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Is that fear? Domestic dogs' use of social referencing signals from an unfamiliar person

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ABSTRACT

The aim of this study was to investigate whether dogs could successfully interpret a 'social referencing' cue (either happiness or fear) toward an object after viewing a human emotional expression. Fearful expressions are more likely to be unfamiliar to dogs, and thus they may not understand the meaning of such expressions. When confused, dogs could avoid contact with an object as in Merola et al. (2012, 2011). The present study compared an experimenter's fearful or happy response when an ambiguous object appeared with a control condition (experimenter was confusing). We examined 114 dogs in one of three conditions; happiness, fearful and the control. We found that dogs were more attentive to the experimenter when she displayed the fearful and control expressions compared to when happy, with no difference between the control and fear conditions. When left alone with the toy, they showed a similar pattern – more interest in the toy in both the fearful and control conditions. Our findings suggest that dogs may not understand the cues in the fearful and control conditions and instead respond with a possible attempt to gain more information from the experimenter.

1. Introduction

Social referencing, a form of referential communication, is often tested in an ambiguous situation and requires a reference towards another to guide one's actions (Klinnert et al., 1986; Stenberg and Hagekull, 2007). For instance, a mother expresses either fear or happiness toward an object and then observes a human infant's reaction to the object. Studies have investigated facial expressions (Sorce et al., 1985), vocal expressions (Mumme et al., 1996), as well as combined facial and vocal signals (Kim et al., 2010) with similar conclusions. When a mother expresses fear toward an object, infants tend to avoid the object. In contrast, infants tend to approach the object when viewing a mother's happy expression. Furthermore, studies with a familiar (parent) (Rosen et al., 1992) or unfamiliar (experimenter) person (Klinnert et al., 1986) as the informant produce similar responses in infants.

Studies involving nonhuman primates such as chimpanzees (*Pan troglodytes*), (Itakura, 1995; Russell et al., 1997), and macaques (*Macaca sylvanus*) (Roberts et al., 2008) have provided evidence that social referencing can occur both within and between species. Infant chimpanzees witnessed happy or fearful expressions toward a familiar object by a human caregiver (Russell et al., 1997). The infant chimpanzees avoided the object when a fearful expression was given, but looked longer at the object when a happy expression was given.

Because dogs have been domesticated, with certain qualities selected for in breeding over others, one might assume that they could reference a human experimenter's facial or vocal gestures, and therefore, regulate their behavior towards an object. Even if dogs had no innate tendency for social referencing, domestication might have assisted dogs in learning this skill for it is beneficial to recognize human emotions because happy humans tend to be more attentive compared to sad ones (Seligman, 2002).

Two canine social referencing studies showed that dogs may not have understood neutral expressions in a human's face and find it confusing (Buttelmann and Tomasello, 2013; Merola et al., 2013). Dogs had no preference for choosing a box when the experimenter displayed happiness and neutral (Buttelmann and Tomasello, 2013), while in another study, dogs preferred the positive expression versus neutral (Merola et al., 2013).

Two studies tested social referencing in dogs using a fan with green ribbons as the ambiguous stimulus (Merola et al., 2012, 2011) with familiar and unfamiliar informants presenting emotional expressions to dogs. Dog owners presented the emotional

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expressions in the first study (Merola et al., 2011), and in the second study, the informants were either the owners ("familiar") or the experimenter ("unfamiliar") (Merola et al., 2012). Regardless of familiarity, dogs explored the fan when the emoter expressed happiness and were less willing to explore the fan when the emoter expressed fear. Expressions were conveyed through a combination of facial, vocal and bodily cues. The consistent findings over these two studies suggest that the emoter's familiarity to the dog is not crucial to whether they socially reference in ambiguous situations. However, in a third study, when the emoter displayed happiness toward one box and fear toward another, dogs chose a box randomly when the emoter was a stranger, but chose insightfully when the emoter was the owner (Merola et al., 2013). The researchers argue that dogs are more familiar with their owner's expression of happiness compared to that of the stranger, and suggest that dogs might perform somewhat better when the informant is familiar. Nevertheless, there remain doubts regarding the interpretation of canine success on this task. Canine reluctance to explore the fan can be perceived as insightful (indicating an understanding of the threat conveyed by fear and the absence of threat conveyed by happiness) or non-insightful (with a fearful expression creating confusion, or wariness though emotional contagion in the dog, leading the dog to avoid the object).

1.1. Aims and hypothesis

In the present study, we examined canine referencing of human emotional expressions. As stated above, social referencing studies typically employ one positive (e.g. happiness) and one negative (e.g. fear) emotion. However, the contrast between these two emotions is not ideal when examining dogs because happiness is likely to be much more familiar to the dog. Indeed, familiarity with an expression does seem to play a role in deciding which box or object a dog will select (Buttelmann and Tomasello, 2013; Merola et al., 2012, 2011).

