Avens Publishing Group
J Veter Sci Med
May 2021 Volume 9 Issue 1

Exploration Behavior of Pet Dogs During Off-Leash Walks

Open Access Research Article

Journal of Veterinary Science & Medicine

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Submission: 30 March, 2021
Accepted: 1 May, 2021
Published: 5 May, 2021

Keywords: Canine dog cognition exploration orientation behavior

Abstract

Studied was the behavior of free-ranging (off-leash) exploring domestic pet dogs (n=30) whilst walking with their owners in new as well as familiar areas (n=120) and not being signaled or called to. Aim of this study was to collect data to assess distance and time dogs spent away from the owner and to determine movement or exploration patterns. The roaming behavior of the dogs was measured via GPS during four consecutive walks whilst off the leash at all times. Individual runs were assessed if the dog travelled in excess of 20 m away from their owner in any direction (n= 3145 runs) and seven different exploration patterns were evaluated.

All dogs herein found back to their owner, in known and unknown areas even subsequent to having explored out of range of visibility. Due to great intraspecific variability three groups were established. Almost half of the dogs displayed a distance of less than 150 m away from the owner (43 %) on all walks; about 1/3 of the dogs never explored beyond the 350 m radius (27 %); 30 % of the dogs explored at least once beyond the 350 m radius. Out of all runs >20 m (n= 3145) the dogs utilized primarily (62 %) the travelling pattern of running ahead of the owner on the path and waiting or following. Results herein are in accordance with expected socioecological differences, in that male dogs explored further than female dogs ($p = 0.003$; Mann-Whitney-U Test), possibly because of a relevant function in reproduction. With respect to reproductive status no differences were found.

All dogs travelled significantly longer distances (Wilcoxon test $p<0.001$) than their owners and at significantly higher speed (Wilcoxon test $p<0.001$).These are important indications that dogs need to walk off leash to choose their physiological walking pace. In conclusion, most dogs stay close to their owner and off leash restrictions should be reconsidered.

Introduction

The majority of domestic dogs (approximately 80 % of the global dog population)are considered feral or free roaming and live in a human-dominated niche [1,2]. Pet dogs therefore represent only a fractional part of the entire dog population. In the main, these dogs live either in enclosed properties or their exercise takes place in a daily round of walks with their owner, often on a leash [3]. This may raise health and welfare concerns [4-7].

In numerous studies the close bonding, reliance, attachment and resulting specific behavior of domestic dogs with respect to their human owner has been demonstrated [8-12] therefore we hypothesized that dogs have high motivation based on this strong bonding to return to their owner, regardless of breed, area or external stimuli.

The majority of current literature proposes that domestic dogs, primarily due to domestication, have lost or have a reduced ability of spatial orientation compared to wolves [13,14]. We hypothesized, however, that off-leash pet dogs will find back to a specified, varying non-stationary locality (i.e. their owner) in different environments. Even subsequent to having explored a certain distance i.e. out of range of visibility or/and olfaction, based on their ability to establish cognitive maps and the use of spatial reference systems [15,16]. Herein all of the dogs found their respective owners on all runs >20m.

Exploration is important for animals to be able to gather information about features of their environment that may directly or indirectly influence survival and reproduction [17] as it enables them to collect information about food distribution, shelters or escape routes [18]. Exploratory behavior is considered as an aspect of sensory processing involved in investigating novel stimuli, rather than an instinctive behavior [19] and partially depends on motor and spatial capabilities and on the motivation to explore [20]. Studies have demonstrated a linkage between learning, memory, exploratory behaviors and genetics [21,22], and breed differences have been proposed [23,24]. Spatial orientation may either be maintained allocentrically by memorizing specific landmarks (e.g. roads, trees, etc.), positions and locations in known locations [15] in which the dog updates its position in the environment using a reference system external to the body and anchored in the environment [25]. Dogs may also orient egocentrically by integrating signals or cues indicating the extent of self-motion along their locomotion trajectory [26], in which the dog updates an object's location with respect to its own body, using a reference system centered on the body, typically defined by the reference directions of front, back, right and left [26,27]. We therefore hypothesized, that dogs, depending on their individual traits, character, learning experience, breed, socialization and age would utilize different exploration patterns.

The aim of this study was to garner data about the factual exploratory behavior of pet dogs. This is in particular important because of the strict regulations and prejudices currently existing and their implications for domestic pet dogs, specifically their physical and psychological welfare and the impact on cognitive abilities and functions by being frequently walked on a leash [28,29].

