Dog behaviour on walks and the effect of use of the leash

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ABSTRACT

This paper describes how often pet dogs interact with other dogs, people and the environment, whilst being walked. Such interactions may involve aggression or the transmission of infectious disease. We also assessed the effect of the use of a leash as a modifier of these outcomes. In study one, the behaviour of pet dogs being walked in popular public walking areas was observed (286 observations). Interactions with people were much rarer than interactions with dogs. Multivariable modelling suggested that percentage duration spent sniffing the ground was associated with the UK Kennel Club Breed Type, and whether the dog was observed urinating. Gundogs were observed to sniff more than other breed types. In study two, dogs ($n = 10$) were filmed twice walking along a pre-defined route, alternately once on leash and once off leash, in order to assess the effects of leash use on interactions between the subject dog and any other dog or person encountered. Multilevel modelling suggested that if either dog was on the leash, then the likelihood of an interaction with a dog occurring was reduced. There was no evidence for statistical interactions between these variables, therefore the effect of the leash on one dog did not seem to be influenced by whether the other dog was on or off leash. We conclude that in circumstances where interactions need to be prevented, such as to reduce spread of infectious diseases during an outbreak, both dogs should be leashed.

1. Introduction

Although the ways in which particular dogs interact with the environment, people and other dogs whilst out walking may be well known to observant dog owners, there has been little scientific research into this area. It is surprising how little we know about the domestic dog, considering its huge practical and emotional impact on human lives, whereas the wolf and other wild canid relatives have been studied in far greater detail (Serpell, 1995). Past work has focused mainly on the ecology of free-roaming dogs (for example Beck, 1973; Miller and Lago, 1990; Boitani et al., 1995; Meek, 1999), owned and stray dog populations in rabies areas (for example Matter et al., 2000; Kitala et al., 2001), or studied the individual behaviours patterns in dog–dog interactions (Bradshaw and Lea, 1992). Most recently, the potential for contact between pet dogs was demonstrated through analysis of the public space used for dog walking (Westgarth et al., 2009a).

It can be observed that dogs interact with other dogs whilst out walking, through behaviours such as sniffing, play and aggression. Dogs may also interact with people other than their usual household members, such as other dog walkers. Opportunities for interactions might be affected by human preferences such as walk frequency and on/off leash preferences, the walking environment, and individual dog behaviours and type. In recent years there has been increased emphasis on the importance of socialisation (Hunthausen and Seksel, 2002), thus these interactions are likely to be socially beneficial for the dogs

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and will also enhance their welfare by providing stimulation and exercise (Defra, 2009). However, they may also present a risk of infectious disease transmission between dogs, for example in the transmission of upper respiratory tract diseases by contact with infectious discharges or by aerosol (Greene, 2006). Dogs may also investigate excretions and alternative food sources whilst on a walk and these might also be considered a disease risk. For example, the enteric pathogen canine coronavirus can survive warm temperatures for several days but seems to prefer colder temperatures and therefore may survive longer during winter months (Tennant et al., 1994). Feline parvovirus shed in faeces can survive in the environment for several months (Ikeda et al., 2002) and it is likely that canine parvovirus is the same. Campylobacters also manage to persist in the environment despite lacking many of the usual bacterial survival mechanisms (Murphy et al., 2006). Younger dogs have been shown to be at increased risk of *Campylobacter* spp. carriage (Sandberg et al., 2002; Wieland et al., 2005; Westgarth et al., 2009b) and one mechanism to this may be because younger dogs show more exploratory behaviours (Siwak et al., 2001). Although classical rabies was eradicated from the UK in 1922, there are concerns over re-introduction via imported animals (Defra, 2009). The epidemiology of rabies spread through pet dogs may be a future concern, as would be the emergence of a new virulent disease.

Despite utilisation of a large repertoire of visual communication methods from wolf-like ancestry, visual communication has been suggested to play a smaller role in dog–dog interactions than might be expected, most likely as signalling structures have been modified between breeds, so reducing the reliability of visual signalling (Bradshaw and Nott, 1995). Bradshaw and Lea (1992) recorded the behaviour sequences that occur during dog–dog interactions in popular walking areas; after an initial approach phase, the majority of interactions consisted of olfactory inspections, in particular of the head and anal regions. Female dogs were more likely to concentrate on the head area and males the anal area of the other dog. These close-contact olfactory inspections are likely to be sufficient for infectious disease transmission. However this study did not quantify how frequently the interactions occurred, which is likely to be important in terms of both disease risk to the individual and subsequent transmission through a population.

