

Cooperative and trained dogs follow misleading human cues regardless of human beliefs

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Abstract

Studying theory of mind (ToM) in animals can clarify its nature and origins in humans. One persistent difficulty in non-verbal ToM tasks for animals is distinguishing reliance on others' observable behaviour from inferences about unobservable mental states. We embedded an experience-projection method into a change-of-location task: a human communicator either held a true (TB) or a false belief (FB) about a food reward's location, while dogs (*Canis familiaris*; N = 120) could observe all hiding events and track the reward to its final location. Across conditions the communicator behaved identically, only the visual affordance of a hidden barrier differed. After food relocation, the communicator misleadingly suggested (with ostensive cues – no pointing gestures were used) the now-empty location. Although dogs remembered the tunnel's visual affordance, they were equally likely to follow the misleading cues in both conditions, suggesting that they did not use the communicator's belief state in this task. Irrespective of condition, cooperative breeds and professionally trained dogs were more likely than independent breeds and untrained dogs to follow the cue. Our study underscores the importance of controlling for confounding behavioural cues, contributes to the discussion on ToM abilities in animals, especially regarding generalisation across first- and third-person perspectives, and proposes dogs as comparative models for susceptibility to social influence.

208 words.

Background

Fundamental to most human social endeavours is the ability to take others' perspective and think about what they might see, know and (possibly mistakenly) believe from their point of view. This ability was famously named "Theory of Mind" (ToM; Dennett, 1978; Premack & Woodruff, 1978). A central issue when testing animals' ToM with non-verbal tasks is the difficulty of finding measures that tap into the animals' ability to go beyond the mere observation of directly visible cues and that actually require the additional inference of an invisible mental state to be passed (Heyes, 1998). Despite the centrality of the question, only few studies have attempted to disentangle whether animals' performance in non-verbal ToM tasks is based on behaviour-reading (the observation of directly visible cues) or mind-reading (the additional inference of mental states from those directly visible behaviours).

One methodology proposed to overcome this logical problem is the so-called "experience-projection" test (Heyes, 1998; Lurz & Krachun, 2019), which requires the participants to project what they have previously experienced in first person about novel visual barriers (i.e., the possibility to see through them or not) onto a third person. And there is some evidence that human infants and great apes might be capable of experience-projection (Kano et al., 2019; Karg et al., 2015; Meltzoff & Brooks, 2008). In recent years, dogs (*Canis familiaris*) have become a particularly interesting model species for testing this and other forms of perspective-taking, especially when confronted with humans. For instance, canine researchers have manipulated (blocked or allowed) a human's visual access to a target using (respectively, opaque or transparent) visual barriers that were directly observable for the dogs during the

tests (e.g., Bräuer et al., 2004; Heberlein et al., 2017; Huber et al., 2025; Kaminski et al., 2009). In these situations, dogs reacted as if they were capable of level-I perspective taking (Flavell et al., 1981), i.e., capable of telling whether the human could see or not through the barriers. For example, dogs in these studies retrieved a toy or stole food more likely when it was visible behind a transparent barrier than hidden behind an opaque one from the perspective of the human who was asking them to bring the toy or who forbade them to eat the food. However, the properties (see-through or opaque) of the visual barriers were accessible from the dog's point of view at the moment of choice. If dogs can perceive this directly observable difference between the barriers and have learnt during their life that stealing attempts are more successful when they happen behind opaque barriers, explaining their performance in terms of mind-reading is no longer necessary. At least, one cannot rule out that dogs' appropriate response is supported by an egocentric strategy (i.e., approach/avoid, depending on the context of the experiment, the barrier from which the dog can in principle see the human), rather than truly taking the human's perspective (approach/avoid the barrier through which the human can see). Only the latter, altercentric strategy (considering what the human can see) would be supported by mind-reading, but providing evidence of mindreading requires more sophisticated tests such as those that apply the experience-projection paradigm (for another novel, non-verbal method to differentiate between behaviour-reading and mind-reading, see Lonardo et al., 2025).

Two studies adapting this methodology for dogs have failed to provide evidence for such an ability in this species (Lonardo et al., 2024; West-Brownbill et al., 2024), suggesting that dogs might pass perspective-taking tasks by relying on their own (egocentric) perspective and behaviour-reading instead of taking on others' visual perspective. In both above-mentioned studies, dogs initially received firsthand experience with novel apparatuses containing a barrier on each side, one barrier allowed to see through it, the other was fully opaque. Crucially, from the dogs' starting position during subsequent test trials both sides of the apparatus looked identical (except for irrelevant features such as shape or colour, useful to help dogs' memory) but it was no longer possible for the dogs to observe directly which side was see-through and which one was opaque. For example, in one such study, this setup including see-through and opaque barriers was embedded in a gaze-following task. Dogs followed an experimenter's gaze to a possible foraging target irrespective of whether this was behind the see-through or the opaque barrier (inserted in big wooden tunnels) from the experimenter's point of view (Lonardo et al., 2024; experiment 1). In another instantiation, the setup was embedded in a stealing task, in which dogs had to infer that an experimenter, located at the other side of the tunnels, could see them approaching forbidden food through the transparent but not the opaque tunnel (Lonardo et al., 2024; experiment 2). Importantly, from their starting position the dogs could not see the barriers inside the tunnels, therefore they must project their experience with them to the human. In neither study did dogs show evidence of experience-projection; they did not preferentially approach the side of the apparatus from which they could have not been seen (Lonardo et al., 2024; West-Brownbill et al., 2024). However, it is possible that having to keep track of the properties of two hidden barriers might be too demanding for the dogs (though dogs did pass a manipulation check suggesting that they did remember which barrier was see-

through). Alternatively, the stealing and gaze-following tasks might have not been motivating enough to bring out dogs' perspective taking ability.