Taking into account legal restrictions in many countries as well as the preconceptions often voiced i.e. by the hunting community that pet dogs will chase prey, it is important to ascertain how dogs actually explore whilst off the leash. Furthermore, recent studies showing the result of Covid-19 restrictions on dogs underline the detrimental effect of leash walking, even within a short period of weeks or month [28,30].

Results herein might be useful in establishing areas where off leash dog walking is allowed, help dog-trainers to get more information

ISSN: 2325-4645

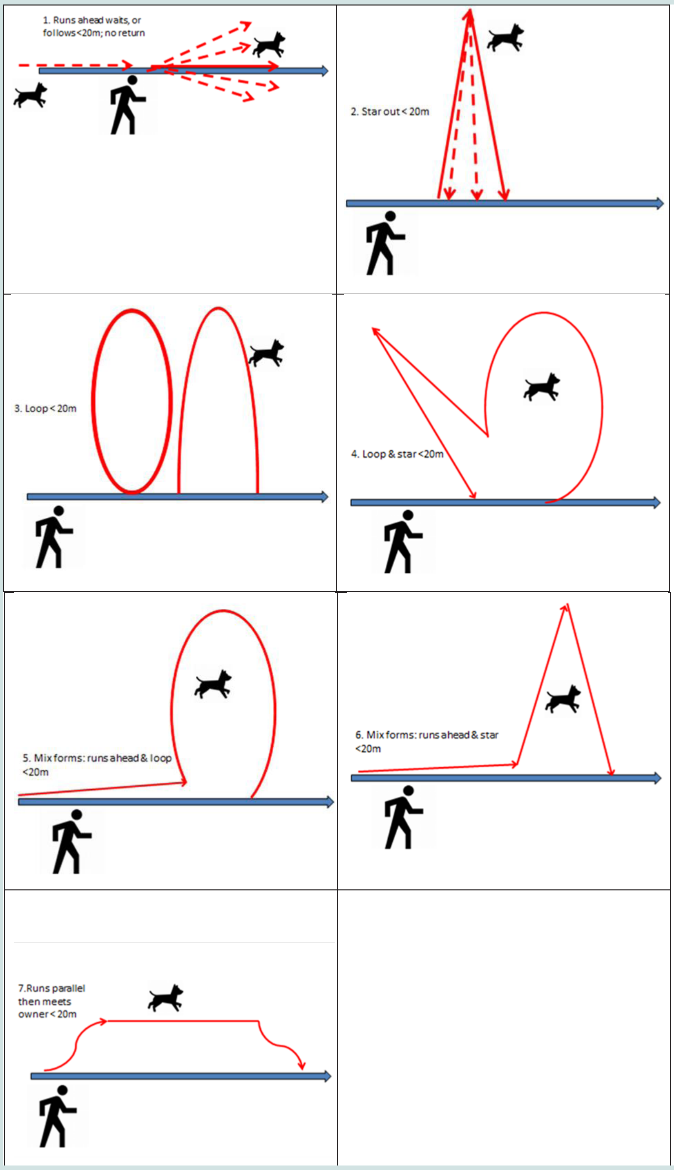

Figure 1: Pictogram illustrating the seven different travelling patterns.

about exploratory behaviour of pet dogs and may benefit in designing walking areas, as dog walking is a popular method for increasing human physical activity [31,32]. The omnipresence of the domestic dog inspired many scientific endeavors, but research on pet dog walks mainly focused on applicable aspects of health effects for the owner, epidemiology [33], or has been conducted in enclosed areas or laboratory settings [34-36].

To our knowledge, no research has actually been done to ascertain how domestic pet dogs in fact do behave whilst off the leash, unrestricted and in an unenclosed area.

Materials and Methods

GPS data were collected on trials (n = 3145) of free ranging, freely exploring domestic pet dogs (n=30) of different breeds, size, reproductive status, sex and age (Table 1) while walking with their owners on four consecutive walks in two known and two unknown areas in North Rhine Westphalia, Germany (n=120). A dog had to travel a minimum distance of 20m away from the owner to be recorded as a run, and seven different travelling patterns were distinguished, see Figure 1, pictograms. Lengths of the walks depended on age and physical ability of the dog, the average length was mean 89 min. +/- 24 min per walk.

