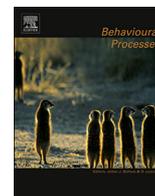




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Human facial expression affects a dog's response to conflicting directional gestural cues

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ABSTRACT

There is growing scientific interest in both the ability of dogs to evaluate emotional cues and their response to social cueing, we therefore examined the interaction between these by investigating whether human facial expression impact on dogs' approach preference to conflicting directional gestural signals. During testing, a human demonstrator simultaneously pointed in one direction and faced (looked towards) in another towards one of two food bowls placed on opposite sides of the demonstrator with either a happy, angry or neutral facial expression. Thirty-six pet dogs were assessed for their approach preference, approach time, alongside aspects of their temperament (positive/negative activation and impulsivity via validated questionnaires). Dogs significantly preferred to follow the 'point' over 'face' cue when the demonstrator displayed angry or neutral expressions but showed no significant preference when the demonstrator displayed a happy expression. Additionally, dogs scoring higher for impulsivity approached the chosen cue significantly faster than those with lower scores. The findings show that dogs integrate information available from human emotional facial expressions with directional gestural information in their response choices within dog-human interactions.

1. Introduction

In comparison with other domestic or social animals, dogs (*Canis familiaris*) are good at detecting, discriminating and responding to human communicative behaviours, such as various gestural cues (Hare and Tomasello, 2005). Two factors have been proposed as the potential underlying mechanism. One is domestication, in which dogs may have been selected for and underwent a process of adaptation for cooperative communication with humans (Bräuer et al., 2006). The other is dogs' prior experience of interacting with humans or exposure effects (e.g. D'Aniello et al., 2017; Udell et al., 2008). Although their relative contribution to the development of this ability is still debated (Udell et al., 2010), it is generally well-recognised that (even without specific training) pet dogs with typical levels of human contact are able to follow a range of human-given visual cues, such as pointing, head-turning, glancing and nodding. This occurs even when the cue-giver is a person other than their owner (Miklósi et al., 1998). Indeed it is widely recognised that dogs are better than chimpanzees at responding to such cues (Hare et al., 2002; Kirchofer et al., 2012) and their performance in pointing object-choice tasks is comparable to that of 2-year-old children (Lakatos et al., 2009). Furthermore, dogs show different sensitivities to conflicting directional gestural cues given concurrently.

They tend to follow visual gestural cues more reliably than verbal cues (D'Aniello et al., 2016), and their responses to visual cues are less dependent on signal-giver familiarity (Scandurra et al., 2017). Among the different types of visual directional gestural cues, pointing is more reliably responded to than glancing or gazing (Miklósi et al., 1998). This may be because pointing is a conventional human gesture consistently used to communicate, whereas looking is not always used as an intentional communicative cue (Bräuer et al., 2006). Recently Carballo et al. (2016) proposed that the pointing cue is easily processed by dogs, as they found dogs spent relatively little time watching the pointing gesture but were still able to follow it successfully. Whilst these results indicate that dogs generally prefer 'pointing' gestural cues over 'looking' cues, the potential effect of wider contextual cues that might be expected to impact on this ability does not appear to have been investigated in the scientific literature.

Facial expressions of emotion provide important adjunctive information that can significantly modify our interpretation or evaluation of the communicative relevance of another's directional gestural signals (e.g. a pointing gesture paired with a happy expression normally encourages approaching behaviour, Bruce and Young, 2012), but it remains unknown whether dogs also take facial expression into consideration when responding to human directional gestural signals. Dogs

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can visually discriminate common human facial expressions of opposing emotional valence (Albuquerque et al., 2016; Müller et al., 2015; Nagasawa et al., 2011), and behave differently as a result, such as showing different gaze bias direction when inspecting happy versus angry faces (Racca et al., 2012) and engaging in more mouth-licking behaviour when presented with angry compared to happy human faces (Albuquerque et al., 2018). Like human infants, dogs seem to be capable of using human emotional expressions to locate desirable hidden food (Buttelmann and Tomasello, 2013), to initiate approach/avoidance behaviour toward novel objects (Merola et al., 2012a, 2014), and to initiate retrieval behaviour towards previously owner-interacted object (Turcsán et al., 2015), but these studies involve a simple association between the emotional expression and target, rather than its influence on a specifically directed action. Taking this empirical evidence together, it is plausible that dogs possess some sort of functional understanding of common human facial expressions and are able to apply this to modifying their responses to human directional gestural signals.

