Journal of Comparative Psychology

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Online First Publication, March 14, 2019. http://dx.doi.org/10.1037/com0000171

American Psychological Association

Journal of Comparative Psychology

0735-7036/19/$12.00

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When Walking in an Outside Area, Shelter Dogs (*Canis familiaris*) Synchronize Activity With Their Caregivers but Do Not Remain as Close to Them as Do Pet Dogs

Charlotte Duranton
Aix-Marseille University & CNRS and AVA Association, Cuy-Saint-Fiacre, France

Thierry Bedossa
AVA Association, Cuy-Saint-Fiacre, France, and Alfort National Veterinary School

Florence Gaunet
Aix-Marseille University & CNRS

When taken for walks, pet dogs synchronize their walking with that of their owners. The aim of this study was to ascertain whether shelter dogs do the same with their caregivers. We documented the behavior of 30 shelter dogs when they were taken outside in their regular walking area by their principal caregivers. The caregivers were instructed to behave in three ways: stay still, walk normally, and walk fast. The shelter dogs synchronized their locomotor activity with their caregiver less strongly than did pet dogs in a previous study. Shelter dogs also maintained greater distances to their caregivers than pet dogs with their owners. The present study predicts that the strength of the social bond between the caregiver and the dog explains most of the findings, which are similar to those found between adult human interacting partners. Further research could disentangle what aspects of experience contribute to the differences between pet dogs and shelter dogs in behavioral synchronization with a familiar human.

Keywords: dog–human synchronization, dog–-human affiliation, locomotor synchrony, interspecific synchronization, shelter dogs

Supplemental materials: http://dx.doi.org/10.1037/com0000171.supp

Behavioral synchronization can generally be defined as doing the same thing at the same time and in the same place as other individuals (Louwerse, Dale, Bard, & Jeuniaux, 2012). There are several subtypes of behavioral synchronization, such as temporal synchrony (switching activity at the same time; Dostálková & Špinka, 2007), activity synchrony (exhibiting the same behavior at the same time, also called behavioral similarity, mimicry, allomimicry or behavioral matching; Chartrand & Bargh, 1999; Chartrand & Lakin, 2013; Gautrais, Michelena, Sibbald, Bon, & Deneubourg, 2007), and location synchrony (being in the same place at the same time; Bertram, 1980; King & Cowlishaw, 2009). Behavioral synchronization can be observed in simple situations such as walking side by side (in humans: van Ulzen, Lamoth, Daffertshofer, Semin, & Beek, 2008; in dogs: Duranton, Bedossa, & Gaunet, 2017b,2018) and in more complex ones implying a third party such as social referencing when a dog adjusts to the social cues provided by the partner (Duranton, Bedossa, & Gaunet, 2016; Merola, Prato-Previde, & Marshall-Pescini, 2012).

Behavioral synchronization is broadly observed in mammals and is supposed to have various adaptive values, such as reducing predation pressure and increasing group members' survival (Duranton & Gaunet, 2016a). One value that is of interest for the present work is its role in social bonds: Behavioral synchronization is acknowledged to increase social cohesion by increasing affiliation between individuals (Chartrand & Lakin, 2013), by allowing better social learning between individuals (Fragaszy et al., 2017), and better empathy (in humans: Koehne, Schmidt, & Dziobek, 2016; in nonhuman primates: Mancini, Ferrari, & Palagi, 2013). Conversely, the more affiliated two individuals are, the more behavioral synchronization they display (see Duranton & Gaunet, 2016a for a review). For example, the more two cetaceans are affiliated, the more synchronized pair-swimming behaviors they display (e.g., wild bottlenose dolphins: Sakai, Morisaka, Kogi, Hishii, & Kohshima, 2010; long-finned pilot whales: Senigaglia, de Stephanis, Verborgh, & Lusseau, 2012). In humans, rapport and liking are linked to a higher level of behavioral synchronization

Charlotte Duranton, Cognitive Psychology Laboratory (UMR7290), Aix-Marseille University & CNRS, and AVA Association, Cuy-Saint-Fiacre, France; Thierry Bedossa, AVA Association, Cuy-Saint-Fiacre, France, and Alfort National Veterinary School; Florence Gaunet, Cognitive Psychology Laboratory (UMR7290), Aix-Marseille University & CNRS.

The authors are grateful to Charlyne Eury for the reliability coding. We also thank the caregivers who volunteered for the study. This work was funded by the National Association for Research and Technology, the Aide aux Vieux Animaux (AVA) association, the French National Centre for Scientific Research, and Aix-Marseille University.

Correspondence concerning this article should be addressed to Charlotte Duranton who is now at Ethodog, Research in Canine Behaviour, 5bis Impasse Pierre Curie, 78600 Maisons-Laffitte, France. E-mail: charlotte.duranton@cegetel.net

between the interacting partners in a variety of situations (Chartrand & Lakin, 2013; Cheng & Chartrand, 2003).