The aim of the present study was to investigate whether dogs could successfully interpret a 'social referencing' cue (either happiness or fear) toward an object, but unlike in previous studies, we included one additional control cue. We suspect that fearful expressions are most likely to be unfamiliar to dogs compared to happy expressions and that dogs may not understand the meaning of fearful expressions and thereby become confused. A likely response, when confused, is that dogs will look to the experimenter, seeking more information, and avoid contact with an object as in Merola et al. (2012, 2011). Therefore, an important control for potential canine confusion is for the experimenter to respond toward the toy in a way that, like fear, is unfamiliar, but unlike fear, conveys no emotional content about the object. The control expression selected in the present study involved the experimenter pretending to be a chicken. Although somewhat bizarre and humorous to a knowledgeable human, this expression would be unfamiliar and confusing to a dog, yet would convey no emotional content about the object. The question was whether dogs would show a similar level of wariness toward the toy as when the experimenter reacted fearfully.

2. Method

2.1. Subjects

One hundred and fourteen dogs (69 females, $M = 5.24$ years, $SD = 3.13$) participated in this study (Appendix A). Dogs were recruited from advertisements placed in the university newsletter, local canine clubs and flyers distributed to dog owners from the local city council. Dog owners were given a petrol voucher as compensation for participating in the study, and dogs received sausage pieces as reward at completion.

2.2. Experimental design

The experimental design was a between-subjects design, with each dog participating in only one of the three conditions (happiness, fear, or control), and with random assignment to condition. Out of the 114 dogs, 37 were presented with happiness, 38 with fear, and 39 with the control condition.

2.3. Materials

The ambiguous objects were two remote-controlled toy robots. Each robot was 30 cm tall and 18 cm wide, and had moving arms and legs, and a helmet. When the remote was activated, the robot glided forward with a soft mechanical sound. The robots glided out from a makeshift garage (30 cm × 50 cm × 40 cm cardboard box with two white sheets of paper, 21 cm × 30 cm, as doors).

2.4. Procedure

At the beginning, the dog was given 10 min to explore the experimental area in the presence of the owner (3.0 m × 3.2 m) (Appendix B). The experimental area also contained a couch, and a desk with a chair. Owners were asked to verify whether dogs were familiar with the toy robot and only four dogs had experience with a similar toy robot at home. No food was provided to the dog, and water was provided *ad libitum*. The owner was then separated from the dog and waited in another room before the experiment began.

The experimenter sat on the floor facing the dog, and parallel to the makeshift garage placed on the floor, calling out the dog's name to get its attention and without bringing any attention to the garage. While the dog was attending to her, the experimenter pressed the remote control hidden in her left palm for the robot to emerge from the garage. The robot moved approximately 0.8 m from the garage. As the toy glided towards the dog, the experimenter displayed either a happy, fearful or control expression for approximately 20 s. For happiness and fear, the experimenter alternated her gaze between the toy and the dog to indicate her expression referred to the toy. After the emotional display, the experimenter left the room for one minute, leaving the dog alone with the toy.

The happy expression included smiling, a pleasant face, tilting the head slightly on both sides, saying "aww", and pointing towards the robot. The experimenter moved in tandem with the robot (which was also towards the dog) calmly, and after the 'happy' display, she stood and left the room calmly. The fearful expression consisted of widely opened eyes, a furrowed brow, pulled-back lips, a slightly opened mouth, audible sounds such as gasps, and pointing towards the robot while the experimenter moved away from the toy rapidly. The experimenter then stood up, glanced briefly at the toy and left the room quickly. In the control condition, the experimenter mimicked a chicken–tucking her fingers under each armpit and flapping her arms, making audible clucking noises, tilting her head from side to side, and duck-walking in circles from the garage towards the opposite wall. She did not look at the dog or the toy throughout the expression and left the room without making eye contact with the dog or toy.

2.5. Emotion expression analysis

To check on human interpretations of the experimenter's emotional presentations in this experiment, we presented 89 videos (78%) taken during emoting to 20 university students (18 females, $M = 19.5$ years, $SD = 2.03$) to determine whether the portrayed expressions were correctly identified. For each video, participants

Table 1
Mean number of correct responses for the categorization of expressions.

Expression	Mean number of correct responses (max = 20)	Mean correct response (%)	*p*-value (one-tailed)
Happy	18.5	93	< .001
Fearful	12.6	63	< .001
Control	17.3	86	< .001

were asked to choose one option from seven: Anger, Disgust, Fear, Happy, Sad, Surprise, Other. They were informed that the emotion expressions were at times clearly identifiable and sometimes not. Participants were generally successful at identifying all three expressions. A binomial test showed that participants were able to identify emotions at a level above chance responding (chance = 14.3% correct), including the control condition identified as "other" (Table 1). In general, fear was harder to identify than happiness, a result that mimics general findings for facial expressions of emotions (Young et al., 2010).