In this study we systematically examined this possibility by presenting two conflicting human directional gestural cues concurrently (i.e. pointing and looking at two food rewards placed on opposite sides of a demonstrator) under one of three facial expression conditions (happy, neutral or angry), noting initially the dogs' cue-following choice and secondly its response latency. Additionally as dogs' viewing preference towards social stimuli (e.g. human facial expression of different valence, human biological motion of different direction) is affected by their personality and sociability (Hori et al., 2011; Ishikawa et al., 2018), we explored the potential for dogs' personality, in terms of sensitivity to signals of reward and punishment (Positive and Negative Activation Scale, PANAS; Sheppard and Mills, 2002) and speed of executive decision functioning using the Dog Impulsivity Assessment Scale (DIAS; Wright et al., 2011) to relate to their behavioural performance.

2. Materials and methods

2.1. Subjects and ethics

Thirty-six pet dogs (21 male and 15 female: 18 neutered males, 3 entire males, 10 neutered females and 5 entire females) of different breeds, aged between 6 months and 5 years 3 months (mean 1 year 1 month, see Supplementary Table 1 for the details), were recruited for the study. Subjects included 17 dogs of pure pedigree breeds, 17 single cross-breed dogs and 2 mixed breeds. Two dogs with evident health problems and one dog with known relevant behavioural issues were excluded. The detailed dog information (e.g. age, breed, sex/neuter status, amount of training, food allergies, and number of dogs in the household) was provided by the owners online. All dogs had either previously attended training classes (17 dogs) or had at least one individual training session (19 dogs, ranged between 1 and 6 sessions) with the primary researcher (GF). Across the dogs, the gap between training class/session and experimental testing varied between 2 weeks and 23 months (mean 8.1 months). Therefore, all the dogs were familiar with the demonstrator (person giving the pointing and looking cues with different facial expressions) and 30 of them were familiar with the room in which the study took place.

Ethical approval was granted by Compass Education and by the designated authority of the University of Lincoln, School of Life Sciences. The testing procedures were designed in accordance with the *British Psychological Society's Guidelines and Code of Ethics (2009)*. All owners provided written informed consent to take part, along with information about any food intolerances in their dogs. No dogs were food deprived before the experiment. During testing, all dogs were accompanied by one of their owners, partially to help make them feel comfortable in this novel situation and because it has been suggested that the presence of the primary carer may be important to behavioural

sensitivity to a stranger's emotional message (e.g. facial expression) (Merola et al., 2012a).

2.2. Experimental procedure

Prior to testing, all owners were asked to complete the Positive and Negative Activation Scale (PANAS, Sheppard and Mills, 2002) and Dog Impulsivity Assessment Scale (DIAS, Wright et al., 2011) questionnaires online.

The testing was undertaken over two days (2nd and 16th December 2017) in a village hall (15 m × 9 m) in Hertfordshire, UK, with three sets of six dogs being tested on each occasion. Each dog was tested individually with no other dogs present in the room at the time. There was no training or familiarisation phase before testing began, but owners were given instructions about the procedure to be followed by an assistant before entering the room.

In each trial, two identical bowls (with the same colour and size, 15 cm in diameter) were placed one to the left and one to the right side of the demonstrator with 2 m distance between them. The same type and quantity of food treat (one "Nature's Menu Meaty Treat") was placed in both of the bowls. This was to avoid the dogs simply 'following their noses' and also because reinforcement (due to having food in only one of the bowls) may have affected the results due to operant conditioning of a behaviour (Buttelmann and Tomasello, 2013). The demonstrator knelt down and looked at one bowl and pointed at the other. This lowered body position (rather than standing) was chosen to ensure the demonstrator's face was more closely aligned with the position of the bowls and to decrease the distance between the pointing finger and the bowl (45 cm), since proximal pointing appears to be more easily understood than distal pointing (D'Aniello et al., 2017; Udell et al., 2010; Reid, 2009). All dogs were tested in each of three experimental conditions (happy, angry or neutral facial expression of the demonstrator).

