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Dog–human behavioral synchronization: family dogs synchronize their behavior with child family members

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Abstract

Research on dog social cognition has received widespread attention. However, the vast majority of this research has focused on dogs' relationships and responsiveness towards adult humans. While little research has considered dog–child interactions from a cognitive perspective, how dogs perceive and socially engage with children is critical to fully understand their interspecific social cognition. In several recent studies, dogs have been shown to exhibit behavioral synchrony, often associated with increased affiliation and social responsiveness, with their adult owners. In the current study, we asked if family dogs would also exhibit behavioral synchrony with child family members. Our findings demonstrated that dogs engaged in all three measured components of behavioral synchrony with their child partner—activity synchrony ($p < 0.0001$), proximity ($p < 0.0001$), and orientation ($p = 0.0026$)—at levels greater than would be expected by chance. The finding that family dogs synchronize their behavior with that of child family members may shed light on how dogs perceive familiar children. Aspects of pet dog responsiveness to human actions previously reported in studies with adult humans appear to generalize to cohabitant children in at least some cases. However, some differences between our study outcomes and those reported in the dog–adult human literature were also observed. Given the prevalence of families with both children and dogs, and the growing popularity of child-focused animal-assisted interventions, knowledge about how dogs respond to the behavior of human children may also help inform and improve safe and successful dog–child interactions.

Keywords Human · Animal interaction · Behavioral synchronization · Synchrony · Dog · Family · Children

Introduction

The capacity for behavioral synchrony, defined as the temporal matching of movement, gesture, or action between two or more individuals (Duranton and Gaunet 2016), is often considered an important factor in a range of cognitive abilities including cooperation, imitation, and theory of mind (Baimel, Severson, Baron, and Birch 2015). Synchronous behavior is considered an important part of social development in the species that exhibit it, as it has been associated with improved chances of survival, reduced energy expenditure, and increased social cohesion and attachment (Mariette and Griffith 2012; Duranton and Gaunet 2016). While behavioral synchronization research is commonly conducted with intraspecific groups and dyads, interspecific dyads have been shown to engage in behavioral synchronization as well (Paukner, Anderson, Borelli, Visalberghi, and Ferrari 2005; Duranton and Gaunet 2016; Duranton, Bedossa, and Gaunet 2017). For example, several studies have demonstrated that domestic dogs, *Canis familiaris*, actively synchronize their behavior with the behavior of their adult human owners, even in the absence of explicit training (Duranton, Bedossa, and Gaunet 2017, 2018).

While various approaches have been used to evaluate synchronous activity, the dog–human literature has typically analyzed behavioral synchronization according to the correspondence of three components: activity synchrony, local synchrony, and temporal synchrony (Duranton, Bedossa, and Gaunet 2019). In one study, researchers investigated whether pet dogs would synchronize their locomotor behavior with their owner in an unfamiliar indoor space, and found that the dogs indeed synchronized their behavior with their owner, moving when the owner moved, standing still when

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the owner was stationary, maintaining close proximity to the owner, and gazing in the same direction as the owner (Duranton, Bedossa, and Gaunet 2017). In another study, researchers conducted a similar investigation, but this time in an open outdoor space that was already familiar to the dog and human. Again they found that the dogs synchronized their behavior with their owner in terms of activity synchrony, local synchrony, and temporal synchrony (Duranton, Bedossa, and Gaunet 2018). However, there is also evidence that dogs do not synchronize activity equally with all humans, suggesting that other factors including lifetime experience, context, or the identity/familiarity of the human partner may play an important role. For example, Duranton, Bedossa, and Gaunet's (2019) found that on average shelter dogs exhibited activity synchrony and temporal synchrony with their caregivers at a lower rate than pet dogs did with their adult owners. While this could be because more closely affiliated pairs are more likely to exhibit greater behavioral synchrony (Duranton and Gaunet 2016; Duranton, Bedossa, and Gaunet 2017), more research is needed to fully understand the origin of these differences.

