalisation stimulus, (ii) looking at negative face with a positive vocalisation, (iii) looking at positive face with negative vocalisation, (iv) looking at positive face with positive vocalisation, (v) looking at negative face with control sound, (vi) looking at positive face with control sound. If mouth-licking was displayed when the dog was looking away from the screens (right after it had been looking at the images) we referred to the most recent image that they had looked at before mouth-licking.

To answer the central question of whether the occurrence of mouth-licking is related to the perception of emotional information, we first looked at all trials when the behaviour occurred and analysed the effect of image and sound. Therefore, a 2 (image valence: positive and negative) × 3 (sound valence: positive, negative and control) repeated-measures analyses of variance (ANOVA) was conducted to examine the effect of valence of the emotional cues and the interaction between sensory modalities on dogs' mouth-licking behaviour. The normality assumption was verified by visually inspecting plots of residuals with no important deviation from normality identified.

To investigate what influenced the occurrence or the absence of mouth-licking, we conducted a complementary analysis using the raw data (count; for all individuals in all trials) in a Generalised Estimated Equation (GEE) model with Poisson distribution; the within subjects' dependence was incorporated using an exchangeable working correlation matrix, which assumes the same correlation among measures from the same individual. Species of stimulus, sex of stimulus and their first order interaction were included as factors. We used SPSS (IBM SPSS 22) for all statistical analysis and a 5% significance level on two tailed tests for interpretive purposes.

## 3. Results

Fifteen of the seventeen dogs displayed mouth-licking during stimulus presentation. It occurred 71 times (N = 29 for dog stimulus and N = 42 for human stimulus), equivalent to 22% of the 236 analysed trials. Overall, the analysis showed that $I_{ML}$ was significantly different from zero ($F_{1,96} = 37.13$, $p < 0.0001$), indicating it to be a useful measure for analysis. The ANOVA also showed a significant effect of the image that the dogs were looking towards at the onset of (or immediately prior to) the display of a mouth-lick ($F_{1,96} = 4.73$, $p = 0.032$, Fig. 2), with subjects displaying mouth-licking more frequently when looking at the negative faces (0.196 ± 0.034, Mean ± SE) compared to positive faces (0.093 ± 0.034). However, neither the sound being played nor the interaction between valence of image and valence of the auditory stimulus had a significant effect on mouth-licking behaviour ($F_{2,96} = 0.78$, $p = 0.46$ and $F_{2,96} = 2.12$, $p = 0.13$, respectively).

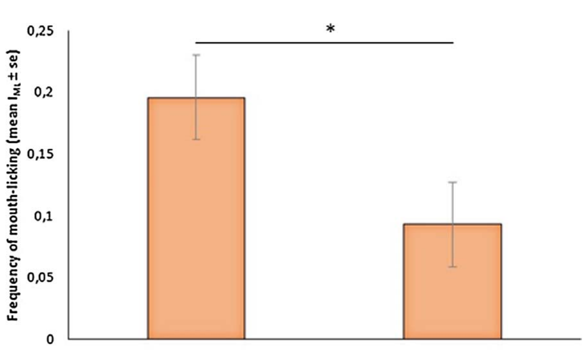



**Fig. 2.** Relative occurrence of mouth-licking (calculated by $I_{ML}$) towards negative and positive faces. *$p < 0.05$.

The GEE model with the raw data confirmed mouth-licking occurrence was significantly different from zero (Wald = 31.52, *df* = 1, $p < 0.0001$). The model also showed an effect of the stimulus species presented to the dogs (Wald = 8.52, *df* = 1, p = 0.004), with subjects displaying more mouth-licking towards human stimuli (0.395 ± 0.092, Mean ± SE) than to dog stimuli (0.210 ± 0.055). There was no effect of stimulus gender (Wald = 1.97, *df* = 1, p = 0.160) or the interaction between gender and species (Wald = 1.19, *df* = 1, p = 0.275).