A location was marked on the floor, 4 m in front of the demonstrator position, for the owner with their dog. A lightweight, solid (opaque), removable barrier (78 cm high and 185 cm wide) was positioned in front of the owner and dog. For each trial, the owner was directed to take their dog behind the barrier, to look down and to hold the dog by its collar/harness until instructed. The demonstrator (GF) then adopted the appropriate position for the trial (pointing at one bowl and facing the other with the appropriate emotional facial expression). The facial expression variable was either 'happy', 'neutral' or 'angry'. Consistent with the Facial Action Coding System (Ekman and Friesen, 1978; or see <https://www.cs.cmu.edu/~face/facs.htm>), 'happy' was expressed with raised cheeks (AU6, action unit 6), lip corners pulled obliquely (AU12) and the lips relaxed and parted (AU25). In contrast, 'angry' was expressed with the eye brows lowered and drawn together (AU4), the lower eyelids raised (AU7) and lips pressed together (AU24). For the neutral expression, the lips, eyes, brows and cheeks were relaxed. Depending on whether the demonstrator was facing the bowl to their left or right, there was also a ~67° head turn in the associated direction (A51 or AU52). Across tests, the order of trials involving the three facial expressions ('happy', 'neutral' or 'angry') was counterbalanced within the population in blocks of six using a Latin Square. The allocation of which bowl was pointed at and which bowl was looked at for a given subject was random (via a random number generator) and made in advance of the experiment. In total, 108 trials were undertaken and 36 tests with 3 trials per dog.

After the barrier had been removed (allowing the subject to see the demonstrator and the bowls) the dog was released by the owner. The owner was instructed to stand still and not interact with their dog or cue the dog to do anything when it was released. Therefore, neither the owner nor the demonstrator actively engaged with the dog for the duration of each trial, beyond the static cue being given by the experimenter. Dogs were given up to 15 s (determined on the basis of pilot observations as a reasonable cut off point) to approach a bowl (defined

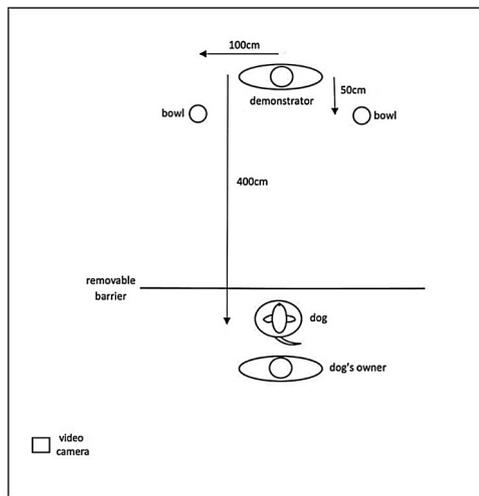


Fig. 1. a Diagram of experimental arrangement of the trials, showing the location and position of the dog, owner, bowls, demonstrator, barrier and video camera. 1b: sample happy, angry and neutral facial expressions.

as when the dog had clearly put their nose over the bowl), and were allowed to feed from both bowls. From a data gathering perspective, the trial ended as soon as a dog fed from both bowls, or after 15 s, whichever was sooner. Across 108 trials, dogs needed between 1.26 and 14.59 s to approach the first bowl, and in 25 trials across 19 different dogs they did not approach the second bowl (one dog did not approach the second bowl on any of the three trials). Both the gaze and the pointing gesture given by the demonstrator were sustained for the duration of each trial as dogs use a continuous point cue more effectively than an instantaneous point cue (Bräuer et al., 2006).

A video camera was set up on a tripod and positioned to ensure that the footage captured the movement of the dog from behind the barrier and the position and facial expression of the demonstrator (Fig. 1a and b).

Between each trial, dogs were given a short break (typically between 5 and 10 min) away from the room while the other dogs in their block of six completed their trial. Owners were instructed to keep their dog on the lead or take them back to their car (not allowing high arousal exercise or play) in between trials, to avoid any change in the dogs' mood impacting on the results. This break was designed to minimise carry-over effects from one condition to the next. For this reason, three different colour bowls were also used for each of three trials.

The following variables were recorded from the video recording: (1) the facial expression of the demonstrator (neutral/ happy/ angry) for the trial, (2) which bowl the dog approached (putting their nose in it or touching it) first within 15 s (i.e. the bowl which was pointed at/ looked at/ none) and (3) the latency of approach to the chosen bowl (i.e. the elapsed time from the owner releasing the dog to the dog approaching

the bowl).

2.3. Data analysis

Two trials (one each from two separate dogs, but both involving the angry facial expression) out of a total of 108 trials were removed from analysis because the dogs failed to approach a bowl within the time allowed. All statistical analyses were undertaken using Minitab 18.0 and Sofastats v1.4.6. An initial Ryan Joiner normality test indicated that the time taken to approach the first bowl was not normally distributed ($p > 0.05$). Therefore, non-parametric tests were used throughout.

