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When facing an unfamiliar person, pet dogs present social referencing based on their owners' direction of movement alone

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When confronted with an unfamiliar object, dogs, *Canis familiaris*, engage in social referencing, i.e. synchronizing their reaction with that of their owner. The question of whether, like infants, they do so when confronted with an unfamiliar person, has not yet been studied. We tested the reactions of 72 pet dogs (36 shepherds and 36 molossoids) that were confronted with an unfamiliar person who approached them in a neutral manner. The dogs' owners were instructed to behave in one of three ways towards the stranger: stay still, approach or retreat. The dogs performed referential looks and gaze alternations between the experimenter and their owner. In the retreat condition, the dogs looked at the stranger significantly sooner and took significantly more time before first contact with the stranger compared to the approach condition. Moreover, in the retreat condition the dogs interacted more with their owners compared to other conditions. Additionally, sex had an effect on dogs' behaviours, with males looking towards their owner for information less than females. Breed also influenced dogs' reactions, with molossoid dogs behaving more independently than shepherd dogs. This study shows that pet dogs use social referencing with their owner in an approach paradigm involving a stranger. These findings provide evidence of similar processes in dogs with their owners and human infants with caregivers, and suggest a new way to manage dogs' reactions in public places.

The domestic dog, *Canis familiaris*, is a common species in human homes, and has had a long association with human society, beginning approximately 15 000 years ago (Ardalan et al., 2011; Savalainen, Zhang, Luo, Lundeberg, & Leitner, 2002). Consequently, dogs are sensitive to human communicative cues. For example, in an object choice task paradigm, dogs are able to find hidden food by exploiting a demonstrator's behavioural cues, including human pointing (Hare & Tomasello, 1999; Miklósi & Soproni, 2006; Soproni, Miklósi, Topál, & Csányi, 2001, 2002), gazing (Agnetta, Hare, & Tomasello, 2000; Miklósi, Polgárdi, Topál, & Csányi, 1998; Téglás, Gergely, Kupán, Miklósi, & Topál, 2012) and facial expressions (Buttelmann & Tomasello, 2013; Merola, Prato-Previde, & Marshall-Pescini, 2014; Turcsán, Szánthó, Miklósi, & Kubinyi, 2015), even if the owner is misleading them (Prato-Previde, Marshall-Pescini, & Valsecchi, 2008; Szetei, Miklósi, Topál, & Csányi, 2003). In a study by Miller, Rayburn-Reeves, and Zentall (2009), a bidirectional control procedure confronted dogs with a problem that could be solved by one of two strategies. In the absence of cues, dogs were equally likely to choose either strategy; however, if they witnessed a human demonstrator solving the problem with one strategy, dogs were more likely to adopt it (Miller et al., 2009). In another study by Kubinyi, Topál, Miklósi, and Csányi (2003), dogs were given a task that required the manipulation of a box which when opened provided access to a ball. Although there was an alternative method for getting access to the ball, dogs opened the box using the method that they saw their owner use (Kubinyi et al., 2003). This tendency to mimic the behaviour of humans is well established in dogs (Range, Huber, & Heyes, 2011). Finally, dogs are capable of forming strong bonds with their owners, aiding in their ability to integrate within human homes (Barrera, Jakovcevic, Elgier, Mustaca, & Bentosela, 2010; Gácsi, Topál, Miklósi, Dóka, & Csányi, 2001; Gaunet & Milliet, 2010).

While these abilities support cohabitation, interaction and communication between humans and dogs, and enable humans to handle dogs in their daily lives, there are still problems with people misunderstanding dogs' behaviour that can lead to biting and other aggressive behaviours (Cornellissen & Hopster, 2010; Ortolani, Vernooij, & Coppinger, 2009). This often occurs during

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encounters with a stranger in a public place (Casey, Loftus, Bolster, Richards, & Blackwell, 2014; Cornellissen & Hopster, 2010; Neessen, 2013). For this reason, dogs' sensitivity to the behaviour of strangers has been increasingly studied. Such studies typically use an approach paradigm, in which a stranger approaches the dog while the owner stands nearby, remaining still, without moving or speaking (Barrera et al., 2010; Gácsi, Vas, Topál, & Miklósi, 2013; Győri, Gácsi, & Miklósi, 2010; Kim et al., 2006; Lore & Eisenberg, 1986; Ortolani et al., 2009; Vas, Topál, Gácsi, Miklósi, & Csányi, 2005; Vas, Topál, Győri, & Miklósi, 2008). Some studies have shown that dogs are less likely to initiate contact with men than with women (Lore & Eisenberg, 1986; Wells & Hepper, 1999). However, dogs' behavioural reactions also depend on the behaviour of the stranger. When approached in a threatening way by a human, dogs exhibit more avoidance behaviours, averted gazes and vocalizations than when they are approached in a friendly way (e.g. Vas et al., 2005; Vas et al., 2008). Dogs also adjust their behaviour in response to changes in the behaviour of strangers. For example, if a human first approaches a dog in a friendly way, then in a threatening way, and finally switches back to friendliness, the dog typically adjusts its behaviour towards the stranger from passive/friendly to aggressive/avoiding and then back to friendly again (Barrera et al., 2010; Gácsi et al., 2013; Győri et al., 2010; Vas et al., 2005; Vas et al., 2008).

Previous studies using an approach paradigm have observed the reactions of shelter dogs or pet dogs to a stranger (Barrera et al., 2010; Gácsi et al., 2013; Győri et al., 2010; Kim et al., 2006; Lore & Eisenberg, 1986; Ortolani et al., 2009; Vas et al., 2005; Vas et al., 2008). In these studies, the caretaker or owner did not react to the stranger or give the dog any cues on how to react. In daily situations, however, owners typically interact with their dogs during encounters with unknown individuals. Finally, as mentioned above, dogs are sensitive to human behaviour and emotional cues, and use them to adjust their own behaviour.

The social referencing paradigm has recently been used to study the effect of owner reactions to a dog's behaviour directed at an unfamiliar object (Merola, Prato-Previde, & Marshall-Pescini, 2012a, 2012b; Merola, Marshall-Pescini, D'Aniello, & Prato-Previde, 2013). This paradigm originated in the study of interactions between human infants and their mothers. In this paradigm, a stranger or an unknown object is presented to the child in the mother's presence; the child's mother is instructed to behave in either a positive/curious way or a negative/frightened way. These studies have shown that infants' behaviour towards the stimulus (approaching or avoiding it) corresponds to their mothers' reaction (De Rosnay, Cooper, Tsigaras, & Murray, 2006; Klinnert, Emde, Butterfield, & Campos, 1986). Social referencing is characterized by two components: referential looks (gaze alternations between the stimulus and the informant) and behavioural regulation based on the informant's reaction (Russell, Bard, & Adamson, 1997). Recently, this ability has been studied in an interspecific context, between dogs and humans. Merola et al. (2012a, 2012b; 2013) found that when confronted with an unknown object, dogs alternated their gaze between a human (either their owner or a stranger) and the object. These authors also showed that dogs regulate their behaviour according to their owner's reactions; thus, when a dog's owner behaves negatively towards an object (e.g. fearful expression, frightened voice, moving away), the dog keeps its distance from the object for longer and is stiller than when the owner shows a positive and curious reaction (Merola et al., 2012a, 2012b, 2014). This confirms that dogs are influenced by their owners' behaviour towards a new stimulus: in these cases, an object.