## 4. Discussion

Our results revealed that dogs mouth-licked more frequently having seen a negative facial expression than when observing a facial expression with a positive valence. Interestingly, the effect was only observed in the visual domain and preferentially in response to human stimuli. There was no significant effect of the valence of the auditory cue, or interaction between the audio-visual emotional cues on the target behaviour. The results indicate that mouth-licking is not simply a response to stressful stimuli and has the potential to be a functional response to certain cues of negative valence. Thus, the findings suggest that dogs may be able to functionally respond to emotionally competent stimuli and that the form of the response is linked to the sensory mode of the stimulus, and may be part of a visual emotional exchange of signals.

As the mouth-licking behaviour was associated with the viewing of negative faces, it is likely that these negative emotional visual stimuli were perceived as aversive by the dogs. The subjects' perception of negative facial expressions appear to have activated a cognitive representation of a negative emotion category (as reported by Albuquerque et al., 2016), which potentially led to an affective response resulting in the display of this behaviour. This relationship between cognitive and other affective responses is consistent with dogs having a functional understanding of emotionally charged expressions.

The evolutionary emergence of social cognition is believed to be closely linked to complex social demands such as individual recognition, the development of strategies for group maintenance and behaviours that facilitate the coordination of actions (de Haan and Nelson, 1999). Facial recognition plays an important social role and is considered especially important within cooperative groups (Parr et al., 2000). For example, Schwab and Huber (2006) argue that working dogs have been selected for their ability to read human communicative signals, including visual ones.

In this study, we also found an effect of the stimulus species on the occurrence of mouth-licking, with dogs showing the behaviour more often when presented with human stimuli. Humans are known to be very visual and rely heavily on facial expressions for intraspecific (*e.g.* Schmidt and Cohn, 2001) and interspecific communication (*e.g.* Savalli et al., 2014; Savalli et al., 2016). The ability to obtain information from faces and to respond appropriately may carry adaptive advantages for both intra and interspecific relationships (Guo et al., 2009), especially when the emotional content of the faces has ecological value. In this sense, the mouth-licking behaviour in dogs may have been selected for (possibly non-consciously) as it may facilitate dog-human communication.

From an ethological perspective, the perception of negative stimuli together with a differential behavioural response towards the stimuli has functional relevance as it provides crucial information regarding one's social environment and allows individuals to potentially predict others' behaviour and thereby respond appropriately (Bruce and Young, 1986). If the behaviour was simply a more general response to distress or to non-emotional factors, such as any discomfort associated with the experimental set up, we would expect the behaviour to occur randomly.

Likewise, the response cannot be explained by conditioned effects such as the anticipation of a food reward, as we used the spontaneous looking behaviour of dogs and did not train them with food to look at the screens as has been done in other studies (*e.g.* Müller et al., 2015). It might be argued that mouth-licking is simply an unconditional response to the unconditional stimulus of an angry face. However, if this was the case, then there should be a high level of contingency between the two, and our finding that it occurred in only 22% of instances and without a discernible pattern in relation to a given image, would indicate this is not the case.

Moreover, although dogs use auditory information in emotional and individual recognition settings (*e.g.* Albuquerque et al., 2016; Taylor et al., 2011; Faragó et al., 2010), this does not mean that, in some contexts, visual cues cannot be more salient to them (*e.g.* Skyrme and Mills, 2010). Facial communication plays a crucial role in the social cognition of several animal species (Guo et al., 2009) and rapid discrimination between positive and negative facial expressions may be fundamental to success (Gothard et al., 2003). This is particularly relevant for domestic dogs who live in mixed species groups with humans, a species that relies extensively on visual signals for communication (Schmidt and Cohn, 2001). Animals are equipped with multiple sensory channels, which allow the acquisition of qualitative information about the surrounding environment. Individuals can rely on specific sensory channels during the discrimination and recognition process and this asymmetric engagement of perceptual modalities is stimulus-dependent (Yuval-Greenberg and Deouell, 2009) and so could result in differential behavioural outcomes. For example, in a study conducted by Parr (2004), chimpanzees were shown to rely more on visual than auditory cues when presented with negative multimodal expressions of conspecifics. Visual information is more specifically associable with an immediate and specific source (*i.e.* provides more accurate target location information) compared to signals using other sensory modalities (Ernst and Bülthoff, 2004).