The aim of our studies reported here was to investigate the frequency and nature of interactions of pet dogs with other dogs, people and the environment, whilst being walked, and to assess the effect of the use of a leash in modulating such interactions. Study one investigated dogs being routinely walked in popular outdoor environments and recorded the frequencies of contact with other people and other dogs, and interactions with the environment such as sniffing or defaecating.

Factors associated with the common behaviour of sniffing the ground were investigated further. It was hypothesised that sniffing may be reduced if alternative behaviours such as interacting with another dog were available. In contrast, sniffing may be more likely to occur before urination and defaecation.

Study two was an experimental test of the hypothesis that putting a dog on a leash may affect the frequency with which it interacts with other dogs and people that it meets. The effect of putting a dog on a leash may also vary depending on whether the other dogs in the environment are on or off leash. In support of this hypothesis, Bradshaw and Lea (1992) observed that no dog on a leash was the initiator of an interaction, and no interactions were recorded where both dogs were on leash. However their study was not specifically designed to assess the use of a leash in relation to the frequency of interactions. Putting a dog on a leash could be used as an intervention to reduce disease transmission between dogs, and also between dogs and people, during a disease outbreak. It may also be useful in reducing antagonistic encounters between dogs.

2. Methods

For both studies, an interaction with a person was defined as observation of physical (or almost physical) contact, such as the dog jumping up, sniffing a person, or a person patting the dog. An interaction with another dog was defined as two dogs being in close physical proximity with attention focused on each other, for example sniffing each other, or a bout of play, including chasing each other. Even though the dogs may not be in actual physical contact in such interactions, accidental contact is possible and aerosol transmission of a pathogen might occur.

2.1. Study one – observational study in popular dog walking areas

Three areas in the Wirral region of Cheshire/Merseyside were used; West Kirby (a beach), Royden Park (a field enclosed by woodland) and a sports field in Parkgate, Neston. These locations had been identified as popular dog walking areas in a previous questionnaire survey of dog owners in the vicinity (Westgarth et al., 2008). In each of the three areas an observation point was selected, such as a park bench, and an observation area defined in which a dog could be observed easily without often going out of sight. Popular times of day for dog walking had been identified previously (Westgarth et al., 2008) and thus the areas were visited for 2-h periods approximating 8–10 am, 3–5 pm and 5.30–7.30 pm on weekdays and 10 am–12 pm, 1–3 pm and 3.30–5.30 pm on weekend days. Each of the three study areas was visited once a day in time rotation for each of these observation periods across six days (three week and three weekend) in September 2006.

All focal observations were conducted by one person (CW), from dog entry into the study area up to a maximum of 10 min. For dog-owner units with more than one dog, only one dog was chosen for observation; the first or second dog to appear was sampled alternately to avoid potential bias. If the dog being observed had been observed previously in the current 2-h session, or could be remembered as being observed on a previous occasion, this was noted and the dog's behaviour recorded as usual. The assumption was made that dogs and people walking together belonged to the same household. Behaviours of each focal dog were recorded using Noldus Pocket Observer

XT software (Noldus, 2004, 2006) on a Psion Workabout Pro handheld (Psion Teklogix 2006) and then uploaded on to a desktop computer for analysis.

The ethogram of behaviours is presented in Table 1. An interaction between dogs was classed as a state (and would therefore have a duration) whereas an interaction between a dog and a person was recorded as an event. This was so that it would be possible to record, for example, a person patting a dog whilst it was sniffing another dog. Interactions were excluded if they involved the dog and its presumptive owner or other dogs from the same household, as it was assumed that there would be extensive contact between these individuals in the home environment. It is also likely that dogs behave differently during interactions with familiar people or dogs than with strangers.

For each observation the independent variables recorded were day, time, location, number of dogs in dog-owner unit, number of owners in dog-owner unit, types of owners (e.g. male, female or child), type of dog, and gender of dog. Dog types were later classed into UK Kennel Club categories, crossbreed, or unknown (including some breed types that are difficult to identify accurately). For the purposes of this study, Jack Russell and Patterdale Terriers were classed as Terriers, even though they are not currently recognised by the UK Kennel Club.

