Similarity between an unfamiliar human and the owner affects dogs' preference for human partner when responding to an unsolvable problem

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Abstract

This study investigates whether dogs are able to differentiate between people according to whether or not they show similarities to their owners. We hypothesized that dogs would show a preference for the “similar” partner when interacting with unfamiliar humans. After having familiarized with two experimenters displaying different degrees of similarity to their owners, dogs ($N = 36$) participated in a situation where the desired toy object was made inaccessible in order to find out whether they initiate interaction with the two partners differently. Two different types of “similarity cues” were used (either alone or combined with each other): (1) persistent behavioral characteristics (i.e., familiar vs. strange motion pattern and language usage) and (2) an unfamiliar arbitrary group marker (i.e., one of the potential helpers was wearing clothing similar to that worn by the owner). Results show that although dogs paid equal attention to the human partners displaying various types of similarity to their owners during familiarization, they exhibited a visual attention preference for the human whose motion pattern and language usage were similar to their owner's in the inaccessible-toy task. However, there was weak evidence of discrimination based on the arbitrary group marker (clothing). Although dogs' different tendencies to interact with the potential helpers do not necessarily imply an underlying ability to create social categories based on the degree of similarity between the owner and unfamiliar people, these results suggest that functionally human infant-analogue forms of social categorization may have emerged in dogs.

Keywords Social categorization · Dog (*Canis familiaris*) · Dog–human interaction · Similarity cue · Social preference

Many social animals, including humans, have a fundamental propensity to divide the social world into groups and make decisions based on in-group/out-group distinctions. Although there is no reason to assume that nonhuman animals have a full understanding of these social categories, a crucial aspect of social categorization is that it may serve the function of mapping the opportunities and risks of cooperation (Balliet, Wu, & De Dreu, 2014). Ample evidence suggests that social species have an evolutionary prewired capacity to identify the members of

their groups and to select potential co-operators. This capacity may manifest through different mechanisms, including kin recognition (an innate ability to detect genetic similarity; Hamilton 1964) and sensitivity to familiarity (capacity to discriminate familiar from unfamiliar individuals; Hepper, 1986).

One of the challenges that lie in cooperative behavior in groups is identifying those from a large pool of individuals that an individual can trust to be willing to cooperate. For this challenge, the so-called tag-based cooperation may provide a solution in both human and nonhuman species (Axelrod, Hammond, & Grafen, 2004). During this, individuals engage in cooperative behavior with another individual based on whether they possess a certain indicator of being a good partner for cooperation (i.e., will not defect, will reciprocate, etc.). These “tags” are certain phenotypic traits that can guide social preferences and thus may be viable tags for cooperation (Cohen, 2012). It is important to note, however, that different phenotypic traits could serve as a reliable basis for establishing social and cooperative preferences simply via familiarization with those cues without forming conceptually rich social categories.

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Studies have clearly demonstrated that nonhuman species are able to classify conspecifics as familiar or unfamiliar, ranging from primates (Perrett, Mistlin, & Chitty, 1987), rodents (Ferguson, Young, & Insel, 2002), and birds (Vignal, Methévon, & Mottin, 2007) to microbes (West & Gardner, 2010). Familiarity has the potential to increase social tolerance between individuals (Lodé, 2008), and it may also be an important factor for mate choice (Randall, Hekkala, Cooper, & Barfield, 2002). Experimental studies on the susceptibility to social influence (empathic responses) have also provided evidence that empathic responses are based on familiarity, rather than any kind of more complex inference or category representation. Chimpanzees (*Pan troglodytes*), for example, tend to yawn more when watching videos of familiar rather than unfamiliar conspecific yawning (Campbell & de Waal, 2011). A similar phenomenon appears to occur in domestic dogs (*Canis familiaris*); they tend to yawn more frequently when watching their owners acting out a yawn than when observing an unfamiliar human model (Romero, Konno, & Hasegawa, 2013). Studies have also found a tendency toward higher prosocial behaviors in dogs when the conspecific is familiar than when it is a stranger (Dale, Quervel-Chaumette, Huber, Range, & Marshall-Pescini, 2016; Quervel-Chaumette, Dale, Marshall-Pescini, & Range, 2015).

Although human studies have shown that category-based social preferences emerge early in development, young infants' categorization performance stems also from familiarity with phenotypic characteristics (e.g., language, accent; Kinzler & Liberman, 2017) rather than from a sophisticated understanding of in-group/out-group distinction (for a review, see Anzures, Quinn, Pascalis, Slater, & Lee, 2013). For example, preverbal infants prefer speakers of their native language (Kinzler, Dupoux, & Spelke, 2007), and, when raised in a racially homogeneous environment, they prefer to look at faces of their own race (Bar-Haim, Ziv, Lamy, & Hodes, 2006). In addition, preference of their respective race emerges earlier for female faces than for male faces (Liu et al., 2015). In contrast, social preferences based on novel arbitrary group markers (e.g., clothing cue) seem to emerge later, around 5 years of age (e.g., Dunham, Baron, & Carey, 2011), indicating a conceptually rich understanding of "in-groupness" by age 5.

Familiar behavioral characteristics (such as language, accent, and other learned behaviors) are not only viable tags for cooperation but also play a crucial role in learning from others as well as indirectly influence the relevance of information and the use of resources in the learning processes. It has recently been shown, for example, that following a demonstration made by an adult speaking their native language rather than by a speaker of an unfamiliar language, 14-month-old infants are more likely to imitate suboptimal means to achieve a goal (Buttelmann, Zmyj, Daum, & Carpenter, 2013). Moreover, 3-year-old children tend to select similar and familiar informants—over dissimilar and

unfamiliar ones—as information sources (Reyes-Jaquez & Echols, 2013) and are more likely to generalize object functions to a category of artifacts after having seen a demonstration by a linguistically familiar adult experimenter (vs. a model speaking in a foreign language) on how to use the tool (Oláh, Elekes, Pető, Peres, & Király, 2016).

