Accuracy of canine vs. human emotion identification

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Accuracy of Canine vs. Human Emotion Identification: The Impact of Dog Ownership and Belief in Animal Mind

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Abstract

Humans are adept at extrapolating emotional information from the facial expressions of other humans but may have difficulties identifying emotions in dogs. This can increase risk for compromised dog and human welfare. Experience with dogs, and beliefs in animal minds, may influence interspecies emotional communication, yet limited research has investigated these variables. In this study, participants (n = 122 adults) were asked to identify human and dog emotional facial expressions (happiness, fearfulness, anger/aggression) through an online experimental emotion recognition task. Experience with dogs (through dog ownership and duration of current dog ownership), emotion attribution (through beliefs about animal mind), and demographics were also measured. Results showed that fear and happiness were more easily identified in human faces, whereas aggression was more easily identified in dog faces. Duration of current dog ownership, age, and gender identity did not relate to accuracy scores, but current dog owners were significantly better at identifying happiness in dog faces than non-dog owners. Dog ownership and duration of ownership related to increased beliefs about, and confidence in, the emotional ability of dogs. Additionally, belief in animal sentience was positively correlated with accuracy scores for identifying happiness in dogs. Overall, these exploratory findings show that adult humans, particularly current dog owners and those who believe in the emotionality of dogs, can accurately identify some basic emotions in dogs but may be more skilled at identifying positive than negative emotions. The findings have implications for preventing negative human-animal interactions through intervention strategies that target animal emotionality.

Key words*:* belief in animal mind; dog ownership; emotions; facial expressions; human-dog interactions.

1.1 Introduction

Facial signals are fundamental for nonverbal social communication across some mammalian species and have been evolutionarily preserved in animals with complex social structures (Andrew, 1963; Ekman, 1993). Humans evolved the ability for emotional expression through facial structures that appear to be governed by universal rules, coded into 'action units' (Fox, 1970). These facial action units have also been shown in dogs (Waller et al., 2013). Indeed, dogs use facial expressions and other fine-tuned skills to express and communicate emotions (Bremhorst et al., 2019; Kaminski et al., 2017). They show similarities in their facial signalling of basic emotions during close-range social interactions (Bolwig, 1964) that seem to influence how humans behave toward them (Waller et al., 2013). Interspecies emotional communication is particularly interesting between humans and domestic dogs given their long shared evolutionary history, cohabitation, inter-dependence, and potential cognitive co-evolution (Hare, 2007; Skoglund et al., 2015).

Nonverbal communication is an important aspect of human-dog communication (Siniscalchi et al., 2018). Dogs understand, and respond to, human emotional cues via facial expressions and eye-gaze (Call et al., 2003; Mongillo et al., 2010; Racca et al., 2012). Dogs also may have internal representations of their owner's faces, actively generating a visual image of their owner from auditory information (Adachi, 2007). Dogs can also distinguish between human emotional expressions (such as anger, fear, and smiling) and neutral or blank expressions (Deputte & Doll, 2011; Müller et al., 2015; Nagasawa et al., 2011). These abilities facilitate interspecies emotional understanding, which may be advantageous for both species. A mutual understanding of inner states and the ability to attend to facial signalling may be important for detecting threat and preventing harm (e.g., dog bites; Aldridge & Rose, 2019), giving correct responses to signals provided (Worsley & O'Hara, 2018), and facilitating the human-dog bond (Martens et al., 2016).

Humans are adept at detecting faces and extrapolating information about emotion from the facial expressions of other humans (Leppänen et al., 2007). However, humans may have difficulties decoding some facial signals in other animals due to species-specificity of emotional signalling (i.e., emotional signalling may have evolved to facilitate communication within one's own species rather than between species; Siniscalchi et al., 2018). Humans, for example, can display difficulties in correctly identifying and recognising dog emotional cues from facial expressions (Horowitz, 2009; Meints & De Keuster, 2009) even when information-based training on dog emotions has been received through educational intervention (Morrongiello et al., 2013). Other studies have found that young people often misinterpret aggressive dogs as happy ones (Meints et al., 2010a, 2010b), and have difficulties recognising fearful dogs (Aldridge & Rose, 2019; Lakestani et al., 2014).

Interestingly, an fMRI study has shown that "dog experts" (those extensively involved in dog training and associated activities), compared to a control group with no particular dog expertise, displayed comparable brain activity when interpreting human and dog emotional expressions through bodily postures (Kujala et al., 2012). This suggests that level of experience with dogs may influence the ability to accurately identify emotions. In support of this idea, Dalla Costa et al. (2014) found that pet ownership influenced the ability to accurately identify emotional states through photographs of dog faces. Other studies investigating experience with dogs and emotion identification have also focused on body language, auditory signals (e.g., barking), or olfactory signals (e.g., Demirbas et al., 2016; Molnár et al., 2010; Wan et al., 2012), though it is important to note that humans largely focus on faces and body when interpreting dog emotions (Correia-Caeiro et al., 2020; Lakestani et al., 2014). Thus far, few studies have focused on facial expressions when examining the link between emotion identification and experience with dogs, justifying the need for further investigation.

