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Research

Reciprocal attention of dogs and owners in urban contexts

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ABSTRACT

Laboratory-based studies have shown that paying attention to humans is an important determinant of dogs' behavior. However, there are no data on how gaze is deployed between dogs and owners in non-laboratory conditions. This study aimed at characterizing dogs' and owners' attention to each other in 2 urban contexts, characterized by a different density of dynamic stimuli. Short videos of 176 dog–owner couples walking in streets and squares of the city center (CC) or green areas (GAs) of the center of Padova (Italy) were recorded. Continuous sampling was used for recording when dogs and owners were visually oriented toward their respective partners. These data allowed calculation of the average length of continuous gazes, number of gazes per minute, and the percentage of time in which dogs and owners were oriented toward their partners; also computed were the frequency and duration of mutual gazes. Eighty-three dogs and 32 owners never looked at their reciprocal partners for the entire duration of the video. On average, dogs were oriented to owners for 0.6% of the time and looked at them 0.5 times per minute, in bouts of 0.5 seconds. All parameters of dogs' attention were higher for off-leash dogs in GAs than for on-leash dogs in both GAs and CC. Although such limited attention to owners may reflect the requirements of ongoing action, it also suggests that most dogs do not need to look at their owners during walks, possibly because they are not confronted with situations of uncertainty. Owners were oriented to their dogs for 5.3% of the time and looked at them 1.7 times per minute, in bouts of 1.4 seconds. Owners' attention was lower in CC than in GAs, which may reflect differences between contexts in the number of distracting stimuli or in owners' motivations for looking at their dogs while walking in these different contexts.

Introduction

Paying attention to other group members is an essential feature in the social life of a species. Dogs are distinctive in this regard as living in human societies may require them to direct attention toward heterospecific companions. Indeed, dogs' propensity to look at humans seems so embedded in the species that it was proposed as a distinguishing feature between dogs and wolves (Miklósi et al., 2003). Dogs' ability to exploit visual information from humans takes many forms: dogs are predisposed to follow overt human communicative gestures to locate resources (Hare and Tomasello, 2005; Virányi et al., 2008) and to refine this ability through experience (Udell et al., 2010). Witnessing human demonstrators influences dogs' performance in detour (Pongrácz et al., 2001) and manipulative tasks (Miller et al., 2009) and, with appropriate training, dogs can learn to imitate some human motor patterns (Topál et al., 2006; Fugazza and Miklósi, 2014). Dogs can also determine humans' attentional states by looking at them and can modify their behavior accordingly: they prefer to obey and beg from attentive rather than nonattentive humans (Gácsi et al., 2004; Virányi et al., 2004) and can take advantage of inattention, for instance by eating forbidden pieces of food when the forbidding human appears not to be looking at them (Call et al., 2003; Schwab and Huber, 2006).

The mentioned studies offer substantial evidence that dogs resort to looking at humans in a variety of situations. Nonetheless, dogs will not pay the same level of attention to *any* person in a given context. A few studies have been focusing on the role of the identity of the human partner on the distribution of gazes, showing, for instance that the dogs' owner involved in a manipulation task will receive higher attention than an unfamiliar person performing

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Figure 1. Video still of a dog–owner dyad walking in the city center. Arrows (N = 10) indicate the position of people and objects in motion, exemplifying the high density of stimuli in this context.

the same activity (Range et al., 2009). Another manipulation situation used by Horn et al. (2013) indicated that such increase in attention levels requires a close relationship, rather than mere familiarity. The owner's capacity to elicit particularly high levels of attention by dogs becomes especially evident if the animal is presented simultaneously with 2 human "targets," a condition in which dogs will look at their owner with much longer gazes than at a stranger (Mongillo et al., 2010).

