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Pet dogs synchronize their walking pace with that of their owners in open outdoor areas

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Abstract

Affiliation between interacting partners is associated with a high level of behavioural synchronization in many species. Pet dogs are known to share strong affiliative bonds with their owners and to synchronize their behaviour with them when moving freely indoors. Surprisingly, outdoor dog–human interspecific synchronization has seldom been investigated. We therefore explored whether, when allowed to move freely in a familiar outdoor space, dogs synchronize their behaviour with their owners' movements. We found that dogs visibly synchronized both their location (staying in close proximity) and their activity (moving when their owner moved, and at the same pace, and standing still when their owner stood still) with those of their owners. By demonstrating that owners act as attractors for their dogs in an outdoor space, the present study contributes new data to the understanding of interspecific behavioural synchronization.

Keywords Dog–human synchronization · Location synchrony · Activity synchrony · Interspecific synchronization · Pet dogs

Introduction

Behavioural synchronization is broadly characterized as doing the same thing at the same time and in the same place (see Duranton and Gaunet 2016, for a review). It can be divided into activity synchrony, defined as exhibiting the same behaviour at the same time, and location synchrony, defined as being in the same place at the same time (Duranton and Gaunet 2016). These behaviours have been widely studied in humans, who consciously synchronize their action in a variety of situations, including dancing and singing (Wiltermuth and Heath 2009). Actively synchronizing behaviour can lead to cooperation, that is, when two or more individuals consciously synchronize their actions to achieve common goals they could not attain alone (Dávid-Barrett and Dunbar 2012; Rand and Nowak 2013; West et al. 2007). However, individuals often synchronize their behaviour without being aware of it (nonconscious behavioural synchronization; Lakin et al. 2003). Human dyadic partners nonconsciously synchronize their behaviours in numerous daily situations, such as sitting side by side in rocking chairs (Richardson et al. 2007), walking together (van Ulzen et al. 2008), or chatting together (Richardson et al. 2008). For example, during conversations or discussions, listeners synchronize their movements with the speakers' speech and movements, thereby making the interaction smoother (Kendon 1970). Nonconscious behavioural synchronization is evolutionarily adaptive for humans, as it contributes to communication between individuals by signalling the convergence of their inner states (Guéguen et al. 2009) and fostering social cohesion (Chartrand and Bargh 1999; Chartrand and Lakin 2013; Duranton and Gaunet 2015).

Despite the large number of studies evidencing behavioural synchronization in human dyads, very little is known about it at the interspecific level. However, it is essential to study interspecific behavioural synchronization in order to understand it better and pin down the factors at play. Dogs

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may well be a good biological model for studying interspecific synchronization (Duranton and Gaunet 2015). The dog is a species known for being well integrated in human societies, forming strong affiliative bonds with humans, and being highly sensitive to our behavioural cues, such as body movement (see Duranton and Gaunet 2015, for a review). It has recently been found that when they are unleashed and free to move in an enclosed room, dogs display behavioural synchronization with humans' movements, whether their owners are simply walking around (Duranton et al. 2017b) or react to an encounter with an unfamiliar person by staying still, approaching or walking backwards (Duranton et al. 2016). However, these two studies were conducted in rooms and locations that were unfamiliar to the dog–owner dyads. Even though the dogs were given 15 min to explore and familiarize themselves with their surroundings, and the authors controlled for stress, the dogs' reactions may have differed from the behaviour they display in more familiar areas. It is therefore important to investigate dogs' behavioural synchronization in more familiar areas, where the dogs are used to moving around with their owners. This is why, in the present study, we investigated dogs' behavioural synchronization with their owners' movements in a familiar outdoor area, with a view to gaining a better understanding of interspecific behavioural synchronization.

We tested two breed groups (shepherd dogs and molossoid dogs) as both are working breeds more skilled at using human cues than other nonworking breeds (Mehrkam and Wynne 2014) and in which behavioural synchronization with humans has already been observed when walking inside (Duranton et al. 2016, 2017b).