It is not only accuracy of emotion identification that can influence human-dog interactions but also humans' *beliefs* in dog emotions, commonly referred to as 'belief in animal mind' (Hawkins & Williams, 2016). The attribution of emotions to animals can also influence the strength of human-animal bond (Martens et al., 2016) and ownership of a particular species may relate to greater belief in that species' ability to experience complex and basic emotions (Morris et al., 2012). Pet owners, and those who identify as female, are more likely to attribute emotions to animals (Walker et al., 2014) and there seems to be a general trend toward the attribution of basic rather than complex emotions, except for sadness (Martens et al., 2016). The ability to accurately identify dogs' emotional facial expressions may therefore be confounded by emotion attribution; however limited research has investigated this possibility.

The aim of this exploratory study was to advance previous work into interspecies emotional communication and explore human adults' ability to accurately identify dog emotions through an experimental task. This study took into consideration the potential influence of experience with dogs (through current dog ownership and duration of current dog ownership), emotion attribution (through beliefs about animal mind), and basic demographics (age and gender identity).

Key questions to be explored include:

1) Are adult humans better at identifying basic emotions in human faces compared to dog faces?
2) Does experience with dogs influence emotion identification of dog faces?
3) Does belief in animal mind influence emotion identification of dog faces?
4) Does experience with dogs influence beliefs about animal minds?

2.1 Methods

2.1.1 Participants and Design

A total of 122 adult participants, ages ranging from 19 to 75 years (*M* = 30.97, *SD* = 12.65) completed the experiment. Of these participants, eighty-five identified as female, the remaining thirty-seven identified as male, and seventy-eight were currently, or had previously been, dog owners. Breeds of pet dogs were varied. Duration of current dog ownership ranged from one to five years (*M* = 3.52 years, *SD* = 1.23). The sample size was based upon a G*Power sample size calculation which demonstrated that this number was more than sufficient for the intended within-subject analyses of variance; it was further based on previous experiments investigating the lateralization of emotion perception that had fewer participants (Bourne, 2010; Indersmitten & Gur, 2003; Racca et al., 2012). Participants were recruited using convenience sampling via sharing on social media. The experiment was completed online using SurveyHero (www.surveyhero.com/).

The study used a quasi-experimental design; within-subject variables included emotion identification for human vs. dog faces, whereas between-subject variables included demographics (age, gender identity, current dog ownership, and duration of current dog ownership), and belief in animal mind scores. For the main accuracy analysis, independent variables included type of basic emotion (happiness, fear, aggression/anger), species (dog faces, human faces), and current dog ownership (yes, no), and the dependent variable was proportion of accurately identified emotions. Demographic variables were also used as correlational variables in relation to accuracy. This study was approved by the University's ethics committee.

2.1.2 Materials

2.1.2.1 Chimeric faces task

The split field chimeric face task was designed for the purpose of a study on functional brain laterality and emotion but allowed us to test for emotion identification. Chimeric faces are composite visual stimuli wherein one half of the face displays an emotion, and the other half displays a neutral expression, but are viewed and evaluated as whole faces. These stimuli can be used as an implicit measure of attentional direction and attentional bias during emotion processing but are also used for emotion identification tasks (Bourne & Gray, 2011; Coronel & Federmeier, 2014; Indersmitten & Gur, 2003; Luzzi et al., 2007). Dog and human faces were created such that one half of the face was neutral, and the other half showed a happy, fearful, or angry/aggressive expression. Chimeric human faces were created using images from the JaCFEE and JaCNeuF facial databases (Matsumoto & Ekman, 1988, as used by Workman et al., 2006), which are validated and widely used sets of human emotional and neutral expressions. Due to the unavailability of openly available validated and behavioural anchored dog face images, chimeric dog faces were created based on the research team's database of images, sourced from copyright-free online databases using search terms such as "aggressive dog." A database of potential images was first collated and then reviewed based on applying externally created material on emotional expressions in dogs (Bloom & Friedman, 2013; RSPCA, 2021; Vet Behaviour Team, 2021) before a final review by an "external expert" in dog behaviour and welfare who agreed on the final images for this study. All faces were front-facing for the purpose of the experiment. A small gap was left between the two halves of the faces to allow for some mismatch in the positioning of the faces; some emotions shifted the alignment of the eyes, nose, and mouth so a small gap allowed for a more coherent percept compared to when the two halves were directly joined. This gap was also implemented in the human chimeric faces to keep the stimuli consistent across species. To control for potential effects of face processing for specific breeds of dog, a range of breeds were chosen, and preliminary analyses revealed no significant differences in accuracy scores between individual images for each dog emotion (e.g., between fearful dog images). In total, there were four happy, four fearful and four angry/aggressive chimeric faces paired with their mirrored versions for counterbalancing. One additional happy dog and angry human face was constructed for practice trials. The term “aggression” is used for dog faces and “anger” for human faces based on previous studies and validation of emotion images (Bloom & Friedman, 2013; Matsumoto & Ekman, 1988). The pictures were manipulated to ensure they were greyscale, of similar brightness, contrast, and size (600×600 pixels resolution) and were placed on a uniform white background. Example stimuli can be viewed in Figure 1.