The studies cited so far have all been conducted in strictly controlled experimental conditions. However, a possible limitation of these laboratory-based studies is that they may not adequately model how attention is deployed between dogs and owners in more natural circumstances, for a laboratory can hardly incorporate the quantity and types of stimuli to which dogs are likely to be exposed in real life. Although there are a few studies that focused on dogs' social interactions in natural contexts (Bekoff and Meaney, 1997; Westgarth et al., 2010; Řezáč et al., 2011), there are no data on dog–human attention in such contexts.

This study aimed at providing a characterization of attention between dogs and owners in non-laboratory conditions; to this aim, we chose to run the study in urban areas, which allowed us to observe a great number of dogs and owners engaging in spontaneous behavior, which would have been harder to obtain otherwise, for example, by recording in owners' private properties. The urban environment also provides well-characterizable contexts, varying in the type and density of stimuli, which gave us the opportunity to assess, as a further aim of the study, how dogs' and owners' attention is deployed in the presence of a great number and type of stimuli as opposed to a relatively less rich context.

Materials and methods

Subjects and procedure

The present study was carried out in the city of Padova (Italy). Short videos were taken of 176 dog–owner couples walking in various areas of the city. In detail, 2 types of contexts were chosen: (1) the streets and squares of the old city center (CC), characterized by a relatively high density of people and of objects in motion (e.g., bicycles, baby carriages, wheelchairs; Figure 1) (median N of stimuli/video frame = 11; minimum = 5, maximum = 22), as well as by sounds and noises, and (2) the grassy embankments of the canals in the city (green areas [GAs]), with fewer stimuli (median N of stimuli/video frame = 2; minimum = 0, maximum = 11; Mann–Whitney U test = 128, $P < 0.000$). The number of couples recorded was balanced between the 2 types of area (N = 88 per type). The videos were taken between May and November 2010 in good weather conditions, in sessions of 60-120 minutes in daylight, during hours in which owners and dogs are typically found in the two contexts. A total of 23 sessions was necessary to complete the recordings. The operator had the camera mounted on a tripod with a rotating video head and monitored a sector of approximately 40 m of radius and 160° angle in front of him. Each time a dog–owner couple entered in this field, the operator started recording, moving the camera so to keep the two subjects in the frame, and continued recording as long as they were frontally visible; while recording a given dog–owner couple, other couples entering the mentioned field were ignored. Also ignored were subjects who had been recorded previously in this study or couples engaged in activities different from walking (e.g., playing, jogging). No other criterions were used for sampling. Notices stating that the area was subjected to video recording were placed in these areas, in accordance with the Italian law. Apart from such notices, the owners were not aware in advance of being recorded, and the position of the camera and its operator was chosen so that it was unlikely that the latter were seen or noted by dog owners. Immediately after they had been filmed, another experimenter approached the dog owners to ask their explicit consent for collecting data from the video and to acquire information about the dog's age and sex. All the interviewed owners consented to have their videos analyzed and provided the requested information.

Data collection

Video recordings were imported into Noldus Observer XT software (Noldus Information Technology, Wageningen, The Netherlands). Data were collected from all videos by continuous sampling on focal subjects, recording at any point in time whether the dogs were visually oriented toward their owners' body or not, and vice versa. As the distance did not allow to determine the exact orientation of the eyes, head orientation was used as a proxy for gaze direction. These data supplied 3 measures of dogs' and owners' attention: the average gaze length (GL), gaze frequency (GF, gazes/minute), and the percentage of time (looking time [LT]) in which dogs and owners were oriented to the respective partners. The same data were used to compute parameters of mutual attention, that is, GL, GF, and the percentage of time in which dogs and owners were concurrently oriented toward each other. Intervals in which the head orientation of dogs or owners could not be clearly determined were excluded from the computation of attention parameters. Last, data were recorded on whether the dogs were on leash or off leash.

Data analysis

Because none of the variables was normally distributed, nonparametric statistical tests were used for all analyses. Interobserver reliability was assessed by computing correlations between data collected by two independent observers on 20% of the videos (N = 36) and was found to be good for all the parameters of dogs' and owners' attention (Spearman rho > 0.7, $P < 0.01$ in all cases).