We focused our research on the presence of local and activity synchrony, asking whether dogs stay close to their owners when walking freely outside, and whether they copy their owners' changes in walking pace. Based on the literature showing that, when walking outdoor, dogs mimic the walking direction of their owners (Kubinyi et al. 2003), we predicted that the dogs would exhibit a high level of behavioural synchronization with their owner in an outside area. We also investigated the potential effects of sex, breed, and age.

Methods

Participants

We tested 36 pet dogs (18 molossoids and 18 shepherds; counterbalanced for sex) from the city of Maisons-Laffitte, France. Sample size was defined beforehand, on the basis of previous research (see Charan and Biswas 2013). The dogs were between 1 and 12 years old (mean ± SE = 4.36 ± 0.27 years; shepherds = 3.89 ± 0.52 years and molossoids = 4.83 ± 0.86 years) and did not exhibit either signs of ageing (e.g. eye or joint problems) that might have prevented them from moving freely or behavioural problems (according to their owners' reports). All the dogs were very familiar with humans, comfortable in outside open areas, and used to obeying basic commands.

Ethical approval

The study was conducted in accordance with the legal requirements of France (where it was carried out) and the institutional guidelines of the Aix-Marseille Université, France. The owners all signed a consent form for study participation and publication of identifying images. The dogs were neither physically nor psychologically harmed in the course of the study. They were all free to move 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 pet dogs returned home with their owners.

Procedure

The pet dogs were individually tested in an open area they were used to walking in Maisons-Laffitte, France (Fig. 1). At the beginning of the experiment, each dog was given 15 min to roam freely in the presence of its owner and the experimenter. During this time, the experimenter explained the test procedure to its owner, with instructions on how to behave in each of three testing conditions. The order of the conditions was randomly assigned to each dyad, and there were no breaks between them. In the stay-still condition, the owner stayed still for 10 s. In the normal-walk condition, the owner walked at his/her normal speed for 10 s. In the fast-walk condition, the owner walked fast for 10 s. Owners were told when to change condition via the seconds free smartphone application. The phone was connected to an earpiece in the owner's left ear, and a beep sounded every 10 s, indicating that it was time to switch conditions. The owners were trained to use the smartphone application, but not to perform the different walking phases and speeds, as the dogs were present and we did not want them to become accustomed to the exercise. Throughout the test, the dogs were off leash. The owners were instructed not to show any emotional reaction, talk to their dogs, or look at them. All owners performed the task correctly. Examples of dogs and owners performing the three conditions are provided in Videos S1.

Fig. 1 Testing area for pet dogs, Maisons-Laffitte, France

Behavioural analysis and interobserver agreement

The experimenter stayed behind and recorded the movements of both dogs and owners with a hand-held camera. The variables we studied were: staying within close range of their owners (within a 1-m radius); time spent stationary (dog motionless, all four paws still); time spent walking (four-beat gait, e.g. right posterior, then right anterior, then left posterior, then left anterior); time spent trotting (two-beat gait, e.g. right anterior and left posterior simultaneously, then projection phase, then left anterior and right posterior simultaneously); time spent cantering (three-beat gait, e.g. left posterior, then left anterior and right posterior simultaneously, then right anterior, then projection phase); and time spent gazing at the owner. To test the reliability of the behavioural coding, in addition to the coding of 100% of the behaviours by the first author (CD), a blind coder (CB), who was unaware of the hypotheses and aims of the study, was trained to use Solomon Coder and then coded the above behaviours for a randomly selected subset of 33% of the data. The resulting Pearson correlation coefficients were good (time spent close to the owner: 95% agreement, $P < 0.001$; time spent gazing at the owner: 70% agreement, $P < 0.001$; time spent stationary: 99% agreement, $P < 0.001$; time spent walking: 99% agreement, $P < 0.001$; time spent trotting: 98% agreement, $P < 0.001$; time spent cantering: 97% agreement, $P < 0.001$).