This aspect of behavior has recently been investigated in dogs. Dogs display more behavioral synchronization with dogs to which they are closely affiliated (see Duranton & Gaunet, 2015 for a review). For instance, dogs more readily synchronize with a leader toward whom they exhibit affiliative behavior than with other individuals (Bonanni, Cafazzo, Valsecchi, & Natoli, 2010). In addition, dogs exhibit more activity synchrony (e.g., facial rapid mimicry) with dogs with whom they are more affiliated (Palagi, Nicotra, & Cordoni, 2015). However, little is known about the effect of affiliation on behavioral synchronization at the interspecific level, specifically between dogs and humans.

Dogs have been divided into different populations, based not on genetic differences but on differences in their living environment and the amount of contact/relationship they have with humans (see Duranton & Gaunet, 2016b for a review). Pet dogs live in people's homes; interact with their favorite human partner each day, be it playing, walking or sleeping together; and are often treated as a member of the family (Duranton & Gaunet, 2016b). By contrast, shelter dogs mainly live in enclosures, either alone or with a small number of conspecifics, and interact with humans for very short periods of time (e.g., at feeding time or when the enclosure is being cleaned). They sleep without humans and are only occasionally taken for walks, depending on the shelter's facilities (Duranton & Gaunet, 2016b). It is broadly acknowledged that even if shelter dogs form affiliative bonds with humans (Gácsi, Topál, Miklósi, Dóka, & Csányi, 2001), these bonds are generally not as strong as those forged between pet dogs and their owners (Duranton & Gaunet, 2016b). These weaker bonds, linked to a lower level of interaction with humans, are known to impair dogs' sensitivity to humans' social cues such as attentional state and ability to use humans' communicative gesture (for a review, see Duranton & Gaunet, 2016b). Regarding behavioral synchronization, pet dogs have recently been shown to synchronize their behavior with that of their owners in a variety of situations, such as when walking indoors or outdoors, or when encountering an unfamiliar object or person (Duranton et al., 2016, 2017b, 2018; Merola, Prato-Previde, Lazzaroni, & Marshall-Peschini, 2014). However, the effect of affiliation on dogs' behavioral synchronization with humans has so far been little investigated in the shelter dog population. Duranton, Bedossa, and Gaunet (2017a) found that shelter dogs did not synchronize activity with their caregivers when encountering an unfamiliar person. We suggest that the social setting in that study was too complicated for shelter dogs to synchronize their behavior with their caregiver. We therefore investigated the existence of behavioral synchronization in shelter dogs in a simpler situation (walking with a caregiver) that did not involve a third person. Because synchronization between individuals is known to be greater in large areas than in small places (Sibbald, Shellard, & Smart, 2000), we decided to perform our observations in a large outdoor area. Pet dogs exhibit a high level of behavioral synchronization when walking outside with their owners (Duranton, Bedossa, & Gaunet, 2018), so applying the exact same paradigm to shelter dogs would help us to understand the effect of affiliation on dogs' behavioral synchronization with humans and thus build instruction for staff working with the dogs, as well as for potential adopters.

We observed shelter dogs' behavior in relation to their caregivers' movements in an outside area in which they were used to walking. We focused our research on evidence for location and activity synchrony. Would the shelter dogs stay close to their caregivers when walking freely outside? Would they follow their caregivers' changes in walking pace? Based on previous research on shelter dogs' sensitivity to humans' behavioral cues (Duranton et al., 2017a; see Duranton & Gaunet, 2016b for a review) and from findings by Duranton and colleagues (2018), we hypothesized that shelter dogs would display behavioral synchronization with their caregivers (e.g., stay in close proximity with the caregivers, stay still when the caregivers are still, or move fast when the caregivers walk fast), but at a lower level than what was found between pet dogs and their owners. To ensure that our results are robust across dogs, and to reproduce the procedure of Duranton et al. (2018), we also investigated the potential effects of sex, breed, and age.

Method

Participants

A total of 30 shelter dogs from two breed groups, to mirror as precisely as possible, (Duranton et al., 2018; 10 molossoids, including four females, and 20 shepherds, including nine females) living at the Aide aux Vieux Animaux rescue center in Cuy-Saint-Fiacre (France) were tested with their favorite caregivers (determined according to shelter staff reports). The shelter's facilities are designed to reduce the dogs' stress as much as possible. The dogs are kept in groups (size of the groups can vary from 2–5 individuals in each), in large outdoor enclosures with vegetation (size of the groups varies depending on the enclosure), in which they can explore, run, and play when they want to. They are walked off leash at least once a week and are regularly given environmental enrichment (e.g., toys).

The dogs that took part in the study were chosen on the basis of their age (more than 1 year old), breed type (shepherd or molossoid), and the length of time they had spent at the shelter (i.e., more than 6 months). Sample size was determined by the availability of dogs at the shelter. The dogs were aged 3 to 15 years ($M \pm SE =$ 7.63 $\pm$ 0.13 years) and showed no signs of ageing (e.g., eye or joint problems) that might have prevented them from moving freely. All the dogs were very familiar with humans, comfortable in open outside areas, and used to obeying basic commands. They spent approximatively 1 hr per day interacting with their caregiver, during feeding time, medical care, and walks.