2.6. Measured variables

All behavioral coding was conducted by two coders. The primary coder was blind to the conditions and to the hypothesis, and was not involved in collecting data. The secondary coder, the first author of this paper, coded 33% of the dogs for inter-rater reliability. The coding was divided into two parts; during emoting and when alone with the toy. The variables coded during emoting were time spent looking at the experimenter's face and at the toy, number of looks at the toy, and overall interest in the experimenter and toy. At every 2-second interval, interest was coded on the basis of canine gaze, that is, whether dogs looked towards the experimenter, the toy, or toward something else, with interest towards a target coded as 1 (present) or 0 (not present). The variables coded when dogs were left alone with the toy were number of looks at the toy, time spent looking at the toy, overall interest in the toy (coded every 2 s as above), and proximity to the toy. For proximity, the room was divided into three sub-sections (close to toy, close to door, the area in-between) and canine position in the room was coded. The correlations between the two coders indicate acceptable inter-rater reliability (Table 2).

Table 2
Inter-rater correlations for each measured variable for both phases.

Phase	Item	Inter-rater correlation, r_s
While emoting	Time looking at experimenter's face	.72
	Time looking at toy	.94
	Number of looks at toy	.98
	Interest in toy	.95
	Interest in experimenter	.92
Alone with toy	Interest in toy	.95
	Interest in experimenter	.95
	Proximity to toy	.93
	Proximity to door	.91
	Proximity to in-between area (not close to toy or door)	.94

3. Results

The raw data were examined using Shapiro-Wilk's test for normality (all *ps* < .01), and together with the histograms, suggested that the data were non-normal. For this reason, non-parametric analyses were used.

3.1. During emoting

Fig. 1 shows canine attention towards the toy and the experimenter while she was displaying an emotional expression. Dogs attended to the toy differently across the three expressions, $p < .01$ (Kruskal-Wallis Test). Each pair was then analyzed using Mann-Whitney U tests with Holms correction for multiple comparisons. Dogs paid more attention to the toy when the experimenter looked happy compared to the control condition, $U = 399.50$, $p < .01$, $r = .39$, and when fearful compared to the control, $U = 410.50$, $p < .01$, $r = .39$. In contrast, there was no difference in attention to the toy in the happy and fearful conditions, $U = 671.00$, $p = .73$, $r = .04$.

Canine attention to the experimenter was also significantly different across the three expressions, $p < .01$ (Kruskal-Wallis Test). Dogs paid more attention to the experimenter in the control condition compared to the happy condition, $U = 431.50$, $p < .01$, $r = .35$, and in the fear condition compared to the happy condition, $U = 501.50$, $p = .03$, $r = .25$, but there was no significant difference in attention to the experimenter in the fear and control conditions, $U = 657.50$, $p = .39$, $r = .10$.

3.2. Alone with toy

Fig. 2 shows canine interest in the toy when the dog was left alone with the toy. Canine interest in the toy was significantly different between the three conditions, $p = .02$ (Kruskal-Wallis Test). Each pair was then analyzed using Mann-Whitney U tests with Holms correction for multiple comparisons. Dogs were more interested in the toy in the fear, $U = 477.50$, $p < .01$, $r = .28$, and control conditions, $U = 491.50$, $p < .02$, $r = .28$, compared to the happy condition. There was no difference in interest toward the toy in the fear and control conditions, $U = 718.00$, $p = .81$, $r = .03$. None of the other variables such as number of looks at the toy, and time spent looking at the toy were significantly different in the three conditions, all *ps* > .13 (Kruskal-Wallis Test). In addition, we checked for fearful responding using criteria established in previous research

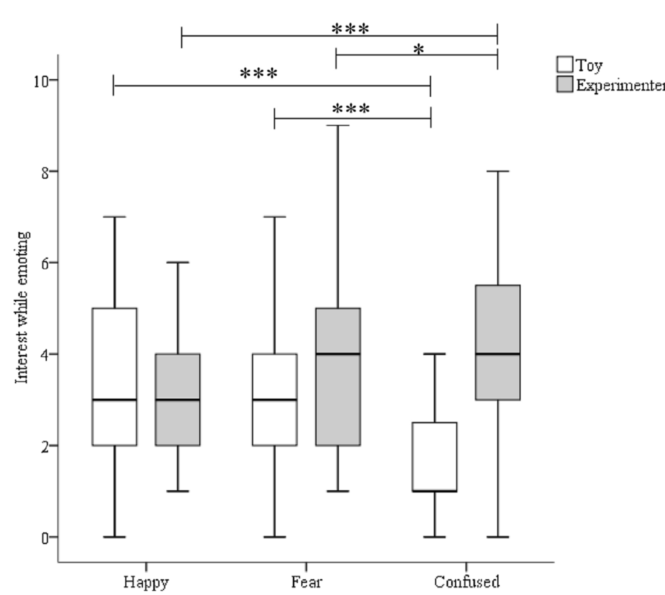

Fig. 1. Box and whisker plot displaying canine median interest to the toy and to the experimenter while the experimenter was emoting.