These results led us to use the approach paradigm in a novel context, looking for a similar phenomenon in situations where dogs are confronted with an unfamiliar person rather than an unknown object, a situation that is highly relevant to the daily lives of dogs. For example, during walks dogs are often confronted with unusual/unfamiliar humans such as individuals with a different gait (e.g. elderly individuals) or people with different silhouettes, because, for example, they are wearing a hat. Better understanding dogs' reactions in such situations is essential. Importantly, during encounters between a dog and an unfamiliar person, it is difficult to ask the person to behave in a particular way to influence the behaviour of the dog. If owners were able to manage their dogs more effectively through the use of their own behaviour, this knowledge would be extremely useful. Furthermore, extending the study of social referencing in dogs to their responses to humans could provide evidence of similar processes to those in human infants (e.g. Gaunet, 2010; Gaunet & El Massioui, 2014). Thus, we decided to investigate whether the influence of dog owners' behaviours on their dogs' reaction during an encounter with a stranger. We tested two breed groups: shepherd dogs and molossoid dogs. Both are working breeds (herding and as guard dogs, respectively), are close to their owners (Eken Asp, Fikse, Nilsson, & Strandberg, 2015) and are more skilled at using human cues than other nonworking breeds (Mehrkam & Wynne, 2014).

Owners were asked to behave in different ways towards a stranger (either by approaching, standing still or retreating) while we observed the dogs' behavioural reactions. On the basis of previous studies on dogs' sensitivity to human behaviour, we hypothesized that the dogs would be sensitive to their owners' behaviour, synchronizing and adjusting their behaviour according to that of their owners (Aoki, Sakai, Miller, Visser, & Sato, 2013; Capella, 1981; De Rosnay et al., 2006; Gaunet, Pari-Perrin, & Bernardin, 2014; Merola et al., 2012a, 2012b). We therefore predicted that the dogs' behaviour would differ between conditions, and that in the retreat condition, the dogs would be slower to initiate contact with the stranger and interact less with her than in the approach and stand still conditions. We also predicted that the dogs' behaviour towards their owners would also be affected, with the dogs interacting more with or staying closer to their owner in the retreat condition than in the approach and stand still conditions. We also predicted that the dogs would be more synchronized with their owners if they moved (approach or retreat conditions) than if they did not move (stand still condition), since the latter does not involve any change in activity (Dostálková & Špinka, 2007; Kerepesi et al., 2005). Finally, possible effects from other factors such as dogs' sex, breed and age were examined in exploratory analyses.

METHODS

Participants

Fifty-eight owners (79% women) were recruited in Paris, France, and its surroundings. In total, 36 molossoid and 36 shepherd pet dogs (18 males and 18 females in each group) were tested. The dogs were between 1 and 13 years old (mean $\pm$ SE $= 5.3 \pm 0.38$ years) and did not show any signs of ageing (e.g. eye or joint problems) or behavioural problems (according to the owners' reports). The selected dogs were familiar with humans and were used to meeting strangers (for instance, during walks or home visits from unfamiliar people). They were all new to the test room.

Ethical Note

The dogs were not physically or psychologically harmed in the course of our study. They were free to move in the room without physical constraints and did not undergo any physical intervention

(such as blood or saliva sampling). After the test, all dogs returned home with their owners.

Procedure

Dogs were tested in an unfamiliar, empty, quiet room (5.92 × 5.80 m) in the AVA Animal Rescue Center (Cuy-St-Fiacre, France). At the beginning of the experiment the dog was given 10 min to roam freely in the room while Experimenter 1 and the dog's owner were present. This allowed the dog to become familiar with the space. Meanwhile Experimenter 1 explained the procedure of the test to the owner, with instructions on how to behave corresponding to the single condition randomly assigned to each dyad. The dog, its owner and the experimenter then left the room. The test lasted for a maximum of 2 min. In all conditions the owner entered the room with the dog off leash, and walked to a predefined location (location SS; see Fig. 1). After 15 s, the owner gently called the dog towards him or her (Area 1; see Fig. 1). As soon as the dog entered Area 1 (the dog's location was monitored by Experimenter 1 through a window, hidden from the dog), Experimenter 2, who was unfamiliar to the dog, entered the room. Looking only at the owner, she took three regular steps towards another predefined location (location E; see Fig. 1). As soon as the experimenter started to walk, the owner moved to (or remained in) the second predefined location, still facing the experimenter, according to the condition. In the approach condition, the owner took three regular steps towards the experimenter (location AP); in the stay still condition, the owner remained in the same place (location SS); and in the retreat condition, the owner took three regular steps away from the experimenter (location MB). Experimenter 2 and the owner then remained in these locations for 1.5 min.

Throughout the test, the dogs were off leash. The owners were instructed not to show any emotional reaction, talk to their dogs or look at them: their task was to look at Experimenter 2 without saying anything or making any gestures. Experimenters 1 and 2 were the same individuals for all trials.

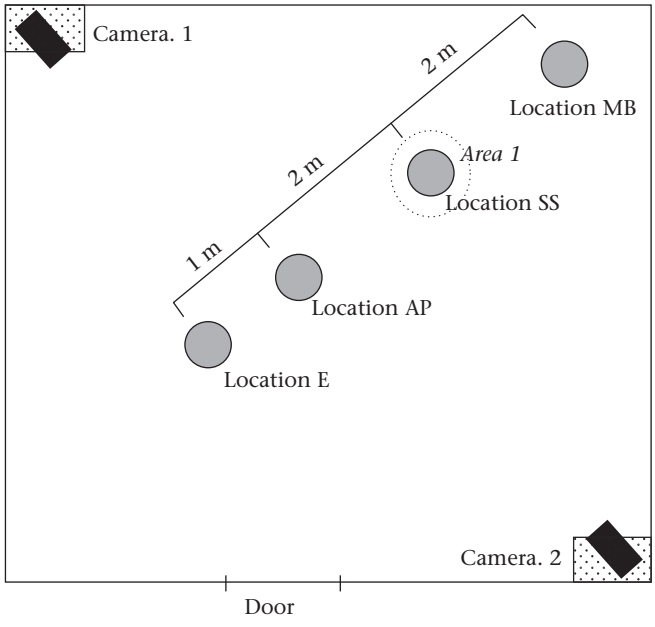

Figure 1. Experimental setting. Location of the experimenter (E) and different locations of the owners according to the condition (approach (AP), stand still (SS) or retreat (MB)).

Behavioural Analysis

All trials were recorded by two video cameras. The different locations were marked on the floor, and the room was marked out in 1 m squares. Behaviours were then recorded with Actogram Kronos 2 (actogram-kronos.software.informer.com/). The variables studied for all conditions are described in Table 1.