The study of canine behavior offers intriguing possibilities to study the unique susceptibility of humans to social influence and the general tendency of our species toward in-group favoritism in comparative perspective. Domestic dogs have widely been suggested to be an ideal model of human social behavior as they show several functionally human-like social skills and appear human-tuned in their social behavior (Kaminski, 2009; Miklósi & Topál, 2013). Dogs can efficiently use human behavior cues to perform functionally equivalent "imitative" responses (Fugazza, & Miklósi, 2014), they can use the emotional information provided by a human about a novel object (Merola, Prato-Previde, & Marshall-Pescini, 2012; Turcsán, Szánthó, Miklósi, & Kubinyi, 2015) and are able to recognize the different valences of the human emotional sounds (Huber, Barber, Faragó, Müller, & Huber, 2017). Experiments with third-party interactions also revealed that dogs spontaneously show reputation-like inference for humans from indirect exchanges (Kundey, De Los Reyes, Royer, Molina, & Monnier, 2011) and they are capable of eavesdropping on interactions between humans and use that information when making decision about the cooperative/generous intent of their partner (Chijiwa, Kuroshima, Hori, Anderson, & Fujita, 2015; Marshall-Pescini, Passalacqua, Ferrario, Valsecchi, & Prato-Previde, 2011). The capacity to recognize people even after short interactions is a fundamental aspect of social categorization, which is likely to be expressed naturally by dogs. Although there remain some inconsistencies in the evidence, dogs appear able to categorize people based on gender (Ratcliffe, McComb, & Reby, 2014) or other personal features of their potential human partner (Carballo et al., 2015 but see Freidin, Putrino, D'Orazio, & Bentosela, 2013), as well as based on earlier observation of human behavior (observing third-party interactions; e.g., Rooney & Bradshaw, 2006; but see Nitzschner, Melis, Kaminski, & Tomasello, 2012).

In summary, although there is ample evidence to suggest that social preference for in-group members is one of the central aspects of human behavior from very early on, it is still unclear whether dogs are able (and willing) to categorize people into in-groups and out-groups in order to select potential co-operators and whether the perceived level of similarity to the caregiver (owner) has an influence on dogs' social preferences. Moreover, the available research evidence is insufficient to determine whether dogs' social preferences are simply driven by familiarity (i.e., dogs, like human infants, develop preferences based on persistent behavioral characteristics such as language usage), or, like in older children, novel arbitrary

group markers (e.g., clothing cues) can also guide dogs to select certain prospective social partners over others.

The main purpose of this study therefore was to investigate whether dogs, after having familiarized with two unfamiliar experimenters displaying different degrees of similarity to their owners, would show behavioral signs of attentional preference in a subsequent unsolvable task (i.e., when the reward is unreachable by the dog but two experimenters—potential helpers—are available). Two different types of similarity cues were manipulated in order to examine the effects of similarity between the owner and the potential helpers on dogs' tendency to initiate social interaction with humans. In other words, we tested the effects of (a) previously unfamiliar and arbitrary group marker conveying transient similarity to their owners (yellow vest–clothing cue) and (b) the effects of persistent familiar behavioral characteristics (language and motion pattern). Dogs were tested in three experimental groups. In the consistent-similarity group, the different types of similarity cues (i.e., clothing; language usage and motion pattern) were consistently shared across the two potential helpers. One of them represented the maximum level of similarity (wearing clothing similar to that worn by the owner, using the same language, and moving in the same manner as the owner). In the inconsistent-similarity group, the owner and the potential helpers were similar in one aspect but different in the other aspect (i.e., one of them used the same language and moved in the same manner as the owner while the other was wearing clothing similar to that worn by the owner). In the behavioral-only-cues group, human participants were wearing different clothes, and the similarity between the owner and potential helpers could be assessed by the dog only on the basis of behavioral cues (language usage and motion pattern).

In line with the findings that familiarity-driven social categorization and preferences emerges early in childhood, and nonhuman social species also seem to perceive and respond to such visually salient distinctions, we predicted that dogs would prefer to look at a prospective human partner with physical appearances similar to their owner in terms of familiarity cues (motion pattern and language usage). However, a strong tendency to rely on previously unfamiliar and arbitrary group markers (clothing cue) was not expected when dogs initiate social interactions and share their attention between two potential helpers, as this would require a more sophisticated understanding of in-group/out-group distinction.

Method

Subjects

Forty-one (older than 1 year) pet dogs and their owners were recruited on a voluntary basis from the Family Dog Research Database at the Department of Ethology, Eötvös University.

The main criteria for selection were as follows: (a) dogs had to be sufficiently motivated to play with and retrieve toy objects, (b) owners speak to their dogs in their native language (Hungarian), (c) there were no people with disabilities living in the owner's household, and (d) dogs were not trained to work with people with disabilities. Five dog-owner dyads were rejected because they did not meet the preselection criteria. Thirty-six ($M = 4.69$, $SD = 2.79$ years, 15 males and 21 females from 17 different breeds and 14 mixed breeds), were tested and included in the data analysis. Dogs were assigned to the consistent-similarity ($N = 13$), inconsistent-similarity ($N = 12$) groups, and behavioral-only-cues ($N = 11$) groups quasirandomly so that the distribution of age and gender did not differ across groups (see Table 1).

The human participants consist of two potential helpers (O.K. & K.K., the first and second authors), a trainer (S.Z.F., the third author), and the dog's owner.

Apparatus and experimental arrangement

The experiment took place in a room (4.5×3.7 m) at the Department of Ethology, Eötvös Loránd University, Budapest. Only two chairs, some toys for the dog, and some accessories for the demonstration were placed in the room. Tests were video recorded from six different angles (using cameras fixed to the walls).

Procedure

Consistent-similarity group The experimental procedure consisted of four phases: (1) toy-preference test—choosing the right reward (toy object) for the dog, (2) familiarization with the two potential helpers (PH), (3) training trials ($N = 6$) with the trainer (T) in order to make the dog familiar with the test situation, and (4) testing the dogs' behavior in the inaccessible-toy task—to see whether they interact with the two PHs differently. At the beginning of the whole procedure, the owner (O) was asked to wear a yellow vest, and the trainer explained all the necessary instructions to her or him.

Toy-preference test. made the dog stand at a predetermined point in the room. T put three toys (a rope, a plastic bone, and a rubber ball on rope) on the floor 2 metres from the dog. The placement of these toys was counterbalanced to avoid a side effect. O subsequently released the dog and encouraged it to choose a toy. The whole procedure was repeated until the dog retrieved the same toy twice in a row. The preferred toy was then used as reward in the inaccessible-toy task (see below).