A total n=120 measurements with an n=3145 total runs >20 m resulted. There were 18 different owners, 15 female (83 %) and three male (17 %). 83 % of the owners had more than one dog. 17 % owned one dog. Out of the 30 dogs eight belonged to a single dog household owner, 22 to a two or more dog owner – in this group ten owners accounted for 22 dogs. The median age of the dogs was 63.5 months. 40 % of the dogs were male (n=12), of which 75 % of were neutered and 60 % were female (n=18), of which 72 % were spayed; of all dogs

ISSN: 2325-4645

Table 1: All dogs, breed and size (shoulder height).

Pure breeds n=20	**>60cm**	**<60cm**	**<40cm**
Size	Large	Medium	Small
Sighthounds n=9	Borzois n=3 (# 26,28,30)	Whippets n=3 (# 11,24,13) Silken Windsprite n=1 (# 8)	Italian Greyhound n=2 (# 19,25)
Herding dogs n=2	Collies n=2 (# 1,29)		
Hunting/sPORting dogs n=4	Standard Poodle n=1 (# 3)	Labrador Retriever n=2 (# 2,22)	Miniature Pinscher n=1 (# 14)
Toy breed n=2			Pugs n=2 (# 10,21)
Working group n=3	Rhodesian Ridgeback n=2 (#6,17)	Perro de Aqua Espanol n=1 (# 18)	
Mixed breeds n=10	**>60cm**	**<60cm**	**<40cm**
	Great Dane Mix (#4)	Husky Shepard Mix (# 5)	Terrier/Chinese Crested Mix (# 27)
	Mastiff Mix (# 12)	Labrador Mix (# 7)	
	Greyhound Mix (# 23)	Perro de Aqua Espanol Mix (# 9)	
		Pastor Mallorcin Mix (# 15)	
		Collie-Shepherd Mix (# 16)	
		Labrador Mix (# 20)	

Table 2: Each dog minimum, maximum and median distance of runs >20 m, Grouped: Group 1: radius < 150 m; Group 2: 150 m < = radius <350 m; Group 3: radius > = 350 m

Dog/breed	**Max distance of runs > 20 m of 4 walks in m**			**Group (1: radius < 150 m; 2: 150 m < = radius <350 m; 3: radius > = 350 m)**
N=30 F/M; i/n	**Minimum**	**Median**	**Maximum**	
Amanda/Collie F/i	87	125	174	1
Amy/Labrador F/n	166	223	303	2
Arthur/Poodle M/i	147	182	239	2
Balin/Great Dane mix M/n	72	146	191	1
Balou_Mix/ Labrador Mix M/i	299	457	839	3
Balou_RR/Ridgeback M/n	111	129	246	1
Bill/Labrador Mix M/n	521	588	646	3
Dr. Pepper/Silken Windsprite M/i	48	80	407	1
Emma/Perro de Aqua Espanol Mix F/n	19	65	126	1
Freya/Pug F/n	78	99	193	1
Honey/Whippet F/n	157	417	479	3
Kaito/Mastiff Mix M/n	250	795	1000	3
Kimi/Whippet F/n	167	333	704	2
Lea/Emma/Miniature Pinscher F/i	105	242	392	2
Lili/Shepard Mix F/n	92	113	173	1
Lou/Shepard Mix M/n	249	495	1000	3
Luna/Ridgeback F/n	239	285	377	2
Mala/Perro de Aqua Espanol F/n	0	35	157	1
Manja/Italian Greyhound F/i	0	92	354	1
Marley/Labrador Mix M/n	374	1600	2300	3
Molly/Pug F/n	90	104	124	1
Nele/Labrador F/n	71	134	217	1
Nina/Greyhound Mix F/n	135	334	607	2
Odin/Whippet M/n	47	58	68	1
Raffaele/Italian Greyhound M/n	115	365	658	3
Raiya/Borzoi F/i	306	445	881	3
Tamina/Terrier Mix F/n	406	1400	1900	3
Thorin/Borzoi M/n	142	218	300	2
Wantje/Collie F/i	89	119	156	1
Zlata/Borzoi F/n	171	211	338	2

30 % were intact and 70 % neutered/spayed. 33 % (n=10) of the dogs were mixed breeds and 67 % (n=20) of the dogs were pure breeds, see Table 1.