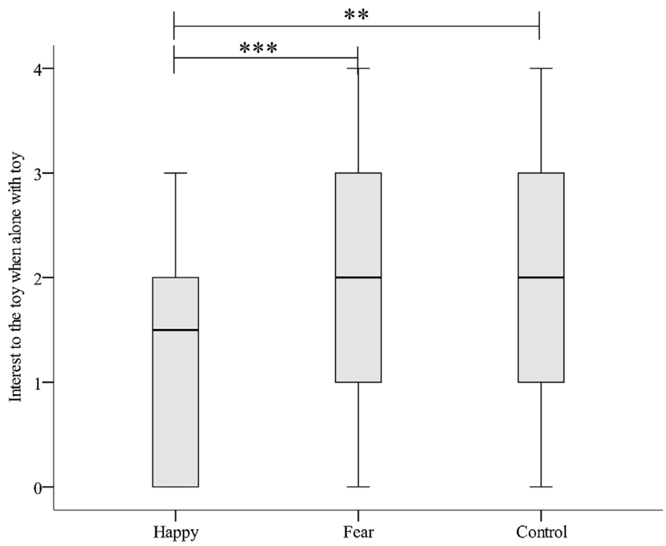

Fig. 2. Box and whisker plot displaying canine median interest to the toy when the dog was left alone with the toy.

(Beerda et al., 1998; Blackwell et al., 2013; Dreschel and Granger, 2005; Dreschel, 2010). There was no evidence of fearful responding, such as yawning (0 dogs), 'whale eye' (seeing the whites of the dog's eyes in a half moon shape as the dog looks away) (0 dogs), whining (0 dogs) or barking (3 dogs barked).

There was no difference in canine proximity to the toy across the three conditions, $p > .33$ (Kruskal-Wallis Test), with only non-significant and weak trends for dogs to spend more time near the toy when the experimenter had expressed happiness ($Mdn = 3.28$ s) compared to fear ($Mdn = 1.89$ s) or the control condition ($Mdn = 2.97$ s) (Fig. 3).

3.3. Cue salience

When displaying an emotional expression, there were four relevant components: arm movements, vocalizations, body movements, and emotional expressions. With regard to arm movements, the experimenter pointed at the toy consistently using her index finger while emoting in the happy and fear conditions, whereas there were whole arm movements in the control condition, although it is not clear which type of movement would be more salient. Second, the experimenter made different vocalizations in each condition (aww's for happy, gasps for fear, and clucking for control) (Fig. 4). We checked two thirds of the dogs tested (total $n = 84$; 26 happy, 30 fear, 28 confused). On average, the experimenter uttered "aww" for 9.21 s in the happy condition, gasped for 11.96 s in the fearful condition, and clucked for 14.23 s in the control condition. Using a one-way ANOVA, the vocalizations were significantly different in length between the three conditions, F (2, 81) = 68.77, $p < .001$. Paired t-tests showed that the experimenter spent more time clucking compared to gasping, t (57) = 52.01, $p < .001$, and compared to awws, t (54) = 29.93, $p < .001$. The experimenter also spent more time gasping compared to awws, t (56) = 36.53, $p < .001$. Third, the experimenter sat on the floor in the happy and fearful conditions, but displayed more active body movements (duck-walking) in the control condition. Fourth, the experimenter's emotional expression was relatively intense in the fear and happy conditions, but neutral in the control condition. Thus, in some ways the experimenter's behavior in the control condition might have been more salient, but in other ways her behavior might have been more salient in the fear and happy conditions.

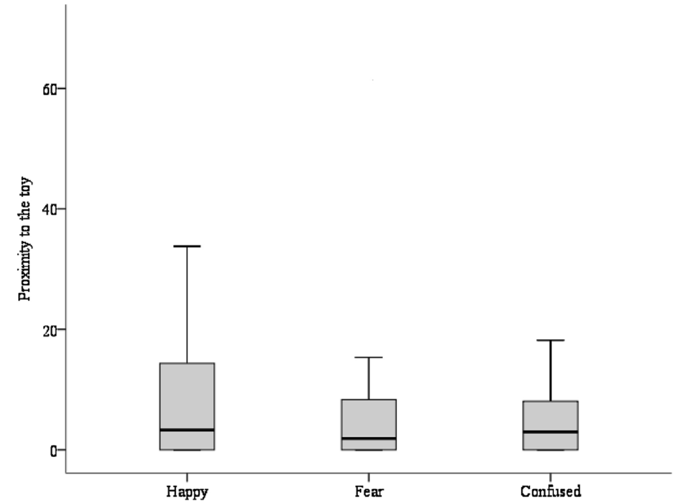

Fig. 3. Box and whisker plot displaying canine proximity to the toy when the dog was left alone with the toy.

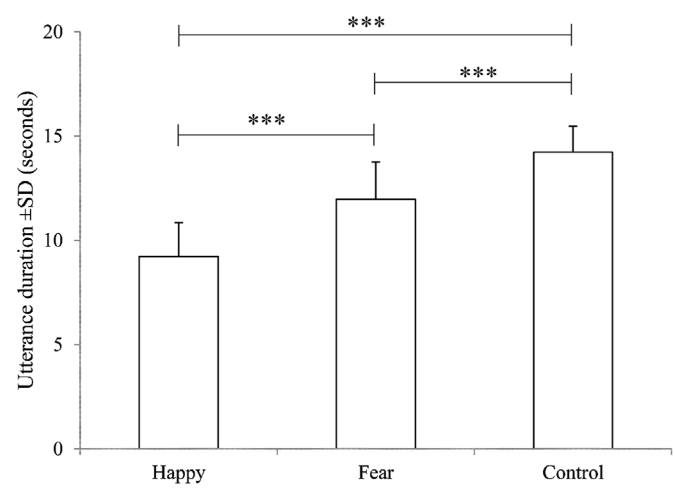

Fig. 4. Mean utterance duration while the experimenter was emoting.