To test the reliability of the behavioural analysis, a blind coder who was unaware of the hypotheses and of the aims of the study was trained to use Actogram Kronos, and then coded a randomly selected subset of 40% of the data from both the occurrence and duration variables. The resulting Pearson correlation coefficients were good (first gaze at experimenter: 74% agreement, $P < 0.001$; first gaze at owner: 86% agreement, $P < 0.001$; first contact with experimenter: 99% agreement, $P < 0.001$; first contact with owner: 94% agreement, $P < 0.001$; time spent gazing at owner: 98% agreement, $P < 0.001$; time spent in contact with experimenter: 99% agreement, $P < 0.001$; number of shaking, grooming and urinating behaviours: 100% agreement).

Statistical Analysis

To analyse the potential effects of experimental condition, sex, age and breed and any interactions between them on dogs' behavioural responses, we used R (version 3.2.0, The R Foundation for Statistical Computing, Vienna, Austria, http://www.r-project.org). Data from all three test phases were included in the analysis. To test whether the numbers of referential looks and gaze alternations were significantly greater than zero, we used permutation tests. For variables that were normally distributed and that did not exhibit heteroscedasticity (referential looks, gaze alternations, latencies, gazes, contacts, indices, duration of stress-associated behaviours, proximity), we used analyses of variance (ANOVA); where needed, we carried out post hoc comparisons with Holm-Bonferroni corrections for multiple tests. For the binomial variable (urination), we used the generalized linear model (GLM); and where needed we carried out post hoc comparisons with Holm-Bonferroni corrections for multiple tests. Correlations were performed to test for effects of age. We used backward elimination to remove nonsignificant interactions from the models. As no dog barked during the test, and only two dogs growled, we did not analyse these variables.

RESULTS

Only variables with significant results are provided in the text; nonsignificant results are available in the tables. All descriptive data are provided in Table 2.

Referential Looks and Gaze Alternations

One of the aims of this study was to assess whether dogs engaged in referential looks and gaze alternations between the stranger and their owner, one of the two essential criteria for social referencing. Among the 72 pet dogs, 76.4% showed at least one referential look between the experimenter and their owner, while 72.2% showed at least one gaze alternation. Table 3 shows that the number of referential looks and gaze alternations was significantly greater than zero for each level of condition, sex and species, as well as for all dogs pooled together.

There was no significant effect of condition, breed or age on the number of referential looks and gaze alternations. There was, however, a significant effect of sex with female dogs making more referential looks and gaze alternations than male dogs (see Table 4 and Fig. 2).

Table 1
Variables used in the study

Category	Variable	Description of behaviour
Referencing	Number of referential looks	The dog gazed consecutively at experimenter and owner (or vice versa) within 2 s
	Number of gaze alternations	The dog gazed first at owner, then at experimenter, then back to owner; or first at experimenter, then at owner, then at experimenter
Behavioural modification	Gaze at owner (duration and latency, s)	The dog looked at the owner (i.e. head directed towards the owner)
	Gaze at experimenter (duration and latency, s)	The dog looked at the experimenter (i.e. head directed towards the experimenter)
	Index for behaviours towards owner	The index of behaviours of dogs towards owners=((duration+occurrences) of moving towards the owner)/2
	Index for behaviours towards experimenter	The index of behaviours of dogs towards experimenter=((duration+occurrences) of moving towards the experimenter)/2
	Proximity (duration, s)	The dog was 1 m or less from the owner
	Contact with owner (duration and latency, s)	At least one part of the dog's body touched one part of the owner's body
	Contact with experimenter (duration and latency, s)	At least one part of the dog's body touched one part of the experimenter's body
Stress-related behaviours	Dog movements (duration, s)	The dog moved, i.e. walked, trotted or ran in the room without interacting with its environment
	Stress-related behaviours (duration, s)	The dog performed at least one of the following behaviours: body shake, self-grooming, yawn, licking lips
	Urination (yes/no)	The dog urinated at least once in the room
Vocalizations	Whine (duration in seconds)	The dog whined
	Growl (yes/no)	The dog growled at least once
	Bark (yes/no)	The dog barked at least once

The variables are defined following Beerda, van Hooff, de Vries, & Mol, 1998; Deldalle & Gaunet, 2014; Gaunet & Deputte, 2011; Savalli, Ades, & Gaunet, 2014; Merola et al., 2012a, 2012b. Three behaviours were coded as binomial variables (instead of durations or numbers) because very few dogs performed them.

Table 2
Descriptive data for all variables

Variable	Approach (*N*=24)	Stand still (*N*=24)	Retreat (*N*=24)	Male (*N*=36)	Female (*N*=36)	Molossoid (*N*=36)	Shepherd (*N*=36)
Referential looks	2.79±0.58	2.92±0.47	2.50±0.49	2.05±0.36	3.42±0.44	2.39±0.42	3.08±0.40
Gaze alternations	1.70±0.41	2.04±0.42	2.46±0.48	1.53±0.30	2.61±0.39	2.25±0.44	1.89±0.25
Latency gaze at owner	20.77±4.71	20.07±4.38	13.48±2.26	23.03±4.10	13.26±1.69	22.22±3.80	14.07±2.36
Gaze at owner	10.30±1.74	15.20±1.95	18.14±2.85	11.48±1.63	17.62±2.00	14.57±2.07	14.53±1.69
Latency move towards owner	30.92±5.51	28.71±5.45	16.92±4.15	30.43±4.43	20.60±3.88	31.44±5.17	19.59±2.70
Index: owner	3.12±0.51	5.14±0.79	6.85±1.18	4.98±0.63	5.08±0.49	4.24±0.55	5.83±0.54
Latency contact owner	67.75±7.03	58.12±7.19	58.99±7.79	68.15±5.30	55.10±6.43	67.72±5.77	55.52±6.04
Contact with owner	4.06±1.84	2.32±1.19	7.71±3.45	2.28±0.99	7.12±2.50	6.45±2.52	2.94±1.03
Proximity with owner	56.79±5.23	32.02±6.54	33.22±6.78	40.55±5.04	40.80±6.63	40.50±5.22	40.85±4.43
Latency gaze at experimenter	1.36±0.07	1.30±0.05	1.15±0.04	1.28±0.06	1.26±0.03	1.27±0.03	1.27±0.06
Gaze at experimenter	30.28±3.30	30.62±2.46	37.18±4.04	33.24±2.82	32.16±2.69	36.60±3.13	28.30±2.44
Latency move towards experimenter	1.82±0.23	4.98±3.05	7.01±4.18	3.96±2.04	5.25±2.80	4.57±2.63	4.65±2.25
Index: experimenter	4.49±0.40	5.50±0.63	6.10±1.13	6.13±0.79	4.60±0.43	5.32±0.76	5.40±0.50
Latency contact experimenter	4.44±0.42	14.36±5.70	27.50±8.00	11.23±3.90	19.66±5.59	15.06±4.64	15.82±5.09
Contact with experimenter	20.05±3.12	19.83±4.05	11.60±2.37	20.34±3.12	13.98±2.52	22.02±3.50	12.3±1.74
Stress-related behaviours	2.09±0.80	0.62±0.30	0.99±0.27	1.28±0.45	1.19±0.41	1.34±0.40	1.14±0.46
Dog's movements	26.21±3.32	30.34±6.19	30.25±6.17	29.07±2.57	28.79±2.94	26.08±2.94	31.78±2.48
Whines	2.56±1.23	2.90±0.99	3.41±1.53	2.32±0.76	3.60±1.19	1.52±0.48	4.39±1.29
Urinate	0.04±0.04	0.09±0.06	0.22±0.11	0.17±0.06	0.03±0.03	0.05±0.04	0.14±0.06

Data presented in the table are mean ± SE.