After obtaining a descriptive analysis of dogs' and owners' attention, to explore whether attention levels of dogs were somehow correlated to that of their owners, Spearman signed rank correlations were calculated between GL, GF, and LT of owners and dogs. Because the relatively high number of cases in which dogs and owners were never oriented to their partners would have provided misleading results, only cases in which both dogs' and owners' LT

Table 1
Frequency of dog breeds represented in sample

Breed	N	Percent	Breed	N	Percent
Mixed breed	65	36.93	Weimaraner	2	1.14
English cocker spaniel	10	5.68	Beauceron	1	0.57
Labrador retriever	10	5.68	Bedlington terrier	1	0.57
Jack Russell terrier	7	3.98	Belgian shepherd	1	0.57
Maltese	7	3.98	Bernese mountain dog	1	0.57
Beagle	6	3.41	Welsh border collie	1	0.57
Bolognese	5	2.84	Boston terrier	1	0.57
Poodle	5	2.84	Dalmatian	1	0.57
Toy pinscher	5	2.84	Doberman pinscher	1	0.57
German shepherd	4	2.27	Fox terrier	1	0.57
West Highland white terrier	4	2.27	French bulldog	1	0.57
Yorkshire terrier	4	2.27	German shorthaired pointer	1	0.57
Basset hound	3	1.70	Great Dane	1	0.57
Boxer	3	1.70	Irish setter	1	0.57
Cavalier King Charles spaniel	3	1.70	Italian greyhound	1	0.57
Whippet	3	1.70	Italian shepherd	1	0.57
Chihuahua	2	1.14	Scottish border collie	1	0.57
Epagneul Breton	2	1.14	Shih Tzu	1	0.57
Golden retriever	2	1.14	Siberian husky	1	0.57
Italian pointer	2	1.14	Tibetan terrier	1	0.57
Italian Scenthound	2	1.14	Toy Schnauzer	1	0.57

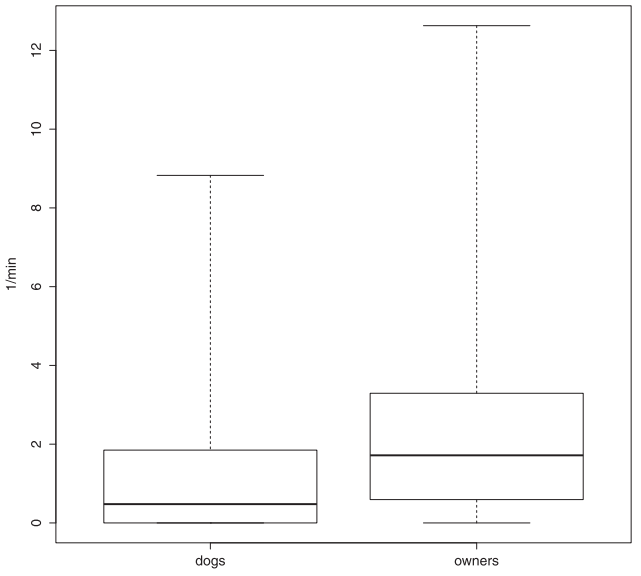

Figure 2. Distribution (minimum, first quartile, median, third quartile, maximum) of dogs' and owners' gaze frequency to respective partners.

was higher than 0 were included in this analysis. Then, we aimed at assessing the effect of the type of context on attention by comparing attention parameters between couples filmed in GAs versus CC. However, although all the dogs in CC were kept on leash, about half of those in GAs was kept off leash, and a preliminary analysis had found a significant effect of leash use on dogs' attention. Therefore, a Kruskal–Wallis test was used to compare parameters of attention of dogs and owners using as between subjects a 3-level factor, which took into account both context and leash use (CC, GAs on leash, GAs off leash); pairwise comparisons followed whenever appropriate.

All analyses were carried out in the SPSS 20 software (IBM Corp., Armonk, NY, USA). Charts were made using R software (R Core Team, 2013).