Despite the growing body of research focused on social interactions between dogs and adult owners/caretakers, far less research has considered social interactions between dogs and children, including those that live within the same home (Wanser, Vitale, Thielke, Brubaker, and Udell 2019). Given the prevalence of families with both children and dogs (Jalongo 2015; Purewal et al. 2017), and also the widespread use of dogs in child-focused animal-assisted interventions (Parish-Plass 2008; Tepfer et al. 2017; Wanser, Simpson, MacDonald, and Udell 2020), understanding dog–child interactions is an important and understudied area of investigation. From a cognitive perspective, understanding how dogs perceive children (compared to adults) and respond to them socially, may be important to fully understanding dog social cognition, including to what extent dogs generalize social responsiveness and socio-cognitive task performance to humans beyond adult owners. While many studies have utilized comparisons between human owners and human strangers to evaluate the influence of human identity on dog performance in tests of social cognition, household children are another relevant group for these comparisons, as they represent individuals who are often equally familiar to the dog, but may differ in other ways including physical features, behavior, and level of responsibility for the dog's care (Hall, Liu, Kertes, and Wynne 2016; Wanser et al. 2020). For example, a recent study looking at attachment styles between children and dogs found that while dogs were capable of forming secure attachments to children, secure attachments were significantly more common between dogs and their adult owners (Wanser et al. 2020).

The current study asked if family dogs would exhibit behavioral synchrony with child family members. We predicted that dogs would exhibit behavioral synchrony with child family members to some extent, but potentially at a lower rate than previously reported for pet dogs and their adult owners (Duranton, Bedossa, and Gaunet 2019) due to differences in primary caregiving responsibilities (Davis 1987; Hall et al. 2016) and attachment (Wanser et al. 2020), which could influence affiliative responses (Duranton and Gaunet 2016; Duranton, Bedossa, and Gaunet 2017).

Methods

Participants

Thirty youth between 8 and 17 years old were recruited for participation in this study with their family dog (see Table 1) as part of a larger research program evaluating

Table 1 Child and dog participant demographic information

Child participants (*n* = 30)	
Age (years)	Range = 8–17; mean = 12.5; SD = 2.6
Sex	Female = 11; male = 19
Race	White = 24; Latino/Hispanic = 2; African American = 1; Alaskan Native = 1; White and Latino/Hispanic = 1; unknown = 1
Disability	No disability = 5; autism spectrum disorder = 8; Down syndrome = 4; fetal alcohol spectrum disorders = 3; ADHD = 2; intellectual disability = 2; developmental delay = 2; physical disability = 2; anxiety disorder = 2
Dog participants (*n* = 29)	
Age (years)	Range = 0.3–12; mean = 5.1; SD = 3.5
Sex	Female = 16; male = 13
Years living with the child	Range = 0.02–10; mean = 3.7; SD = 2.9
Breed	Golden Retriever mix = 5; Labrador Retriever mix = 4; Golden Retriever = 2; Labrador Retriever = 2; Pit Bull mix = 2; Pit Bull = 1; Miniature Poodle = 1; Toy Poodle = 1; Poodle mix = 1; Australian Shepherd = 1; Beagle = 1; Great Dane = 1; Rough Collie = 1; Australian Cattle Dog mix = 1; Australian Kelpie mix = 1; Border Collie mix = 1; Jack Russell Terrier mix = 1; Whippet mix = 1; unknown mix = 1

Animal-Assisted Interventions for children with and without developmental disabilities. One pair of siblings participated with the same family dog, thus a total of 29 pet dogs participated. Per parental report, 83 percent of the youth had a developmental disability. The data associated with the current study were collected prior to participation in any intervention.

Ethical approvals

All child–dog dyads participated on a voluntary basis. Written informed consent was obtained from the parents/guardians of all child participants and owners of all dogs, and assent was obtained from all of the children explicitly indicating their understanding and desire to participate in the research. The Institutional Review Board (IRB) and Institutional Animal Care and Use Committee (IACUC) of Oregon State University approved all methods and procedures for this study (IRB #7848; ACUP #4898).

Synchronization assessment

The testing area was a large empty room. At the beginning of the assessment, each dog was given a 3- to 6-min habituation period to explore freely, with the child participant and experimenter both waiting passively. The experimenter explained the test procedure to the participant during this habituation period. Based on the protocol of Duranton, Bedossa, and Gaunet (2019), the habituation period was ended by the experimenter when the dog re-approached and was attentive to the participant on its own accord.