A chi-square test was used to test for significant associations between the choice made (approaching the bowl to which the demonstrator was either facing or pointing) and the demonstrator's facial expression (happy, angry or neutral). Cumulative binomial probability distribution tests were used to examine whether dogs had a preference for a particular gesture overall, and within each test condition. Mann Whitney and Kruskal Wallis tests were used to evaluate differences in the latency of response according to bowl chosen (pointed at versus looked at) and facial expression respectively, with common language effect sizes (CLES) used to indicate the likelihood of a randomly selected subject from one group having a greater score than a subject selected from the other group, where the differences were significant.

Subjects were grouped into high and low scorers based on whether they scored below/equal to or above the median score for the population for each of the temperament assessments (PANAS and DIAS). Chi-square tests were then used to determine whether impulsivity or positive/negative activation was associated with either choice of bowl under each of the facial expression conditions or the latency of dogs' responses in the trials overall.

3. Results

As expected, there was no general association between the demonstrator's facial expression and the bowl chosen (point: angry = 24, neutral = 24, happy = 19 vs face: angry = 10, neutral = 12, happy = 17; Chi Square = 2.666, d.f. = 2, $p = 0.26$) or the time taken to approach a bowl (Kruskal Wallis = 1.731, d.f. = 2, $p = 0.42$, Table 1). Although two trials for the 'angry' condition were excluded from this analysis as the dogs did not approach either bowl within the time allowed, including the data from these subject as lowest rank latencies, did not change the effect seen.

However, dogs were more likely to approach the bowl being pointed at over the bowl being looked at (63% vs 37% of trials; cumulative binomial probability, $p < 0.001$). They also approached the 'pointed at' bowl more quickly than the 'faced' bowl (median approach time: 2.29 s vs 2.56 s; Mann Whitney U = 950.0, $p = 0.019$, CLES = 0.733 Fig. 2).

Our primary interest concerned dogs' preferences for the 'pointed at' versus 'faces' bowl within conditions (i.e. with different facial expressions), and these effects are described in Fig. 3. Dogs were significantly more likely to approach the 'pointed at' bowl when the demonstrator displayed angry expressions (cumulative binomial probability, $p = 0.01$), with a similar but weaker effect seen with neutral expressions ($p = 0.03$), but there was clearly no significant preference when the demonstrator displayed a happy expression ($p = 0.43$).

Table 1
Time Taken (s) to Approach Chosen Bowl According to Facial Expression.

	N	Median	Minimum	Maximum
Angry	34	2.32	1.38	7.35
Happy	36	2.81	1.26	14.59
Neutral	36	2.35	1.38	10.36

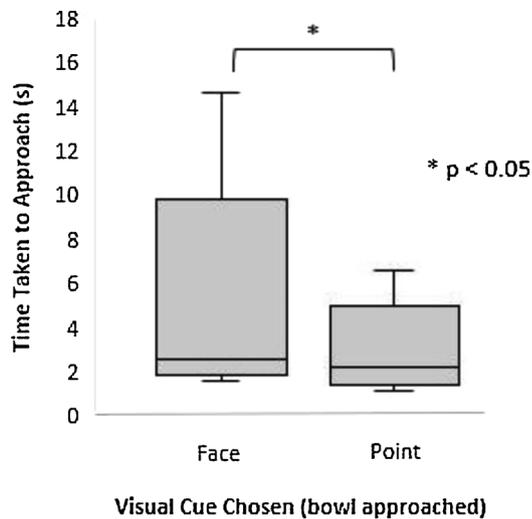


Fig. 2. Median (represented by bold lines) and interquartile range (represented by boxes) for time taken to approach when given conflicting visual cues. The whiskers indicate the minimum and maximum measures.

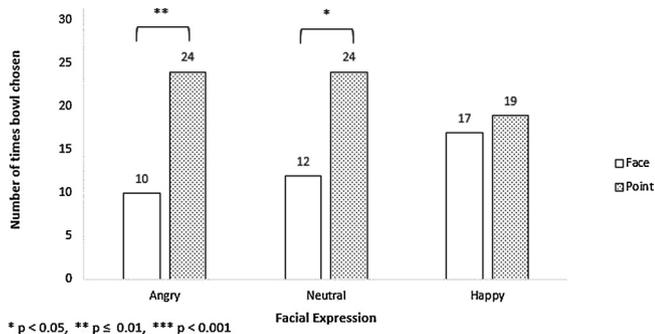


Fig. 3. Number of times each bowl/cue was chosen (Point vs. Face) for each facial expression condition (angry $N = 34$, neutral $N = 36$, happy $N = 36$).