In addition to revealing evidence of functionally relevant responding to emotional cues, our findings show that mouth-licking was contingent only with negative facial expressions, and preferentially human ones; this indicates that it is not generally associated with just any form of negative context, but it may be a more specific affective behavioural response to what dogs see. Thus, this valence and modality-dependent signal should not be considered a simple adjunctive behaviour, *i.e.* one that arises as a spontaneous response to physical and social uncertainties in the environment (Falk, 1977), as is often implied in the applied ethological literature. The results of the current study add to our earlier findings, that dogs can extract the emotional content of facial expressions of others (Albuquerque et al., 2016), by indicating that they can also respond to this information in a functional way.

## Acknowledgements

We thank Fiona Williams for assisting with data collection and double coding. This work was supported by the Brazilian National Council for Scientific and Technological Development (CNPq).

## References

Albuquerque, N., Guo, K., Wilkinson, A., Savalli, C., Otta, E., Mills, D., 2016. Dogs recognize dog and human emotions. Biol. Lett. 12, 20150883. http://dx.doi.org/10.1098/rsbl.2015.0883.

Beerda, B., Schilder, M.B.H., van Hoff, J.A.R.A.M., de Vries, H.W., 1997. Manifestations of chronic and acute stress in dogs. Appl. Anim. Behav. Sci. 52, 307–319.

Beerda, B., Schilder, M.B.H., van Hoff, J.A.R.A.M., de Vries, H.W., Mol, J.Á., 1998. Behavioral, saliva cortisol and heart rate responses to different types of stimuli in dogs. Appl. Anim. Behav. Sci. 58, 365–381.

Bruce, V., Young, A., 1986. Understanding face recognition. Br. J. Psychol. 77 (3), 305–327.

Castles, D.L., Whiten, A., Aureli, F., 1999. Social anxiety, relationships and self-directed behaviour among wild female olive baboons. Anim. Behav. 58, 1207–1215.

Deldalle, S., Gaunet, F., 2014. Effects of 2 training methods on stress-related behaviors of the dog (*Canis familiaris*) and on the dog-owner relationship. J. Vet. Behav. 9, 58–65. http://dx.doi.org/10.1016/j.jveb.2013.11.004.

de Haan, M., Nelson, C.A., 1999. Brain activity differentiates face and object processing in 6-month-old infants. Dev. Psychol. 35, 1113–1121.

de Waal, F.B.M., Aureli, F., 1997. Conflict resolution and distress alleviation in monkeys and apes. Ann. N. Y. Acad. Sci. 807, 317–328. http://dx.doi.org/10.1111/j.1749-6632.1997.tb51929.x.

Ernst, M.O., Bülthoff, H.H., 2004. Merging the senses into a robust percept. Trends Cognit. Sci. 8 (4), 162–169. http://dx.doi.org/10.1016/j.tics.2004.02.002.

Falk, J.L., 1977. The origin and functions of adjunctive behavior. Anim. Learn. 5 (4), 325–335.

Faragó, T., Pongrácz, P., Range, F., Virányi, Z., Miklósi, A., 2010. 'The bone is mine': affective and referential aspects of dog growls. Anim. Behav. 79, 917–925. http://dx.doi.org/10.1016/j.anbehav.2010.01.005.

Frank, D., Minero, M., Cannas, S., Palestrini, C., 2007. Puppy behaviours when left home alone: a pilot study. Appl. Anim. Behav. Sci. 104, 61–70. http://dx.doi.org/10.1016/j.applanim.2006.05.003.

Fraser, O.N., Stahl, D., Aureli, F., 2008. Stress reduction through consolation in chimpanzees. PNAS 105 (25), 8557–8562. http://dx.doi.org/10.1073/pnas.0804141105.

Gaunet, F., 2010. How do guide dogs and pet dogs (Canis familiaris) ask their owners for their toy and for playing? Anim. Cognit. 13, 311–323. http://dx.doi.org/10.1007/s10071-009-0279-z.

Gothard, K.M., Erickson, C.A., Amaral, D.G., 2003. How do rhesus monkeys (*Macaca mulatta*) scan faces in a visual paired comparison task? Anim. Cognit. 7, 25–36. http://dx.doi.org/10.1007/s10071-003-0179-6.