Table 3
Mean numbers and comparisons with zero for referential looks and gaze alternations

Group	*N*	Referential looks			Gaze alternations		
		Mean±SE	*Z*	*P*	Mean±SE	*Z*	*P*
Retreat condition	24	2.50±0.49	−4.10	<0.01	2.46±0.48	−4.14	<0.01
Approach condition	24	2.79±0.58	−3.96	<0.01	1.70±0.41	−3.58	<0.01
Stand still condition	24	2.92±0.47	−4.64	<0.01	2.04±0.42	−3.99	<0.01
Male	36	2.05±0.36	−4.72	<0.01	1.53±0.30	−4.38	<0.01
Female	36	3.42±0.44	−5.73	<0.01	2.61±0.39	−5.29	<0.01
Molossoid	36	2.39±0.42	−4.70	<0.01	2.25±0.44	−4.41	<0.01
Shepherd	36	3.08±0.40	−5.67	<0.01	1.89±0.25	−5.63	<0.01
All dogs pooled	72	2.74±0.29	−7.35	<0.01	2.07±0.25	−6.79	<0.01

Data are provided for all dogs pooled and for each modality of the three factors tested (permutation tests for all).

Table 4
Referential looks and gaze alternations

Dependent variables	Independent variables	*F*	*df*	*P*	ES	95% CI
Referential looks	Condition	0.09	2, 66	0.90	0.07	see text
	Sex	**5.50**	**1, 66**	**0.02**	**0.56**	**0.23 to 2.50**
	Breed	11.26	1, 66	0.26	0.28	−0.47 to 1.86
	Age	0.78	1, 66	0.38	−0.13	−0.35 to 0.10
Gaze alternations	Condition	0.88	2, 66	0.42	0.14	see text
	Sex	**4.70**	**1, 66**	**0.03**	**0.52**	**0.11 to 2.06**
	Breed	0.67	1, 66	0.41	0.17	−1.37 to 0.65
	Age	1.03	1, 66	0.31	−0.10	−0.33 to 0.13

ANOVAs were conducted. Bold type indicates significant results. When condition had a significant effect, details of the post hoc comparisons with 95%CI are provided in the text. ES = effect sizes, corresponding to Cohen's *f* for condition, Cohen's *d* for sex and breed and Pearson's *r* coefficient for age.

Behavioural Modification of the Dogs

Behaviours towards the owner

There was no significant effect of condition, breed or age on the time it took the dog to gaze at his or her owner. There was, however, a significant effect of sex, with female dogs waiting for a shorter period of time before first looking at their owners than male dogs (see Fig. 3 and Table 5). There was no significant effect of breed and age on the total time the dog looked at his or her owner. There was a significant effect of condition, but the effect was not significant after correction for multiple tests (conditions approach/retreat: $F_{1,46} = 5.51$, $P = 0.02$, Cohen's $d = 0.68$, 95% CI = [1.08–14.59]; conditions approach/stand still: $F_{1,46} = 3.50$, $P = 0.07$, Cohen's $d = 0.54$, 95% CI = [0.37–10.16]; conditions retreat/stand still: $F_{1,46} = 0.72$, $P = 0.40$, Cohen's $d = 0.25$, 95% CI = [4.03–9.90]). There was, however, a significant effect of sex, with female dogs spending more time looking at their owners than male dogs (Table 5).

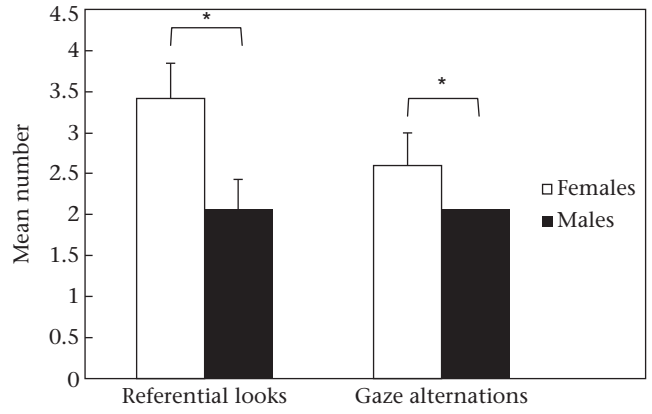

Figure 2. Dogs' gazing behaviour in relation to sex. Females: $N = 36$; males: $N = 36$. ANOVAs: $^*P < 0.05$. Error bars show + SE.

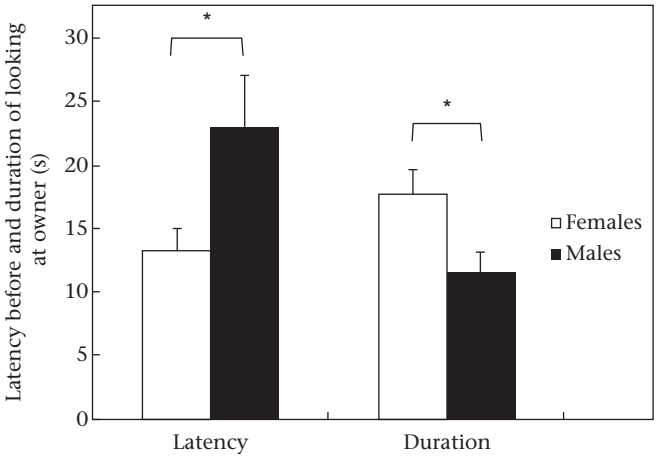

Figure 3. Dogs' gazing behaviour towards owners in relation to sex. Females: $N = 36$; males: $N = 36$. ANOVAs: $^*P < 0.05$. Error bars show + SE.