4. Discussion

There were two main findings from the two phases in the present study. First, during emoting, dogs were more attentive to the experimenter when she was displaying the control and fearful expressions compared to when happy, with no difference between the control and fear conditions. In contrast, dogs were more attentive to the toy during the happiness and fearful expressions compared to the control, with no difference between happiness and fear. Second, when dogs were left alone with the toy, they looked more at the toy in both the fear and control conditions compared to the happy condition, and again, with no difference between control and fear.

If dogs understood the meaning behind each expression, we would expect them to be most attentive to both the toy and the experimenter in the fearful condition compared to control and happy conditions during both emoting and when left alone with the toy. Instead, dogs showed inconsistent interest to the toy and the experimenter during emoting, looking more at the toy during the happy and fearful displays and more at the experimenter during the fearful and control display. One could argue that greater canine interest in the experimenter during emoting in the fear and control condition was due to the greater salience of the experimenter's actions. Three points are relevant to this argument. First, in some ways (i.e. the intensity of the emotional reaction), the experimenter's behavior was likely more salient during the fear and happy conditions than the control. Second, one component of salience (the length of the experimenter's auditory output) was greatest during the control, second highest during fear, and lowest during happiness. If this component of salience was responsible for canine responding, then interest in the toy versus the experimenter should have clearly reflected the three levels of salience, yet it did not. Third, canine responding was measured not only when the experimenter was displaying an expression, but also *after the dog was left alone with the toy*, at which time there was no cue to respond to.

Crucially, when left alone with the toy, dogs had a similar response in the fear and control conditions so that even if cue salience could explain some facet of canine responding during the emoting, it is not clear what dogs would do after the experimenter left when there was no cue to respond to. In particular, after the experimenter had left, dogs responded very similarly in the control and fear conditions despite the potentially different cue salience in these conditions when the experimenter was present. This suggests that dogs' differential reaction in the happy and fear conditions may have stemmed from confusion rather than emotional insight. That is, when confronted with the fearful expression (and the control expression), dogs may have become confused leading them to look towards and check the toy after the experimenter had left. Furthermore, greater canine attention to the experimenter while emoting in the fear and control conditions can be perceived as an attempt to *gain more information* about the situation because they failed to understand the emotional cues. Zarbatany and Lamb (1985) found a similar response in human infants - 'uncertain' infants who were unclear about the emotional expressions from the emoter looked longer at the fearful face but were less likely to approach the adult, compared to 'certain' infants who were more likely to approach the adult and less likely to approach the object (toy spider).

Although dogs may not understand the emotional content of the experimenter's fear expression, it is known that they use human expressions (e.g. pointing) to guide their behavior (Udell and Wynne, 2008). We think it is likely that they attempt to do the same in the present paradigm, yet dogs are confused by the human expression of fear. When left alone with the toy, a confused dog might have been expected to look at the toy in an attempt to understand what the experimenter's earlier expression might have conveyed. In this sense, dogs might look to humans for information, and use human expressions to help guide their exploration of the world, yet they might not understand that a human's fearful expression conveys "fear" or "danger".

In attempting to reconcile the present results with those of past studies, three variables should be considered: who does the emoting (owner versus a stranger), what kind of toy is used, and the duration of the emotional display. First, in the present study, dogs may have chosen to ignore the expressions by a stranger and/or had heightened anxiety due to the owner's presence in another room. Zarbatany and Lamb (1985) proposed that human infants have a 'selectivity postulate', which meant that familiarity with primary caregivers would make messages from the caregiver a more powerful behavioral regulator of the infant's behavior (as opposed to messages from a stranger). However, in the present study (as in Buttelman and Tomasello, 2012, and Merola et al., 2011, 2012), dogs responded differently to the experimenter's fear and happiness cues, indicating that our use of the experimenter as emoter did not undermine the results.

Second, the robot itself may not have been sufficiently interesting or large to be perceived as a threat to the dog. The stimulus in social referencing studies generally evokes some degree of fear (Merola et al., 2011; Sorce et al., 1985). Yet again, the differential reaction of dogs in the three conditions suggests this was not responsible for the present results. That is, dogs were least interested in the toy after witnessing the experimenter expressing happiness towards it, but maintained an interest towards the toy in both the fear and control conditions.

Third, one could argue that the duration of the expression was too short. In the present study, the experimenter stopped displaying an emotional expression when the toy stopped moving, a procedure similar to human infants' social referencing studies (Kim et al., 2010; Klinnert et al., 1986). Nevertheless the expression in the present study was displayed for about 20 s, but the duration in human infant studies was longer–Klinnert et al. (1986) used one minute, and Kim et al. (2010) used 30 s, similar to Merola et al.'s (2011) study with dogs. Yet, despite the shorter duration in the present study, the distinct behavioral differences shown across the three conditions, and the similarity in canine responding in the present study and Merola et al. (2011) in the happy and fear conditions, suggests that cue duration was not the critical factor.