Statistical analysis

We calculated a linear mixed-effects model (LMER) for dependent data to test the effects of condition, breed, sex, and age on all the variables of the dogs' behaviour, using R software (version 3.2.0). Where needed, we carried out post hoc comparisons with Holm–Bonferroni corrections 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

Location synchronization

Proximity to owner

Per condition, the pet dogs spent an average of 7.29 ± 0.01 s within close range of their owners, that is, an average of 72.90% of total testing time. There was no effect of condition (LMER, $\chi^2 = 1.45$, $df = 2$, $P = 0.48$), breed (LMER, $\chi^2 = 0.88$, $df = 1$, $P = 0.160$), sex (LMER, $\chi^2 = 0.02$, $df = 1$, $P = 0.34$), or age (LMER, $\chi^2 = 0.27$, $df = 1$, $P = 0.59$) on the amount of time the dogs spent close to their owners.

Activity synchronization

Locomotor activity

Dogs spent more time stationary in the stay-still condition ($M = 8.18 \pm 0.42$ s) than in either the normal-walk condition ($M = 1.43 \pm 0.37$ s) or the fast-walk condition ($M = 0.84 \pm 0.21$ s; LMER: overall effect: $\chi^2 = 282.80$, $df = 2$, $P < 0.001$). Pairwise post hoc comparisons yielded the following results: stay-still/normal-walk: $\chi^2 = 145.55$, $df = 1$, $P < 0.001$ (significant after correction for multiple tests), Cohen's $d = 2.80$, 95% CI [− 8.09, − 5.41]; stay-still/fast-walk: $\chi^2 = 267.42$, $df = 1$, $P < 0.001$ (significant after correction for multiple tests), Cohen's $d = 3.63$, 95% CI [− 8.26, − 6.41]; and normal-walk/fast-walk: $\chi^2 = 1.93$, $df = 1$, $P = 0.16$, Cohen's $d = 0.32$, 95% CI [− 0.29, 1.46]; see Fig. 2a. We found no effect of breed (LMER, $\chi^2 = 0.25$, $df = 1$, $P = 0.61$), sex (LMER, $\chi^2 = 0.60$, $df = 1$, $P = 0.43$), or age (LMER, $\chi^2 = 0.35$, $df = 1$, $P = 0.54$) on this variable.