The GPS used were a Garmin Astro® 320 and the dog collars DC™ 50, and T5 Mini, Garmin International Inc., Kansas, USA. Data were then analyzed using the software Garmin BaseCamp™ 4.5.2.1. The dogs were monitored through a GPS collar (Garmin T5 and DC™ 50)

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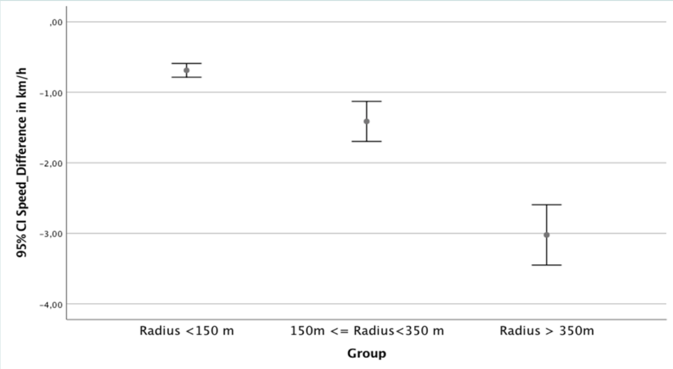

Figure 2: Mean speed difference in km/h and Group 1, 2 and 3 of owner-dog dyad.

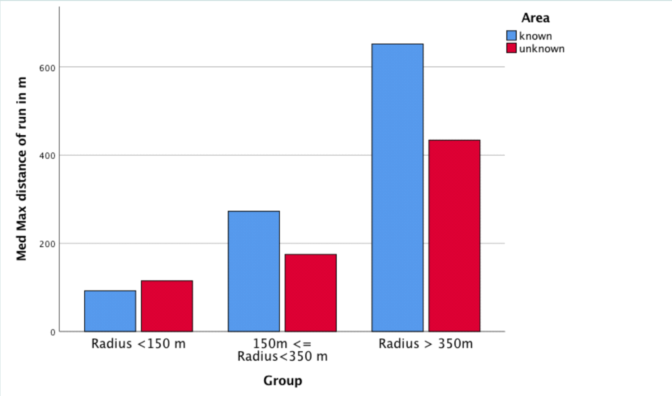

Figure 3: Median of maximum distance in meter all runs >20 m; grouped; known (blue) versus unknown (red) area.

and the owner carried a hand held GPS device (Garmin Astro® 320) to determine the distance between dog and owner. The margin of error for the Astro® 320 is within +/- 3.65 m. Dog collar details: The DC™ 50 weighs 289g (sender; antennae and collar); the size is (B x H x T): 9 x 4.9 x 4.6 cm; distance of recording is up to 14.5km. The T5 weights 198g (sender; antennae and collar); size (B x H x T): 8.9 x 4.4 x 4.7 cm; distance of recording up to 12km. The Video camera used was a Garmin VIRB® Elite. Size: (H x B x T): 32 mm x 53 mm x 111 mm; weight 170g. Datatype: MP4; 1080p-HD-Video: 1920 × 1080; 30 fps. Video data were also displayed on Garmin BaseCamp™4.5.2.1. The camera, however, was only used on the larger dogs as it was too heavy and difficult to attach to the small dogs.Wind speed and direction was measured with an anemometer (Technoline EA-3000) and handheld compass. Ambient temperature was also recorded therewith.

Trials were performed in wooded areas, preferably with dense underbrush to prevent visual contact. If two dogs from one owner participated in any given trial data from both dogs, as visualized on Garmin BaseCamp™, were used and compared, individually and grouped. Solely uninhabited areas, without roads or major pathways, were visited. The owner was not to whistle or call or offer any other kind of acoustic or visual signal. Seven travelling patterns were differentiated for each run > 20m: 1. Dog runs ahead and waits/follows; 2. star; 3. loop; 4. Loop + star; 5. Mix forms: runs ahead & loop; 6. Mix forms: runs ahead & star; 7. Runs parallel then meets owner. Regarding the travelling patterns, see Figure 1 for pictograms.

Descriptive analysis was performed calculating number of valid measurements (n), mean (m), median, quartiles and standard deviation (SD). Relationships were plotted using scatterplots, bar charts, boxplots or mean +/- 95 % confidence interval. Nonparametric tests were used for inductive statistics. Mann-Whitney U Test was used to compare two independent samples, Wilcoxon test for dependent samples of ordinal data. Also randomization (or permutation) tests were applied for comparison of dependent or independent groups of interval scaled data.