[FIGURE 1 HERE]

2.1.2.2 Belief in animal minds questionnaires

Two widely used and previously-validated measures on beliefs about animal minds were used in this study. The Belief in Animal Mind Questionnaire (BAM) by Hills (1995) measured general beliefs about animal sentience. Participants rated their level of agreement with four statements on a scale of 1-9, with larger scores indicating greater belief in animal sentience (α=.60). The Beliefs about Animal Minds Scale (Morris et al., 2012) was adapted for this study to focus on dogs only and measured belief in dogs’ capability to experience seven primary and nine secondary emotions. Larger scores on this measure indicated a belief in a larger repertoire of emotional experiences. Each item on this measure was accompanied with a confidence rating, wherein participants indicated how confident they were (on a scale of 1-5) with each judgement of whether a dog can feel the emotion in question. Larger confidence scores indicated greater certainty in one’s own accuracy. This measure demonstrated moderate-high reliability in our sample (total beliefs in dog emotions: α=.70; total confidence in dog emotions score: α=.88).

2.1.3 Procedure

Participants received digital information about the study and signed an electronic consent form prior to completing the study. Following two practice trials, participants completed 48 experimental trials in total (24 per species) whereby they were instructed to observe the chimeric faces, and after each picture, were requested to identify the emotion displayed. Participants made their emotion identification selection on screen from a forced-choice response of happy, fear, and anger/aggression. Correctly identified emotions were given a score of 1, incorrect emotion identifications were given a score of 0, and the proportion of accurate responses were calculated across images separately for each species and emotion category.

For each trial, participants viewed a human or dog face paired together with a mirror-reversed version of the same image; therefore, one image displayed the emotion on the left hemi-face, and the other displayed the emotion on the right hemi-face. The images were positioned one above the other, and each mirrored pair was eventually judged twice for counterbalancing purposes: once with the emotional left hemi-face on top, and once with the emotional right hemi-face on top. This procedure was to investigate laterality of emotion processing for a separate study (using a different measure of facial preference), but for the purposes of the present study accuracy scores were used instead. The accuracy scores were averaged across the counterbalanced conditions for each chimeric face. The order of images was semi-randomised using an online randomiser. Thus, participants made a total of 24 emotion judgements for each species (human/dog). The experimental task took 15 minutes to complete. Following the chimeric faces task, participants completed basic demographic questions and the belief in animal mind questionnaires that took approximately 5-10 minutes to complete. They were provided with an educational debriefing online (which included links to relevant articles about the subject topic) and thanked for their time at the end of the study.

3.1 Results

3.1.1 Dog Ownership and Emotion Identification Accuracy

The proportion of accurately identified emotions was calculated separately for each species and each emotion, and then submitted to a 2 (species: dog, human) by 3 (emotion: fear, anger/aggression, happy) by 2 (current dog owner: yes, no) mixed model ANOVA. Results revealed a main effect of species, $F(1, 120) = 31.84$, $p < .001$, $\eta_p^2 = .21$, such that human emotional expressions were generally more accurately identified (*M*=.87, 95% CI [.85, .89]) than dog emotional expressions (*M*=.81, 95% CI [.78, .83]). A main effect of emotion (F [2, 240] = 7.39, $p = .001$, $\eta_p^2 = .06$) indicated that across species, happy facial expressions were the most accurately identified (*M*=.87, 95% CI [.84, .90]), followed by fear (*M*=.83, 95% CI [.80, .85]) and anger/aggression (*M*=.82, 95% CI [.79, .84]). However further analyses (detailed below) indicated that when considering species, happiness was most accurately identified in human faces, followed by fear and aggression, whereas for dog faces, aggression was the most accurately identified, followed by happiness and then fear. Moreover, a main effect of dog ownership ($F[1, 120] = 11.99$, $p = .001$, $\eta_p^2 = .09$) demonstrated more accurate identification of emotions in current dog owners (*M*=.87, 95% CI [.85, .90]) compared to non-dog owners (*M*=.80, 95% CI [.77, .83]). Two-way interactions were observed between emotion and dog ownership (F[2, 240] = 3.43, $p = .03$, $\eta_p^2 = .03$), and emotion and species (F[2, 240] = 76.57, $p < .001$, $\eta_p^2 = .39$), and a three-way interaction between all independent variables was also statistically significant (F[2, 240] = 4.44, $p = .01$, $\eta_p^2 = .04$).

To further explore the three-way interaction, analyses were run to determine whether current dog owners significantly differed from non-dog owners in how accurately they could identify emotions in both dog and human faces. The assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances (*p* = .001 to .002) so Welch t-tests were run. As shown in Figure 2, current dog owners were significantly more accurate than non-dog owners at identifying happiness in dog faces, $t(62.06) = -3.34$, $p = .001$, 95% CI [-.26, -.06]. They were also more accurate at identifying anger in human faces, $t(68.16) = -2.49$, $p = .02$, 95% CI [-.21, -.02]. Paired samples t-tests also showed that, for both current dog owners and non-dog owners, fear and happiness were more accurately identified in human faces than dog faces (non-dog owner fear identification: $t(43)$=-7.35, $p < .001$; dog owner fear identification: $t(77)$=-8.16, $p < .001$; non-dog owner happiness identification: $t(43)$=-5.00, $p < .001$; dog owner happiness identification: $t(77)$=-5.92, $p < .001$). In contrast, aggression was more accurately identified in dog faces than anger in human faces (non-dog owner aggression identification: $t(43)$=3.89, $p < .001$; dog owner aggression identification: $t(77)$=4.46, $p < .001$).