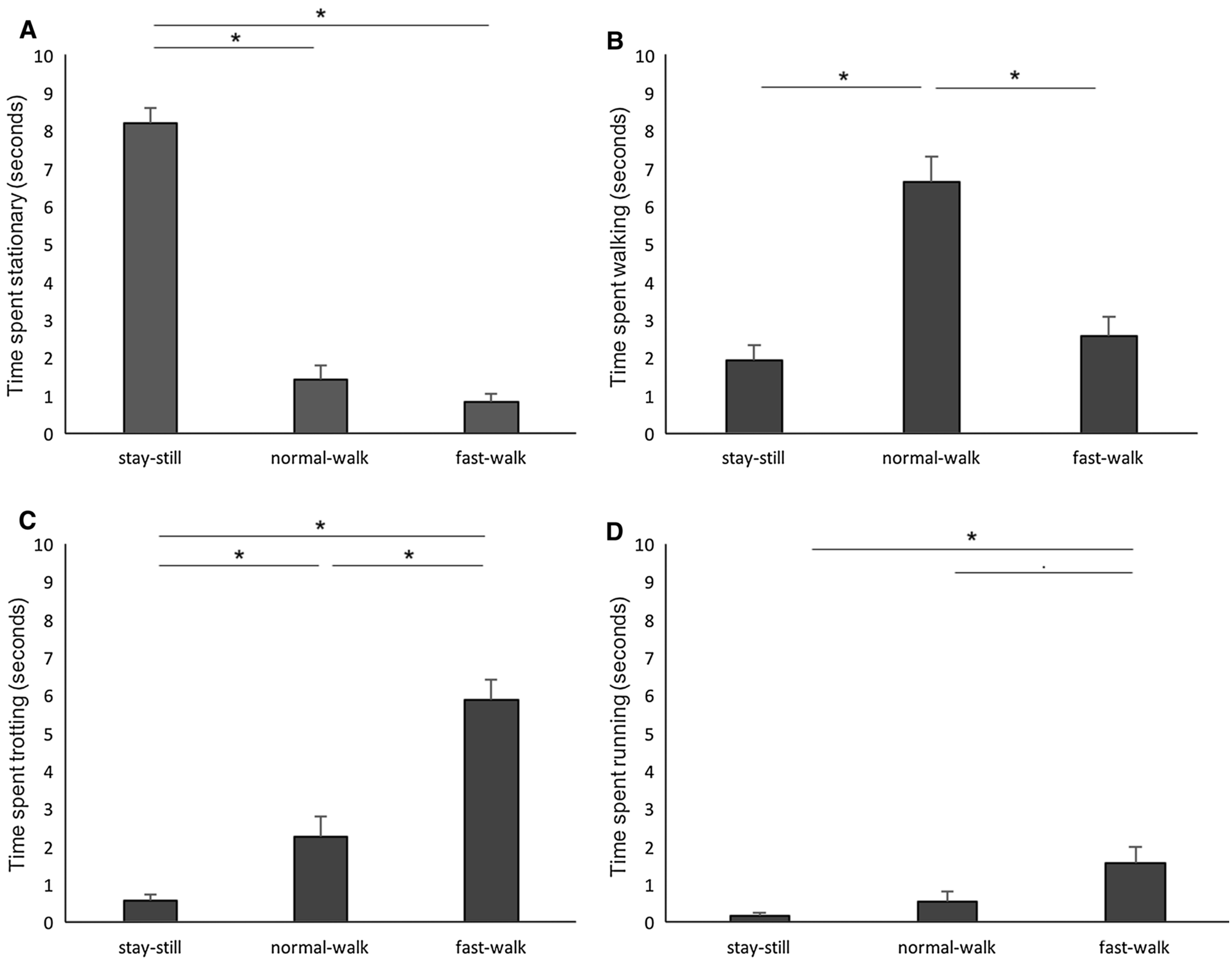

Fig. 2 Time spent by the dogs performing different paces. *$P < 0.05$; •$0.1 < P < 0.05$

Dogs spent more time walking in the normal-walk condition ($L = 6.64 \pm 0.68$ s) than in either the stay-still condition ($M = 1.92 \pm 0.42$ s) or the fast-walk condition ($M = 2.56 \pm 0.53$ s; LMER, overall effect: $\chi^2 = 48.99$, $df = 2$, $P < 0.001$). Pairwise post hoc comparisons yielded the following results: stay-still/normal-walk: $\chi^2 = 38.10$, $df = 1$, $P < 0.001$ (significant after correction for multiple tests), Cohen's $d = 1.37$, 95% CI [3.14, 6.29]; stay-still/fast-walk: $\chi^2 = 1.24$, $df = 1$, $P = 0.26$, Cohen's $d = 0.22$, 95% CI [− 0.54, 1.83]; and normal-walk/fast-walk: $\chi^2 = 24.19$, $df = 1$, $P < 0.001$ (significant after correction for multiple tests), Cohen's $d = 1.10$, 95% CI [2.37, 5.78]; see Fig. 2b. Breed also influenced dogs' walking behaviour, with molossoid dogs walking for longer ($M = 4.50 \pm 0.55$ s) than shepherd dogs ($M = 2.91 \pm 0.49$ s; $\chi^2 = 6.92$, $df = 1$, $P = 0.008$, Cohen's $d = 0.40$, 95% CI [− 2.95, − 0.21]). No effect of sex (LMER, $\chi^2 = 0.30$, $df = 1$, $P = 0.58$) or age (LMER, $\chi^2 = 1.44$, $df = 1$, $P = 0.22$) was found.