Hierarchical cluster analysis was applied to find walks with similar running patterns and to find the appropriate number of clusters. Squared Euclidian distance was used as measure of distance and Ward method was used as linkage method. K-Means clustering with three Clusters was applied to assign all walks to the cluster. A Cluster analysis is neither parametric nor non-parametric as the algorithms are based on exploratory data mining.

All tests were performed two-tailed on a 5 % level of significance. Standard Bonferroni correction of p-values < 0.05 was applied in case of multiple testing. Two-tailed tests were performed unless otherwise denoted. SPSS version 25, IBM Inc. was used for analyzing the data. StatKey (http://www.lock5stat.com/) was used for performing randomization tests using a simulated sample of size n= 5000.

ISSN: 2325-4645

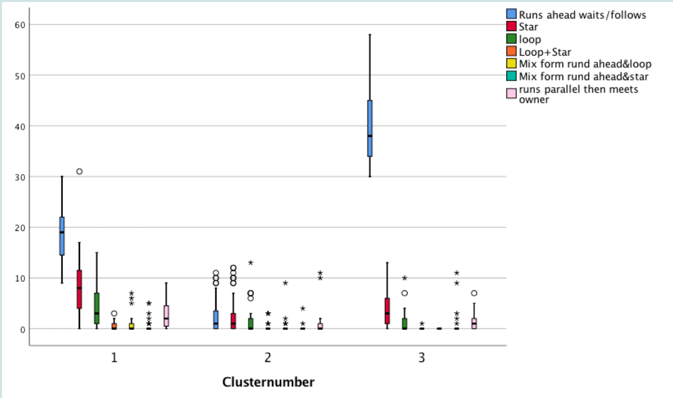

Figure 4: Distribution of patterns between the cluster groups.

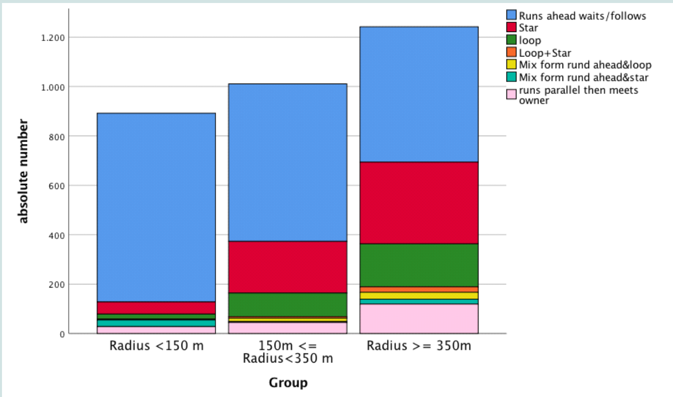

Figure 5: Distribution of patterns between Groups 1, 2 and 3 and travelling patterns of each Group.

Ethical Approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Results

All dogs, independent of sex, age, reproductive status or breed, found and returned to their owner in different environments subsequent to having travelled at least 20 m away from their owner. Length of trials (runs > 20 m) varied greatly, therefore three groups were established to determine travelling patterns in more detail and describe difference between the dogs more specifically: Group 1: radius < 150 m maximum distance from owner travelled by the dogs; Group 2: 150 m <radius< = 350 m maximum distance from owner; Group 3: radius > = 350 m distance from owner.

Data demonstrated great intraspecific differences: 50 % of the dogs showed a median difference in walking distance to their owner of 1000 m, with a lower quartile of 400 mand an upper quartile of 2300 m difference between owners and dog distance walked, which corresponds to a 43 % increase. The distance difference travelled was significantly larger for dogs compared to owners (p<0.001). Dogs of all three groups travelled longer distances than their owners.

Results also showed significant speed difference between owners and dogs (p<0.001; Wilcoxon Test).The mean speed of owners was 4.4 +/- 0.4 km/h compared to 6.0 +/- 1.2 km/h of the dogs, independent of the group the dogs belonged to or factors like age, size or exploration patterns see Figure 2. Altogether 50 % of the owners displayed a walking speed of less than 4.4 km/h; 50 % of the dogs had a walking speed of less than 5.7 km/h. A quarter of the owner had a travelling speed of less than 4.2 km/h while the lower quartile of the dogs ‘speed was 5.2 km/h. The higher quartile of owner walking speed was 4.7 km/h; compared to the dogs travelling speed of 6.6 km/h. The total median speed difference amounted to -1.1 km/h; mean 1.6 km/h. Speed differences could also be established between the three groups, with Group 3, the dogs with the largest radius, displaying the highest speed differences compared to their owners, see Figure 2 (in km/h).