Across emotions, current dog-owners (M=.85, SD=.12) were significantly better at identifying dog emotions in general than non-dog owners (M=.76, SD=.15), $t(75)$=3.30, p =.001, CI [.03, .14], and current dog-owners (M=.90, SD=.10) were also significantly better at identifying human emotions in general than non-dog owners (M=.84, SD=.15), $t(66)$=2.31, p =.024, CI [.01, .11]. Paired samples t-tests also showed that, for both current dog owners ($t(44)$=-3.77, p <.001, CI [-.36, -.11]) and non-dog owners ($t(77)$=-4.06, p <.001, CI [-.23, -.08]), in general, emotions were more easily accurately identified for humans.

[FIGURE 2 HERE]

3.1.2 Duration of Dog Ownership, Belief in Animal Sentience, and Emotion Identification

A series of Pearson's correlations were run to explore the relationships between duration of current dog ownership (expressed in years), scores on general beliefs in animal sentience, scores on beliefs in animal emotions, and scores for confidence in belief in animal emotions. As shown in Table 1, positive correlations were found between nearly all these variables. The longer a participant had owned their current dog, the stronger their general belief in animal sentience. Interestingly, actual scores on beliefs in all dog emotions did not change according to the duration of current dog ownership, suggesting that all dog owners had similar beliefs about general dog emotionality. However, *confidence* in that belief increased the longer one had owned their current pet dog; this was found across all emotions, and for complex dog emotions. Confidence also increased with stronger beliefs in both animal emotionality and sentience. Sensibly, the more strongly a person believed in animal sentience, the more they believed in animal emotionality. This was found across emotions, and for both basic and complex emotions.

[INSERT TABLE 1 HERE]

Next, a series of Pearson's correlations were run to explore the relationships between proportion of facial expressions correctly identified and measures of dog ownership and belief in animal minds (Table 2). Positive correlations were found such that a stronger general belief in animal sentience was related to increased accuracy in detecting all dog emotions, and specifically happiness in dogs. Confidence in overall dog emotionality was also positively correlated with accuracy in identifying happiness in humans. Confidence in basic dog emotions and general belief in animal sentience were positively correlated with accuracy in identifying both human anger and happiness specifically, but also with accuracy scores across all human emotions. No other significant correlations were observed, including no significant correlation between participant age and any of the measures (all *p*s >.05) and no significant difference between gender identity and emotion accuracy across emotions and species (all *p*s >.05).

[INSERT TABLE 2 HERE]

3.1.3 Dog Ownership, Demographics, and Belief in Animal Mind.

Independent sample *t*-tests were run to investigate whether there were group differences in beliefs about animal minds. With respect to dog ownership, current dog owners (M=30.35, SD=4.03) scored significantly higher on general beliefs about animal sentience than non-dog owners (M=26.29, SD=6.2), $t(120)=-4.39$, $p<.001$, CI [-6.11, -1.98]. Current dog owners (M=37.58, SD=5.58) also scored significantly higher on confidence in complex dog emotions than non-dog owners (M=35.07, SD=6.78), $t(120)=-.2.21$, $p=.029$, CI [-4.76, -.26]. All other differences between these two groups were non-significant ($p>.05$).

Moreover, participants who identified as female (M=29.82, SD=4.97) scored significantly higher on general beliefs in animal sentience than participants who identified as male (M=26.73, SD=5.30), $t(120) = 3.096$, $p = .002$, CI [1.11, 5.7]. Females (M=37.47, SD=5.65) also scored significantly higher on confidence in dog complex emotion than males (M=34.84, SD=6.84), $t(120)=2.22$, $p=.029$, CI [.28, 4.99]. There were no significant correlations between age and any of the beliefs about animal mind measures or proportion of facial expressions correctly identified (all $p>.05$).

4.1 Discussion

This exploratory study examined human adults' ability to identify human and dog emotions through an experimental task. It also took into consideration the potential influence of experience with dogs (through current dog ownership and duration of current dog ownership), emotion attribution (through beliefs about animal mind), and basic demographics (age and gender identity).

The first objective was to examine accuracy in emotion identification both across and between species and emotion. As expected, human emotional expressions were more accurately identified than dogs', suggesting that within-species emotion identification is easier than inter-species identification. For human faces, happy facial expressions were the most accurately identified emotion, followed by fear, and then aggression. These findings support previous theories that positive emotional expressions may be more easily, quickly, and more confidently identified (Leppänen & Hietanen, 2004; Wan et al., 2012). However, when examining differences in accuracy scores between species, fear and happiness were more accurately identified in human faces whereas aggression was more accurately identified in dog faces. Both current dog owners and non-dog owners identified aggression better in dog faces compared to happiness and fear. These findings contrast those of others that found difficulties in human's ability to identify aggression and fear in dogs (e.g., Aldridge & Rose, 2019; Tami & Gallagher, 2009; Meints et al., 2010a, 2010b). However, compared to these previous investigations, our study was with an adult, rather than a child, population and utilised photographs of faces, rather than video clips. The conflicting findings may therefore be a result of methodological differences. A potential explanation of our finding is that aggression is more commonly signalled by dogs through their mouth region, baring their teeth prior to biting (Guy et al., 2001; Jacobs et al., 2003) which may explain why humans process aggression differently in dogs (focusing on the mouth region) compared to anger in human faces (focusing on the eye region) (Hawkins et al., 2021). Our findings support those of Schirmer et al. (2013) who found that humans are more skilled at recognising human emotions than dog emotions (i.e., displayed higher accuracy scores for human faces) but can still successfully distinguish between positively and negatively valenced emotions in dogs. This is perhaps due to similar processing mechanisms (similar face-scanning patterns of areas of interest; Correia-Caeiro et al., 2020) suggesting that the face and emotion processing mechanism underlying interspecies communication is an innate ability (Kujala, 2017).