Associations involving dichotomous variables were analysed in Minitab (Minitab.Inc, 2007) using Chi-squared, Kruskal–Wallis and Mann–Whitney tests, as appropriate. Spearman's rank correlations in SPSS (SPSS.Inc, 2003) were used to assess associations between continuous variables. Sniffing durations (s) and percent of time spent sniffing were ($\log_{10} + 1$) transformed as they were non-normal distributions and a high proportion of the values were zero, then, a multivariable model of percentage time spent sniffing the ground was built using stepwise backward elimination of those variables identified as $P < 0.3$ during univariable analysis.

2.2. Study two – experimental study of the effect of leash use

The owners of 10 dogs (subjects) were recruited via posters and email at the University Veterinary Teaching Hospital. The study area chosen was a mostly enclosed footpath and bridleway of disused railway line, now a country park (N53:17:30, W3:04:45), of 1 km distance between the chosen start and end points. The dogs were all familiar with the area and had walked the route at least once previously. The volunteer dogs recruited were all over 1 year of age, of various breeds, and the owner stated that they were comfortable walking the dog both on and off leash around other dogs. Data were collected between November 2006 and April 2007 between the hours of 8.30 am and 5 pm on both week and weekend days. Each dog was required to walk the route (in both directions) on two occasions, no more than 2 weeks apart, and at the same time and day of the week. In the first session the dog walked the length of the route off leash first and then on leash on the way back. In the second session the on and off leash walking was reversed, to account for any behaviour differences due

to stage during walk (e.g. beginning/end) rather than leash use. However, it has been suggested that dog behaviour differs little between when they are first let free, in intermediate segments and on completion of their walks (Bekoff and Meaney, 1997).

The dogs wore a flat or half-check collar, or body harness, depending on what the owner and dog were comfortable using. Leashes were of a general short length, or extendible locked short. Obedience-style heelwork was not performed, and no dog pulled on the leash repeatedly, nor did owners need to restrain their dogs except momentarily if horses or bicycles passed by. Owners were instructed to behave normally with the dog, other than keeping the dog on/off leash as requested, and did not know the purpose of the study other than to 'observe dog behaviour whilst walking'. At the beginning of each session the dog was provided with two minutes free run in a nearby park, and was then walked on a leash to the start of the study area (approx. another 2 min), in order to acclimatise to the observer following them. All observations were carried out by a single observer (CW) and recorded using a concealed video camera (Canon M500i) with a wide-angled lens sports camera attachment (Bullet/helmet colour camera, Model Land and Air) (Cameras4sports, 2007) which was hidden in the observer's hand.

The number of walkers the dog both could, and did, interact with, and the directions in which they were travelling (same or opposite) was recorded. The proportion of possible interactions that happened was then calculated. The same process was conducted for cyclists, horse riders and other dogs met (in addition whether the other dog was on or off leash was recorded). An interaction was considered possible if a person or dog was seen at any point on the video recording for that walk.

Descriptive analysis (means, medians and ranges) was conducted in Minitab (Minitab.Inc, 2007). Due to the low numbers of interactions with people compared to dogs, statistical analysis on the effect of the leash on interactions with people was not possible, and only a general description of these interactions is therefore reported.

Multivariable three-level models for dog–dog interactions were developed initially using a residual iterative generalised least-squares (RIGLS) algorithm and second order penalised quasi-likelihood (PQL) in MLwiN (CMM, 2006). The variables dog, session and "potential interaction" were set as levels 3, 2 and 1, respectively, to account for non-independence of the data (grouped by dog, and by session for each dog). The outcome of the model was binary; whether or not an actual interaction occurred when there was potential for an interaction with another dog. The variables considered for inclusion in the model were: whether the subject dog was on or off leash, whether the other dog was on or off leash, and whether the two dogs were being walked in the same direction or opposite (i.e. from which direction the owners were travelling). Two- and three-way statistical interactions between these variables were also assessed. Variables of (Wald χ^2) $P > 0.05$ were removed sequentially by backward elimination from the multivariable model.

The final model was fitted by Markov-chain Monte Carlo (MCMC) simulation using a Metropolis–Hastings sampler

Table 1
Ethogram of dog behaviours recorded in study one, plus "Picked up", since it affects potential disease transmission.