5. Conclusion

The findings of the present study make it uncertain whether dogs really understand the emotion conveyed in happy versus fearful cues. Dogs might simply become confused by fearful expressions and then avoid exploration of the environment.

Acknowledgments

We thank dog owners in Dunedin whom have participated in this research.

Appendix A.

A.1. Demographic data of participating dogs

No	Dog breed	Sex	Neutered	Age	Condition	Robot at home
1	French mastiff	Female	Yes	2.71	Happy	No
2	Labrador	Female	Yes	8.62	Happy	No
3	Labrador Retriever	Female	Yes	12.95	Happy	No
4	Golden Retriever	Female	Yes	11.84	Happy	Yes
5	Labrador	Female	Yes	4.32	Happy	No
6	Staffy	Female	No	2.55	Happy	No
7	Huntaway Collie cross	Female	No	1.75	Happy	No
8	Boxer	Female	Yes	9.22	Happy	No
9	Golden Retriever	Female	Yes	2.18	Happy	No
10	Schnauzer	Female	Yes	2.59	Happy	No
11	Staffordshire bull terrier	Female	Yes	7.37	Happy	Yes
12	English Setter	Female	Yes	4.28	Happy	No
13	Lab cross	Female	Yes	1.25	Happy	No
14	Shetland Sheepdog	Female	Yes	10.19	Happy	No
15	Collie/Husky/Heading	Female	No	7.16	Happy	No
16	Labrador Retriever	Female	No	0.93	Happy	No
17	Labrador/Huntaway/Beagle cross	Female	Yes	1.33	Happy	No
18	Bearded collie/Huntaway cross	Female	Yes	6.67	Happy	No
19	Labrador	Female	No	1.08	Happy	No
20	Border Collie	Female	Yes	5.75	Happy	No
21	Maltese cross	Female	Yes	6.67	Happy	No
22	Whippet	Female	Yes	2.67	Happy	No
23	Labrador	Female	Yes	4.25	Happy	No
24	Labrador/Huntaway	Male	Yes	5.72	Happy	No
25	Bearded collie/border collie x	Male	Yes	2.22	Happy	No
26	Labrador	Male	No	1.78	Happy	No
27	Golden Retriever	Male	Yes	7.76	Happy	No
28	English Setter	Male	Yes	10.12	Happy	No
29	Miniature poodle/Tibetan terrier	Male	Yes	1.97	Happy	No
30	Springer spaniel	Male	Yes	8.01	Happy	No
31	Collie/Husky/Heading	Male	No	2.60	Happy	No
32	Collie/Husky/Heading	Male	Yes	5.70	Happy	No
33	Labrador	Male	Yes	9.02	Happy	Yes
34	Jack Russell/fox terrier	Male	Yes	9.42	Happy	No
35	Chinese Crested	Male	Yes	2.58	Happy	No
36	Beardie/Huntaway	Male	Yes	6.42	Happy	No
37	Cairn Yorkshire Maltese terrier cross	Male	Yes	2.75	Happy	No
38	American Red-nose pitbull	Female	Yes	5.56	Fear	No
39	Labrador/Border collie	Female	No	2.37	Fear	No
40	Mini fox terrier	Female	Yes	4.35	Fear	No
41	Labrador/Greyhound/collie/bully	Female	Yes	1.85	Fear	No
42	Labrador	Female	Yes	4.32	Fear	No
43	Lab/collie	Female	Yes	1.64	Fear	No
44	Border Collie	Female	No	9.77	Fear	No
45	Border Collie	Female	Yes	5.95	Fear	No
46	Border Collie	Female	Yes	1.73	Fear	No
47	Border collie	Female	Yes	3.72	Fear	No
48	Beardie collie cross	Female	Yes	4.88	Fear	No
49	Schnauzer	Female	Yes	9.54	Fear	No
50	Labrador	Female	Yes	5.01	Fear	No
51	Staffy cross	Female	Yes	3.34	Fear	No
52	Golden Retriever	Female	Yes	5.42	Fear	No
53	Belgian Shepherd	Female	Yes	5.01	Fear	No
54	Boxer	Female	Yes	7.35	Fear	No
55	German Shepherd	Female	Yes	4.17	Fear	No
56	Black lab	Female	Yes	3.40	Fear	No
57	American Dingo	Female	Yes	9.92	Fear	No
58	Boxer/collie cross	Female	Yes	4	Fear	No
59	Labrador	Female	Yes	1.75	Fear	No
60	Staffordshire Bull Terrier Collie cross	Female	Yes	6.17	Fear	No
61	Labrador/Staffordshire Terrier	Male	Yes	5.38	Fear	No
62	Bichon Frise	Male	No	2.04	Fear	No
63	Lab huntaway cross	Male	Yes	7.00	Fear	No
64	Bearded collie	Male	No	1.55	Fear	No
65	Border collie/Siberian Husky	Male	Yes	5.38	Fear	No
66	German wire-haired pointer	Male	Yes	3.56	Fear	No
67	Lab cross	Male	Yes	8.65	Fear	No
68	Hungarian Viszla	Male	Yes	3.47	Fear	No
69	Labrador	Male	No	10.68	Fear	No
70	Golden Retriever	Male	Yes	5.42	Fear	No
71	Staffy cross	Male	Yes	4.41	Fear	No
72	Weimaraner	Male	Yes	3.42	Fear	No
73	Irish wolfhound	Male	Yes	9.42	Fear	No