Interestingly, Bloom and Friedman (2013) found that participants who were "inexperienced" with dogs were better able to identify dog aggression, as compared to "experienced" participants. This raised the possibility that those who spend more time with dogs (such as through dog ownership), may be more likely to give the dog "the benefit of the doubt" when interpreting negative emotions, thus perceiving them as less aggressive. Other previous studies (e.g., Dalla Costa et al., 2014; Kujala et al., 2012) further point to the possibility that experience with dogs may influence emotion recognition ability, so we predicted that current dog owners, and particularly longer duration of current dog ownership, would increase identification scores. Unexpectedly, duration of dog ownership did not relate to accuracy, although participants in our study only reported on how long they had owned their *current* pet dog and so displayed a shorter duration of dog ownership (ranging from 1-5 years) compared to previous studies. Future studies should therefore consider measuring total length of experience with dogs through current and past dog ownership, and through experience with dogs outside of dog ownership (e.g., through social networks or work occupation). As expected, current dog owners were significantly better at identifying dog emotions than non-dog owners, supporting the theory that experience might increase emotion identification (Dalla Costa et al., 2014). When we analysed differences between emotions, current dog owners were significantly better at identifying happiness in dog faces than non-dog owners, complementing previous similar findings (Wan et al., 2012), although contrasting with others that found no impact of experience (e.g., Bloom & Friedman, 2003; Schirmer et al., 2013). Given the mixed evidence into experience via dog ownership and ability to accurately interpret dog emotions, further research is warranted. Future studies should consider past dog ownership as well as current dog ownership.

Researchers have argued that for humans to process emotions in nonhuman animals, there needs to be a *belief* that animals are sentient (De Vere & Kuczaj, 2016). A novel objective of our work was to therefore explore the possibility that anthropomorphic tendencies, through beliefs about animal minds (BAM), would influence the ability to identify emotions in dogs. As expected, a stronger belief in animal sentience was significantly positively related to the proportion of dog facial expressions correctly identified. Specifically, stronger belief in animal sentience was significantly positively correlated with accuracy in identifying happiness, but no other significant correlations were observed, suggesting that BAM may only play a small role in the identification of positive dog emotions. It is important to note that the significant correlations found were also weak, and this could possibly be explained by a low variability in the BAM measure due to having a convenience sample. Perhaps those who are interested in animals and possess a higher BAM are more likely to participate in a study regarding animal emotions. Although not the focus of the current paper, interestingly, stronger beliefs in animal sentience and confidence in dog emotionality positively correlated with increased accuracy in identifying human emotions. Additionally, dog owners were significantly better at identifying human emotions than non-dog owners. Together, these results suggest that anthropomorphic tendencies and dog ownership may also influence emotion processing of human faces. Alternatively, perhaps those who are better at processing human emotions are also those more likely to acquire a pet dog and believe deeper in animal sentience, and perhaps this is mediated by a third factor such as empathy (Kujala, 2017). Indeed, increased levels of empathy (particularly empathetic social skills) are related to improved identification of facial emotions (Besel & Yuille, 2010), and empathy is arguably key to developing anthropomorphic tendencies (Airenti, 2015). This may be worth investigation in a follow-up study.

The final objective of this study was to explore demographic differences. Firstly, we found that age did not significantly relate to the proportion of facial expressions correctly identified for either species nor beliefs about animal minds. Exploring age-related changes with these variables may, therefore, only be relevant with younger or elderly populations where developmental and cognitive abilities may play a role in emotion processing (Isaacowitz et al., 2007; Lakestani et al., 2014; Meints et al., 2010b). Secondly, we found that participants who identified as female scored significantly higher on beliefs in animal sentience and confidence in complex dog emotions compared to participants who identified as male (note that no participants identified as nonbinary or a different gender). This supports previous studies (Cornish et al., 2018; Herzog & Galvin, 1997; Knight et al., 2004). However, gender identity did not impact emotion identification accuracy for either species, in contrast to previous work that found that females were more sensitive to affective information (e.g., Schirmer et al., 2013). We found that current dog owners scored significantly higher on beliefs about animal sentience and significantly higher on confidence in complex dog emotions than non-dog owners. We also found that the longer a participant had owned their dog, the stronger their general belief in animal sentience and the more confident they were that dogs were sentient. Overall, our findings support previous theories that having a pet increases confidence in and beliefs about the emotionality of that species (Hawkins & Williams, 2016; Morris et al., 2012) and influences the ability to correctly identify emotions, particularly happiness, as reported above.