Results

Sample characteristics

The overall sample included 86 small dogs (height at shoulder below 30 cm; CC: 48; GAs: 38), 44 medium-sized dogs (height between 30 and 60 cm; CC: 22; GAs: 22), and 46 large dogs (height above 60 cm; CC: 18; GAs: 28). With regard the breeds, the relative majority of dogs were of mixed breed (N = 65), followed by English cocker spaniel (N = 10) and Labrador retriever (N = 10). The frequency of breeds represented in the sample is listed in Table 1. There were 75 females (CC: 37; GAs: 38) and 101 males (CC: 51; GAs: 50) in the sample, with a mean ± standard deviation (SD) age of 4.8 ± 3.6 years (CC: 4.5 ± 3.7; GAs: 5.0 ± 3.6). With regard to the use of a leash, 134 dogs were kept on leash (CC: 88; GAs: 46) and 42 off leash (CC: 0; GAs: 42); notably, all the off-leash dogs were observed in GAs.

Characteristics of dogs' and owners' attention

Videos had a usable duration (i.e., dog and owner heads clearly visible) of 85.5 ± 53.0 seconds (mean ± SD; minimum = 31 seconds; maximum = 224 seconds). On average, dogs were oriented toward their owners for 0.6% (0.0%-61.6%) of this time, looking at them 0.5 times per minute (Figure 2), with gazes of 0.5 seconds (Figure 3). Owners were oriented toward their dogs for 5.3% (0.0%-59.1%) of the video duration and looked at their dogs 1.7 times per minute (Figure 2), in bouts of 1.4 seconds (Figure 3). Eighty-three of the dogs (47.2%) and 32 of the owners (21.6%) never looked at their partners for the entire duration of the video. Mutual attention was observed in 53 of the couples, who looked at each other on average for 1.1% (0.1%-26.2%) of the time and 1 time per minute (0-5 $^{1}/_{\text{minute}}$), in bouts of 0.8 seconds (0.0-3.8 seconds).

Within both dogs and owners, significant correlations were found between the parameters of attention to the respective partner, and positive correlation was also found between the length gazes of dogs and owners, indicating a certain reciprocity within couples in the degree of attention paid to each other. The length and frequency of mutual gazes were respectively correlated with the length and frequency of gazes by both dogs and owners; moreover, all the parameter of mutual attention correlated with the total LT of dogs to owners (Table 2).

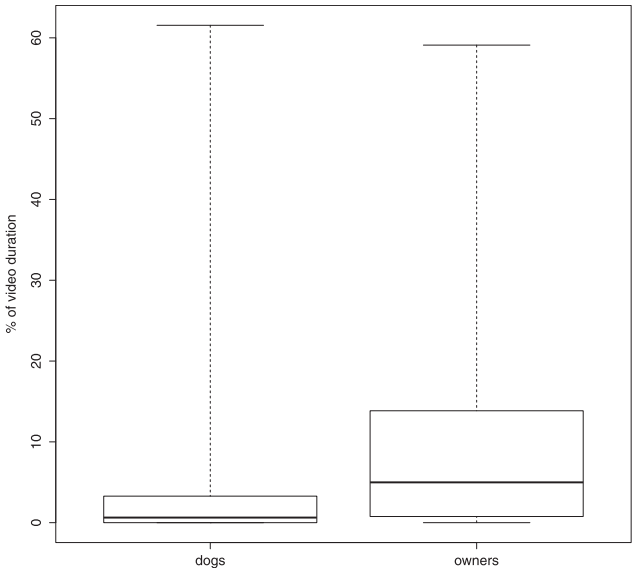

Figure 3. Distribution (minimum, first quartile, median, third quartile, maximum) of dogs' and owners' gaze length to respective partners.