Ethical Note

The study was conducted in accordance to the legal requirements of France (where it was carried out) and the institutional guidelines of the Aix-Marseille Université, France. The dogs were neither physically nor psychologically harmed in the course of the study. All of the dogs were free to move around in the testing area without any physical constraints. They did not undergo any physical intervention (e.g., blood or saliva sampling). After the test, all the shelter dogs were returned to their enclosures.

Procedure

The shelter dogs were tested in an area they were used to walking in, at the rescue center. For safety reasons, the testing area was enclosed because we wanted to observe the shelter dogs off leash (Figure 1). The protocol was as similar as possible to the one used in the study by Duranton et al. (2018) to allow direct comparison and is presented in the following paragraph.

At the beginning of the experiment, each dog was given 15 min to roam freely in the presence of its caregiver and the experimenter. During this time, the experimenter explained the test procedure to the caregiver, with instructions on how to behave in each of the three testing conditions. The test started when the dog came close to (less than 1 m) and payed attention to (was looking at) the caregiver. When the experimenter estimated that the criteria were fulfilled, she asked the caregiver to start. The order of conditions was randomly assigned to each dyad, and there was no break between the conditions (see supplemental material). In the *stay-still* condition, the caregiver stayed still for 10 s. In the *normal-walk* condition, the caregiver walked at his or her normal pace for 10 s. In the *fast-walk* condition, the caregiver walked fast for 10 s. We used the Seconds smartphone application to tell the caregivers when to change condition: T phone was connected to an earpiece in the caregiver's left ear, and a beep rang every 10 s, indicating that it was time to switch to the next condition. The caregivers were trained to use the application before starting the test. Throughout the test, the dogs remained off leash. The caregivers were instructed not to show any emotional reaction, talk to the dogs, or look at them. All the caregivers performed their task correctly, and none of the dogs had to be removed from the experiment.

Behavioral Analysis and Interobserver Agreement

The experimenter stayed behind the starting point and recorded the movements of both dogs and caregivers with a handheld camera. The variables we studied were as follows: (a) for location synchrony: time staying within close range of the caregiver (within a 1-m radius, in seconds), (b) for activity synchrony: (i) time spent stationary (not moving, all four paws still) in seconds, (ii) time spent walking (four-stroke pace; right posterior, then right anterior, then left posterior, then left anterior, etc.) in seconds, (iii) time spent trotting (two-stroke pace; right anterior and left posterior simultaneously, then projection phase, then left anterior and right posterior simultaneously, etc.) in seconds, (iv) time spent running (three-stroke pace; left posterior, then left anterior and right posterior simultaneously, then right anterior, then projection phase, etc.) in seconds, and (v) time spent gazing at the caregiver, in seconds. To test the reliability of the behavioral coding, in addition to the coding of 100% of the behaviors by the first author (CD), a coder who was blind to the study's aims and hypotheses coded a randomly selected subset (33%) of the data. The resulting Pearson correlation coefficients were satisfactory (time spent in proximity to the caregiver: 78% agreement, $p < .001$; time spent gazing at the caregiver: 90% agreement, $p < .001$; time spent stationary: 94% agreement, $p < .001$; time spent walking: 88% agreement, $p < .001$; time spent trotting: 93% agreement, $p < .001$; time spent running: 97% agreement, $p < .001$).

Statistical Analysis

We applied a linear mixed-effects model for dependent data to test the effects of condition and to control for any effect of breed, sex, and age on all the variables of the dogs' behavior, and for independent data to test the effect of group (shelter dogs compared with pet dogs) using R software (Version 3.2.0; www.r-project.org). Where needed, we carried out post hoc comparisons with the Holm-Bonferroni correction for multiple tests. Effect sizes (Cohen's d for lmer and r coefficient for Pearson's correlations) and 95% confidence intervals (CIs) are provided.

Results

Table 1 provides descriptive data for all the variables. Table 2 provides main results for all variables, but details are provided in the text when a significant effect was found.

Location Synchronization

Proximity to caregiver. The shelter dogs spent an average of 4.29 ± 0.01 s within close range of their caregivers (i.e., 39.68%

Figure 1. Testing area (Cuy-Saint-Fiacre, France). Photograph: Charlotte Duranton. See the online article for the color version of this figure.

Table 1
Descriptive Data for All Variables

Variable	Stay-still (N = 30)	Normal-walk (N = 30)	Fast-walk (N = 30)	Male (N = 17)	Female (N = 13)	Molossoid (N = 10)	Shepherd (N = 20)
Proximity to caregiver	4.17 ± .80	4.34 ± .70	4.36 ± .61	4.63 ± .56	3.84 ± .58	3.40 ± .49	4.74 ± .54
Time still	4.91 ± .62	1.74 ± .52	0.39 ± .13	2.39 ± .47	2.29 ± .49	2.13 ± .42	2.46 ± .45
Time walking	3.91 ± .65	3.59 ± .65	1.63 ± .50	3.21 ± .50	2.82 ± .52	4.02 ± .48	2.55 ± .45
Time trotting	1.47 ± .44	3.29 ± .60	5.13 ± .65	3.14 ± .48	3.49 ± .55	2.6 ± .47	3.64 ± .46
Time running	0.34 ± .19	2.17 ± .56	3.68 ± .66	1.97 ± .42	2.19 ± .52	1.89 ± .45	2.15 ± .41
Gazing at caregiver	2.54 ± .59	1.34 ± .41	1.7 ± .44	2.10 ± .42	1.54 ± .35	2.26 ± .41	1.67 ± .35

Note. Data presented in the table are mean of the variable ± standard error (in seconds).

of the total testing time). We did not find any effect of the independent variables (Table 2).