4.1.1 Limitations and Implications

This study was exploratory in nature, and so there were limitations that need to be considered and addressed in future work. Most importantly, we were unable to obtain access to existing banks of validated and behaviourally anchored dog images used in other investigations (e.g., Albuquerque et al., 2016; Bloom & Friedman, 2013; Racca et al., 2012; Schirmer et al., 2013), and we lacked the resources to build our own such database. Our study is therefore exploratory in that we cannot be certain that the images used in our experiment are true depictions of the dogs' internal states and so may reflect emotion *interpretation* rather than accuracy. Nevertheless, our study does highlight the possibility of differences between intra- and inter species emotion recognition abilities that should be replicated when possible. Making such standardised behaviourally anchored images freely accessible to future research teams would help to advance this field.

Moreover, our study included a variety of breeds but not enough to test for inter-breed differences. This may be of interest in the future if a wider bank of images is obtained (e.g., comparing dolichocephalic and brachycephalic dog breeds). Preliminary analyses, however, found no significant difference in accuracy identification between the dog images within each emotion (e.g., fear images).

It could be argued that humans are better able to identify emotions from still 2D photographs than they are from 3D images or moving video clips which are more reflective of everyday life, so examining human's ability to identify dog emotions in real-world dynamic settings would be an interesting avenue to explore in the future. We also used a task that forced participants to choose out of three options which could have increased the chances of a participant selecting the correct response even if they were unsure. Future studies could therefore include a "don't know" option or decoy options such as emotions that are not present within the task. Furthermore, when exploring interspecies emotion processing, future studies could consider potential cultural differences (see Amici et al., 2019; Kaminski & Nitzschner, 2013), the intensity of the emotion displayed (see Hess et al., 1997), psychological processes such as empathy and personality (see Balconi & Canavesio, 2016), "high empathisers" bias toward identifying negative emotions (Chikovani et al., 2015), "dark personalities" such as callous-unemotional traits (see Hartmann & Schwenck, 2020), attachment to pets (see Hawkins & Williams, 2016), and other individual differences such as brain differences and genotypes (see Hamann & Canli, 2004). As mentioned, prior, future studies should address our limitations by including a measure for total length of experience with dogs through current and past ownership, as well as experience with dogs outside of ownership (such as work occupation, volunteer work, social and family networks). Most of our participants identified as female, so future research should also aim to recruit more diverse participants with other gender identities. Finally, participants in our study completed the beliefs in animal mind measure following the emotion identification task to prevent the potential influence of this measure on accuracy. In the future, it is advisory to counterbalance the procedure so that some participants complete the measures prior to the experiment.

It is important to consider that, although dogs do communicate to humans via nonverbal communication including facial expressions, and that facial expressions alone are sufficient for interpreting emotional states (Ekman, 1993), dogs also communicate vocally, and through body odour (Siniscalchi et al., 2018). Thus, interspecies emotional communication is more complex than face processing alone. Nevertheless, our study adds important new knowledge about adult humans' ability to identify basic dog emotions, highlighting potential innate cross-species face processing abilities, but also that some emotions (e.g., happiness) are more easily recognised than others (e.g., fear).

Emotional understanding and beliefs in animal sentience are fundamental for animal welfare, with implications for the feelings (affective), attitudes (cognitive) and behaviours exhibited towards nonhuman animals (Burghardt, 2009; Špinka, 2012; Muldoon et al., 2009). Accurately identifying or misinterpreting emotional states can impact the welfare and care of pet dogs, dogs within therapeutic settings (e.g., therapy dogs), and working animals (e.g., service animals). It could also safeguard humans via injury prevention. For example, pet dogs can become aggressive in response to inappropriate social responses to their displays of appeasement, placing their owner at risk for being bitten (Shepherd, 2002; Shen et al., 2016). Moreover, emotional understanding is important for empathy and compassion (Chikovani et al., 2015), whereas a lack of understanding may place a person at risk for animal cruelty, neglect, and other negative interactions (Hawkins et al., 2020; Knight et al., 2004; Ledger & Mellor, 2018). Increasing both young people's and adults' understanding of animal sentience and recognition of emotional signals has therefore been at the core of educational interventions (e.g., Coleman et al., 2008; Fonseca et al., 2011; Hawkins & Williams, 2019; Lakestani & Donaldson, 2015; Schwebel et al., 2016) and our research suggests that focusing on negative emotional signalling (particularly how to recognise fear) may be important.

5.1 Conclusion

This study adds novel findings to the under-researched area of interspecies nonverbal emotional communication between humans and dogs. The findings from this study show that adult humans, particularly current dog owners and those who believe in the emotionality of dogs, can accurately identify some basic emotions in dogs. However, they may be more skilled at identifying positive emotions than negative emotions. Future research should replicate this study with a larger set of validated and behaviourally anchored dog images when available. Preventing the misinterpretation of animal emotions and increasing beliefs about animal sentience may be important for promoting positive human-animal interactions, safeguarding animal welfare, and preventing negative interactions such as animal cruelty and potential human injury.