Table 2
Spearman rank correlations between GL, GF, and total LT of dogs and owners and for mutual attention

	Dog			Owner			Mutual		
	GL	GF	LT	GL	GF	LT	GL	GF	LT
Dog									
GL	—	0.183	**0.678**	**0.258**	0.041	0.170	**0.630**	0.021	0.424
		0.079	**<0.001**	**0.013**	0.694	0.102	**<0.001**	0.878	0.002
GF	0.183	—	**0.800**	−0.130	0.047	−0.037	−0.005	**0.439**	**0.283**
	0.079		**<0.001**	0.214	0.653	0.721	0.719	**0.001**	**0.040**
LT	**0.678**	**0.800**	—	0.060	0.071	0.057	**0.283**	**0.351**	**0.457**
Owner	**<0.001**	**<0.001**		0.571	0.496	0.589	**0.038**	**0.009**	**0.001**
GL	**0.258**	−0.130	0.060	—	**0.493**	**0.673**	**0.333**	0.101	**0.257**
	0.013	0.214	0.571		**<0.001**	**<0.001**	**0.014**	0.468	**0.064**
GF	0.041	0.047	0.071	**0.493**	—	**0.759**	−0.184	**0.385**	0.232
	0.694	0.653	0.496	**<0.001**		**<0.001**	0.182	**0.004**	0.094
LT	0.170	−0.037	0.057	**0.673**	**0.759**	—	−0.099	0.014	0.079
Mutual	0.102	0.721	0.589	**<0.001**	**<0.001**		0.476	0.313	0.574
GL	**0.630**	−0.005	**0.283**	**0.333**	−0.184	−0.099	—	0.164	**0.735**
	<0.001	0.719	**0.038**	**0.014**	0.182	0.476		0.237	**<0.001**
GF	0.021	**0.439**	**0.351**	0.101	**0.385**	0.014	0.164	—	**0.750**
	0.878	**0.001**	**0.009**	0.468	**0.004**	0.313	0.237		**<0.001**
LT	0.424	**0.283**	**0.457**	**0.257**	0.232	0.079	**0.735**	**0.750**	—
	0.002	**0.040**	**0.001**	**0.064**	0.094	0.574	**<0.001**	**<0.001**	

GL, gaze length; GF, gaze frequency; LT, looking time.
Values are reported for ρ (upper line in each cell) and P (lower line); bold type indicates significant correlations ($P < 0.05$).

Effect of context and leash use on dogs' and owners' attention

All the parameters of dogs' attention differed between groups classified by context and use of leash (Table 3). In detail, all the parameters of dogs' attention were higher for off-leash GA dogs than for on-leash dogs in both GAs (GL: $U = 3.50$, $P = 0.001$; GF: $U = 3.10$, $P = 0.006$; LT: $U = 3.46$, $P = 0.002$) and CC (GL: $U = 5.80$, $P < 0.001$; GF: $U = 3.70$, $P < 0.001$; LT: $U = 4.78$, $P < 0.001$).

With regard to owner's attention, significant differences between groups were found for the length of gazes and the total LT but not for the frequency of gazes (Table 3). Specifically, both the length of owners' gazes and their total LT at dogs were lower in CC than in GA couples with both on-leash dogs (GL: $U = 3.93$, $P < 0.001$; LT: $U = 4.19$, $P < 0.001$) and those with off-leash dogs (GL: $U = 5.84$, $P < 0.001$; LT: $U = 3.69$, $P = 0.001$), suggesting a more important role of context rather than use of leash on owners' attention.

The effect of context and use of leash on mutual attention data was not assessed because of the limited number of couples that exhibited mutual attention.