Moreover, there was no significant effect of condition, sex or age on the time it took the dog to move towards his or her owner. There was, however, a significant effect of breed, with shepherd dogs waiting for a shorter period of time before first moving towards their owners than molossoid dogs (see Table 5). Additionally, there was no significant effect of sex, breed or age on the number of behaviours made by the dog towards his or her owner. There was, however, a significant effect of condition with dogs exhibiting more behaviours towards their owners in the retreat and stand still conditions than in the approach condition (conditions approach/retreat: $F_{1,46} = 16.70$, $P < 0.01$, Cohen's $d = 1.18$, 95% CI = [1.87–5.59]; conditions approach/stand still: $F_{1,46} = 9.31$, $P < 0.01$, Cohen's $d = 0.88$, 95% CI = [0.68–3.36]; conditions retreat/stand still: $F_{1,46} = 2.89$, $P = 0.09$, Cohen's $d = 0.49$, 95% CI = [0.32–3.74]; see Fig. 4 and Table 5).

Finally, there was no significant effect of age and breed in the time the dog spent in proximity with his or her owner. There was, however, a significant interaction between condition and sex. In the approach condition, male dogs spent significantly more time near their owners than female dogs ($F_{1,22} = 6.09$, $P = 0.02$, Cohen's $d = 1.00$, 95% CI = [−43.09 to 3.59]), whereas males and females did not differ in the stand still ($F_{1,22} = 1.70$, $P = 0.20$, Cohen's $d = 0.53$, 95% CI = [−7.74 to 33.87]) and retreat ($F_{1,22} = 0.82$, $P = 0.37$, Cohen's $d = 0.37$, 95% CI = [−14.25 to 36.31]) conditions. There was no significant effect of condition, sex or breed on the total time the dog spent in contact with his or her owner. There was, however, a significant effect of age, with older dogs spending significantly more time in contact with their owners than younger dogs (see Table 5).

Behaviours towards the experimenter

There was no significant effect of sex, breed or age on the time it took the dog to gaze at the experimenter. There was, however, a significant effect of condition, with dogs waiting for a shorter period of time before their first look at the experimenter in the retreat condition than in the approach condition (conditions approach/retreat: $F_{1,46} = 6.40$, $P = 0.01$, Cohen's $d = 0.73$, 95% CI = [0.04–0.36]; conditions approach/stand still: $F_{1,46} = 0.58$, $P = 0.45$, Cohen's $d = 0.22$, 95% CI = [−0.10 to 0.23]; conditions retreat/stand still: $F_{1,46} = 4.55$, $P = 0.04$, Cohen's $d = 0.62$, 95% CI = [0.01–0.23]; see Table 6). Additionally, there was no effect of condition, sex or age on the total time the dog spent looking at the experimenter. There was, however, a significant effect of breed, with molossoid dogs looking longer at the experimenter than shepherd dogs (see Table 6).

Moreover, there was no significant effect of sex, breed or age on the time it took the dog to come in contact with the experimenter. There was, however, a significant effect of condition, with dogs waiting for a longer period of time before their first contact with the experimenter in the retreat condition than in the approach condition (conditions approach/retreat: $F_{1,46} = 8.29$, $P < 0.01$, Cohen's $d = 0.83$, 95% CI = [39.67 to −6.50]; conditions approach/stand still: $F_{1,46} = 3.02$, $P = 0.09$, Cohen's $d = 0.50$, 95% CI = [−21.73 to 1.88]; conditions retreat/stand still: $F_{1,46} = 1.79$, $P = 0.18$, Cohen's $d = 0.39$, 95% CI = [−33.00 to 6.68]; see Fig. 5 and Table 6). Finally, there was no significant effect of sex or age on the total time the dog

Table 5
Behaviours of dogs towards their owners

Dependent variables	Independent variables	*F*	*df*	*P*	ES	95% CI
Latency gaze at owner	Condition	1.92	2, 65	0.15	0.18	See text
	Sex	**5.97**	**1, 65**	**0.02**	**0.52**	**18.68 to −0.85**
	Breed	0.87	1, 65	0.35	0.43	−17.11 to 0.81
	Age	0.88	1, 65	0.35	0.07	−0.16 to 0.30
Gaze at owner	Condition	**3.28**	**2, 66**	**0.04**	**0.30**	**See text**
	Sex	**6.00**	**1, 66**	**0.02**	**0.56**	**1.02 to 11.26**
	Breed	<0.01	1, 66	0.95	<0.01	−5.38 to 5.29
	Age	0.81	1, 66	0.37	0.10	−0.13 to 0.32
Latency move towards owner	Condition	2.68	2, 66	0.08	0.25	See text
	Sex	2.97	1, 66	0.09	0.39	−21.57 to 1.93
	Breed	**3.99**	**1, 66**	**0.05**	**0.48**	**0.15 to 23.56**
	Age	1.26	1, 66	0.26	0.11	−0.12 to 0.34
Index: owner	Condition	**9.60**	**2, 66**	**<0.01**	**0.52**	**See text**
	Sex	0.02	1, 66	0.89	0.03	−1.49 to 1.68
	Breed	**4.90**	**1, 66**	**0.03**	**0.48**	**0.04 to 3.12**
	Age	0.25	1, 66	0.62	0.05	−0.28 to 0.18
Latency contact with owner	Condition	0.52	2, 66	0.60	0.12	See text
	Sex	2.41	1, 66	0.12	0.37	−29.69 to 3.58
	Breed	2.05	1, 66	0.15	0.34	−28.86 to 4.46
	Age	0.04	1, 66	0.83	0.05	−0.18 to 0.28
Proximity with owner	Condition	**6.1**	**2, 66**	**<0.01**	**0.12**	**See text**
	Sex	<0.01	1, 66	0.96	<0.01	−13.40 to 13.90
	Breed	0.10	1, 66	0.92	0.01	−13.31 to 14.00
	Age	0.26	1, 66	0.61	0.08	−0.15 to 0.31
Contact with owner	Condition	0.82	2, 66	0.45	0.20	See text
	Sex	3.64	1, 66	0.06	0.42	−0.60 to 10.26
	Breed	1.32	1, 66	0.25	0.30	−9.00 to 1.98
	Age	**5.22**	**1, 66**	**0.02**	**0.30**	**0.07 to 0.49**

Results of the ANOVAs are provided, with bold type indicating significant results. When condition had a significant effect, details of the post hoc comparisons with 95%CI are provided in the text. ES = effect sizes, corresponding to Cohen's *f* for condition, Cohen's *d* for sex and breed and Pearson's *r* coefficient for age.

spent in contact with the experimenter. There was, however, a significant interaction between condition and breed, with molossoid dogs spending more time in contact with the experimenter than shepherd dogs in the stand still condition ($F_{1,22} = 9.31$, $P < 0.01$, Cohen's $d = 1.25$, 95% CI = [−42.08 to −7.11]), whereas no difference was found in either the approach ($F_{1,22} = 0.46$, $P = 0.50$, Cohen's $d = 0.28$, 95% CI = [−17.50 to 8.93]) or retreat ($F_{1,22} < 0.01$, $P = 0.96$, Cohen's $d = 0.03$, 95% CI = [−8.97 to 8.42]) conditions (see Fig. 6 and Table 6).