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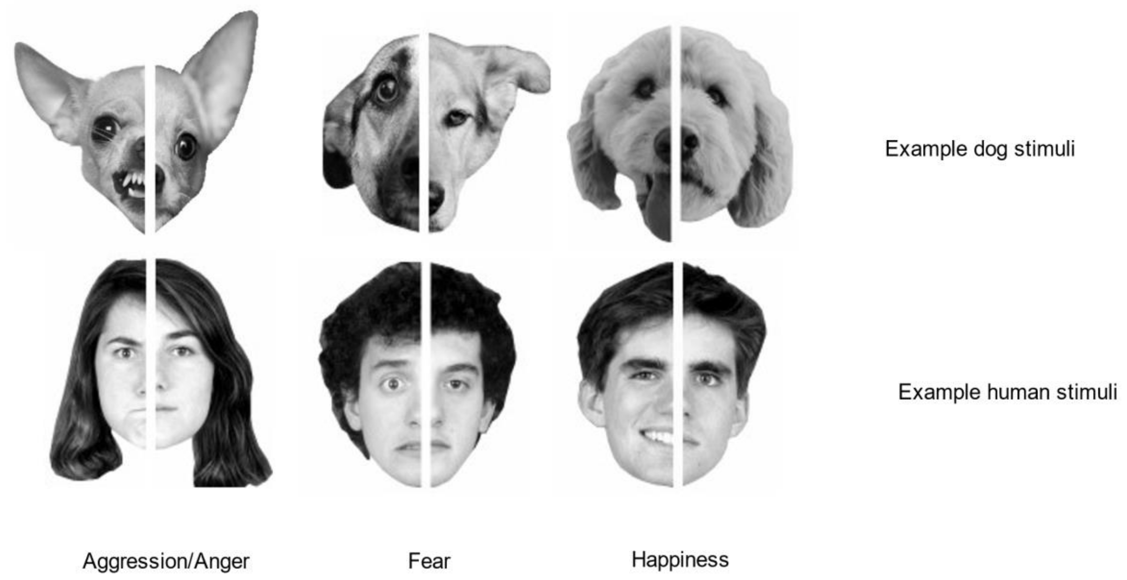

Figure 1. Example stimuli used in the experiment. Each mirrored pair was judged twice for counterbalancing purposes: once with the emotion on the right side of the face, and once with the emotion on the left side of the face. Human images from Matsumoto & Ekman (1988).

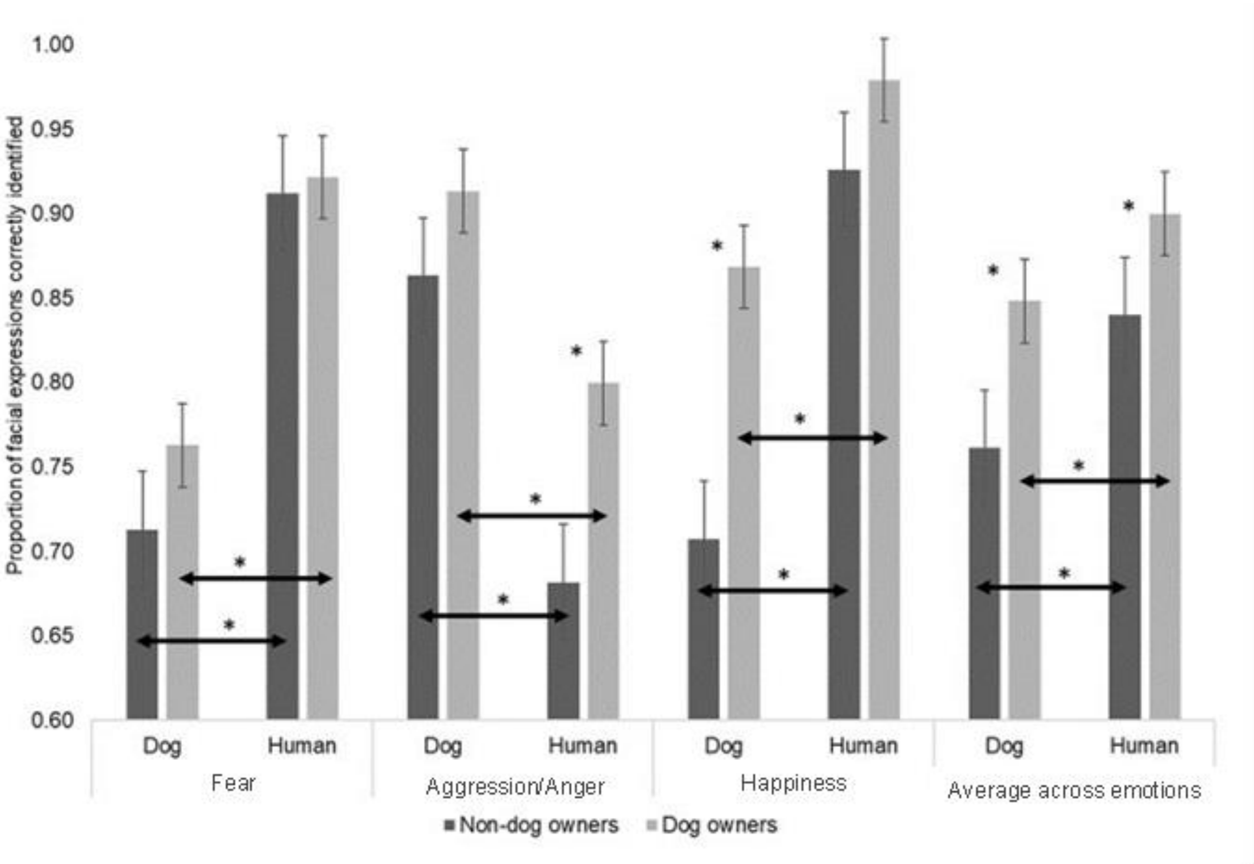

Figure 2. Proportion of facial expressions correctly identified in dog and human faces. *Note: error bars are s.e.m.* *Significant differences between indicated groups.