Guo, K., Meints, K., Hall, C., Hall, S., Mills, D., 2009. Left gaze bias in humans, rhesus monkeys and domestic dogs. Anim. Cognit. 12, 409–418. http://dx.doi.org/10.1007/s10071-008-0199-3.

Horváth, Z., Igyártó, B., Magyar, A., Miklósi, A., 2007. Three different coping styles in police dogs exposed to a short-term challenge. Horm. Behav. 52, 621–630. http://dx.doi.org/10.1016/j.yhbeh.2007.08.001.

Kujala, M.V., 2017. Canine emotions as seen through human social cognition. Anim. Sent. 14 (1), 1–34.

Müller, C.A., Schmitt, K., Barber, A.L.A., Huber, L., 2015. Dogs can discriminate emotional expressions of human faces. Curr. Biol. 25, 601–605. http://dx.doi.org/10.1016/j.cub.2014.12.055.

Miklósi, A., 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.

Nagasawa, M., Murai, K., Mogi, K., Kikusui, T., 2011. Dogs can discriminate human smiling faces from blank expressions. Anim. Cognit. 14, 525–533. http://dx.doi.org/10.1007/s10071-011-0386-5.

Palestrini, C., Minero, M., Cannas, S., Rossi, E., Frank, D., 2010. Video analysis of dogs with separation-related behaviors. Appl. Anim. Behav. Sci. 124, 61–67.

Parr, L.A., Winslow, J.T., Hopkins, W.D., de Waal, F.B.M., 2000. Recognizing facial cues: individual discrimination by Chimpanzees (*Pan troglodytes*) and Rhesus monkeys (*Macaca mulatta*). J. Comp. Psychol. 114, 47–60.

Parr, L., 2004. Perceptual biases for multimodal cues in chimpanzee (Pan troglodytes) affect recognition. Anim. Cognit. 7, 171–178. http://dx.doi.org/10.1007/s10071-004-0207-1.

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. http://dx.doi.org/10.1371/journal.pone.0036076.

Rooney, N.J., Gaines, S.A., Bradshaw, J.W.S., 2007. Behavioural and glucocorticoid responses of dogs (*Canis familiaris*) to kennelling: investigating mitigation of stress by prior habituation. Physiol. Behav. 92, 847–854.

Savalli, C., Ades, C., Gaunet, F., 2014. Are dogs able to communicate with their owners about a desirable food in a referential and intentional way? PLoS One 9 (10), e111387. http://dx.doi.org/10.1371/journal.pone.0111387.

Savalli, C., Resende, B., Gaunet, F., 2016. Eye contact is crucial for referential communication in pet dogs. PLoS One 11 (9), e0162161. http://dx.doi.org/10.1371/journal.pone.0162161.

Schmidt, K.L., Cohn, J.F., 2001. Human facial expressions as adaptations: evolutionary questions in facial expression research. Yearb. Phys. Anthropol. 44, 3–24.

Schwab, C., Huber, L., 2006. Obey or not obey? Dogs (*Canis familiaris*) behave differently in response to attentional states of their owners. J. Comp. Psychol. 120, 169–175.

Skyrme, R., Mills, D.S., 2010. An investigation into potential overshadowing of verbal commands during training. J. Vet. Behav. 5 (1), 42. http://dx.doi.org/10.1016/j.jveb.2009.09.039.

Smith, A.V., Proops, L., Grounds, K., Wathan, J., McComb, K., 2016. Functionally relevant responses to human facial expressions of emotion in the domestic horse (Equus caballus). Biol. Lett. 12. http://dx.doi.org/10.1098/rsbl.2015.0907.

Taylor, A.M., Reby, D., McComb, K., 2011. Cross modal perception of body size in domestic dogs (Canis familiaris). PLoS One 6, e0017069. http://dx.doi.org/10.1371/journal.pone.0017069.

Yuval-Greenberg, S., Deouell, L.Y., 2009. The dog's meow: asymmetrical interaction in cross-modal object recognition. Exp. Brain Res. 193, 603–614. http://dx.doi.org/10.1007/s00221-008-1664-6.