Familiarization. Toy preference test was immediately followed by the behavioral demonstration of similarity to O at different levels ("similar" and "dissimilar" potential helpers: PH_{SIM} and PH_{DISSIM}). Dogs were repeatedly

Table 1 Breed, age and sex of dogs tested in the study

Nickname	Breed	Age (in months)	Sex	Group
Ardbeg	Sheltie	32	Male	Consistent similarity
Bogi	Mixed breed	Unknown (approx. 36)	Female	Consistent similarity
Doris	Groenendael	93	Female	Consistent similarity
Guszt	Pembroke Welsh Corgi	12	Male	Consistent similarity
József	Yorkshire Terrier	94	Male	Consistent similarity
Lali	Whippet	65	Male	Consistent similarity
Letti	Mixed breed	39	Female	Consistent similarity
Lili	Mixed breed	36	Female	Consistent similarity
Momo	American Pit Bull Terrier	19	Male	Consistent similarity
Nancy	Parson Russell Terrier	83	Female	Consistent similarity
Punky	Mixed breed	Unknown (approx. 96)	Female	Consistent similarity
Rudi	Spitz	34	Male	Consistent similarity
Szöcske	Mixed breed	32	Female	Consistent similarity
Bodor	Mixed breed	141	Male	Inconsistent similarity
Borso	Fox Terrier	143	Female	Inconsistent similarity
Csele	Mudi	72	Female	Inconsistent similarity
Fruti	Mixed breed	92	Female	Inconsistent similarity
Füles	Mixed breed	73	Male	Inconsistent similarity
Mabon	Border Collie	41	Male	Inconsistent similarity
Manna	Yorkshire Terrier	30	Female	Inconsistent similarity
Mano	Mixed breed	88	Female	Inconsistent similarity
Merlin	Mixed breed	Unknown (approx. 24)	Male	Inconsistent similarity
Missi	Papillon	25	Female	Inconsistent similarity
Sky	Mixed breed	Unknown (approx. 18)	Male	Inconsistent similarity
Szamba	Mixed breed	15	Female	Inconsistent similarity
Áfonya	Mixed breed	34	Female	Behavioral-only cue
Bunny	Border Collie	115	Female	Behavioral-only cue
Leopold	Boxer	42	Male	Behavioral-only cue
Lili	Magyar Vizsla	58	Female	Behavioral-only cue
Macska	Golden Retriever	91	Male	Behavioral-only cue
Maszat	Border Collie	53	Male	Behavioral-only cue
Milka	Border Collie	44	Female	Behavioral-only cue
Mona	Labrador Retriever	21	Female	Behavioral-only cue
Nina	Mixed breed	24	Female	Behavioral-only cue
Prince	Golden Retriever	34	Male	Behavioral-only cue
Rozi	Labrador Retriever	23	Female	Behavioral-only cue

presented with a predetermined sequence of events (tug-of-war game and then passive observation; see below) with participation of both PH_{SIM} and PH_{DISSIM}. O.K. (the first author) acted as PH_{SIM} for half of the dogs and played the role of PH_{DISSIM} while interacting with the other half of the dogs. PH_{SIM} behaved in a normal manner (her walking movements were balanced and well-coordinated and

talked to the dog using familiar language—Hungarian) and was wearing an overdress (yellow vest) similar to that of the owner's. However, PH_{DISSIM} was wearing hidden arm and leg splints, asymmetric shoes (high and low heeled), and thus behaved in an unusual manner (poorly coordinated and weird movements) while speaking in a foreign language (Romanian or Spanish), and she was

not wearing yellow vest. Importantly both PH_{SIM} and PH_{DISSIM} were young women of similar body size and shape and were unfamiliar to the dog.

Tug-of-war game. O was asked to sit down on a chair while holding the dog on leash (see Fig. 1a). One of the potential helpers (PH_{SIM} or PH_{DISSIM}) captured the dog's attention with the toy object in her hand, then she threw the toy at a distance of approx. 2–3 m. After a few seconds she retrieved the object and brought it back to the dog. She let the dog grab it and played tug-of-war for 15–30 seconds with the dog. Next, O helped her take away the toy, and the whole procedure was repeated two times (three tug-of-war sessions in total).

Passive observation. Immediately after tug-of-war, O was instructed to get the dog to stand oriented toward PH and to hold the dog in this position (by holding its collar) without speaking (see Fig. 1b). During this, PH presented her predetermined role following the scenario (i.e., she presented a monologue with accompanying actions):

“Now I would like to prepare and present the room of the experiment. In this section, please just listen to me and follow me quietly with your eyes. That's my chair! (She slowly walks to the chair and sits down.) This chair is always somewhere else. This will be rolled over there, because its place is there. (She carries the chair to the opposite side of the room.) These books could obstruct the road; I had better put them in the cupboard. (She walks to the books, lifts them off the floor and brings them to the cupboard, then puts all of them on the floor next to the cupboard.) Where are my keys? (She looks at

the owner and begins rummaging in his pocket.) I cannot find my keys. They have to be in my bag. (She walks across the room to where his bag is, and starts rummaging in the bag.) Here they are! (She takes the key out of the bag, goes back and shuts the cupboard door. Then looks around the room and walks back into the middle of the room.) We're done! Let's begin the next part.”

This was followed by a 2-min break, and then the other potential helper (PH_{SIM} or PH_{DISSIM}) repeated the same procedure (tug-of-war game and passive observation). Note that neither PH_{SIM} nor PH_{DISSIM} was talking to the owner, but they praised the dog equally. The demonstration of the two different roles took approximately 5.5 minutes (5.22 ± 0.69 min.), and the order of demonstrators was counterbalanced across dogs.

Training trials. Immediately after familiarization, dogs participated in a toy-retrieval task in the same room. The experimental arrangement is shown schematically in Fig. 1c. Trials consisted of the repetition of the following series of actions:

T initiated a game, saying: “Hi XY (dog's name), look!” to attract the dog's attention. She started to wiggle the same toy used before in the tug-of-war game, and told the dog, “Take it!” Once the dog tugged playfully without letting go for 5 to 10 seconds, PH took the toy and “accidentally” threw the toy onto the window ledge (out of the dog's reach). She left the toy there while she was standing and looking at the dog. After 2–3 seconds T asked: “Where is the toy?” When the dog initialized eye contact with her, she tried to keep continuous

Fig. 1 Experimental layout for the tug-of-war game (a) and the passive observation part (b) of familiarization with the two potential helpers (PH). Each PH is playing with the dog (a); then presenting the scene of the experiment with large movements while speaking and carrying objects

following a set of predetermined directions (b). Layout for the training trials when the trainer introduces the dog to the inaccessible-toy task (c), and then the dog has the opportunity to interact with the potential helpers (d). O = owner; T = trainer; PH = potential helper

eye contact with it. After 4 seconds, T took the toy, praised the dog (“Good dog, here it is!”), and rewarded the dog with a piece of dry dog food and resumed playing with the dog. The trial was repeated five times (six trials in total). During this time, O was sitting silently on a chair with his or her back turned toward the dog and T. PH_{SIM} and PH_{DISSIM} were also present, they were standing motionless in the “background,” at the back of the room.