Behaviour	State (S) or event (E)	Description	Modifier
Lead class			
On leash	S	Connected to owner by leash	
Off leash	S	Not connected to owner by leash	
Interaction class			
Sniffing ground	S	Sniffing the ground whilst standing still or moving slowly	
Null state	S	Any other behaviour	
Interacting with dog	S	Play, sniffing, aggression, etc.	Dog 1, 2, 3 . . .
Interacting with person	E	Patted, jumps up, given a treat, etc.	Person 1, 2, 3 . . . or observer
Approached observer	E	Approached observer	
Defaecate	E	Passed faeces	
Picked up	E	Faeces picked up by owner	
Urinate	E	Passed urine	
Roll	E	Roll on ground	
Eat	E	Eating, chewing or drinking	
Unobserved	Suspend and resume	Subject is out of sight	

State behaviours in a single class were mutually exclusive.

with diffuse priors (Rasbach et al., 2000). The number of iterations used was determined by examination of the Raftery–Lewis and Brooks–Draper Nhat statistics (Rasbach et al., 2000). This indicated that a chain of 50,000 iterations was sufficient. The fit of each model was assessed by examining the posterior distributions of the fixed variables included in the model (data not shown). Following the selected burn-in period and chain length, all fits were smooth and regular and approximated a normal distribution.

3. Results

3.1. Study one – observational study in popular dog walking areas

Two hundred and eighty-six observations of a dog-owner unit were suitable for analysis; 16 (5%) were excluded due to an error in the software if an animal went repeatedly out of sight without changing its behaviour. Twenty-three observations (8%) were identified having been seen before (due to the rarity of this, observations were treated as independent). Most dogs (69%) were being walked on their own, 24% of owners had two dogs, 4% three dogs, up to a maximum of eight dogs. The majority of the dogs were observed walking with one person (59%), 30% with two people, 7% with three, up to a maximum of six people. Two dogs entered the study area and were observed without any sign of an owner. Single male, and single female owners accounted for 29% and 30% of observations, respectively, with a further 21% being walked by a pair consisting of one male and one female. A child was present in 9% of the observations. The most popular type of dog seen was the Labrador Retriever (14%) followed closely by crossbreed types (13%) and Collie (11%). Gundogs (32%) were the most popular of the UK Kennel Club breed types. For 14 dogs (5%) the type was classed as unknown. The duration of the observations varied from 10 s to the maximum possible of 600 s, with a median of 136 s and mean of 180 s.

There were differences in the number of owners, and number of dogs, observed walking during weekdays and weekend days, with more multiple dogs seen during weekdays (Chi-square = 8.2, d.f. = 1, $P < 0.01$, Table 2), and more multiple owners at weekends (Chi-square = 8.3, d.f. = 1, $P < 0.01$, Table 2). There were also differences in the breed types that were observed in groups of owners compared to single owners (Chi-square = 14.3, d.f. = 6, $P = 0.03$, Table 2), and groups of dogs compared to single dogs (Chi-square = 12.2, d.f. = 6, $P = 0.06$, Table 2). In addition, there were differences in the use of the leash during the week compared to at weekends (Chi-square = 6.4, d.f. = 2, $P = 0.04$), with dogs more likely to be seen off leash only (73% and 59%, respectively, for week and weekend) and less likely to be observed on leash only (11% and 18%). During the week they were also less likely to be seen both on and off leash (16% compared to 23% at weekends). In 66% of observations the dog was never observed to be on a leash; in 14% of observations the dog was never observed to be off leash.

The frequencies and rates of interactions with other dogs are presented in Table 3. In most observations no dog–dog interactions occurred (73%). Interactions with one other dog were observed in 21% of observations. As would be expected, the number of different dogs interacted with and the number of interactions with other dogs observed were highly correlated ($P < 0.001$, Pearson's correlation 0.9). There was no evidence that dogs were cutting short their interactions with a dog due to the appearance of another dog, because the mean interaction episode length did not vary with the number of dogs observed to interact with (Kruskal–Wallis $H = 1.1$, d.f. = 2, $P = 0.6$). There was also no evidence that percentage duration spent interacting with dogs or mean interaction episode length differed by location (Kruskal–Wallis $H = 2.4$, d.f. = 2, $P = 0.3$; and Kruskal–Wallis $H = 2.9$, d.f. = 2, $P = 0.2$, respectively).