Table 1. Correlations between length of current dog ownership (years) and belief in animal minds.

		Duration of dog ownership	General belief in animal sentience	Beliefs in *all* dog emotions	Confidence in *all* dog emotions	Beliefs in *basic* dog emotions	Confidence in *basic* dog emotions	Beliefs in *complex* dog emotions	Confidence in *complex* dog emotions
Duration of current dog ownership	*r*	-							
	p								
General belief in animal sentience score (Hills, 1995)	*r*	**.246***	-						
	p	**0.026**							
Beliefs in *all* dog emotions (adapted Morris, Knight, & Lesley, 2012)	*r*	0.12	**.268****	-					
	p	0.284	**0.003**						
Confidence in *all* dog emotions (adapted Morris, Knight, & Lesley, 2012)	*r*	**.268***	**.311****	**.529****	-				
	p	**.015**	**<.0001**	**<.0001**					
Beliefs in *basic* dog emotions (adapted Morris, Knight, & Lesley, 2012)	*r*	0.13	.178*	.678**	.312**	-			
	p	0.244	0.05	<.0001	<.0001				
Confidence in *basic* dog emotions (adapted Morris, Knight, & Lesley, 2012)	*r*	0.187	**.349****	.536**	.822**	**.436****	-		
	p	0.092	**<.0001**	<.0001	<.0001	**<.0001**			
Beliefs in *complex* dog emotions (adapted Morris, Knight, & Lesley, 2012)	*r*	0.089	**.250****	.926**	.514**	.350**	.459**	-	
	p	0.429	**0.005**	<.0001	<.0001	<.0001	<.0001		
Confidence in *complex* dog emotions (adapted Morris, Knight, & Lesley, 2012)	*r*	**.291****	**.260****	.474**	.967**	.215*	.732**	**.493****	-
	p	**0.008**	**0.004**	<.0001	<.0001	0.017	<.0001	**<.0001**	

Note: Values of interest are in bold.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2. Correlations between emotion identification accuracy and measures of dog ownership and belief in animal minds.

	Dog Fear	Dog Aggression	Dog Happy	Total Dog Emotion Accuracy	Human Fear	Human Anger	Human Happy	Total Human Emotion Accuracy
Duration of current dog ownership	*r* = -.011 *p* = .920	*r* = .014 *p* =.901	*r* = .144 *p* =.197	*r* = .075 *p* =.502	*r* = .155 *p* =.165	*r* = .106 *p* = .342	*r* = .210 *p* = .058	*r* = .203 *p* = .068
General belief in animal sentience	*r* = .027 *p* =.771	*r* = .122 *p* =.180	***r* = .321**** ***p* =.0001**	***r* = .248**** ***p* =.006**	*r* = .076 *p* =.403	***r* = .293**** ***p* = .001**	***r* =.271**** ***p* = .003**	***r* = .311**** ***p* = .0001**
Beliefs in *all* dog emotions	*r* = .039 *p* =.673	*r* = -.031 *p* =.731	*r* = -.010 *p* =.914	*r* = -.005 *p* =.955	*r* = .009 *p* =.921	*r* = .031 *p* = .732	*r* = .158 *p* = .083	*r* = .082 *p* = .372
Confidence in *all* dog emotions	*r* = -.061 *p* =.503	*r* = -.039 *p* =.669	*r* = .014 *p* =.874	*r* = -.031 *p* =.735	*r* = .026 *p* =.779	*r* = .141 *p* = .121	***r* = .213*** ***p* = .019**	*r* = .176 *p* = .052
Beliefs in *basic* dog emotions	*r* = .006 *p* =.946	*r* = .090 *p* =.326	*r* = .176 *p* =.053	*r* = .142 *p* =.118	*r* = .109 *p* =.233	*r* = .050 *p* =.586	***r* = .277** ***p* =.002**	*r* = .177 *p* = .052
Confidence in *basic* dog emotions	*r* = -.102 *p* =.263	*r* = .091 *p* =.319	*r* = .087 *p* =.343	*r* = .052 *p* =.570	*r* = .005 *p* =.954	***r* = .192*** ***p* = .034**	***r* = .272**** ***p* = .002**	***r* = .222*** ***p* = .014**
Beliefs in *complex* dog emotions	*r* = .046 *p* =.615	*r* = -.086 *p* =.346	*r* = -.103 *p* =.259	*r* = -.080 *p* =.382	*r* = -.044 *p* =.628	*r* = .014 *p* =.876	*r* = .059 *p* =.520	*r* = .013 *p* = .886
Confidence in *complex* dog emotions	*r* = -.033 *p* =.718	*r* = -.106 *p* =.246	*r* = -.026 *p* =.777	*r* = -.073 *p* =.425	*r* = .034 *p* =.708	*r* = .100 *p* =.274	*r* = .160 *p* =.078	*r* = .135 *p* = .139

Note: Values of interest are in bold.

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).