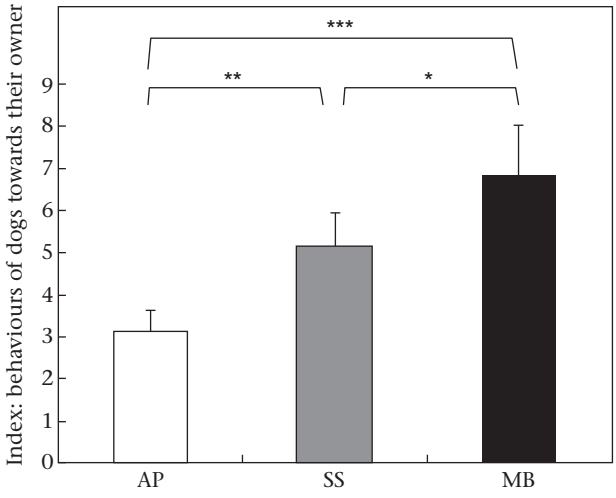

Figure 4. Dogs' behaviours towards their owners in relation to condition. MB = retreat condition, $N = 24$; SS = stand still condition, $N = 24$; AP = approach condition, $N = 24$. ANOVA: $^{*}P < 0.1$; $^{**}P < 0.01$; $^{***}P < 0.001$. Error bars show + SE.

Stress-related behaviours and vocalizations

There was no effect of breed or age on the total time the dog spent moving. There was, however, a significant interaction between condition and sex. Male dogs spent significantly more time moving in the stand still and retreat conditions than in the approach condition (conditions approach/retreat: $F_{1,22} = 9.16$, $P < 0.01$, Cohen's $d = 1.24$, 95% CI = [−29.04 to −5.06]; conditions approach/stand still: $F_{1,22} = 6.37$, $P = 0.02$, Cohen's $d = 1.03$, 95% CI = [−22.17 to 1.98]; conditions reatreat/stand still: $F_{1,22} = 0.56$, $P = 0.46$, Cohen's $d = 0.31$, 95% CI = [−18.78 to 8.83]; see Table 7), whereas no difference was found for female dogs (conditions approach/retreat: $F_{1,22} = 1.42$, $P = 0.24$, Cohen's $d = 0.49$, 95% CI = [−6.64 to −24.6]; conditions approach/stand still: $F_{1,22} = 0.27$, $P = 0.60$, Cohen's $d = 0.21$, 95% CI = [−11.49 to 19.12]; conditions retreat/stand still: $F_{1,22} = 0.57$, $P = 0.46$, Cohen's $d = 0.31$, 95% CI = [−8.97 to 19.29]; see Table 7). There was also a significant effect of breed with shepherd dogs spending more time moving than molossoid dogs (see Table 7).

Moreover, there was no significant effect of condition, sex or breed on the time a dog spent whining. There was, however, a significant effect of age with younger dogs whining longer than older dogs (see Table 7). Finally, there was no significant effect of condition, breed or age on the likelihood that a dog urinated. There was, however, a significant effect of sex, with more males urinating than females (see Table 7).

DISCUSSION

The aim of the present study was to investigate whether dogs would show signs of social referencing and modify their behaviour towards a stranger based on their owners' reaction in an approach paradigm. Dogs performed referential looks and gaze alternations when presented with a stranger, and as predicted, dogs were more hesitant in approaching the unfamiliar person in the retreat condition than in the approach and stand still conditions. It was also evident that dogs displayed more owner-directed behaviours in the retreat condition than in the approach condition. Our results thus supported our hypothesis that dogs display social referencing and synchronization with their owners. Additionally, female dogs looked more towards their owners than male dogs, and molossoid dogs interacted more with the unfamiliar person than shepherd dogs.

In the present study, all dogs looked at the experimenter soon after she entered the room. Three-quarters of the dogs made referential looks and alternated their gaze between their owners and the stranger, indicating that they were seeking information on how to behave from their owners. Previous research established that dogs engaged in social referencing in response to an unfamiliar object (Merola et al., 2012a, 2012b); we found that this extends to a stranger, as reported in human infants (Russell et al., 1997). Importantly, the rate of information-seeking behaviours was stable across the three conditions. Stress-related behaviours also did not differ depending on the owner's response to the stranger. Several factors may explain these findings: first, our selection of dogs were used to meeting unfamiliar people; second, we asked owners to perform smooth displacements, which are common in daily life; and lastly, there was an absence of obvious emotional signals.

The second essential point regarding social referencing was the observation that dogs adjusted their behaviour in response to that of their owners. Our findings showed a significant effect of condition on the dogs' attitude towards the experimenter. In the retreat condition, the dogs took significantly less time before their first look at the stranger and took significantly more time before their first contact with the stranger than in the approach condition. This suggests that the backward steps that their owners took made the

Table 6
Behaviours of dogs towards the experimenter

Dependent variables	Independent variables	*F*	*df*	*P*	ES	95% CI
Latency gaze at experimenter	Condition	**4.07**	**2, 66**	**0.02**	**0.33**	**See text**
	Sex	0.06	1, 66	0.80	0.06	−0.15 to 0.11
	Breed	0.09	1, 66	0.76	0.04	−0.12 to 0.14
	Age	2.57	1, 66	0.11	0.15	−0.09 to 0.37
Gaze at experimenter	Condition	1.52	2, 66	0.22	0.20	See text
	Sex	0.09	1, 66	0.77	0.06	8.85 to 6.69
	Breed	**5.57**	**1, 66**	**0.02**	**0.55**	**1.26 to 16.27**
	Age	0.29	1, 66	0.59	<0.01	−0.24 to 0.22
Latency move towards experimenter	Condition	0.78	2, 66	0.31	0.15	See text
	Sex	0.12	1, 66	0.73	0.09	−5.63 to 8.20
	Breed	<0.01	1, 66	0.96	<0.01	−6.83 to 7.00
	Age	0.70	1, 66	0.40	−0.09	−0.32 to 0.14
Index: experimenter	Condition	1.09	2, 66	0.34	0.18	See text
	Sex	2.87	1, 66	0.09	0.40	−3.33 to 0.27
	Breed	<0.01	1, 66	0.97	0.02	−1.75 to 1.91
	Age	0.28	1, 66	0.59	−0.05	−0.28 to 0.18
Latency contact with experimenter	Condition	**3.95**	**2, 66**	**0.02**	**0.35**	**See text**
	Sex	1.67	1, 66	0.20	0.29	−5.20 to 22.05
	Breed	0.03	1, 66	0.85	0.03	−13.00 to 14.50
	Age	0.68	1, 66	0.41	0.11	−0.13 to 0.33
Contact with experimenter	Condition	2.43	2, 66	0.09	0.24	See text
	Sex	3.64	1, 66	0.06	0.37	−14.37 to 1.65
	Breed	**6.02**	**1, 66**	**0.02**	**0.58**	**−17.58 to −1.86**
	Age	1.05	1, 66	0.31	0.10	−0.13 to 0.33

Results of the ANOVAs are provided, with bold type indicating significant results. When condition had a significant effect, details of the post hoc comparisons with 95%CI are provided in the text. ES = effect sizes, corresponding to Cohen's *f* for condition, Cohen's *d* for sex and breed and Pearson's *r* coefficient for age.

dogs more visually attentive to the unfamiliar stimulus and more reluctant to approach it, as predicted. It is reasonable to presume that the dogs used their owner's behaviour in the retreat condition as a cue indicating a potentially threatening person, as moving back could be assimilated into a flight or avoidance strategy when facing a threat (Walker, Fisher, & Neville, 1997). This is consistent with the findings of recent studies on social referencing in responses to new objects in dogs (Merola et al., 2012a, 2012b) and human infants (De Rosnay et al., 2006; Mumme, Fenald, & Herrera, 1996; Russell et al., 1997).