Inaccessible toy task. Immediately after the sixth trial, T continued the task with a modified version of the training trial. During this, she initiated playing with the toy in the same manner described in Training Trials. However, it is important to note that she threw the toy onto the window ledge and then left the room through the side door (Door 2) without saying a word. At the same time PH_{SIM} and PH_{DISSIM} took up their predetermined position; facing the toy object, 1.5 m behind the window ledge so that the toy object–PH_{SIM}–PH_{DISSIM} formed a triangle (see Fig. 1d). They were waiting passively with their hands behind their backs and watching the dog in silence for 2 minutes so that the dog could easily make eye contact with them. In two cases, however, we had to finish the task a few seconds earlier because these dogs jumped on the window ledge and took the toy. PH_{SIM} and PH_{DISSIM} had not changed their body posture during the trial (i.e., they did not turn their upper body when the dog walked away and left their field of view). When the dog made eye contact with one of them, the respective PH gave a predetermined hand signal (the dog could not see the signal, but this made it possible for coders to record numbers and durations of eye contacts). The left/right position of PH_{SIM} and PH_{DISSIM} was counterbalanced across subjects. After 2 min, T entered the room again, picked up the toy, and gave it to the dog. Finally, PH_{SIM} and PH_{DISSIM} alternately interacted with the dog for a few minutes by playing or petting (depending on the preference of the dog).

Inconsistent-similarity group The procedure was identical to that of consistent-similarity group, except that the two PHs showed either similarity in appearance or behavioral similarity to the owner (PH_{APP} and PH_{BEH}). Namely, PH_{BEH} behaved owner-like in her language usage and motion pattern, but was not wearing yellow vest, while PH_{APP} behaved differently than O, as regards language usage and motion pattern, but was wearing the overdress (yellow vest) similar to that of the owner’s. The procedure in all other respects remained unchanged.

Behavioral-only-cues group The procedure was identical to that described in the consistent-similarity group, except there were no continuously visible similarities (clothing cue) between O and one of the PHs (i.e., neither the O nor PHs were

wearing a yellow vest). The potential helpers behaved either similarly (PH_{BEH_SIM}) or differently (i.e., poorly coordinated and weird movements while speaking in a foreign language—PH_{BEH_DISSIM}) to the owner.

Behavior coding and data analysis

Dogs’ behavior was analyzed by frame-by-frame coding of all experimental recordings (with a 0.2-s resolution, using Solomon Coder (beta 091110, ©2006e 2008 by András Péter, <http://solomoncoder.com/>). In order to assess interobserver agreement, a second trained observer blind to the hypotheses scored a randomly selected sample of 30 %. Cohen’s kappa coefficients are given below for each variable. The following behaviors were coded:

During familiarization:

- Relative duration, that is, the percentage of the total time (t%) spent playing with the two different PHs during the tug-of-war game (Cohen’s $\kappa = 1.00$).
- The percentage of the total time (t%) spent looking at the two different PHs during the passive-observation phase of familiarization (Cohen’s $\kappa = 0.86$).

Moreover, we also coded the signs of avoiding the interaction with the two different PHs in those parts of the tug-of-war game when PH approached the dog with the toy in her hand while looking directly at it (this happened 3/3 times during familiarization; see Procedure, above). To this, we have applied the behavior-coding scheme proposed by Vas, Topál, Gácsi, Miklósi, and Csányi (2005). Thus, the dogs’ responses were coded as “avoidance” (a) if the subject averted its gaze from PH while lowering its ears and/or holding its tail down low, or (b) if the subject moved toward the owner or behind the owner while gazing at PH and/or vocalizing (Cohen’s $\kappa = 1.00$).

During the training trials:

- Signs of disinterest (the number of times the dog turned its head away from T and/or the toy when the toy was on the window ledge; Cohen’s $\kappa = 1.00$).

During the inaccessible-toy task:

- Relative durations of the head orientation toward the two different PHs (Cohen’s $\kappa = 0.93$).
- Number of eye contacts with the two different PHs (Cohen’s $\kappa = 1.00$).
- Relative duration (t%) of eye contacts with the two different PHs (Cohen’s $\kappa = 0.92$).

Wilcoxon signed-rank test was used to test whether dogs paid attention to the two potential helpers and engaged in playful interactions with them equally during familiarization.

Kruskal–Wallis test was used to compare the dogs' willingness to participate in the training trials across the three groups.

Dogs' behavior during familiarization and in the inaccessible-toy task was also analyzed with random intercept generalized linear mixed-effect models (GLMM, IBM SPSS 22). The model included two fixed explanatory variables: (a) whether or not the PH wears the yellow vest throughout the whole procedure (VEST; Yes or No–binary factor) and (b) whether or not the PH displayed behavior (language use and motion pattern) similar to the owner during familiarization (BEHAV; Yes or No–binary factor), as well as the interaction of the above variables. Moreover, the dog ID (subjects' identity) as a random factor was also included in the models, and nonsignificant effects were removed from the model in a stepwise manner (backward elimination technique). Statistical tests were two-tailed, α value was set at 0.05, and the statistical package SPSS Version 23 was used.

Results

Familiarization

The analysis of the percentage of the total time spent looking at PHs shows that the dogs paid attention to the two potential helpers similarly during the behavioral demonstration phase of the familiarization in all three groups. That is, the dogs' average looking time did not differ significantly between the potential helpers in the consistent-similarity (PH_{SIM}, vs. PH_{DISSIM}; Wilcoxon signed-rank test, $N = 12$, $Z = 55.00$, $p = .209$), inconsistent-similarity (PH_{BEH} vs. PH_{APP}; $N = 13$, $Z = 24.00$, $p = .721$), as well as in the behavioral-only-cues (PH_{BEH_SIM}, vs. PH_{BEH_DISSIM}; $N = 11$, $Z = 34.00$, $p = .929$) groups. The finding that the dogs paid attention to the different types of potential helpers similarly is further supported by the GLMM analysis of the percentage of the total time spent looking at PHs: Neither of the main effects (VEST), $F(1, 68) = 0.125$, $p = .725$; (BEHAV), $F(1, 67) = 0.001$, $p = .972$; nor their interactions (VEST $\times$ BEHAV), $F(1, 66) = 0.266$, $p = .608$, was statistically significant.