Dogs spent more time trotting in the fast-walk condition ($M = 5.87 \pm 0.53$ s) than in either the normal-walk condition ($M = 2.27 \pm 0.51$ s) or, above all, the stay-still condition ($M = 0.57 \pm 0.15$ s; LMER, overall effect: $\chi^2 = 87.79$, $df = 2$, $P < 0.001$). Pairwise post hoc comparisons yielded the following results: stay-still/normal-walk: $\chi^2 = 13.85$, $df = 1$, $P < 0.001$ (significant after correction for multiple tests), Cohen's $d = 0.74$, 95% CI [0.75, 2.64]; stay-still/fast-walk: $\chi^2 = 94.58$, $df = 1$, $P < 0.001$ (significant after correction for multiple tests), Cohen's $d = 2.26$, 95% CI [4.16, 6.43]; and normal-walk/fast-walk: $\chi^2 = 24.54$, $df = 1$, $P < 0.001$ (significant after correction for multiple tests), Cohen's $d = 1.15$, 95% CI [− 5.31, − 1.88]; see Fig. 2c. Breed also influenced dogs' trotting behaviour, with shepherd dogs trotting for longer ($M = 3.43 \pm 0.49$ s) than molossoid dogs ($M = 2.37 \pm 0.42$ s; LMER, $\chi^2 = 6.63$, $df = 1$, $P = 0.009$, Cohen's $d = 0.31$, 95% CI [0.03, 2.09]). No effect of sex (LMER, $\chi^2 = 1.32$, $df = 1$, $P = 0.24$) or age (LMER, $\chi^2 = 1.31$, $df = 2$, $P = 0.20$) was found.

Dogs spent more time cantering in the fast-walk condition (M = 1.56 ± 0.42 s) than in either the normal-walk condition (M = 0.54 ± 0.28 s) or the stay-still condition (M = 0.16 ± 0.09 s; LMER, overall effect: χ^2 = 13.86, df = 2, P < 0.001). Pairwise post hoc comparisons yielded the following results: stay-still/normal-walk: χ^2 = 2.81, df = 1, P = 0.09, Cohen's d = 0.29, 95% CI [− 0.08, 0.84]; stay-still/fast-walk: χ^2 = 12.25, df = 1, P < 0.001 (significant after correction for multiple tests), Cohen's d = 0.76, 95% CI [0.57, 2.21]; and normal-walk/fast-walk: χ^2 = 4.29, df = 1, P = 0.03 (nonsignificant after correction for multiple tests), Cohen's d = 0.47, 95% CI [− 2.02, − 0.00]; see Fig. 2d. Breed also influenced dogs' running behaviour, with shepherd dogs running for longer (M = 1.12 ± 0.31 s) than molossoid dogs (M = 0.39 ± 0.15 s; χ^2 = 4.01, df = 1, P = 0.04, Cohen's d = 0.39, 95% CI [0.00, 1.45]). No effect of sex (LMER, χ^2 = 0.21, df = 1, P = 0.64) or age (LMER, χ^2 = 0.08, df = 2, P = 0.76) was found.

Gazing activity

Dogs spent more time gazing at their owners in the fast-walk condition (M = 3.22 ± 0.40 s) than in either the normal-walk condition (M = 2.26 ± 0.35 s) or, above all, the stay-still condition (M = 0.95 ± 0.20 s; LMER, overall effect: χ^2 = 31.06, df = 2, P < 0.001). Pairwise post hoc comparisons yielded the following results: stay-still/normal-walk: χ^2 = 10.61, df = 1, P < 0.001 (significant after correction for multiple tests), Cohen's d = 0.75, 95% CI [0.48, 2.15]; stay-still/fast-walk: χ^2 = 35.41, df = 1, P < 0.001 (significant after correction for multiple tests), Cohen's d = 1.18, 95% CI [1.48, 3.06]; and normal-walk/fast-walk: χ^2 = 4.76, df = 1, P = 0.029 (significant after correction for multiple tests), Cohen's d = 0.41, 95% CI [− 1.86, − 0.05]. Breed also influenced dogs' gazing behaviour, with shepherd dogs gazing for longer at their owner (M = 2.77 ± 0.34 s) than molossoid dogs (M = 1.52 ± 0.20 s; χ^2 = 10.62, df = 1, P < 0.001, Cohen's d = 0.59, 95% CI [0.47, 2.03]). No effect of sex (LMER, χ^2 = 1.88, df = 1, P = 0.16) or age (LMER, χ^2 = 0.49, df = 1, P = 0.48) was found.