Frequencies and rates of interactions with people observed are presented in Table 3. Interactions with people were less commonly recorded than interactions with dogs. In most observations the subject dog did not interact with any people (91%). Seventy-two percent of dogs were observed to interact with neither people nor dogs: 19% interacted with dogs only; 2% people only; and 8% both people and

Table 2
Crosstabs of number of dogs, number of owners, week or weekend day, and dog type, in study one, $n = 286$.

Variable	Dogs (%)			Owners (%)		
	Single	Multiple	P	Single	Multiple	P
Week or weekend						
Weekend	77	23	<0.01	50	50	<0.01
Weekday	62	38		67	33	
UK Kennel Club Type						
Crossbreed	51	49	0.06[a]	54	46	0.03
Gundog	63	37		59	41	
Hound or Working	79	21		43	57	
Pastoral	79	21		76	23	
Terrier	79	21		53	47	
Toy	69	31		31	69	
Utility	73	27		60	40	

[a] 2 expected cell counts less than 5.

dogs. There was an association between meeting people and meeting dogs; a dog–person interaction was more likely to be observed if a dog–dog interaction occurred (odds ratio (OR) = 16.7, 95% confidence interval (CI) = 6.1–46.2).

Frequencies and rates of defaecation and urination are presented in Table 3. Defaecation was only observed in 11% of observations. In 63% of observations involving defaecation, all faeces deposited were picked up; in 28% no faeces were picked up. In the remainder, the owner was observed to pick up faeces following some, but not all, of the defaecation events. Owners were seen to pick up faeces more often after their dogs had defaecated when the dog was on a leash (100% vs 62%). Urination was observed in 37% of observations. Eating was only recorded in six observations

(max four times in one observation). Rolling behaviour was observed in eight observations (max four times).

Frequencies and rates of sniffing behaviour are presented in Table 3. Durations and episode lengths of sniffing behaviour and interactions with other dogs are presented in Table 4. Statistical comparisons between on leash and off leash were only performed for sniffing duration, as other behaviours were not observed frequently enough. From descriptive analysis, the median percentage duration spent sniffing when off leash was 16% compared to 4% whilst on a leash (Mann–Whitney $W = 46356.0$, $P < 0.001$), although this assumes that all observations are independent, when some dogs were observed both on and off leash. A truly independent comparison between those dogs observed only off leash, or on leash, showed a similar trend but

Table 3
Frequencies and rates of defaecate, pick up, urinate, roll, eat, sniffing ground and interact with a person or dog in study one, $n = 286$.

Event/state	Frequency per observation			Rate (number/min)		
	Range	Mean	Median	Range	Mean	Median
Interactions with dogs	0–18	0.7	0.0	0–3.9	0.2	0.0
Off leash	0–17	0.6	0.0	0–3.9	0.2	0.0
On leash	0–11	0.1	0.0	0–3.1	0.1	0.0
Number of dogs interact with	0–8	0.4	0.0	0–1.4	0.1	0.0
Off leash	0–6	0.3	0.0	0–1.9	0.1	0.0
On leash	0–3	0.1	0.0	0–1.8	0.1	0.0
Interactions with people	0–16	0.3	0.0	0–3.1	0.1	0.0
Off leash	0–16	0.2	0.0	0–3.1	0.1	0.0
On leash	0–6	0.02	0.0	0–0.8	0.01	0.0
Number of people interact with	0–3	0.1	0.0	0–1.4	0.04	0.0
Off leash	0–3	0.1	0.0	0–1.4	0.04	0.0
On leash	0–2	0.01	0.0	0–0.3	0.003	0.0
Sniffing ground	0–46	6.5	5.0	0–12.1	2.5	2.0
Off leash	0–30	5.2	4.0	0–12.1	2.5	2.0
On leash	0–46	1.3	0.0	0–12.0	2.3	1.3
Defaecate	0–3	0.1	0.0	0–1.2	0.04	0.0
Off leash	0–3	0.1	0.0	0–1.2	0.05	0.0
On leash	0–1	0.01	0.0	0–0.3	0.01	0.0
Faeces picked up	0–1	0.1	0.0	0–0.5	0.02	0.0
Off leash	0–1	0.1	0.0	0–0.5	0.02	0.0
On leash	0–1	0.01	0.0	0–0.3	0.01	0.0
Urinate	0–7	0.5	0.0	0–2.5	0.2	0.0
Off leash	0–7	0.5	0.0	0–2.5	0.3	0.0
On leash	0–4	0.05	0.0	0–1.3	0.1	0.0

Table 4
Durations of states sniffing ground and interacting with other dogs in study one, $n = 286$.