Moreover, the dogs engaged in play activities with the potential helpers similarly in both the consistent-similarity (percentage of the total time spent playing: PH_{SIM} vs. PH_{DISSIM}; $N = 12$, $Z = 10.00$, $p = .917$) and behavioral-only-cues (PH_{BEH_SIM}, vs. PH_{BEH_DISSIM}; $N = 12$, $Z = 32.00$, $p = .929$) groups. At the same time, however, they engaged in play activities with the potential helpers differently in the inconsistent-similarity group (PH_{BEH}, vs. PH_{APP}; $N = 13$, $Z = 3.00$, $p = .021$; dogs spent less time playing with PH_{APP}). The GLMM analysis of the percentage of the total time spent playing showed significant

main effects of both types of similarity cues on the dogs' willingness to play with the potential helpers (VEST), $F(1, 67) = 7.035$, $p = .010$; (BEHAV), $F(1, 67) = 4.748$, $p = .033$; but there was no significant VEST $\times$ BEHAV interaction effect, $F(1, 66) = 2.338$, $p = .131$. That is, not only the strange behavior (motion pattern and language usage) of the potential helper but also the unfamiliar and arbitrary group marker (yellow vest) worn by her reduced the dogs' tendency to engage in playful interactions (see Fig. 2).

Importantly, however, the dogs did not show explicit signs of fear or anxiety even when they have interacted with the human partner moving (and speaking) weirdly. This is supported by the finding that only very few dogs showed signs of avoiding the interaction with the potential helper during the tug-of-war part of familiarization: only one out of the 13 dogs displayed an avoidance response toward PH_{SIM} in the consistent-similarity group, and two additional dogs (out of the 12) showed avoidance toward PH_{BEH} in the inconsistent-similarity group. None of the dogs assigned to the behavioral-only-cues group did so. Thus, due to the rare occurrence of avoidance behavior, this variable was omitted from statistical analysis.

Training trials

The dogs' behavior during the training trials clearly shows that subjects were in general highly motivated to participate in the toy-retrieval task. There was no difference between the groups in terms of the signs of disinterest, Kruskal–Wallis test, $H(2) = 0.025$, $p = .987$, $N = 22$ dogs (61%) did not show any signs of disinterest when the toy was unreachable.

Inaccessible-toy task

The GLMM analysis of the dogs' head orientation toward the potential helpers revealed a significant main effect of the behavioral similarity (language usage and motion pattern), $F(1, 70) = 6.198$, $p = .015$, but not the novel arbitrary group marker (yellow vest), $F(1, 69) = 1.148$, $p = .288$, and there was no significant VEST $\times$ BEHAV interaction, $F(1, 68) = 0.526$, $p = .471$ (see Fig. 3). Regarding the number of eye contacts with the potential helpers, we also found a significant main effect of the persistent behavioral characteristics (BEHAV), $F(1, 70) = 6.451$, $p = .013$, and a marginally significant main effect of clothing (VEST), $F(1, 69) = 3.995$, $p = .050$, but there was no significant VEST $\times$ BEHAV interaction, $F(1, 68) = 0.661$, $p = .419$ (see Fig. 4). Neither the main effect of the different types of similarity cues (VEST, BEHAV) nor the interaction of these factors was significant for the relative duration of eye contacts with PHs ($p > 0.1$ for all).

Fig. 2 The effects of persistent behavioral characteristics (language and motion) (a) and arbitrary group marker (yellow vest) (b) on the relative duration of time dogs spent playing with the two potential helpers (medians $\pm$ IQT and outliers)

Discussion

In the present study, we investigated whether dogs show a tendency to interact differently with adult humans in an unsolvable problem (inaccessible toy) situation based on different types of similarities between their owners and unfamiliar human partners. Two types of similarity cues were used: (1) familiar versus strange motion pattern and language usage—to test whether dogs' social preferences are simply driven by the familiarity of persistent behavioral characteristics, and (2) the presence versus absence of a previously unfamiliar “clothing cue”—to study whether arbitrary group markers could also serve as reliable basis for shaping attentional preference toward prospective social partners. Note that the perceptually less salient clothing cue (the yellow vest) was continuously visible to the

dog during both the familiarization phase and the inaccessible-toy task, thus it could act as a trigger to remind the dog of the potential helper's similarity to the owner. In contrast, the overwhelmingly more salient behavioral characteristics (language, motion pattern) were unperceivable to the dog during the inaccessible-toy task (i.e., observed only during familiarization), and thus subjects had to rely on their memory to make the distinction between potential helpers.

The analysis of the dogs' looking behavior clearly shows that they discriminated between potential helpers based on their owners' persistent behavioral characteristics, even though these similarity cues were unperceivable to them during the test trial. Subjects looked longer at the potential helper whose motion pattern and language were similar to their owners, and they also made eye contact significantly more frequently with her. However, the previously unfamiliar similarity marker played only a minor role in the development of a preference to look at the potential helper. We found a marginally significant effect of clothing similar to the one worn by the owner only in one variable (increased number of eye contacts) even though such a similarity cue was clearly visible during the test.

A possible explanation for dogs' differential reaction to the two potential helpers could be that they avoided eye contact with the potential helper who was behaviorally dissimilar to their owners because her presence and proximity may have caused the dog to experience a little more anxiety, and thus subjects' preferential attention toward the “similar” human partner during the inaccessible-toy task was simply an indirect effect of such avoidance. However, the finding that dogs did not show increased avoidance in the presence of dissimilar human partners and paid attention to the different types of potential helpers similarly during familiarization does not seem to support the anxiety-producing

Fig. 3 The effects of persistent behavioral characteristics (language and motion) on the relative duration of head orientations towards the two potential helpers in the inaccessible-toy task (medians $\pm$ IQT and outliers)

Fig. 4 The effects of persistent behavioral characteristics (language and motion) (**a**) and visible cues that express transient similarity to their owners (clothing) (**b**) on the number of eye contacts with the two potential helpers in the inaccessible-toy task (medians $\pm$ IQT and outliers)

effects of weird movements and the use of unfamiliar language. The only significant effect during familiarization was found in the dogs' willingness to play with the potential helpers in the inconsistent-similarity group. It seems that in this group, in which the two types of similarity cues (persistent behavior characteristics vs. clothing cue) opposed one another, dogs tended to engage in more playful interactions with the “behaviorally similar” human partner as opposed to a human showing similarity in outward appearance. That is, contrary to our expectations, the novel arbitrary group marker (i.e., yellow vest as perceivable similarity between the owner and the potential helper) appears to amplify the “unconventional effect” of the human partner's strange behavioral characteristics (weird moving and speaking).