Discussion

The first aim of this study was to characterize dogs' and owners' reciprocal attention in the course of a usual activity in a non-laboratory context and, to this aim, we observed dog–owner couples walking in different urban environments. With regard to dogs, almost half of them were never oriented to their owners and when they did, both the frequency and duration of their gazes were generally very low. Consequently, low values were also found for the total duration of dogs' orientation to owners, which remained below 1% of the time for most dogs. In the lack of other data on spontaneous attention in a non-laboratory environment, it is not simple to contextualize the findings. The figures we obtained seem to tell a different story if compared with the data obtained in the laboratory, where dogs have been shown to look at their owners at least 20 times as much (e.g., Range et al., 2009; Mongillo et al., 2010; Horn et al., 2013), with 3 times longer (e.g., Range et al., 2009; Mongillo et al., 2010) and more frequent gazes (e.g., Range et al., 2009). However, in a day-to-day living context, many different factors are likely to modulate dogs' attention to their human partners.

First, the amount of time an animal can use for looking at other individuals is limited by the inherent requirements of walking. For instance, it has been shown that lemurs' spontaneous gazing to social stimuli is reduced in the course of locomotion, as opposed to stationary observation (Shepherd and Platt, 2008). While walking, information must be dynamically acquired from the environment and attention must be functional, among other things, to control the direction of movement and avoid obstacles, so that less attention can be paid to other stimuli.

Beyond the requirement of motor action, the allocation of attention necessarily reflects individual emotional and behavioral needs and an animal will turn preferentially to stimuli that could be important for the fulfillment of its current goals. Laboratory-based studies have taken advantage of this phenomenon, typically presenting dogs with challenging situations, such as an unsolvable task (Topál et al., 1997; Kerepesi et al., 2014), exposition

Table 3
Median (minimum-maximum) of dogs' and owners' GL, GF, and total LT of couples filmed in the CC and GAs with dogs off leash and on leash

Subject	Parameter	CC on leash (N = 88)	GAs on leash (N = 46)	GAs off leash (N = 42)	*H*	*P*
Dogs	GL	0.0 seconds (0.0-9.3)^{A}	0.5 seconds (0.0-5.9)^{A}	1.4 seconds (0.0-9.3)^{B}	33.65	<0.001
	GF	0.0 $^{1}/_{minute}$ (0.0-8.8)^{A}	0.5 $^{1}/_{minute}$ (0.0-5.4)^{A}	1.3 $^{1}/_{minute}$ (0.0-6.6)^{B}	14.96	0.001
	LT	0.0% (0.0-19.1)^{A}	0.4% (0.0-61.6)^{A}	3.9% (0.0-37.6)^{B}	23.45	<0.001
Owners	GL	0.8 seconds (0.0-11.3)^{A}	2.4 seconds (0.0-5.7)^{B}	3.1 seconds (0.0-11.7)^{B}	51.83	<0.001
	GF	1.4 $^{1}/_{minute}$ (0.0-12.6)	2.3 $^{1}/_{minute}$ (0.0-7.5)	1.6 $^{1}/_{minute}$ (0.0-7.3)	5.30	0.071
	LT	2.4% (0.0-48.9)^{A}	9.6% (0.0-44.1)^{B}	8.1% (0.0-59.1)^{B}	23.47	<0.001

GL, gaze length; GF, gaze frequency; LT, looking time; CC, city center, GAs, green areas, H, Kruskal-Wallis test value.
Different superscript letters within a row indicate groups with significantly different distributions; pairwise comparisons after Kruskal–Wallis test.

to a frightening stimulus (Merola et al., 2012), or being restrained from reaching the owner (Mongillo et al., 2010). In all these cases, the clear orienting responses shown by dogs are likely to result from the necessity to obtain emotional support or intervention by the owner. The limited level of attention observed in most of the dogs of this study could imply that they do not need to look at their owners during a daily city walk, rather than being impeded from doing it, simply because during such activity they are not often confronted with situations of emotional conflict or uncertainty.