Concerning demographic factors that might relate to these findings, there were no significant associations between bowl choice and the classification of the dog with regards to age group (< 1 yr, 1–3yrs, > 3 yrs $\chi^2 = 0.747$, $d.f. = 1$, $p = 0.69$), negative activation ($\chi^2 = 0.294$, $d.f. = 1$, $p = 0.59$), positive activation ($\chi^2 = 1.226$, $d.f. = 1$, $p = 0.27$) or impulsivity ($\chi^2 = 0.095$, $d.f. = 1$, $p = 0.76$), nor was there an association between the choice of bowl within any of the conditions and the facial expression at that time dependent on whether the subjects were high or low scoring for positive or negative activation (high/low positive activation vs choice of face/point orientation for angry facial expression, $\chi^2 = 0.83$, $d.f. = 1$, $p = 0.36$; high/low negative activation vs choice of face/point orientation for angry facial expression, $\chi^2 = 0.283$, $d.f. = 1$, $p = 0.59$; high/low positive activation vs choice of face/point orientation for happy facial expression, $\chi^2 = 0.01$, $d.f. = 1$, $p = 0.92$; high/low negative activation vs choice of face/point orientation for happy facial expression, $\chi^2 = 0.09$, $d.f. = 1$, $p = 0.77$; high/low positive activation vs choice of face/point orientation for neutral facial expression, $\chi^2 = 1.50$, $d.f. = 1$, $p = 0.22$; high/low negative activation vs choice of face/point orientation for neutral facial expression, $\chi^2 = 1.41$, $d.f. = 1$, $p = 0.24$). However, as might be expected, there was some evidence that the latency of approach was related to the dogs' impulsivity. Those dogs scoring higher than the median for impulsivity (DIAS) approached the bowl more quickly than those with lower impulsivity scores (median approach time: 2.30 s vs 2.42 s; Mann Whitney $U = 1067$, $p = 0.034$, $CLES = -0.823$). There was no

significant difference in approach latency based on the dogs' classification for either positive ($p = 0.995$) or negative activation ($p = 0.598$). Furthermore, the sex and neuter status of the dogs had no significant impact on the choice of bowl ($\chi^2 = 7.399$, $d.f. = 3$, $p = 0.06$) or latency of approach (Kruskal Wallis = 0.55, $d.f. = 3$, $p = 0.91$).

4. Discussion

Consistent with previous findings (Bräuer et al., 2006; Miklósi et al., 1998), we found that in the presence of conflicting human directional gestural signals, dogs generally prefer to approach a bowl being pointed at by a human over a bowl being looked at. We also found that dogs chose to approach the pointed bowl more quickly, supporting previous suggestions that the pointing gesture is easily processed by dogs (Carballo et al., 2016). However, our primary interest was whether the facial expression of the demonstrator affects the dog's cued response bias and this was clearly the case. We used a stratified approach to the analysis of our data, as recommended by Perneger (1998) in order to balance the risk of Type II statistical errors associated with the use of adjustments for multiple testing like Bonferroni which assume that all null hypotheses are simultaneously true. When using a stratified approach, the focus of any concern relating to multiple testing should primarily relate to the number of tests used to evaluate the primary hypotheses of interest. Statistical tests of other relationships should then be considered exploratory. Accordingly, we report the significance values for all tests, with common language effect sizes given for the significant differences in the scalar data results, so that readers can judge for themselves the risk of Type I errors for those results found to be significant at $p < 0.05$ given the effect reported. Using this approach, it should be recognised that there were three hypotheses tested simultaneously concerning the effect of facial expression on bowl choice preference (one for each expression). Thus it is clear that (even with a Bonferroni adjustment) dogs preferred to approach the pointed bowl over the faced bowl when the facial expression was angry and showed no preference when the facial expression was happy. The significance of the effect of a neutral face is more debatable ($p = 0.03$), but we suggest is consistent with previous work on gaze bias in relation to facial expression (Racca et al., 2012) which found that the neutral face may have negative associations. Given these results, it is worth noting, that much previous research on pointing has tended to use a human demonstrator displaying gestural signals with a neutral facial expression, presumably to minimise emotional interaction effects, but this might not be having the desired effect, if dogs do indeed interpret a neutral face as aversive. It is not possible to determine from this study, whether the effect seen reflects an enhanced significance given to the pointing gesture when the face is angry or neutral, or a loss of significance when the face is happy.