Activity Synchronization

Locomotor activity. The shelter dogs spent more time stationary in the stay-still condition (M = 4.91 ± 0.62 s) than in either the normal-walk condition (M = 1.74 ± 0.51 s) or the fast-walk condition (M = 0.39 ± 0.13 s; overall effect: χ^2 = 50.67, df = 2, p < .001). Pairwise post hoc comparisons yielded the following results: for stay-still/normal-walk: χ^2 = 15.77, df = 1, p < .001 (significant after correction for multiple tests), Cohen's d = 1.00, 95% CI [−4.83, −1.50]; stay-still/fast-walk: χ^2 = 55.98, df = 1, p < 0 .001 (significant after correction for multiple tests), Cohen's d = 1.82, 95% CI [−5.77, −3.26]; normal-walk/fast-walk: χ^2 = 6.70, df = 1, p < .01 (significant after correction for multiple tests), Cohen's d = 0.64, 95% CI [0.26, 2.42]; see Figure 2A and Table 2.

Table 2
Main Results for Behaviors of Shelter Dogs Toward Their Caregivers

Dependant variables	Independent variables	χ^2	df	p
Proximity to caregiver	Condition	0.05	2	.97
	Sex	0.84	1	.35
	Breed	1.84	1	.17
	Age	0.05	1	.81
Time still	Condition	**50.67**	**2**	**<.01**
	Sex	0.08	1	.77
	Breed	0.32	1	.56
	Age	0.08	1	.77
Time walking	Condition	**17.16**	**2**	**<.01**
	Sex	0.04	1	.82
	Breed	2.15	1	.14
	Age	0.18	1	.67
Time trotting	Condition	**35.02**	**2**	**<.01**
	Sex	0.08	1	.77
Breed	1.30	1	0.25	
Age	.02	1	0.86	
Time running	Condition	**31.79**	**2**	**<.01**
	Sex	0.06		.79
	Breed	0.10	1	.74
	Age	0.00	1	.98
Gazing at caregiver	Condition	**9.21**	**2**	**<.01**
	Sex	1.01	1	.31
	Breed	0.49	1	.47
	Age	2.07		.14

Note. Results of the mixed-effects models are provided, with bold type indicating significant results. When condition has a significant effect, details of the post hoc comparisons with effect size and 95% confidence intervals are provided in the text.

The dogs spent more time walking in the normal-walk condition (M = 3.59 ± 0.64 s) and in the stay-still condition (M = 3.91 ± 0.64 s) than in the fast-walk condition (M = 1.62 ± 0.50 s; overall effect: χ^2 = 17.16, df = 2, p < .001). Pairwise post hoc comparisons yielded the following results: for stay-still/normal-walk: χ^2 = 0.28, df = 1, p = .59, Cohen's d = 0.09, 95% CI [−1.57, 0.93]; stay-still/fast-walk: χ^2 = 12.58, df = 1, p < .01 (significant after correction for multiple tests), Cohen's d = 0.72, 95% CI [−3.62, −0.94]; for normal-walk/fast-walk: χ^2 = 13.12, df = 1, p < .001 (significant after correction for multiple tests), Cohen's d = 0.62, 95% CI [0.83, 3.09]; see Figure 2B and Table 2.

The dogs spent more time trotting in the fast-walk condition (M = 5.13 ± 0.64 s) than in either the normal-walk condition (M = 3.29 ± 0.60 s) or the stay-still condition (M = 1.46 ± 0.44 s; overall effect: χ^2 = 35.02, df = 2, p < .001). Pairwise post hoc comparisons yielded the following results: for stay-still/normal-walk: χ^2 = 9.61, df = 1, p < .001 (significant after correction for multiple tests), Cohen's d = 0.63, 95% CI [0.60, 3.05]; stay-still/fast-walk: χ^2 = 33.75, df = 1, p < .001 (significant after correction for multiple tests), Cohen's d = 1.20, 95% CI [2.35, 4.97]; normal-walk/fast-walk: χ^2 = 8.33, df = 1, p < .01 (significant after correction for multiple tests), Cohen's d = 0.53, 95% CI [−3.16, −0.51]; see Figure 2C and Table 2.