Great intraspecific differences could be perceived between the maximum median distances of runs > 20 m explored by each dog (Table 2).The majority of dogs exhibited a median maximal difference of less than 150 m away from the owner (13 of 30 dogs =43 % Group 1); eight (27 %) of the dogs displayed a median maximal difference away from the owner of less than 350 m (Group 2); nine of the 30 dogs (30 %) had at least one run over 350 m away from the owner (Group 3).

For each group the median of the maximum distance away from the owner of runs >20 m in known as well as unknown

ISSN: 2325-4645

areas was assessed. Looking at the median of the total runs >20 m in known and unknown areas, values of Group 1 were almost identical (known 572 m/unknown 435 m) (p = 0.796, Mann-Whitney-U Test). In Group 2 dogs travelled shorter distances in unknown areas (known 3101 m/ unknown 2524 m – reduction 19 %, p = 0.491, Mann-Whitney-U Test). Group 3 however shows the clearest reduction in travelling distance of runs >20 m from known 5709 m to unknown 4378 m (decrease 23 %, p = 0.126, Mann-Whitney-U Test), Figure 3. For no group a significant reduction could be demonstrated however. Between the three groups differences in exploration time could clearly be seen, with an increase from Group 1 to Group 3. All groups displayed longer exploration times of runs >20 m in known than unknown areas.

The dogs exhibited various travelling patterns. Out of all runs > 20 m (n= 3145) the dogs displayed n=1950 runs, 62 % the travelling pattern of running ahead of the owner on the path and waiting/following (see Figure 1 for pictogram). The star pattern was used n=589 runs; 19 % of the time, thus the dogs basically returned on their path. A loop was displayed n=291 runs; 9 % of the time and the mixed forms together n=95 runs; 3 % of the time. Parallel runs to the owner were used n= 192; 9 % of the time.

Based on the great individual variance displayed by the dogs a hierarchical Cluster analysis using Ward linkage and squared Euclidean Distance measure was applied to establish an appropriate number of clusters. Based thereon a dendrogram was drawn. To determine the optimal number of clusters a trade-off between heterogeneity within the clusters and the number of clusters had to be made. Here a number of three clusters for classifying all walks (total) seemed an appropriate trade-off – For a distribution of patterns between the cluster groups see Figure 4.Walks belonging to Cluster 3 were dominated by the pattern runs ahead waits/follows. Star and runs parallel could also be observed. All other patterns were rare. Cluster 2 showed a low total number of runs, the most frequent patterns were loop, star and runs ahead. Cluster 1 was mainly characterized by the patterns runs a head waits/follows, followed by star, loop and also parallel runs and mixed forms. The number of runs ahead was less compared to Cluster 3.

For the Distribution of patterns between Groups 1, 2 and 3 and travelling patterns of each group see Figure 5. Group 1 dogs predominantly displayed the travelling pattern of running ahead and waiting or following the owner with little variance of other travelling patterns. With increasing distance of runs (Group 2 and 3) the dogs displayed a greater variance of exploration patterns including more cognitively challenging patterns like loops or mixed forms. Dogs of different age and breed were represented in the different groups as well as clusters. Group 1 dogs were underrepresented in Cluster 1 (observed: 8 vs. expected 19) and overrepresented in Cluster 2 (observed: 30 vs. expected 22) and 3 (observed: 14 vs. expected 11). In other words dogs with a low maximal distance away from their owner could be characterized by Cluster 2 (nearly no runs away from owner) or Cluster 3 (high frequency of runs forward/backward and waits). Dogs with a radius >350 m were overrepresented in Cluster 1 (observed: 21 vs. expected 13) und underrepresented in Cluster 3 (observed: 2 vs. expected: 8). Therefore these dogs may be characterized by exploration patterns of star and loop and a medium number of runs ahead waits/follows.