Appendix A (*Continued*)

No	Dog breed	Sex	Neutered	Age	Condition	Robot at home
74	Collie blue heeler cross	Male	Yes	3.5	Fear	No
75	Staffordshire Terrier/Rottweiler cross	Male	Yes	2	Fear	No
76	Labrador/Poodle	Female	Yes	2.48	Confused	Yes
77	Belgian Shepherd	Female	No	1.61	Confused	No
78	Golden Retriever	Female	Yes	1.78	Confused	No
79	Labrador	Female	Yes	10.97	Confused	No
80	Border Collie	Female	No	7.14	Confused	No
81	Border Collie	Female	Yes	10.82	Confused	No
82	Griffon Bruxellois	Female	Yes	3.15	Confused	No
83	Border collie/German Shepard cross	Female	Yes	9.73	Confused	No
84	Miniature poodle	Female	No	1.01	Confused	No
85	Border collie	Female	Yes	9.41	Confused	No
86	Labrador	Female	Yes	8.39	Confused	No
87	Labrador cross	Female	Yes	7.89	Confused	No
88	Standard Poodle	Female	Yes	5.09	Confused	No
89	Collie/Husky/Heading	Female	Yes	2.60	Confused	No
90	Scottish terrier	Female	Yes	2.19	Confused	No
91	Spaniel cross	Female	Yes	6.75	Confused	No
92	Border Collie	Female	Yes	4.5	Confused	No
93	Cocker Spaniel/Labrador	Female	Yes	4.67	Confused	No
94	French bulldog	Female	No	4.42	Confused	No
95	English Pointer	Female	No	1.17	Confused	No
96	French bulldog	Female	Yes	6.5	Confused	No
97	Spoodle	Female	Yes	2.17	Confused	No
98	German Shepherd	Female	Yes	5.08	Confused	No
99	American Red-nose pitbull	Male	No	5.56	Confused	No
100	Spoodle	Male	Yes	4.79	Confused	No
101	Huntaway cross	Male	Yes	1.74	Confused	No
102	Beardie collie cross	Male	Yes	2.88	Confused	No
103	German Shepherd	Male	Yes	2.75	Confused	No
104	Cocker spaniel	Male	No	1.04	Confused	No
105	Australian Shepherd	Male	Yes	3.49	Confused	No
106	Huntaway cross	Male	Yes	7.60	Confused	No
107	Belgian Shepherd	Male	Yes	4.21	Confused	No
108	Huntaway/Staffordshire Terrier	Male	Yes	6.67	Confused	No
109	Lab cross	Male	Yes	11.52	Confused	No
110	Huntaway cross	Male	Yes	2.68	Confused	No
111	Collie cross	Male	Yes	11.86	Confused	No
112	Fox Terrier	Male	Yes	7.17	Confused	No
113	Staffy/Boxer/bull terrier/whippet cross	Male	Yes	10.33	Confused	No
114	Chihuahua/fox terrier cross	Male	Yes	12.33	Confused	No

Appendix B.

B.1. Experimental room set-up.

Fig. A.1

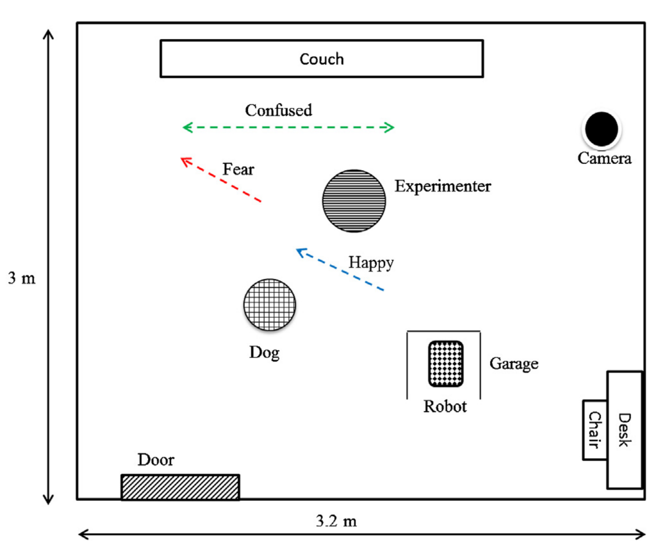

Fig. A.1.

The dashed arrows indicate the experimenter's movement in each emotion. The experimenter always exited from the room using the same door.

References

Beerda, B., Schilder, M.B.H., van Hooff, J.A.R.A.M., de Vries, H.W., Mol, J.A., 1998. Behavioural, saliva cortisol and heart rate responses to different types of stimuli in dogs. Appl. Anim. Behav. Sci. 58, 365–381, http://dx.doi.org/10.1016/S0168-1591(97)00145-7.