The dogs spent more time running in the fast-walk condition (M = 3.68 ± 0.66 s) than in either the normal-walk condition (M = 2.17 ± 0.56 s) or the stay-still condition (M = 0.34 ± 0.19 s; overall effect: χ^2 = 31.79, df = 2, p < .001). Pairwise post hoc comparisons yielded the following results: for stay-still/normal-walk: χ^2 = 11.91, df = 1, p < .001 (significant after correction for multiple tests), Cohen's d = 0.79, 95% CI [0.72, 2.92]; stay-still/fast-walk: χ^2 = 25.87, df = 1, p < .001 (significant after correction for multiple tests), Cohen's d = 1.24, 95% CI [1.97, 4.69]; normal-walk/fast-walk: χ^2 = 6.63, df = 1, p < .01 (significant after correction for multiple tests), Cohen's d = 0.44, 95% CI [−2.72, −0.28]; see Figure 2D and Table 2.

Gazing activity. The dogs spent more time gazing at their caregivers in the stay-still condition (M = 2.54 ± 0.59 s) than in the two other conditions (for normal walk: M = 1.34 ± 0.41 s; for fast walk: M = 1.70 ± 0.43 s; lmer: overall effect: χ^2 = 9.21, df = 2, p < .01). Pairwise post hoc comparisons yielded the following results: for stay-still/normal-walk: χ^2 = 7.07, df = 1, p < 0 .01 (significant after correction for multiple tests), Cohen's d = 0.42,

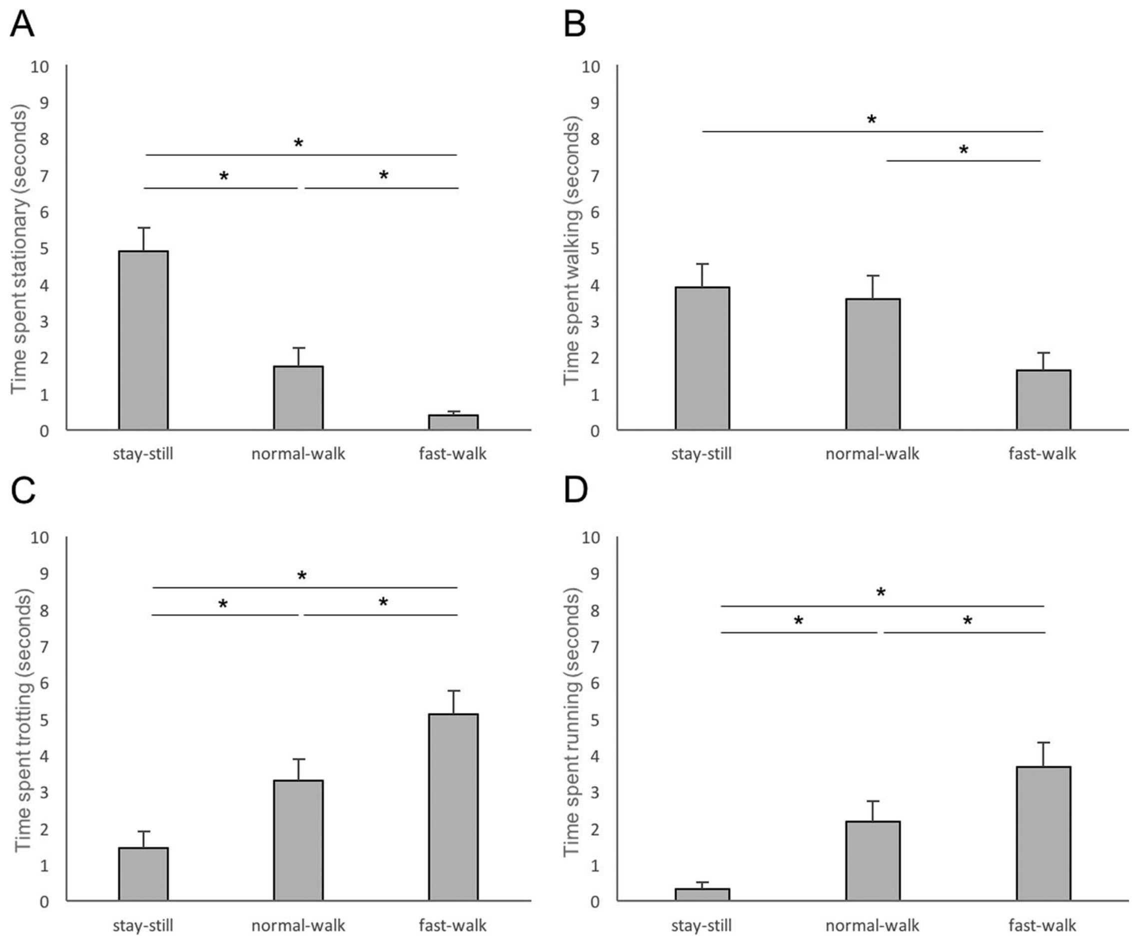

Figure 2. Time spent by the dogs performing each of the different paces: stay-still, normal-walk, and fast-walk.
* $p < .05$.