It is also noteworthy to mention that gazing at the trainer's face was systematically reinforced during training trials (i.e., the trainer waited for the dog to establish eye contact in each trial before giving back the toy), making it unlikely that the dogs' increased visual attention toward the behaviorally similar human partner during the inaccessible-toy task was just a side effect of fear of the dissimilar one. Accordingly, visual preference for a particular human partner may be interpreted in two different ways: (1) as indicating the communicative intent of the dog (soliciting help from human partner), or (2) it is also possible that this behavior serves no communicative function but is simply driven by the dogs' expectations about upcoming events (i.e., looking at the human who will expectedly make a motion and retrieve the out-of-reach ball).

Although the available evidence is insufficient to identify which explanation we should consider more plausible, these results provide support for the notion that even a short, friendly interaction with an unfamiliar human partner is sufficient for dogs to develop some expectations about future interactions with this person. More specifically, dogs may expect the potential helper with less similar behavior and language not to

be as cooperative as the similar one, and/or they expect lower responsiveness (willingness to help) from her.

We should also note that the bias we found in the dogs' human-directed gazing behavior cannot be explained by individual differences between the two potential helpers or by spatial bias in the dogs' visual exploration, because the actors were counterbalanced with regard to the role they played during familiarization phase as well as the left/right position they took up during the inaccessible-toy task. Moreover, although it is widely assumed that differences in dogs' early social experiences may result in differences in their interactions with humans (e.g., Horowitz, 2011), our subjects represented a relatively homogeneous group with respect to their living conditions, socialization background, and level of training, and they were not previously trained to respond differently to people showing unconventional behavioral characteristics used in this study (foreign language, poorly coordinated and weird movements). It is also important to note that enhanced social attention (including attention toward humans) is supposed to be a key factor of the domestication of dogs, and attention skills can vary greatly among different dog breeds (Gácsi, McGreevy, Kara, & Miklósi, 2009; Kovács, Kis, Pogány, Koller, & Topál, 2016). Based on this, it is reasonable to assume that dog breeds with a different history of selection show different social evaluation skills. The present study, however, included different breeds of dogs, and thus the potential effects of breed differences on how dogs evaluate human behaviors in interspecific interactions needs further investigation.

Another important aspect of dogs' social competence is their ability to synchronize their behavior with their owners (Duranton & Gaunet, 2015). It has recently been shown that emotional states such as anxiety or stress experienced by the owner is contagious to dogs and thus has the potential to influence their behavior (Karl, & Huber, 2017; Sümegi,

Oláh, & Topál, 2014). Based on this, we may assume that dogs' performance stems from their ability to take emotional cues from their owners. Namely, if the owner is tense or feels an inconvenience when interacting with certain types of people (e.g., foreign language-speaking and weirdly moving people), then his or her dog will take this as a cue that there is something to be avoided. We should note, however, that we intentionally used a paradigm in which the potential helpers that showed similarity to the owner at different levels did not interact with the owner at all, and dogs had to make social distinction between the potential helpers using somewhat arbitrary dimensions (language, movements, clothing) and not relying upon the observed social relations (owner–experimenter interactions).

We propose that this phenomenon of selective interactivity in dogs (i.e. preferential attention to similar over dissimilar partners in the inaccessible-toy task) bears some similarity to behavioral manifestations of social evaluation processes that underlie in-group favoritism and social discrimination in human children. It has recently been shown that the perception of perceptual differences plays a key role in social categorization processes, and group-based social preferences can be demonstrated in children at an age when the self-concept is weak or even nonexistent (Richter, Over, & Dunham, 2016). However, there is considerable difference in the relative importance young children assign to different cues of group membership. Research suggests that they do not form category representations but simply refrain from interacting with those that are “unusual” and prefer people that are familiar, and this, in turn, also drives selection in collaborative situations (Ziv, & Banaji, 2012). That is, the social categorization system in the early years of life may not operate at a conceptual level but at a low, perceptual level, where the selection criteria could hardly be anything else but salience and familiarity. Young children, therefore, do not discriminate based on any arbitrary cue (e.g., colored arm band; Plötner, Over, Carpenter, & Tomasello, 2015), while the language the potential partner speaks is a fundamental group-relevant characteristic to guide their preferences (Buttelmann et al., 2013; Howard, Henderson, Carrazza, & Woodward, 2015). Moreover, it seems that the conventionality of tool-using behavior is also a relevant indicator of in-group–out-group membership: Even 2-year-olds tend to associate foreign and native languages differentially with people based on the conventionality of the adult's tool-using behavior (Oláh, Elekes, Bródy, & Király, 2014).

Dogs, like young children, are sophisticated social learners; they have a unique ability to perceive and respond to human communicative gestures and emotions (see Topál, Kis, & Oláh, 2014, for a review) and are able to use personal features as cues to discriminate between unfamiliar humans in order to find the most likely cooperative

human partner (Carballo et al., 2015). Although the extent to which human infants rely on associative learning as a fundamental process underlying social category-based thinking is still unclear and calls for further investigation (Paolini, Harris, & Griffin, 2015), results from the current study raise the hypothesis that, functionally, human infant analogue forms of social categorization may have emerged in dogs. It is reasonable to assume that dogs' social categorization and preferences are primarily guided by familiarity and rely on simple associative learning processes rather than on conceptual representation of social categories.

In summary, this study highlights some features of dogs' social categorization processes and points to an intriguing aspect of social cognition in dogs, which can promote the choice of an appropriate human partner to engage in successful cooperation. Dogs seem to be able to develop social engagement based on prior social interactions with potential human partners in a situation, in which not simply the positive or negative outcome of the human's actions but the behavioral similarity between the owner and the unfamiliar human has the potential to trigger the dogs' social preference. Other features that could become triggers for the social evaluation system in dogs warrant further investigation, and it would also be important to uncover the decision rules underlying social preference formation in dogs.

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Compliance with ethical standards

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

Ethics standard The experiment reported in this paper complies with the laws of the country in which it was performed (Hungary). Ethical approval was obtained from the National Animal Experimentation Ethics Committee (Ref. No. PEI/001/1057–6/2015).