State	% Duration			Total duration (s)			Mean episode length (s)		
	Range	Mean	Median	Range	Mean	Median	Range	Mean	Median
Sniffing ground	0–76.0	20.7	15.9	0–280.3	35.3	21.6	0–26.0	4.8	4.0
Off leash	0–76.0	21.7	16.3	0–267.0	30.4	16.9	0–26.7	4.3	3.5
On leash	0–77.7	12.4	4.3	0–166.6	4.8	0.0	0–13.5	0.8	0.0
Interactions with dogs	0–43.2	2.3	0.0	0–185.2	4.9	0.0	0–30.7	1.9	0.0
Off leash	0–43.2	2.6	0.0	0–133.6	3.9	0.0	0–30.7	1.7	0.0
On leash	0–34.0	1.6	0.0	0–107.5	1.0	0.0	0–51.6	0.5	0.0

provided only weak evidence of a difference (median sniffing duration 16% off leash vs 9% on leash, Mann–Whitney $W = 22587.0$, $P = 0.09$). If comparisons were performed in only those dogs where both leash states were observed (i.e. the effect of the leash on the same dog; 20% of the sample), they spent an average of 10% more time sniffing off leash than on leash (Wilcoxon signed rank test statistic = 1108, $P < 0.001$). When comparing those dogs observed on leash only with those observed in both states, a median of 9% increase was seen (Kruskal–Wallis $H = 11.7$, d.f. = 1, $P = 0.001$).

There was no evidence that total sniffing duration differed by location (Kruskal–Wallis $H = 4.1$, d.f. = 2, $P = 0.1$), but there were differences seen in the mean sniffing episode length per observation ($P = 0.04$, medians PG 4.9 s, RP 4.4 s and WK 3.9 s, respectively, Kruskal–Wallis $H = 6.7$, d.f. = 2, $P = 0.04$). Log percentage time spent sniffing was investigated by univariable regression and ANOVA for associations with variables of interest and with other behaviours observed. There was evidence for an association with day of sampling ($F = 2.3$, d.f. = 5, $P = 0.05$). There was also an association with UK Kennel Club Group ($F = 3.8$, d.f. = 6, $P = 0.001$), with Gundogs sniffing more than other types. The binary variables urination and defaecation were also associated with sniffing ($F = 30.4$, d.f. = 1, $P < 0.001$ and $F = 7.5$, d.f. = 1, $P = 0.01$, respectively). In the final multivariable model, factors associated with sniffing percentage duration included day of observation, Kennel Club Group and urination (Table 5). The variables leash use, weather, defaecation, and single or multiple owners, did not improve the fit of the model.

3.2. Study two – experimental study of the effect of leash use

The mean walk duration was 731 s (median 719 s). On leash walks lasted 597–868 s (mean 698, median 597 s) and off leash walks generally took longer, ranging 628–978 s (mean 765, median 628 s). All dogs except one took longer to walk the route off leash than on leash.

Dogs had the opportunity to interact with a range of 0–24 walkers during each walk but actually interacted with 0–4 per walk. As might be expected, it was more common to see walkers passing in the opposite direction (0–24) compared to travelling in the same direction (0–7). On 26 of 40 walks the dog had the opportunity to interact with at least one cyclist (range 0–9 seen). No interactions with a cyclist were observed. No dogs were observed to interact with a horse or its rider, although only two dogs had the

opportunity to. Subject dogs had opportunities to interact with 0–13 dogs on each walk and actually interacted with 0–10. Again it was much more common to encounter dogs walking in the opposite direction (0–11) than the same (0–4).

The multilevel model of interactions with dogs is presented in Table 6, involving 200 potential interactions. The important factors were whether the subject dog was on or off leash, and whether the other dog was on or off leash. If the subject dog was on leash an interaction was half as likely compared to if the subject was off leash. If the other dog was on leash an interaction was again less likely; an interaction was almost four times more likely to happen with an off leash dog than one on leash. Statistical interaction terms were tested in the model and none were significant. Although the amount of variation at the dog level was estimated in the multivariable model (study two), it is inappropriate to interpret this as variation between dogs, as it also includes variation due to the differing times of day/days of week/months at which dogs were observed.