The finding that there was no clear difference in the dogs' behaviour between the stand still and retreat conditions may be due to the fact that seeing their owners standing still without any reaction to a nearby person is somewhat unnatural, and was therefore puzzling and/or negative for the dogs. It has been suggested that owners having a still face can elicit a negative affect in dogs (Buttelmann & Tomasello, 2013) as it does in human infants (Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009). Thus it is possible that dogs were in a negative affective state during both the stand still and the retreat conditions. Another explanation could be that dogs interpreted the stand still condition as a freezing strategy to cope with an approaching threat (Walker et al., 1997), as freezing is a well-documented threat response in dogs (Riemer, Müller, Virányi, Huber, & Range, 2013; Walker et al., 1997) and in humans (Sagliano, Cappuccio, Trojano, & Conson, 2014). For these reasons, our control condition may be negative not neutral for the dogs, explaining the lack of difference between the stand still condition and the retreat condition. This is a limitation of the present study, and future studies should implement an alternative control, such as having the owner stand still while speaking into a cell phone, which might be more common and neutral for dogs.

Importantly, we found a significant effect of condition on the dogs' attitude towards their owner. As predicted, the findings indicate that the dogs moved more towards their owners (index variable) in the retreat condition than in the stand still and approach conditions. This may reflect that in the retreat condition the dogs were looking for security, reassurance and/or any indication from their owner on how to behave. This hypothesis also fits with the findings of many other studies. Merola et al. (2012a) showed that when their owners had a negative facial, behavioural or emotional reaction to a strange object, dogs interacted more frequently with their owners. Additionally, it has been shown that when facing an individual who is expressing behavioural emotional cues, dogs are more sensitive to negative than positive emotions (Deputte & Doll, 2011; Yong & Ruffman, 2015). In the presence of their owner and an unfamiliar human, dogs have been found to explore new objects for longer, probably because they consider their owners a secure base for interacting with their environment (Horn, Huber, & Range, 2013; Merola et al., 2012a). In the present study, when the owners moved back, we propose that the dogs

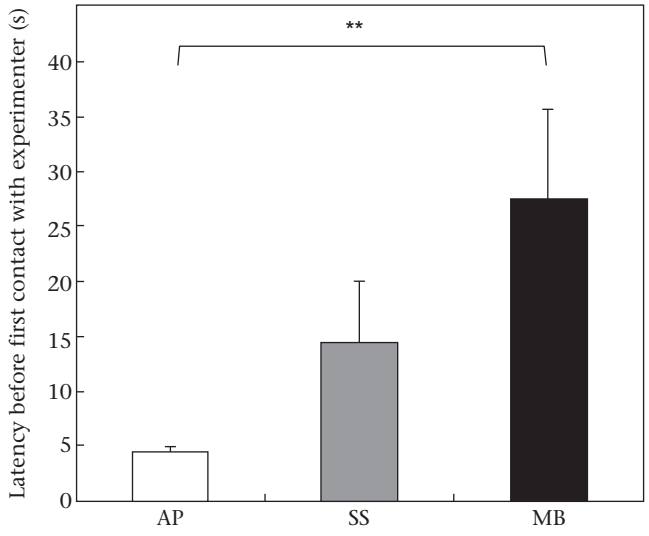

Figure 5. Latency before the dogs' first contact with the experimenter in relation to condition. MB = retreat condition, $N = 24$; SS = stand still condition, $N = 24$; AP = approach condition, $N = 24$. ANOVA: $^{**}P < 0.01$. Error bars show + SE.

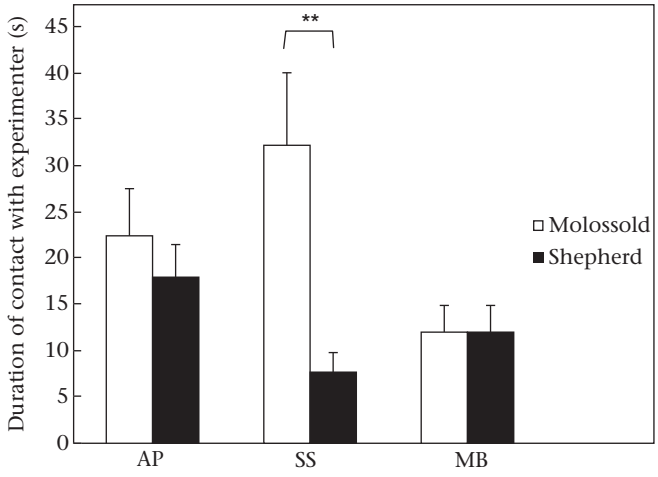

Figure 6. Time spent in contact with the unfamiliar person in relation to condition and breed. MB = retreat condition (molossoid dogs: $N = 12$; shepherd dogs: $N = 12$); SS = stand still condition (molossoid dogs: $N = 12$; shepherd dogs: $N = 12$); AP = approach condition (molossoid dogs: $N = 12$; shepherd dogs: $N = 12$). ANOVAs: $^{**}P < 0.01$. Error bars show + SE.

Table 7
Stress-related behaviours and vocalizations

Dependent variables	Independent variables	F/χ^2	*df*	*P*	ES	95% CI
Time moving	Condition	0.45	2, 66	0.63	0.12	see text
	Sex	<0.01	1, 66	0.93	0.02	−8.08 to 7.50
	Breed	**4.34**	**1, 62**	**0.04**	**0.35**	**−1.98 to 13.37**
	Age	2.94	1, 62	0.09	−0.07	−0.30 to 0.16
Whines	Condition	0.32	2, 66	0.73	0.06	see text
	Sex	0.02	1, 66	0.87	0.21	−1.56 to 4.11
	Breed	1.99	1, 66	0.16	0.49	0.08 to 5.65
	Age	**4.40**	**1, 66**	**0.04**	**−0.22**	**−0.43 to 0.01**
Stress-related behaviours	Condition	0.99	2, 66	0.37	0.25	see text
	Sex	0.02	1, 66	0.89	0.03	−1.30 to 1.14
	Breed	0.30	1, 66	0.58	0.08	−1.42 to 1.02
	Age	0.78	1, 65	0.38	0.01	−0.22 to 0.24
Urinate	Condition	2.45	2.00	0.29	0.06	see text
	Sex	**4.62**	**1.00**	**0.03**	**0.12**	**7.89**
	Breed	1.50	1.00	0.22	0.04	0.34
	Age	0.30	1.00	0.59	0.03	0.93