It has been postulated that sex differences exist in regard to exploration distance between male and female dogs, therefore the distance of runs >20 m with regard to sex was analyzed. The variance between female and male dogs with respect to the distance explored of runs >20 m was significant (p = 0.003; Mann-Whitney-U Test). Male dogs explored significantly longer distances than female dogs. The mean distance of runs >20 m was larger for male dogs (3464 +/- 2732 m), than for female dogs (1862 +/- 1739 m) by an increase of 86 %. Analyzing the duration explored by female and male dogs' similar results became apparent. The duration over all runs >20m was longer in male dogs (22 +/- 16 min.) than in female dogs (13 +/- 16 min.). The difference in the duration of runs > 20 m between female and male dogs was also significant (p = 0.001; Mann-Whitney-U Test).

Discussion

Pet dogs growing up in our complex environment generally have ample learning opportunities of how to interact and communicate with humans, thus garnering experiences enhancing their cognitive skills, an ontogenetic process called "enculturation" [26]. Studies postulate an augmenting effect of domestication on the social skills of dogs in cooperative–communicative tasks [37] like a social walk with their owner, impacting on exploration behavior; on the other hand it has been argued that as a result of domestication dogs' spatial memory capacity has been reduced [38],. Our results reflect intraspecific movement variability, which has also been found in free ranging dogs (see Hudson et al., 2017; 2019: three roaming patterns "Stay-at-home dogs; "Roamer dogs" and "Explorer dogs").

Sex differences have been postulated with respect to spatial [39]. Results herein are in accordance with expected socioecological differences, which encompass an extended home range for male compared to female dog. Male dogs explored significantly further and longer than female dogs. It has been suggested that female dogs are more social in inter specific interactions with humans [40] which may be an additional factor for female dogs staying closer to the owner [41,42] than male dogs. Furthermore it has been argued that male dogs are bolder, thus more proactive and explorative than female dogs indicating a potential to explore further or longer.

Regarding their exploration patterns dogs herein were divided into different groups and different clusters: Those dogs that explored the longest and furthest (in known and unknown areas) displayed the largest variety of exploration patterns, indicating cognitive variability, experience and different strategy (allocentric and egocentric) use.

Another important factor impacting movement patterns were the owners: Dogs form bonds with specific humans and make decisions by attending preferentially to social signals from them [43]. Attachment is the highest within the owner-dog dyad [44,45]. Therefore only owner-dog dyads were used in this study as the motivation to return was assumed the highest. Dogs displayed behaviors indicative of an attachment relationship, for instance proximity seeking, where the dog will seek the owner as a means of coping with stress [46,47], or the safe haven effect [48] in which the presence of the owner may reduce the effect of a stressful event.

It has been suggested that domestication has equipped dogs with

ISSN: 2325-4645

two abilities prerequisite for cooperation—namely social tolerance and social attentiveness, enabling them to adjust their behavior to that of their social partners [49]. Social attentiveness, that is, paying sufficient attention to one's partners in order to adjust behavior and thus to cooperate [50] would form the basis of attending to their owner whilst walking, i.e. the dogs had to pay attention to movement and location (and speed) of the owner in order to find him/her again in addition to establishing a cognitive map of their own position in space and time.

The Group 1 dogs stayed the closest to their owner and spent the shortest time away, predominantly displaying the exploration pattern of running ahead of the owner and waiting or following, arguably the least cognitive challenging pattern and not requiring great orientation skills.