One factor that had a significant impact on dogs' attention to owners in our study is the use of leash, with free running dogs looking at their owners more frequently and with longer gazes than dogs kept on a leash. Several reasons may contribute to this observation. For instance, the constraints of the leash could limit the space available to dogs, requiring them to pay greater attention to potential obstacles than to their owners. Alternatively, being allowed off leash may increase the odds of meeting with challenging situations. Westgarth et al. (2010), for example, reported that being off leash increases the number of encounters and interactions with other dogs, which may carry an emotional challenge. In this case, dogs off leash may resort to look at their owners more often and with longer gazes to regain proximity and feel more secure in a situation of need. At the same time, the simple physical perception of the leash, or other perceptual cues given by the owners' proximity, may be sufficiently informative about the owner's presence for dogs on leash. It is also possible that dogs that pay high levels of attention to their owners are perceived as more reliable and therefore more easily allowed to walk freely; in such case, higher attention levels may be the reason, rather than the consequence, of the dogs being allowed off leash.

In this study, the CC was characterized by a higher density of pedestrians, and other dynamic stimuli, such as cyclists, mothers with baby carriages, and various sounds and noises. As a consequence of the competition between stimuli, we expected a reduction in the frequency of dogs' gazes to owners in the CC compared with GAs. At the same time, the high number of stimuli could have increased the odds of incurring in challenging situations; if in such circumstances dogs were looking for support by their owner, longer gazes would have been expected. In fact, no difference in any of the parameters of dog's attention was found between contexts. On the one hand, the result can be attributed to a floor effect, whereby attention to owners was already minimal in GAs, and the higher number of competing stimuli in the CC could not cause further reduction in the frequency of gazes. On the other hand, the lack of differences in GL could indicate that the dogs' reliance on owners is somehow limited in these urban contexts. An alternative explanation, accounting for both results, is that dogs are generally well habituated to the contexts where they are taken for walks, so that the stimuli present there neither compete for dogs' attention nor represent an emotional challenge requiring the owner's support.

With regard to owners, the frequency and duration of their gazes were only slightly higher than those of dogs; in addition, about a quarter of them did not pay any attention to their dog. Only a handful of studies examined how people distribute their gaze during everyday activities (Land et al., 1999; Shinoda et al., 2001; Jovancevic-Misic and Hayhoe, 2009; Hayhoe and Rothkopf, 2011). Land et al. (1999), for instance, reported that an activity involving a clear goal, such as making a cup of tea, encompasses fixations of a few seconds (2.6 $\pm$ 1.4 seconds, mean $\pm$ SD) at relevant objects. By contrast, Jovancevic-Misic and Hayhoe (2009) analyzed gaze distribution while walking, a more similar activity to that investigated by our study, showing that monitoring other pedestrians to avoid collisions requires gazes of up to about 1 second. In our study, gazes of less than 1 second toward dogs were found by most owners' walking in the CC, which may suggest that the high number of other stimuli competed for the owners' attention and that the latter mainly served to intermittently monitor the dog. This was not the case of GAs, where dogs received by their owners much longer and more frequent gazes, suggesting a different motivation behind owners' attention in this context. The absence of a significant effect of leash on owners' gaze patterns also gives some support to this hypothesis: if attention was mainly functional to monitoring dogs, longer and/or more frequent gazes would have been given to dogs off leash than to those on leash.

Conclusions

In summary, this study provides the first characterization of dogs' and owners' reciprocal attention in a non-laboratory condition. Although it would be improper to compare directly our data with those obtained in laboratory-based studies, the gaze patterns that we observed by dogs and owners in urban contexts seem to be mainly functional to monitoring each other's presence/position, while they hardly allow extensive communication between dogs and owners. On the basis of our data, it is impossible to determine if these results simply reflect the lack of meaningful events that would require higher attention or if the dog–human communication system is somehow hindered in the contexts that we observed. Nonetheless, the ranges and distribution of attention parameters provided by this study should represent an important baseline for the study of dog–human attention in more demanding natural circumstances. An example of such use is provided in the study by Mongillo et al. (in preparation), where we focused on dog–owner attention in the course of problematic behaviors.

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Ethical considerations

The study complied with the relevant Italian laws. Compliance with the policy of the journal on ethical consent and the standards of animal care was not applicable.

Conflict of interest

The authors declare no conflict of interest.

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