References

- Anzures, G., Quinn, P. C., Pascalis, O., Slater, A. M., & Lee, K. (2013). Development of own-race biases. *Visual Cognition*, 21, 1165–1182. <https://doi.org/10.1080/13506285.2013.821428>
- Axelrod, R., Hammond, R. A., & Grafen, A. (2004). Altruism via kin-selection strategies that rely on arbitrary tags with which they co-evolve. *Evolution*, 58, 1833–1838. <https://doi.org/10.1111/j.0014-3820.2004.tb00465.x>
- Balliet, D., Wu, J., De Dreu, C. K., (2014). In-group favoritism in cooperation: A meta-analysis. *Psychological Bulletin*, 140, 1556–1581. <https://doi.org/10.1037/a0037737>

- Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science*, 17, 159–163. <https://doi.org/10.1111/j.1467-9280.2006.01679.x>
- Buttelmann, D., Zmyj, N., Daum, M., & Carpenter, M. (2013). Selective imitation of in-group over out-group members in 14-month-old infants. *Child Development*, 84(2), 422–428. <https://doi.org/10.1111/j.1467-8624.2012.01860.x>
- Campbell, M.W., & de Waal F. B. M. (2011). In-group-out-group bias in contagious yawning by chimpanzees supports link to empathy. *PLOS ONE*, 6(4), e18283. <https://doi.org/10.1371/journal.pone.0018283>
- Carballo, F., Freidin, E., Putrino, N., Shimabukuro, C., Casanave, E., & Bentosela, M. (2015). Dog's discrimination of human selfish and generous attitudes: The role of individual recognition, experience and experimenters' gender. *PLOS ONE*, 10(2), e0116314. <https://doi.org/10.1371/journal.pone.0116314>
- Chijiwa, H., Kuroshima, H., Hori, Y., Anderson, J. R., & Fujita, K. (2015). Dogs avoid people who behave negatively to their owner: Third-party affective evaluation. *Animal Behavior*, 106, 123–127. <https://doi.org/10.1016/j.anbehav.2015.05.018>
- Cohen, E. (2012). The evolution of tag-based cooperation in humans: The case for accent. *Current Anthropology*, 53, 588–616. <https://doi.org/10.1086/667654>
- Dale, R., Quervel-Chaumette, M., Huber, L., Range, F., & Marshall-Pescini, S. (2016). Task differences and prosociality: Investigating pet dogs' prosocial preferences in a token choice paradigm. *PLOS ONE*, 11(12), e0167750. <https://doi.org/10.1371/journal.pone.0167750>
- Dunham, Y., Baron, A. S., & Carey, S. (2011). Consequences of 'minimal' group affiliations in children. *Child Development*, 82, 793–811. <https://doi.org/10.1111/j.1467-8624.2011.01577.x>
- Duranton, C., & Gaunet, F. (2015). Canis sensitivus: Affiliation and dogs' sensitivity to others' behavior as the basis for synchronization with humans? *Journal of Veterinary Behavior*, 10, 513–524. <https://doi.org/10.1016/j.jveb.2015.08.008>
- Ferguson, J. N., Young, L. J., & Insel, T. R. (2002). The neuroendocrine basis of social recognition. *Frontiers in Neuroendocrinology*, 23, 200–224. <https://doi.org/10.1006/frne.2002.022>
- Freidin, E., Putrino, N., D'Orazio, M., & Bentosela, M. (2013). Dogs' eavesdropping from people's reactions in third party interactions. *PLOS ONE*, 8(11), e79198. <https://doi.org/10.1371/journal.pone.0079198>
- Fugazza, C., & Miklósi, Á. (2014). Should old dog trainers learn new tricks? The efficiency of the Do as I Do method and shaping/clicker training method to train dogs. *Applied Animal Behavior Science*, 153, 53–61. <https://doi.org/10.1016/j.applanim.2014.01.009>
- Gácsi, M., McGreevy, P. D., Kara, E., & Miklósi, Á. (2009). Effects of selection for cooperation and attention in dogs. *Behavioral and Brain Functions*, 5, 31. <https://doi.org/10.1186/1744-9081-5-31>
- Hamilton, W. D. (1964). The genetical evolution of social behaviour. *Journal of Theoretical Biology*, 7(1), 1–52. [https://doi.org/10.1016/0022-5193\(64\)90039-6](https://doi.org/10.1016/0022-5193(64)90039-6)
- Hepper, P. G. (1986). Kin recognition: Functions and mechanisms. A review. *Biological Reviews*, 61(1), 63–93. <https://doi.org/10.1111/j.1469-185X.1986.tb00427.x>
- Horowitz, A. (2011). Theory of mind in dogs? Examining method and concept. *Learning & Behavior*, 39, 314–317. <https://doi.org/10.3758/s13420-011-0041-7>
- Howard, L. H., Henderson, A. M., Carrazza, C., & Woodward, A. L. (2015). Infants' and young children's imitation of linguistic in-group and out-group informants. *Child Development*, 86(1), 259–275. <https://doi.org/10.1111/cdev.12299>
- Huber, A., Barber, A. L. A., Faragó, T., Müller, C. A., & Huber, L. (2017). Investigating emotional contagion in dogs (*Canis familiaris*) to emotional sounds of humans and conspecifics. *Animal Cognition*, 20(4), 703–715 <https://doi.org/10.1007/s10071-017-1092-8>
- Kaminski, J. (2009). Dogs (*Canis familiaris*) are adapted to receive human communication. In A. Berthoz & Y. Christen (Eds.), *Neurobiology of Umwelt: How living beings perceive the world* (pp. 103–107). Berlin: Springer Verlag.
- Karl, S., & Huber, L. (2017). Empathy in dogs: With a little help from a friend—A mixed blessing. *Animal Sentience*, 14(13). Retrieved from <https://animalstudiesrepository.org/animsent/vol12/iss14/13/>
- Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences*, 104, 12577–12590. <https://doi.org/10.1073/pnas.0705345104>
- Kinzler, K. D., & Liberman, Z. (2017). Infants' inferences about language are social. *Proceedings of the National Academy of Sciences of the United States of America*, 114(9), 3753–3754.
- Kovács, K., Kis, A., Pogány, Á., Koller, D., & Topál, J. (2016). Differential effects of oxytocin on social sensitivity in two distinct breeds of dogs (*Canis familiaris*). *Psychoneuroendocrinology*, 74, 212–220. <https://doi.org/10.1016/j.psychenue.2016.09.010>
- Kundey, S., De Los Reyes, A., Royer, E., Molina, S., & Monnier, B. (2011). Reputation-like inference in domestic dogs (*Canis familiaris*). *Animal Cognition*, 14, 291–302. <https://doi.org/10.1007/s10071-010-0362-5>
- Liu, S., Xiao, N. G., Quinn, P. C., Zhu, D., Ge, L., Pascalis, O., & Lee, K. (2015). Asian infants show preference for own-race but not other-race female faces: The role of infant caregiving arrangements. *Frontiers in Psychology*, 6, 593. <https://doi.org/10.3389/fpsyg.2015.00593>
- Lodé, T. (2008). Kin recognition versus familiarity in a solitary mustelid, the European polecat *Mustela putorius*. *Comptes Rendus Biologies*, 331(3), 248–254 <https://doi.org/10.1016/j.crv.2007.12.006>
- Marshall-Pescini, S., Passalacqua, C., Ferrario, A., Valsecchi, P., & Prato-Previde, E. (2011). Social eavesdropping in the domestic dog. *Animal Behavior*, 81, 1177–1183. <https://doi.org/10.1016/j.anbehav.2011.02.029>
- Merola, I., Prato-Previde, E., & Marshall-Pescini, S. (2012). Dogs' social referencing towards owners and strangers. *PLOS ONE*, 7(10), e47653. <https://doi.org/10.1371/journal.pone.0047653>
- Miklósi, Á., & Topál, J. (2013). What does it take to become 'best friends'? Evolutionary changes in canine social competence. *Trends in Cognitive Science*, 17(6), 287–294. <https://doi.org/10.1016/j.tics.2013.04.005>
- Nitzschner, M., Melis, A. P., Kaminski, J., & Tomasello, M. (2012). Dogs (*Canis familiaris*) evaluate humans on the basis of direct experiences only. *PLOS ONE*, 7(10), e46880. <https://doi.org/10.1371/journal.pone.0046880>
- Oláh, K., Elekes, F., Bródy, G., & Király, I. (2014). Social category formation is induced by cues of sharing knowledge in young children. *PLOS ONE*, 9(7), e101680. <https://doi.org/10.1371/journal.pone.0101680>
- Oláh, K., Elekes, F., Pető, R., Peres, K., & Király, I. (2016). 3-year-old children selectively generalize object functions following a demonstration from a linguistic in-group member: Evidence from the phenomenon of scale error. *Frontiers in Psychology*, 7, 963. <https://doi.org/10.3389/fpsyg.2016.00963>
- Paolini, S., Harris, N. C., & Griffin, A. S. (2015). Learning anxiety in interactions with the out-group: Towards a learning model of anxiety and stress in intergroup contact. *Group Process: Intergroup Relations*, 10, 275–313. <https://doi.org/10.1177/1368430215572265>
- Perrett, D. I., Mistlin, A. J., & Chitty, A. J. (1987). Visual neurones responsive to faces. *Trends in Neuroscience* 10, 358–364. [https://doi.org/10.1016/0166-2236\(87\)90071-3](https://doi.org/10.1016/0166-2236(87)90071-3)
- Plötnner, M., Over, H., Carpenter, M., & Tomasello, M. (2015). The effects of collaboration and minimal-group membership on children's prosocial behavior, liking, affiliation, and trust. *Journal of Experimental Child Psychology*, 139, 161–173. <https://doi.org/10.1016/j.jecp.2015.05.008>