Blackwell, E.-J., Bradshaw, J.W.S., Casey, R.A., 2013. Fear responses to noises in domestic dogs: Prevalence, risk factors and co-occurrence with other fear related behaviour. Appl. Anim. Behav. Sci. 145, 15–25, http://dx.doi.org/10.1016/j.applanim.2012.12.004.

Buttelmann, D., Tomasello, M., 2013. Can domestic dogs (*Canis familiaris*) use referential emotional expressions to locate hidden food? Anim. Cogn. 16, 137–145, http://dx.doi.org/10.1007/s10071-012-0560-4.

Dreschel, N.A., 2010. The effects of fear and anxiety on health and lifespan in pet dogs. Appl. Anim. Behav. Sci. 125, 157–162, http://dx.doi.org/10.1016/j.applanim.2010.04.003.

Dreschel, N.A., Granger, D.A., 2005. Physiological and behavioral reactivity to stress in thunderstorm-phobic dogs and their caregivers. Appl. Anim. Behav. Sci. 95, 153–168, http://dx.doi.org/10.1016/j.applanim.2005.04.009.

Itakura, S., 1995. An exploratory study of social referencing in chimpanzees. Folia Primatol. (Basel) 64, 44–48, http://dx.doi.org/10.1159/000156831.

Kim, G., Walden, T.A., Knieps, L.J., 2010. Impact and characteristics of positive and fearful emotional messages during infant social referencing. Infant Behav. Dev. 33, 189–195, http://dx.doi.org/10.1016/j.infbeh.2009.12.009.

Klinnert, M.D., Emde, R.N., Butterfield, P., Campos, J.J., 1986. Social referencing: the infant's use of emotional signals from a friendly adult with mother present. Dev. Psychol. 22, 427–432, http://dx.doi.org/10.1037/0012-1649.22.4.427.

Merola, I., Prato-Previde, E., Lazzaroni, M., Marshall-Pescini, S., 2013. Dogs' comprehension of referential emotional expressions: familiar people and

familiar emotions are easier. Anim. Cogn., 1–13, http://dx.doi.org/10.1007/s10071-013-0668-1.
Merola, I., Prato-Previde, E., Marshall-Pescini, S., 2011. Social referencing in dog-owner dyads? Anim. Cogn. 15, 175–185, http://dx.doi.org/10.1007/s10071-011-0443-0.
Merola, I., Prato-Previde, E., Marshall-Pescini, S., 2012. Dogs' social referencing towards owners and strangers. PLoS ONE 7, e47653, http://dx.doi.org/10.1371/journal.pone.0047653.
Mumme, D.L., Fernald, A., Herrera, C., 1996. Infants' responses to facial and vocal emotional signals in a social referencing paradigm. Child Dev. 67, 3219–3237, http://dx.doi.org/10.1111/j.1467-8624.1996.tb01910.x.
Roberts, S.G.B., McComb, K., Ruffman, T., 2008. An experimental investigation of referential looking in free-ranging Barbary macaques (*Macaca sylvanus*). J. Comp. Psychol. 122, 94–99, http://dx.doi.org/10.1037/0735-7036.122.1.94.
Rosen, W.D., Adamson, L.B., Bakeman, R., 1992. An experimental investigation of infant social referencing: Mothers' messages and gender differences. Dev. Psychol. 28, 1172–1178, http://dx.doi.org/10.1037/0012-1649.28.6.1172.
Russell, C.L., Bard, K.A., Adamson, L.B., 1997. Social referencing by young chimpanzees (Pan troglodytes). J. Comp. Psychol. 111, 185–193.
Seligman, M.E.P., 2002. Authentic happiness: Using the new positive psychology to realize your potential for lasting fulfillment. Simon and Schuster, New York.
Sorce, J.F., Emde, R.N., Campos, J.J., Klinnert, M.D., 1985. Maternal emotional signaling: Its effect on the visual cliff behavior of 1-year-olds. Dev. Psychol. 21, 195–200, http://dx.doi.org/10.1037/0012-1649.21.1.195.
Stenberg, G., Hagekull, B., 2007. Infant looking behavior in ambiguous situations: Social referencing or attachment behavior? Infancy 11, 111, http://dx.doi.org/10.1080/15250000709336635.
Udell, M.A.R., Wynne, C.D.L., 2008. A review of domestic dogs' (*Canis familiaris*) human-like behaviors: or why behavior analysts should stop worrying and love their dogs. J. Exp. Anal. Behav. 89, 247–261.
Young, A.W., Perrett, D., Calder, A., Sprengelmeyer, R., Ekman, P., 2010. Facial expression of emotion: Stimuli and tests (FEEST). Thames Valley Test Company, Bury St Edmunds, England.
Zarbatany, L., Lamb, M.E., 1985. Social referencing as a function of information source: Mothers versus strangers. Infant Behav. Dev. 8, 25–33, http://dx.doi.org/10.1016/S0163-6383(85)80014-X.