Color-coded lines of tape were applied to the floor to aid the child participants in following the assessment procedure. The participant was instructed to walk slow on the blue tape lines, stop on the red poly spot and stand still for 15 s (timed by the experimenter), and walk fast on the green tape lines (see Table 2 for protocol and Fig. 1 for diagram). There were two phases with a brief break, lasting for up to 2 min, to assist with participant focus and relocation to the starting position of the second phase. Each phase took an average of 39 s to complete (SD = 6.4 s). Each phase consisted of the child engaging in the same set of actions presented in different orders, and totals were combined across the two phases for the analysis. This was done to simplify the instructions and enhance the child's ability to precisely follow the protocol. The dog began each phase off-leash at the child's side, restrained by the child holding their collar until the experimenter said "go". At this point, the dog was released and the child began walking. The dog was allowed to move freely about the room for the duration of the testing phase, which concluded when the child participant reached the end of the designated walking course. The child participants were instructed that once they began walking they were to stay silent, with their hands at their sides, not talking to or touching their dog for the duration of the phase.

Table 2 Synchronization assessment protocol

Phase 1		
1	Walk slow	6.4 m
2	Turn	90° left
3	Walk slow	6.4 m
4	Stop	15 s
5	Turn	180° right *(turn 90° right, then walk slow 1 m, then turn 90° right again)*
6	Walk slow	6.4 m
7	Walk fast	6.4 m
Phase 2		
8	Walk fast	6.4 m
9	Stop	15 s
10	Walk slow	6.4 m
11	Turn	90° right
12	Walk slow	6.4 m
13	Turn	180° left *(turn 90° left, then walk slow 1 m, then turn 90° left again)*
14	Walk slow	6.4 m

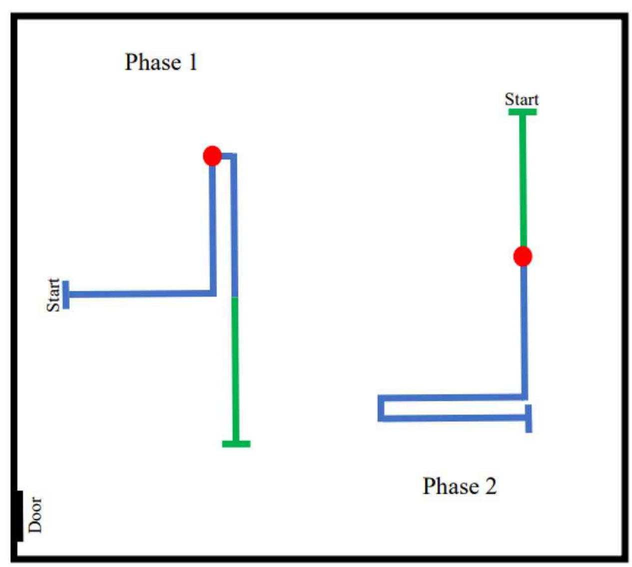

Fig. 1 Synchronization assessment layout

The experimenter remained stationary directly behind the starting point of each phase and videoed the behavior of both the dog and child during the assessment (Duranton, Bedossa, and Gaunet 2018). The experimenter kept their speaking to a minimum except to tell participants "go" at the beginning, "wait there" as a reminder when they got to the red poly spot, and "go" at the end of the 15 s on the spot. A second experimenter, remaining silent and stationary in a balcony overlooking the room or outside a window, also videoed the behavior of the dog and child to provide multiple angles of visibility for later analysis.

Behavior coding and statistical analysis

Videos of both phases were coded together for the following behaviors using the Countee© app (created by Krushka Design and Dr. Varsovia Hernández): movement synchrony (percentage of time that the dog was moving at any speed while the participant was moving at any speed), stationary synchrony (percentage of time that the dog was stationary while the participant was stationary), proximity (i.e., local synchrony; percentage of total combined phase duration that the dog was within a 1 m radius of the participant), and orientation (percentage of total combined phase duration during which the dog's chest was pointed in the same direction as the participant's hips, within 45° to either direction). Additionally, overall activity synchrony was calculated across the two phases by combining the time in seconds of movement synchrony and stationary synchrony and dividing by the total combined phase duration. Mean percentages and standard deviations for all measures are reported in addition to one-sample *t* tests used to assess whether activity synchrony, proximity, and orientation occurred at rates higher than would be expected by chance.