Discussion

Our study revealed location synchronization (i.e. dogs staying next to their owners) in all conditions, as well as strongly synchronized activity between dogs and their owners when walking freely in an open outdoor area. When the owners changed their walking pace, dogs systematically changed theirs accordingly. They therefore spent more time moving fast (i.e. trotting or cantering) when their owners walked fast, more time moving slowly (i.e. walking) when their owners walked at a normal pace, and more time not moving when their owners stayed still. Our working hypotheses were thus confirmed.

Regarding the amount of attention paid to humans, we found that the dogs gazed for longer at their owners when the latter were moving. It has been suggested that during walks, the fewer situations of uncertainty they encounter, the less dogs gaze at their owners (Mongillo et al. 2014). The pet dogs that participated in the present study were used to being regularly walked at a normal pace by their owners, and during these walks their owners would often stop to chat with someone, answer the phone, and so on. Walking fast was far less common during these regular walks. We suggest that pet dogs may have learned that it is worth checking their owners when they encounter unusual situations. In the present case, when their owners walked fast, the dogs were uncertain about what would happen next. For example, their owners might change direction or avoid an obstacle. It was therefore essential for the dogs to obtain more information from their owners, in order to keep moving in synchrony. We also found that shepherd dogs looked for longer at their owners than molossoid dogs. This result is consistent with previous studies, showing that because shepherd dogs have been selected for watching their owner during common activities, they are more focused on their owners than molossoid dogs, which were not selected for this behaviour (Duranton et al. 2016; Mehrkam and Wynne 2014; Passalacqua et al. 2011; Pongrácz et al. 2005). Additionally, it is well known that gazing behaviour in dogs is also affected by dogs' life experiences, such as specific training (Marshall-Pescini et al. 2009; D'Aniello et al. 2015; Scandurra et al. 2015) or level of socialization with humans (Topál et al. 1997; D'Aniello and Scandurra 2016). Even if we controlled as much as possible for the dogs' life experiences—by selecting only pet dogs well socialized to humans and with no extensive training for any working activity—we cannot exclude the possibility that the owners' expectancies, when adopting one specific breed, had influenced their behaviours towards the dogs, thus reinforcing more gazing towards them in shepherd dogs compare to molossoid dogs. We encourage further studies to disambiguate the effect of both phylogeny and ontogeny on gazing behaviours of different breed groups. Finally, we did not replicated one of our previous findings that female dogs spent longer time watching at their owner compare to males (Duranton et al. 2016). It is now well documented that females are more visually focused towards their owners than males in social cognition (Duranton et al. 2016; Mongillo et al. 2016; D'Aniello et al. 2016), as well as physical cognition (Duranton et al. 2015; Müller et al. 2011) tasks. In the present study, such a difference was not evidenced, possibly because of a different setting (outdoor with off-leash dogs), a small sample size, or a floor effect as the dogs were not asked anything to perform in our test. Additionally, nothing is known about sex effect on dogs' gazing behaviour towards humans during spatial tasks, which can be the case here: the owner was providing mainly speed and directional information. Using such information from humans can be proposed to be a core ability present in all dogs, independent of the sex of the individuals. However, we acknowledge that further studies are needed to better understanding the phenomenon.

Dogs are known to exhibit both location and activity synchrony with their conspecifics in a variety of situations, such as resting or moving together (see Duranton and Gaunet 2015, for a review), and the more affiliated they are, the more synchronized they are (Duranton et al. 2017a). Furthermore, it is now acknowledged that pet dogs display strong affiliative bonds with their owners (Duranton and Gaunet 2015), sometimes even preferring to stay close to humans than to other dogs (Gácsi et al. 2005). These findings are consistent with our observation of strong location synchrony between the pet dogs and their owners in the present study. Regarding activity synchrony, we found a high level of synchronization between pet dogs and their owners, consistent with previous studies (Duranton et al. 2016; Gaunet et al. 2014; Naderi et al. 2001). Finally, the breed difference we observed for activity synchrony can easily be explained: molossoids are generally heavier than shepherds, and weight is known to be linked to dogs' velocity (Voss et al. 2010). This would explain why molossoids spent less time trotting and cantering than shepherds in our study. However, the present results are thus only generalizable to the tested breeds, and we encourage further studies to investigate the phenomenon in other breed groups.