It is well established that in monkey and chimpanzee societies, where long fixation towards a conspecific face represents a strong signal of threat (Dunbar, 1991), viewers often simply look at the face briefly to reduce direct gaze contact, especially when encountering faces with angry/aggressive expression or without clear approaching signals (e.g. McFarland et al., 2013). Eye-tracking studies also report similar gaze avoidance behaviour in dogs: they spent less time viewing neutral human faces compared to dog faces (Somppi et al., 2012). Additionally, in comparison with unfamiliar human happy faces in full frontal view, dogs looked preferentially at the lower half of angry faces, avoiding eye contact with a potentially threatening human (Barber et al., 2016), and were reluctant or resistant to approach the angry faces (Müller et al., 2015). Hence it is plausible when two contradictory directional signals are simultaneously presented in the context of 'angry facing' and 'pointing' gestures, dogs chose to avoid the 'facing' gesture and thus followed the 'pointing' gesture. Although it is also possible, that in the presence of an angry face, they may decide to follow the more overt pointing cue.

Such explanation could also be applied to interpret the findings from neutral facial expressions, if these expressions are interpreted as negatively valenced. Neutral human faces do not have clear approach signals and are often judged by other human viewers as cold or even threatening (Lee et al., 2008). From the dogs' perspective, it is rare for someone to respond to a dog in a genuinely neutral way and so the neutral expression may be classified as uncertain and thus psychologically categorised alongside negative human emotions and responded to accordingly (e.g. by showing avoidance behaviour) (Racca et al., 2012). By contrast, no clear avoidance behaviour was observed when the demonstrator displayed happy expressions. Rather than avoiding the facial cue when it is perceived to be negatively valenced, it is possible that the dogs were encouraged to approach the 'face' bowl when there was a positive (happy) facial expression, i.e. following the 'point' gesture over the 'face' gesture would be the typically expected response but the introduction of a happy facial expression enhanced an alternative to the 'normal' response. Either way these results indicate a sensitivity by dogs to human emotional expression that needs to be carefully considered in both an experimental and practical setting (such as training).

Although it might be expected that individuals who score more highly in positive activation may approach a potential food reward more readily and/or those scoring more highly on negative activation might be more avoidant of a relatively unfamiliar individual and thus slower to approach, we found no relationship between the dogs' personality and their approach responses to the conflicting directional gestural signals displayed by the demonstrator overall or with different facial expressions. This might be because the scale used (PANAS, Sheppard and Mills, 2002) was developed largely to assess sensitivity to non-social signals of reward and punishment, and so may not have predictive validity in this sort of social setting. Although a previous report has indicated that dog's individual responses to different human facial expressions (time spent looking at the stimulus) was significantly correlated with personality questionnaires and genotypes (Hori et al., 2011), it could be argued that time spent looking at facial expressions bears no meaningful relation to the approach decisions the dogs had to make in our study. In addition, it is not clear what personality questionnaires were used by Hori et al. (2011). However, we did find evidence of the perhaps more obvious relationship between impulsivity and approach latency. Those scoring more highly for impulsivity approached more quickly than those with a lower score for impulsivity. This result provides further validation of this scale as a measure of behavioural executive function reactivity (Riemer et al., 2014), and indicates that impulsivity may be an important variable to control for, when using any form of response latency as the measure of interest in a dog's response.

In conclusion, this study demonstrated that when facing conflicting human-given directional gestural signals, dogs were more likely to avoid something which is being looked at with a potentially negative facial expression and to preferentially choose the item which is being pointed at (and looked away from) instead. By contrast, dogs responded to both the 'point' and 'look' signal at equal chance when the human facial expression was 'happy'. The findings support the view that dogs may categorise neutral human facial expression as a form of negative emotion (Racca et al., 2012), and that they show a functional understanding of common human facial expressions (Albuquerque et al., 2018); being able to apply such understanding within dog-human interactions. However, it should be noted the current observation was based on static human facial expressions and gesture signals. Future studies could introduce more dynamic and naturalistic manipulations into this research along with more detailed assessment of the factors that moderate the observed effect. Nonetheless, it is clear that dogs' perception of human faces may be far more complex than is routinely given credit in scientific research.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.beproc.2018.12.022>.

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