A rate of 50% was considered chance for activity synchrony as there were two potential activity states that the dog could be engaged in at any given time—stationary or moving—which either matched or did not match the activity state of the child participant at the given moment. The chance value for proximity tests was calculated based on the chance probability of being located within a 1 m radius proximity circle around the child (3.14 square meters) within a 314.6 square meter area (based on the smallest evaluation room used in this study). As a percentage this came to 0.9981% (rounded to 1% for the analysis). For orientation, there was a 25% chance at any time that the dog's chest was pointed in the same direction as the participant's hips within 45° to either direction, as this created a 90° sector based on the child's orientation, equal to one quarter of a circle.

A randomly selected subset of 9/30 videos (30%) were independently coded by a second coder to evaluate interobserver reliability (IRR). IRR on each of the measures of behavioral synchrony was calculated using Pearson correlation coefficients. There was strong agreement for all behavioral measures (movement synchrony: $R = 0.896$, $p = 0.0011$; stationary synchrony: $R = 0.971$, $p < 0.0001$; activity synchrony: $R = 0.722$, $p = 0.0280$; proximity: $R = 0.962$, $p < 0.0001$; orientation: $R = 0.899$, $p = 0.0010$). The final data used in the analysis originated from Coder 1.

Results

The dogs and children exhibited activity synchrony for an average of 60.2% of the assessment, significantly above what would be expected by chance (one-sample *t* test, $m_0 = 50\%$, $t(30) = 4.98$, $p < 0.0001$, SD = 11.2%). Broken down further into active and stationary periods, the dogs were moving for an average of 73.1% of the time that the child participants were moving (SD = 18.5%) and were stationary for an average of 41.2% of the time that the child participants were stationary (SD = 27.0%).

In addition, the dog was in close proximity (within 1 m radius) to the child for an average of 27.1% of the assessment, significantly above what would be expected by chance based on the total area of the room (one-sample *t* test, $m_0 = 1\%$, $t(30) = 6.68$, $p < 0.0001$, SD = 21.4%). The dog was also oriented in the same direction as the child at a rate higher than would be expected by chance, at an average of 33.5% of the assessment (one-sample *t* test, $m_0 = 25\%$, $t(30) = 3.29$, $p = 0.0026$, SD = 14.1%).

Discussion

Overall, the dogs exhibited behavioral synchronization with the child participant at a higher rate than would be expected by chance for all three measured types of synchrony: activity synchrony, proximity, and orientation, supporting the predictions of this study. However, it is worth noting that the percent of time dogs spent engaged in synchronous activity with the child participant was lower than has been observed between dogs and adult caregivers in the prior literature (Duranton, Bedossa, and Gaunet 2019). For example, the present study found family dogs exhibiting stationary synchrony for 41.2% of the time that the child was stationary, while Duranton, Bedossa, and Gaunet (2018) found that pet dogs exhibited synchrony for 81.8% of the time that their adult owner was stationary. The percent of time spent in this form of synchrony was much more similar to what has been found in shelter dogs–adult human dyads, which in a prior study were found to be stationary 49.1% of the time that their caregiver was stationary (Duranton, Bedossa, and Gaunet 2019). The same trend also held true for proximity (i.e. local synchrony). The present study found that family dogs exhibited local synchrony with a child family member for 27.1% of the assessment duration, while Duranton, Bedossa, and Gaunet found local synchronization rates of 72.9% in pet dogs and adult owners (2018) and 39.7% (2019) in shelter dogs and adult caregivers. No studies on dog–human behavioral synchronization have previously assessed body orientation. However, under circumstances in which dogs may have learned to give the human more space due to unpredictable behavior or unpleasant interactions—which could be the case when interacting with children (Burrows, Adams, and Millman 2008)—the orientation measurement may be an indicator of whether dogs are still adjusting their body position and direction of travel based on the body position and direction of movement of the human even when not in close proximity; an element of location synchronization. In the present study, we found that dogs were facing in the same direction as the child for an average of 33.5% of the assessment duration (significantly greater than the 25% expected by chance), further supporting the findings that dogs engaged in multiple aspects of behavioral synchrony with their child partner during testing.