Exploration distance and how a dog seeks support in challenging or new situations during the walks may have been impacted by the type of dog-owner attachment. Links between owner attachment style and dog behavior imply that dogs develop different strategies to handle particular situations, based on the type of support they receive from their owner and influenced by the owner's care giving strategy as experienced in previous interactions [51]. Fearfulness or anxiety for instance, thus an inhibitor of exploration, has been linked to lack of experience and aversive learning strategies [52]. The extent of exploration of an animal is balanced against its level of neophobia. Neophilic animals are quick to approach and explore a novel object, while neophobic animals are slow to do so [53]. Neophobic responses are important because they reduce exposure to danger but, on the other hand, they also constrain explorative behavior and thus opportunities for learning and cognitive development. Using the analog of the parent – child relationship it has been established that two parenting dimensions have been consistently associated with the development of anxiety in children: overprotection and anxious rearing [54,55] . Overprotection has been described as parental behaviors aimed at guiding children during their daily activities thereby reducing the development of autonomy [56]. The exploration (or lack thereof) behavior of Group 1 dogs might thus be influenced by a deficit of cognitive development in that these dogs did not have opportunities to explore, develop orientation strategies and garner experiences, in particular as compared with Group 3 dogs [48] postulated that an owner who is supporting the dog's attempts to independently deal with problems (or herein explore) leads to more confident dogs. This may apply to Group 2 and particularly Group 3 dogs, who were secure enough to explore away from their owner at significant distances and who had previously learned appropriate strategies to find their owner again.Group 1 dogs displayed little cognitive variance regarding exploration patterns and, independent of known or unknown area, essentially ran ahead of the owner or followed on the path. Group 3 dogs on the other hand exhibited a wide range of strategies. Arguably having been able to learn sovereign exploration behavior and thus becoming more autonomous, they developed self-reliant movement resources and greater cognitive orientation applications. This furthermore required memorization of the spatial and temporal relations between the individual and multiple goals e.g. the owner and different landmarks [56]. Memory encompasses the acquisition, encoding, storage and retrieval of information [57]. Retrieval of memorized information is context-dependent i.e. using past experiences for decision making processes and subsequent behaviors, again implicating owner provisions. Thus within this context dogs would have been in similar contexts before (free-ranging) to collect information (past experiences) to establish subsequent exploration patterns.

In young animals spatial information is first used to encode egocentric spatial memory and subsequently allocentric memory [58]. Encoding memories requires learning periods [59], which occur via social or cultural transmission, for instance through the owner or conspecifics. Furthermore capacity, duration and precision of memories are salient because memories will deteriorate unless reinforced and maintained (use it or lose it). Memories should be particularly valuable in landscapes of intermediate complexity like the ones herein, where remembering several locations and their attributes would be sufficient to accrue benefits like finding and returning to the owner through efficient navigation or timely returns as displayed by the dogs herein. Depending on the dogs' biographies and motivation, they investigated their environment with different latencies and for variable periods displaying great variability. Other biological or psychological variables, like breed or age, may of course compound this effect. Data obtained herein reflects furthermore that all dogs travelled significantly longer distances and at significantly higher speed whilst off leash compared to their owner, see Table 1, independent of the group the dogs belonged to or factors like age, size or exploration pattern.

The importance of regular exercise for dogs is well known in helping maintain the dog at a healthy weight and ensure it is less susceptible to psychological conditions such as depression [60]. Each dog has an individual walking pattern, based on size, breed, age and idiosyncrasies, its gait being defined by step frequencies, velocity, length and width of step. To be on a leash restricts the normal walking pattern of a dog, as the dog has to subsume its gait pattern to that of its owner, which affects the function of the nervous and/or the musculoskeletal system and disrupts their interactions, possibly leading to gait disturbances [61]. A gait is formed through complex interactions between the musculoskeletal and the central and peripheral nervous system, where ambulation requires constant adaptation to both intrinsic and extrinsic factors and dogs display a wide range of step frequencies [62]. The biomechanical idiosyncrasies of the dog gait may not be warranted while on the leash, no matter how careful the owner.The leash and even the leash side influence gait symmetry [64] entailing welfare concerns for those dogs often on a leash. In their study [30] reported that German dog owners were running with their dog (18.1%; mean 21 ± .61 h/week) and bicycle riding (20.4%19 ± .53 h/week) which also shows the amount of inappropriate dog exercise raising animal welfare concerns. Similarly popular activities like agility and canicross have been associated with injuries and health [63,64].

Conclusion

Taking into account our current perspective on what constitutes a "good/obedient" dog (including the legal regulations) the Group 1 dogs would probably be considered thus, which may raise further questions with regard to dog welfare, cognitive development and learning issues in our society [65]. All dogs displayed a high motivation arguably based on a strong bonding to return to their

ISSN: 2325-4645

owner, regardless of breed, area or external stimuli whilst off the leash, with a majority of dogs merely running ahead of their owner or following. This strengthens the argument that dogs should be given more opportunities to walk off leash and to establish safe areas where they may explore. Overall dogs did display the cognitive ability of spatial orientation to find their way back to the owner, in known and unknown areas, regardless of distance explored. Dogs utilized various exploration patterns, with those animals exploring furthest exhibiting the greatest cognitive variability, thus signifying the importance of early exploration opportunities being offered enabling the dogs to gather practice. Popular dog-related on leash activities might raise animal welfare concerns in that they disregard the dog's individual walking pace as needed for their physical and physiological health as well as cognitive development.

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