Different mechanisms may be involved in supporting the synchrony of location and activity we observed in a familiar outdoor area. One can argue that the synchronization evidenced was only due to a proximity seeking effect. When coming back to the exact definition, proximity seeking behaviours are behaviours aiming at keeping or regaining contact with an individual and are mainly associated to an anxious situation/reaction (Fallani et al. 2007). It is thus very unlikely to be at play here as we ensured that dogs were not stressed by controlling for stress-related behaviours, and as the tests took place in the usual walking area of the dogs, with their owners present. However, further studies are needed to evidence local synchrony without the interference of any proximity seeking. We suggest that two other mechanisms are more likely to be at play. First, affiliation is known to be linked to leadership in dogs: dogs follow a leader individual better if they are affiliated to it (Bonanni et al. 2010). Leaders are often individuals possessing special skills about the environment, such as owners when walking outside. So in daily life, the fact that it is mainly the owner who makes decisions, such as initiating new directions for walks, may be viewed as a type of leadership by pet dogs (Ákos et al. 2014). It has also recently been suggested that dogs behave in synchrony because they use the owner as a leader (Ákos et al. 2014; Duranton et al. 2017b). As our study relied on volunteers, even if we ensured not to test highly trained dogs, and that all dogs were not in obedience situation, it is possible that only owners who were interested in their dogs' behaviour, and who therefore had a very strong affiliation and/or leadership relationship with their dogs, volunteered to take part, thus explaining the high level of synchronization we observed. In other words, at the very least, the strong affiliation we observed is linked to a specific population of *Canis familiaris*, namely the very well socialized pet dog. Second, it is possible that ontogeny, with learning experiences, influenced dogs' behavioural synchronization with humans. In primates, ability to synchronize with other is already observed in newborns (e.g. Condon and Sander 1974; Ferrari et al. 2009), but the effects of learning are clearly acknowledged. It has been proposed that the architecture enabling behavioural synchronization is innate, but the response may be a product of learning, with, for example, association between one's behaviours and the movement of the other individual that has produce them (Chartrand and van Baaren 2009). The authors suggested that behavioural synchronization can need to be trained and practiced (Chartrand and van Baaren 2009). When considering the present work on interspecific behavioural synchronization, we thus suggest that learning during everyday life experience can affect spontaneous behavioural synchronization between dogs and humans. We suggest that dogs are reinforced to follow their owners and often punished when they do not, especially when they are off leash. Dogs may thus learn that it is beneficial for them to synchronize their walking (location, direction, speed) with that of their owners (Duranton et al. 2017b). As our study was conducted in a public outdoor area, with passers-by, cars, and so on, only owners with well socialized dogs went there. This could explain our results, as it has previously been found that when walking in an open outdoor area, more controllable and companionable dogs spend more time near their owners (Ákos et al. 2014). This hypothesis is in line with our previous finding that older dogs synchronized their walking activity with their owner faster (i.e. they changed to the same activity as their owner faster) compare to younger dogs (Duranton et al. 2017b). We thus encourage further studies, for instance with dogs with no learning experience, to disambiguate the extent to with learning may influence spontaneous behavioural synchronization.

To conclude, the present study highlighted the existence of behavioural synchronization between humans and dogs when freely walking in a familiar outdoor area, despite the presence of natural distractors such as odours on the ground. As previously observed indoors, dogs synchronized their movements with those of their owners, who acted as attractors. Interspecific behavioural synchronization in the dog is thus a robust finding across a variety of situations. Further, our results not only show the existence of a common social ability in dogs and humans, but also suggest that the ability of dogs to synchronize with their owners is a major reason why they are so well integrated within human society.

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Data availability statement Data are available on Open Science Framework at the following address: https://osf.io/fvwam/?view_only=26d195c0dff24f29bc811671aba4b218.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval As the present study was only observational, all applicable international, national, and/or institutional guidelines for the care and use of animals were followed. Also, all procedures were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent All dogs owners signed an informed consent before participating in the study.

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