4. Discussion

These studies have demonstrated that dog behaviour on walks can vary widely, and that the use of a leash can reduce the number of interactions between dogs. Labradors and crossbreeds were the most popular breed types observed and Gundogs the most popular Kennel Club Group, as also reported in a previous survey in this area (Westgarth et al., 2008) and for previous UK estimates (PFMA, 2004). This suggests that the observed dogs may be representative of a wider area. However, any interpretation of the findings must consider that individual differences between the dogs in this particular sample, plus weather, season and environment of data collection, are all likely to affect the behaviours that were observed. In particular, the use of a relatively narrow walking path in study two, rather than a larger open space where the dogs would not be forced to pass so close together, might suggest that there may be an even bigger reduction in contact due to use of the leash in more open spaces. In contrast, dogs being walked in urban areas, on streets, are unlikely to be off leash anyway.

The assumption was made that dogs and owners walking together in a unit were from the same household. This is supported by the proportions of one-, two- and three-dog groups observed in study one, which also approximated to that reported as owned in the questionnaire survey in a nearby community (Westgarth et al., 2007). However, multiple dogs tended to be observed with multiple owners,

Table 5

Multivariable regression model of log percentage time spent sniffing in study one, $n = 286$.

Variable	Coefficient	Standard error of coefficient	P-value
Constant	1.0	0.09	
Day (reference = Friday)			
Saturday 1	0.2	0.1	0.07
Sunday	0.3	0.1	<0.001
Tuesday	0.3	0.1	0.01
Thursday	0.1	0.1	0.2
Saturday 2	0.2	0.1	0.07
Kennel Club Group (reference = Gundog)			
Crossbreed	−0.2	0.1	0.02
Hound and Working	−0.2	0.1	0.2
Pastoral	−0.4	0.08	<0.001
Terrier	−0.2	0.09	0.03
Toy	−0.02	0.1	0.9
Utility	−0.2	0.1	0.3
Urination (reference = no)			
Urination observed yes	0.3	0.06	<0.001

which could be explained by larger families having more dogs, or dogs and their owners that were walking together in groups.

There is evidence that dogs are more likely to be owned by families with children (Westgarth et al., 2007) and yet children were not commonly seen to be out walking the dog. The duty of walking the dog may be performed by an adult without the presence of the children due to the extra effort required to manage the children and dog at the same time, or because they are at school. In contrast to the effect of dog group size, dogs were more likely to be seen with single owners on weekdays compared to at weekends, possibly because the family and friends have more opportunity to walk together at weekends.

The observed differences in number of owners for different dog types may be due to owner preferences when choosing a dog. From personal experience, pastoral breed types (collies, shepherds) are generally active dogs with a strong bond to their owner. A single owner may prefer this type of dog, or there may be only one person available to walk it, due to the amount of exercise required. In contrast, a toy dog may be a more likely choice for a larger household with less time to spend walking the dog.

Single dogs were more likely to be observed on weekends than weekdays, whereas multiple dogs the opposite. Owners with multiple dogs may be more likely to have them as a hobby or interest and make particular effort to walk their dogs during weekdays as they have the time,

or find dog walking enjoyable. Alternatively, multiple dogs may be walked by 'dog walkers' during the week. Possible explanations for dogs more commonly being observed off leash on weekdays rather than weekends include: that the type of owners who are able to (or choose to) walk on weekdays may for some reason like to let their dog off leash; it may be easier to walk multiple dogs off leash than keep them on leash; or there are more dogs and people around on weekends so people chose to keep them on a leash.

In a questionnaire survey in the local area over 90% of dog owners reported always/usually picking up their dogs' faeces (Westgarth et al., 2008). Our observation, that only 63% picked up, suggests that people may have been over-reporting this. Webley and Siviter (2000) reported that 14/36 dog owners claimed that their dog had never fouled, even though all had been observed letting their dog foul, also suggesting that self-reporting should not be relied upon. In our study, owners were more likely to pick up faeces when the dog was on a leash than off leash. This must be interpreted with caution, as numbers observed to defaecate whilst on a leash were low, but it may be easier to notice in this situation (or conversely harder to ignore). Wells (2006) also observed that owners pick up more often when their dog is on a leash. This suggests that policies to keep dogs on leash near play areas may reduce the amount of faeces left behind.