More research is needed to determine what factors contribute to differences in reported levels of synchrony between dogs and children compared to dogs and adult owners/non-owners. One possibility is that differences could stem from attachment security, as prior studies have reported lower rates of secure attachments between shelter dog-caregiver dyads (Thielke and Udell 2020) and family dog–child dyads (Wanser et al. 2020) compared with dog-adult owner dyads. However, given that dogs have been found to also exhibit slightly higher synchrony with adult shelter caregivers compared to children, it is possible that physical/behavioral differences between children and adults are also a contributing factor. For example, some dogs may have experienced a past history of interactions with the child that were unpredictable, uncomfortable, distressing, or excessively rough, which could be avoided by decreasing proximity to the child and, as a result, the likelihood of some types of behavioral synchrony (Burrows, Adams, and Millman 2008). While human age has been noted as a relevant factor when predicting dog bite rates, which are higher for children between 5 and 9 years of age (Overall and Love 2001), and knowledge about dog signaling (Meints, Brelsford, and De Keuster 2018), more work is needed to determine to what extent age (or age related factors) are predictive of other aspects of the dog-child relationship. Future research should also evaluate whether people with and without certain disabilities may exhibit different behavioral patterns with their pet dogs that could influence behavioral synchronization or other aspects of the human–dog bond.

Despite possible differences in dogs' responses to different human partners, evidence of dog-child behavioral synchronization would suggest that dogs perceive familiar children as social partners at some level. Because behavioral synchronization has been shown to increase mutual affiliation (Duranton, Bedossa, and Gaunet 2019), joint activities that allow for this natural synchrony between dogs and children, or that work to strengthen it, could improve outcomes in interactions between children and dogs in home and therapeutic settings. Mutual responsiveness between dog and child has been found to promote stronger attachment bonds (Jalongo 2015), something that can have beneficial impacts on a child's social development, improving communication, and increased social interaction (Purewal et al. 2017). Furthermore, significant behavioral, social, and emotional benefits have been demonstrated in studies that have integrated human–human joint synchronous activities into behavioral therapy for people with developmental disabilities, including people with autism spectrum disorder (Ingersoll and Lalonde, 2010; Koehne, Behrends, Fairhurst, and Dziobek 2016). For example, such activities have been found to promote solidarity (Koudenburg, Postmes, Gordijn, and van Mourik Broekman 2015), social bonding (Tarr, Launay, Cohen, and Dunbar 2015), social attachment and cooperation (Wiltermuth and Heath 2009), as well as improve physical pain thresholds (Tarr et al. 2015) in the human participants. Therefore, synchronous activity cannot only be learned but may also support other aspects of social cognition and affiliation as levels of synchrony increase between two individuals. While we found that dog–child baseline levels of synchronous activity were lower than previously identified in adults, future research should investigate to what extent this outcome can shift with targeted experience or in different contexts. As dog-assisted interventions for children with developmental disabilities become more common, integrating synchronous activities between dog and child into these interactions may also prove beneficial and should be empirically investigated.

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Author contributions MU and MM conceived and planned this study, and all authors carried out the study. SW and MU analyzed the data and wrote the manuscript, with contributions from MM.

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Compliance with ethical standards

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

Ethics approval The Institutional Review Board (IRB) and Institutional Animal Care and Use Committee (IACUC) of Oregon State University approved all methods and procedures for this study (IRB #7848; ACUP

#4898). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent to participate All child–dog dyads participated on a voluntary basis. Written informed consent was obtained from the parents/guardians of all child participants and owners of all dogs, and assent was obtained from all of the children explicitly indicating their understanding and desire to participate in the research.

Consent for publication All authors consented to the publication of this work.

Availability of data and material The datasets generated during the current study are available from the corresponding author on reasonable request.

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