95% CI [−2.13, −0.26]; stay-still/fast-walk: $\chi^2 = 3.47$, $df = 1$, $p = .06$, Cohen's $d = 0.29$, 95% CI [−1.79, 0.09]; normal-walk/fast-walk: $\chi^2 = 1.46$, $df = 1$, $p = .22$, Cohen's $d = 0.15$, 95% CI [−0.96, 0.25]; see Table 2.

Direct Comparison With Pet Dogs (With the Data From Duranton et al., 2018)

Location synchronization.

Proximity with human. We directly compare data from the two studies. Results evidenced that shelter dogs stayed a significantly shorter time (39.68% of the total testing time) in close proximity with the human than pet dogs (67.13% of the total testing time; linear model (LM); $\chi^2 = 18.20$, $df = 1$, $p < .001$, Cohen's $d = 0.75$, 95% CI [1.89, 4.10]).

Activity synchronization.

Locomotor activity. Shelter dogs stayed stationary for a shorter time than pet dogs in the stay-still condition (LM: $\chi^2 = 175.57$, $df = 1$, $F = 19.69$, $p < .001$, Cohen's $d = 1.09$, 95% CI [1.75, 4.79]). Whereas no difference was found for the two other conditions (normal-walk condition: LM, $\chi^2 = 1.54$, $df = 1$, $F = 0.24$, $p = .62$, Cohen's $d = 0.12$, 95% CI [−1.58, 0.97]; fast-walk condition: $\chi^2 = 3.30$, $df = 1$, $F = 2.95$, $p = .09$, Cohen's $d = 0.42$, 95% CI = [−0.05, 0.95]).

Shelter dogs walked for a shorter time than pet dogs in the normal-walk condition, (LM: $\chi^2 = 152.33$, $df = 1$, $F = 10.19$, $p < .001$, Cohen's $d = 0.78$, 95% CI [1.16, 4.93]), whereas shelter dogs walked for a longer time than pet dogs in the stay-still condition (LM: $\chi^2 = 64.87$, $df = 1$, $F = 6.92$, $p = .01$, Cohen's $d = 0.65$, 95% CI [−3.55, −0.42]); No difference was found for the fast-walk condition (LM, $\chi^2 = 14.46$, $df = 1$, $F = 1.61$, $p = .20$, Cohen's $d = 0.31$, 95% CI [−0.51, 2.39]).

Shelter dogs trotted for a longer time than pet dogs in the stay-still condition (LM: $\chi^2 = 13.90$, $df = 1$, $F = 4.20$, $p = .04$, Cohen's $d = 0.50$, 95% CI [−1.83, 0.05]). Whereas in the two other conditions, they did not differ (normal-walk condition: LM, $\chi^2 = 17.06$, $df = 1$, $F = 1.68$, $p = .19$, Cohen's $d = 0.32$, 95% CI [−2.60, 0.56]; fast-walk condition: LM, $\chi^2 = 8.93$, $df = 1$, $F = 0.79$, $p = .37$, Cohen's $d = 0.22$, 95% CI [−0.93, 2.41]).

Shelter dogs ran for a longer time than pet dogs in the normal-walk and in the fast-walk conditions (LMs, normal-walk: $\chi^2 = 43.42$, $df = 1$, $F = 7.30$, $p < .01$, Cohen's $d = 0.66$, 95% CI [−2.90, −0.35]; fast-walk: $\chi^2 = 73.47$, $df = 1$, $F = 7.74$, $p < .01$, Cohen's $d = 0.68$, 95% CI [−3.69, −0.53]). Whereas they did not differ in the stay-still condition (LM, $\chi^2 = 0.53$, $df = 1$, $F = 0.75$, $p = .38$, Cohen's $d = 0.21$, 95% CI [−0.61, 0.25]).

Gazing activity. Shelter dogs gazed for a longer time at the human than pet dogs in the stay-still condition (LM: $\chi^2 = 41.72$, $df = 1$, $F = 7.33$, $p < .01$, Cohen's $d = 0.66$, 95% CI [−2.88, −0.31]), whereas in the fast-walk condition, shelter dogs gazed at the human for a shorter time than pet dogs (LM: $\chi^2 = 38.19$, $df = 1$, $F = 6.47$, $p = .01$, Cohen's $d = 0.62$, 95% CI [0.32, 2.72]); no difference was found for the normal-walk condition (LM, $\chi^2 = 13.85$, $df = 1$, $F = 2.84$, $p = .09$, Cohen's $d = 0.41$, 95% CI [−0.17, 2.01]).

Discussion

The present results showed that although shelter dogs do not display a high degree of location synchrony with their caregivers, they do exhibit temporal and activity synchronies, even if not as strongly as was previously found between pet dogs and their owner. When the caregivers switched their activities, so, too, did the dogs. The shelter dogs were stationary more often when the caregivers were still and moved faster (i.e., trotting or running) when the caregivers walked fast. Our working hypothesis was thus supported.