The relationship between sniffing behaviour and day of observation is difficult to interpret; it is not accounted

Table 6

Multilevel multivariable model of interactions with other dogs in study two (10 subjects, 200 potential interactions). Dog and session levels were included as random effects. Estimates were obtained using MCMC simulations with Metropolis–Hastings sampling.

Variable	Coefficient	Standard error	Odds ratio	95% confidence interval	P-value
Subject dog leash					0.02
Off	0		1		
On	−0.8	0.3	0.5	0.2–0.9	
Other dog leash					<0.01
Off	0		1		
On	−1.4	0.5	0.3	0.1–0.6	

Random effect dog coefficient 0.2, SE 0.6.
Random effect session coefficient 1.0, SE 0.5.

for by differences between week and weekend days, or weather, so is likely due to other unmeasured factors about particular days. Gundog breed types were more likely to perform sniffing behaviours than others, as might be expected from their traditional function. The association between sniffing and urination was not surprising, as dogs can often be seen sniffing around the time of (and particularly preceding) urination, especially if the urination is for marking purposes. From an early age all canids investigate and sniff urine and faeces from other animals, in order to gain information about conspecifics, and may urinate or defaecate on, or roll in, other animals' faeces (Fox, 1984). Such close contact during investigation of faeces and urine of other individuals may provide an opportunity for pathogen transmission. Our univariable analysis suggested that if dogs were allowed both on and off leash more sniffing behaviours were performed whilst off leash, suggesting they may prefer to perform sniffing behaviour whilst off leash, or that stimuli that promote sniffing are less accessible when on a leash.

In both studies, interactions with people were much less commonly observed than interactions with other dogs. This is despite observing more potential interaction with people, than for dogs, on the route of study two. In a small postscript note in the paper by Bekoff and Meaney (1997), findings from an otherwise unpublished study are reported; on leash dogs were seen to initiate contact with humans 5.5 times more than off leash dogs, and people initiated contact with on leash dogs 3.8 times more than with off leash dogs. In contrast, we observed more human–dog contacts if the dog was off leash.

Although study one did not assess the leash status of the other dog in an interaction, the experimental study (two) was designed to investigate this. The findings suggest that it is of consequence whether either of the dogs is on leash or off leash in a situation where interaction is possible. In order to prevent interactions occurring, putting either dog on a leash will reduce the number of interactions, but greater reduction may be achieved if both dogs are on leash. In face of a disease outbreak, it would be important that everyone followed a leash-rule, if interactions were to be reduced to maximum effect. There was no evidence for any interaction effects between the variables, suggesting the effect of the leash for one dog did not vary depending on the leash state of the other dog.

In study two, whether or not the other (non-study) dog was on a leash appeared to have more influence on the probability of an interaction than if the subject dog was on a leash. It may be that our subject dogs were under better control than the general range of dogs met, although our owners were instructed to act as normal and allow their dog to do as it wished, within reason. However, all of our owners had to be happy for their dogs to be off leash around other dogs, in order for them to participate in our study in the first instance, and this may have biased our selection of owners toward those with well-controlled dogs.

Bradshaw and Lea (1992) previously observed that the on leash dog was never the initiator of interactions, and no interactions were observed between two on leash dogs. In our studies, the latter was definitely observed but we did not assess who initiated such interactions. In study one, the duration of interactions with other dogs appeared to be shorter when the dogs were on a leash than when they were off leash. In Bradshaw and Lea (1992) the duration of the interaction was not measured directly but the median numbers of behaviours observed during an interaction was also reduced when the recipient dog was on lead, again suggesting a shorter interaction length. Off leash dogs took longer on their walks in study two, and as interactions with other dogs may also be longer in duration, these processes may further amplify the effects of the leash in reducing contacts.

5. Conclusion

Contacts between dogs are more common than contacts between dogs and people. If a reduction in the number of dog–dog interactions was required, putting dogs on a leash could be a recommended method with fewer welfare implications than a total ban on walking dogs. In order to increase the duration and frequency of beneficial social interactions of a dog with conspecifics, off leash walking is recommended; but for best effect to reduce disease spread during an outbreak, or to modulate the consequences of aggressive encounters, both dogs should be kept on a leash. Further studies with more subjects are required to assess the behavioural nature of on leash and off leash interactions, and whether factors such as breed, age, size or environment, impact the way that leashing affects dog behaviour.

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