- Quervel-Chaumette, M., Dale, R., Marshall-Pescini, S., & Range, F. (2015). Familiarity affects other-regarding preferences in pet dogs. *Scientific Reports*, 5, 18102. <https://doi.org/10.1038/srep18102>
- Randall, J. A., Hekkala, A. E. R., Cooper, L. D., & Barfield, J. (2002). Familiarity and flexible mating strategies of a solitary rodent, *Dipodomys ingens*. *Animal Behavior*, 64, 11–21. <https://doi.org/10.1006/anbe.2002.3029>
- Ratcliffe, V. F., McComb, K., & Reby, D. (2014). Cross-modal discrimination of human gender by domestic dogs. *Animal Behavior*, 91, 126–134. <https://doi.org/10.1016/j.anbehav.2014.03.009>
- Reyes-Jaquez, B., & Echols, C. H. (2013). Developmental differences in the relative weighing of informants' social attributes. *Developmental Psychology*, 49(3), 602–613. <https://doi.org/10.1037/a0031674>
- Richter, N., Over, H., & Dunham, Y. (2016). The effects of minimal group membership on young preschoolers' social preferences, estimates of similarity, and behavioral attribution. *Collabra: Psychology*, 2, 1–8. <https://doi.org/10.1525/collabra.44>
- Romero, T., Konno, A., & Hasegawa, T. (2013). Familiarity bias and physiological responses in contagious yawning by dogs support link to empathy. *PLOS ONE*, 8(8), e71365. <https://doi.org/10.1371/journal.pone.0071365>
- Rooney, N. J., & Bradshaw, J. W. S. (2006). Social cognition in the domestic dog: Behavior of spectators towards participants in inter-specific games. *Animal Behavior*, 72, 343–352. <https://doi.org/10.1016/j.anbehav.2005.10.014>
- Sümegei, Z., Oláh, K., & Topál, J. (2014). Emotional contagion in dogs as measured by change in cognitive task performance. *Applied Animal Behavior Science*, 160, 106–115. <https://doi.org/10.1016/j.applanim.2014.09.001>
- Topál, J., Kis, A., & Oláh, K. (2014). Dogs' sensitivity to human ostensive cues: A unique adaptation? In J. Kaminski & S. Marshall-Pescini (Eds.), *The social dog: Behavior and cognition*. (pp. 319–436). Cambridge: Academic Press.
- Turcsán, B., Szánthó, F., Miklósi, Á., & Kubinyi, E. (2015). Fetching what the owner prefers? Dogs recognize disgust and happiness in human behavior. *Animal Cognition*, 18(1), 83–94. <https://doi.org/10.1007/s10071-014-0779-3>
- Vas, J., Topál, J., Gácsi, M., Miklósi, Á., & Csányi, V. (2005). A friend or an enemy? Dogs' reaction to an unfamiliar person showing behavioural cues of threat and friendliness at different times. *Applied Animal Behaviour Science*, 94, 99–115. <https://doi.org/10.1016/j.applanim.2005.02.001>
- Vignal, C., Methevon, N., & Mottin, S. (2007). Mate recognition by female zebra finch: Analysis of individuality in male call and first investigations on female decoding process. *Behavioral Processes*, 77, 191–198. <https://doi.org/10.1016/j.beproc.2007.09.003>
- West, S. A., & Gardner, A. (2010). Altruism, spite, and greenbeards. *Science*, 327(5971), 1341–1344. <https://doi.org/10.1126/science.1178332>
- Ziv, T., & Banaji, M. R. (2012). Representations of social groups in the early years of life. In S. T. Fiske & C. N. Macrae (Eds.), *The SAGE handbook of social cognition* (pp. 372–389). London: SAGE.