Regarding the amount of visual attention directed toward humans, we observed that the shelter dogs gazed for longer at their caregivers when the latter were still, compared with when they were moving. This finding is the opposite of what was previously found in pet dogs (Duranton et al., 2018). We suggest that this difference is due to the living experiences of the shelter dogs. It is known that during walks, the less pet dogs are exposed to situations of uncertainty, the less they gaze at humans (Mongillo, Adamelli, Pitteri, & Marinelli, 2014). At the shelter in which we conducted the study, when the caregivers took the dogs out of their enclosure, they encouraged as much physical and olfactory exercise as possible, moving and walking in different places, even walking fast or running to encourage the dogs to do so. The shelter dogs may therefore have paid more attention to their caregivers when they were still because this was quite an unusual situation.

Regarding behavioral synchronization, we found that shelter dogs synchronized their activity with their caregiver, but they exhibited weak location synchrony (i.e., they did not consistently remain in proximity). Such a finding is different from what was observed in pet dogs, who exhibit a high degree of both location and activity synchrony with their conspecifics in a variety of situations, including resting or moving together (Duranton et al., 2018). Furthermore, the more affiliated pet dogs are, the more behaviorally synchronized they are (see Duranton & Gaunet, 2015 for a review). Even though shelter dogs are known to form affiliative bonds with humans (Gácsi et al., 2001) and the shelter dogs in the present study were tested with their favorite caregivers, it is plausible that the relationship between these shelter dogs and their caregivers was not strong enough to generate a high degree of location synchrony. It has been suggested that the tendency of dogs to behave synchronously with humans relies on both the experience of the dogs (existence of a bond between the two partners) and an inherited basis (Naderi, Miklósi, Dóka, & Csányi, 2001). Our results are consistent with the first part of this statement, and we encourage further studies with, for example, free-ranging dogs, who do not directly interact with humans for food (Butler & Toit, 2002; Lessa, Guimarães, de Godoy Bergalio, Cunha, & Vieira, 2016), or with wolves, to tackle the potential inherited basis. Artificial selection is indeed known to affect dog's social behavior toward humans (Duranton et al., 2019; Kis et al., 2014; Nagasawa et al., 2015). Furthermore, when humans interact, the extent of their psychological attachment can be inferred from their tendency to maintain proximity (i.e., location synchrony; Plutchik & Kellerman, 2013). We therefore suggest that it is possible that during domestication, behavioral synchronization was selected in dogs, especially activity synchrony when walking outside, favoring dogs that followed human nomads from place to place, or ones that followed humans during hunting expeditions (Coppinger & Coppinger, 2001). We thus suggest that various dog populations may exhibit behavioral synchronization with humans, probably due to the inherited basis, but that the strength of the bond between the two partners influences the degree of synchronization. Such an hypothesis is consistent with what is known in humans: The tendency to behave in a synchronized way with others is ubiquitous to its adaptive values (Duranton & Gaunet, 2018 for a review), but affiliation between the interacting partners affects the degree of synchronization exhibited (Chartrand & Lakin, 2013 for a review).

There are nevertheless several other possible explanations besides affiliation for the apparently lower level of behavioral synchronization between shelter dogs and their caregivers. Because humans are secure bases for dogs (Horn, Huber, & Range, 2013), stressful situations lead them to stay close to humans. However, stress is unlikely to be involved here because the shelter dogs were walked in their usual walking area, and after the test, the caregivers all claimed that the dogs had behaved as usual and did not exhibit stress-related behaviors. Because shelter dogs are generally considered to be walked less often than pet dogs, and to have fewer opportunities to explore their environment, one could therefore argue that they needed to move more and were more curious about their surroundings during the test and thus paid little attention to their caregivers, compared with pet dogs with their owners. However, we considered this explanation unlikely in that specific shelter because dogs are kept in big enclosures with other dogs, to ensure that they can explore, run, or play during the day. Also, the shelter dogs are walked very regularly off leash (from once a day to once a week, precise rate depending on the availability of the staff) in the same area where we conducted our observations. Pet dogs were likewise observed walking in their familiar area. In addition, the shelter dogs receive daily enrichments (toys and food) in their enclosure. All these activities allow shelter dogs to have adequate physical and mental activity, as similar as possible to pet dogs. Finally, three last points enable us to state that the tested shelter dogs were not generally more active or did not generally explore their environment more compared with pet dogs: (a) While their owners are at work, it is known that pet dogs spend most of their time alone at home (Rehn & Keeling, 2011) and are mainly inactive, as shelter dogs; (b) pet dogs are mainly walked on leash, except when walked in adequate dog-park area (Lee, Shepley, & Huang, 2009), which is very similar to the present shelter dogs' daily activity too; (c) as pet dogs in the study by Duranton et al., (2017a), the shelter dogs roamed for 15 min before starting the experiment, to ensure that they had had an opportunity to explore their surroundings beforehand. We thus think that the differences in the activity level of synchronization with the humans are not due to differences in activity needs between the two tested populations.