Bold type indicates significant results. When condition had a significant effect, details of the post hoc comparisons with 95% CI are provided in the text. ANOVAs were conducted for variables time moving, whines and stress-related behaviours; the test statistic is *F* and effect sizes (ES) correspond to Cohen's *f* for condition, Cohen's *d* for sex and breed and Pearson's *r* coefficient for age. GLM was conducted for the variable urinate; the test statistic is χ^2, and ES corresponds to Nagelkerke's r^2 and 95% CI to the odds ratio.

presumably took this to signal a negative reaction, such as a flight or avoidance response away from a threat (Walker et al., 1997). Because dogs are more sensitive to negative human reactions than to positive reactions (Deputte & Doll, 2011; Yong & Ruffman, 2015), we propose that they then sought more information and/or reassurance from their owners. These findings on dogs' attitude towards their owners are similar to what has been found between human infants and their mothers (Ainsworth, 1979; De Rosnay et al., 2006; Mumme et al., 1996).

However, it is important to note that, contrary to the present study, in all of the studies on social referencing mentioned above, the informant provided a vocal cue to express emotional valence to the observer (dog or infant), through the use of either a happy or a fearful voice. Our choice was to focus on movement that we considered an emotional cue and its effect in the absence of other cues. While movement alone could be considered emotionally neutral, our findings are still useful in daily life, as owners do not actually react with overt happiness or fear every time they encounter another person. However, because sound is believed to boost a dog's ability to use humans' cues (Buttelmann & Tomasello, 2013), further study should examine the effect of vocal emotional cues expressing happiness or fear on the behaviour of dogs interacting with strangers.

Interestingly, breed influenced the dogs' behaviours. In the stand still condition, molossoid dogs spent significantly more time in contact with the experimenter than did shepherd dogs. In this condition, the owners remained still and it seems that the dogs were neither able to mimic their owners' behaviour nor derive any information from it on how to behave. It is likely that both breeds behaved according to the temperament for which their breed was selected (Mehrkam & Wynne, 2014). Shepherd dogs are selected for herding livestock and watching their owner during shared activities. Shepherds might be more focused on their owners and less interested in strangers than molossoid dogs (Passalacqua et al., 2011; Vas et al., 2005). This is in line with both the present study, showing that shepherds looked at the experimenter for a shorter period of time than molossoids, and Pongrácz, Miklósi, Vida, and Csányi (2005) who showed that shepherd dogs looked back at their owners more frequently than other breeds. Molossoid dogs, in contrast, were originally selected for guarding work. Several studies based on dogs' personality have found that guarding breeds, including molossoids, are the boldest breed group (Starling, Branson, Thomson, & McGreevy, 2013; Turcsán, Kubinyi, & Miklósi, 2011), and notably bolder than shepherd dogs (Duffy, Hsu, & Serpell, 2008; Svartberg, 2006). Molossoid dogs have been selected to deal well with novel and unusual situations (Starling et al., 2013), and therefore to be less stressed when confronted with such situations. This is in line with our finding that molossoid dogs showed fewer signs of stress than shepherd dogs. Molossoid dogs were also the only ones to growl during our test, and did so only in the retreat condition. This probably reflects their being bred for guarding behaviour (Faragó, Pongrácz, Range, Virányi, & Miklósi, 2010), and supports the hypothesis that selected breed temperaments played a role in these effects. Similar findings have been reported in human infants as individual temperaments strongly influence an infant's behaviour in social referencing paradigms (De Rosnay et al., 2006). It may be that this breed effect was not present when the owner moved around (in the approach and retreat conditions) because of the social referencing phenomenon explained above. In these situations, any breed differences may have been masked by the dogs' synchronization of their behaviour with their owners' behavioural reaction.

We found a sex effect on the dogs' behaviour in this approach paradigm test. Female dogs waited for a significantly shorter period of time before their first look at their owners, and spent significantly more time looking at their owners than male dogs. Females also made significantly more referential looks and gaze alternations than males. A similar sex effect was found in infants in a social referencing paradigm, with girls looking more at their mothers when they showed a negative emotional reaction (Mumme et al., 1996). More generally, these differences may reflect a stronger tendency in female dogs to seek information, and possibly social support, from their owners (Horn et al., 2013). This is supported by a recent finding that when encountering an unusual stimulus, the more confident a dog is, the fewer referential looks and gaze alternations it makes between the stimulus and their owner (Merola et al., 2012a). Another recent study also showed that in an unfamiliar experimental setting (a novel stimulus in a novel environment), males were bolder than female dogs (Duranton, Rödel, Bedossa, & Belkhir, 2015; see also Beerda et al., 1999). In addition, studies on dog temperament using nonsocial objects and social events have frequently reported greater boldness in males than in females (Kubinyi, Turcsán, & Miklósi, 2009; Starling et al., 2013; Svartberg & Forkman, 2002). This could explain the sex effect observed here.

Our results showed an interaction of sex and condition on dogs' location synchrony with their owner. In the approach condition, male dogs spent more time in close proximity with their owners than female dogs. This is in line with our findings that male dogs moved around less in the approach condition than in the stand still and retreat conditions, whereas females did not show any difference in this measure across conditions. Behavioural synchrony with an owner who is approaching a stranger is thus probably linked to bolder temperament (here, in males). Our initial hypothesis of greater behavioural synchronization in the retreat and approach conditions than in the stand still conditions was thus only partially confirmed, probably due to this interaction with the dog's sex. Importantly, our results showed no sex effect on the dogs' behaviour towards the stranger, which is in line with previous results: Lore and Eisenberg (1986) showed that responses to a stranger were sex specific only when the target person was a man.

Finally, our results showed that older dogs spent more time in contact with their owner. This is in agreement with previous

findings in dogs and in rats. Older individuals explore less than younger ones, indicating that general activity and boldness decrease with age (Soffié, Buhot, & Poucet, 1992; Starling et al., 2013). In addition, our results are congruent with those of Starling et al. (2013), who argued that older dogs have more experience and are therefore naturally less engaged with their surroundings, losing interest in exploration and showing a reduction in excitement. Another finding of our study supports this. The younger dogs whined more than the older ones, which could be due to excitement or impatience. It can also be a way to attract the attention of the humans, as whining is a signal indicating an individual's internal state when calling for attention (Lund & Jørgensen, 1999).

To conclude, we found here that, as in infants, social referencing in dogs is present and constant across situations. When encountering a stranger, the direction of the owners' movement alone was sufficient to affect the behavioural responses of dogs but sex, breed and age also modulated them. Finally, when facing a stranger, dogs synchronized their reaction with that of their owners, but many factors seem to have played a role. Further studies are needed to understand the mechanisms underlying these phenomena. The present findings suggest an interesting new way for owners to use their own behaviour to manage their dogs in everyday life when encountering people who are new to their dogs: by moving forwards or backwards, they can physically show their dog how to react.

Acknowledgments

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