It is also possible that our results revealed an effect of proximity seeking instead of location synchrony. It can be suggested that dogs' location synchrony with humans is only a byproduct of proximity-seeking by the dogs. Indeed, proximity-seeking behaviors are behaviors aiming at keeping or regaining contact/proximity with an individual mainly during an anxious reaction (Fallani, Prato Previde, & Valsecchi, 2007). As proximity-seeking is linked to affiliation (Gácsi et al., 2001; Topál, Miklósi, Csányi, & Dóka, 1998), it could also explain why a lower degree of behavioral synchronization was observed in lower affiliated dog–human dyads such as shelter dogs–caregiver compared with pet dogs–owner (Duranton & Gaunet, 2018). However, we limited stress as much as possible to avoid any anxious reaction of the dogs that could have led to proximity-seeking, we visually controlled for stress-associated and proximity-seeking behaviors, and all the caregivers evaluated the dogs as behaving normally, as mentioned earlier. A way to disambiguate location synchrony itself from proximity-seeking consequences in further studies would be to exclude dogs following the humans and/or staying less than 1 m from the human, as well as testing dogs only walking between 1 m and 2 m from the human, at the side of or ahead of the person, not behind her/him. Such a protocol would exclude all dogs potentially exhibiting proximity-seeking behaviors and would thus allow to observe if behavioral synchronization patterns are still the same. Finally, one could argue that comparing shelter dogs with pet dogs tests not only the effect of affiliation but also temperament and/or life experiences. For obvious reasons, it is impossible to have identical groups in terms of life experience and temperament in individuals. Thus, one other way to test the effect of affiliation would be to test, in the exact same setting as in the present study, pet dogs with their owners and pet dogs with a low affiliated person, and compare the two groups. Such a comparison was indeed previously done in another context of behavioral synchronization: social referencing (see Duranton et al., 2016 for more details on the phenomenon). First, pet dogs better use humans' reactions when the referent is a familiar human compared with a human they are not affiliated with (Merola et al., 2014). In addition, when they are facing an ambiguous stimulus, dogs synchronize their behavioral reaction to their owner's reaction and react very differently when the owners react in a positive or a negative way, but when the human is a person the dogs are not affiliated to, dogs do not synchronize their behavioral reaction to the referent's one (Merola et al., 2012). These results emphasize again the importance of affiliation for behavioral synchronization between dogs and humans. The present study does not allow us to clearly disambiguate between the two explanations (affiliation vs. life conditions); however, the aforementioned previous studies suggest that, in the present setting, affiliation between dogs and humans is the main factor affecting dog's behavioral synchronization. Comparing pet dogs with their owners and with an unfamiliar or lower affiliated person would reinforce our findings.

Finally, when considering the influence of affiliation on dogs' behavioral synchronization with humans, three different mechanisms may be at play. First, affiliation is known to be linked to leadership in dogs: Dogs follow the leader with which they are most closely affiliated (Bonanni et al., 2010). Leaders are often individuals that possess special knowledge about the environment, such as humans when walking dogs outside (Ákos, Beck, Nagy, Vicsek, & Kubinyi, 2014). Because it is their caregivers that make most of the decisions at the shelter, such as initiating new directions for walks, the dogs may regard them as displaying a degree of leadership but may not be sufficiently affiliated with them to consider them as full-blown leaders. This would explain why they exhibit a high level of activity synchronization, as we suggest that it is less dependent on affiliation than location synchrony (Duranton, 2017, pp. 155–156). Second, shelter dogs are known to be less efficient than pet dogs at reading and using human behavior, which could explain our findings about the effect of affiliation on behavioral synchronization in open outside areas (Duranton et al., 2016). For example, studies have shown that when they encounter an unfamiliar person in an enclosed room, pet dogs synchronize themselves with their owners' movements, staying close and reacting in the same direction (Duranton et al., 2016), whereas shelter dogs do not (Duranton et al., 2017a). Our hypothesis is therefore consistent with previous findings. We suggest that, because they are not trained regularly, shelter dogs may lose the habit of using human movements in outside areas as an indication of how to behave, explaining their lower degree of behavioral synchronization compared with pet dogs. Clarifying the cognitive processes at play for the three parts of synchronization (i.e., location, activity, and temporal synchronies) and whether they are similar or different, thus remains a promising research area for future studies.

The present findings also have practical implications. Caregivers should walk and train the shelter dogs as much as possible to increase their sensitivity to their referent's behavior and their synchronization with it. It could enable caregivers to better manage the shelter dogs' behavior during visits of potential adopters. A general increase in shelter dogs' ability to behaviorally synchronize with humans could be seen, increasing their likelihood to be adopted as visitors tend to want to adopt a dog that will synchronize his or her behavior with them (Protopopova & Wynne, 2014). Finally, we can expect that, once adopted, shelter dogs will synchronize like pet dogs after they develop a strong bond with their owner.

To conclude, the present study revealed the existence of activity synchrony of shelter dogs with their caregivers but weak location synchrony when walking outdoors. Shelter dogs therefore show a lower degree of behavioral synchronization with humans compared with pet dogs. Further research should disentangle the effect of living environment and of affiliation in the degree of behavioral synchronization between interacting partners from different species.

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Received May 14, 2018
Revision received December 18, 2018
Accepted December 27, 2018 ■