In the present study, we aimed at disentangling between mind-reading and behaviour-reading by combining the experience-projection procedure with a non-verbal change of location task which has been already proven successful in eliciting an altercentric effect in dogs (Lonardo et al., 2021). i.e., in influencing dogs' choices through the manipulation of a bystander's mental state, even though the bystander's mental state is completely superfluous for the dogs to obtain the food and, in this study, the bystander's behaviour is identical between conditions. Compared to the previous studies testing experience-projection in dogs, in the present study we used a simplified (between-subjects) procedure. Dogs see that one experimenter, the hider, hides a treat first in one of two opaque buckets (bucket A) and then relocates the treat to a second bucket (bucket B). A second experimenter, the communicator, always observes the hiding of food in bucket A. In one condition (True Belief, TB) the communicator also sees the subsequent relocation of the treat to bucket B, while in the other condition (False Belief, FB) the communicator does not see this relocation. Therefore, the TB communicator, like the dogs, believes that food is in bucket B, while the FB communicator believes food to be in bucket A, which in reality is empty. In both conditions, however, the communicator suggests to the dogs to look for food in bucket A. This suggestion is completely superfluous for the dogs, because they could witness the whole hiding sequence themselves and therefore know that food is in bucket B. But dogs, some breeds more than others, can be misled by human suggestions in this type of cooperative communicative task (Barnard et al., 2019; Bhattacharjee & Bhadra, 2022; Dwyer & Cole, 2018; Junttila et al., 2022; Lonardo et al., 2021; Marshall-Pescini et al., 2012; Szetei et al., 2003). This was also the case in the visual false belief test (Lonardo et al. 2021): approximately one third of dogs followed the human misleading suggestion to bucket A, but, interestingly, more in the FB than in the TB condition. Only terriers showed the reverse, more human-like tendency of following more the TB than the FB communicator. In this first FB test with dogs, the communicator's apparent belief was operationalised as the communicator leaving the room (for the exact same amount of time) either before or after (TB) or during (FB) the food relocation. Thus, the communicators behaved differently only in the timing of their short absence. Still, dogs might react differently to this timing difference of the communicator's absence (note: in a between-subject design they were tested only in one condition) without necessarily attributing also mental states (such as seeing, knowing, or believing) to the experimenter.

Here we refined the FB task by embedding it in the experience-projection setup and thus manipulating the mental state of the two communicators in a manner not directly observable for the dogs. The communicators, in both conditions, crouched down with upper body leaning forward behind a barrier at the critical moment of the food relocation and observed the scene from there. The barrier was transparent in the TB condition, thus allowing the communicator to see the food relocation, and opaque in the FB condition, thus preventing the communicator from seeing the food relocation. Importantly, like in Lonardo et al. (2024) the barrier was inserted in the middle of a wooden tunnel, therefore it was not directly visible from the dogs' starting position. From their point of view, dogs saw in both conditions that the communicators inserted their head into the tunnel and thus had to infer, based on their own previous

experience with seeing through or not seeing through the same tunnel (we used different colours to make them recognizable), whether the communicator had visual access to the relocation of the food or not (experience-projection). If their success in previous perspective taking tasks is due to only behaviour-reading, dogs in the present experiment should not react differently between the two groups (TB and FB), as in both cases the experimenters behave identically. If their perspective taking is based on the attribution of visual access to the experimenters (who either sit behind a transparent or an opaque barrier), and if dogs are capable of experience-projection (dogs have experienced themselves whether the barrier is see-through or not before the test), then dogs should be able to discriminate between conditions also in the current setting.

Furthermore, we wanted to test whether dogs' rate of following the communicator's misleading suggestion is influenced by the dogs' breed type (cooperative vs independent; Gácsi et al., 2009; Heberlein et al., 2017; Lugosi et al., 2024; Pongrácz & Dobos, 2025). Based on the results reported by Lonardo et al. (2021), we predicted that cooperative breeds should be more likely to choose bucket A when the experimenter has the FB that food is in A compared to when the experimenter knows that A is empty (TB). Independent breeds should show the opposite pattern of results by ignoring the communicator's misleading suggestion (and therefore choosing bucket B) less often in the TB than in the FB condition.

Finally, we explored a third factor that might have affected dogs' following of the communicator's misleading suggestion: their previous training experience, as there is evidence that this might affect dogs' choices in perspective-taking tasks (Heberlein et al., 2017).

Methods

The methods, hypotheses, predictions and confirmatory analysis plan for this experiment were preregistered prior to the beginning of data collection (https://osf.io/645d7/overview?view_only=81ffab642d944b94b9d8dda62a656028).

Ethical note

The experiment was discussed and approved by the ethics and animal welfare committee of the University of Veterinary Medicine of Vienna (ETK-025/02/2025) in accordance with national legislation and the university's good scientific practice guidelines. All caregivers and dogs participated voluntarily. Dogs were only brought to the lab for participating in the study and returned home with their caregivers afterwards. Before the beginning of the session, caregivers signed informed consent forms for their dogs to participate, none of them asked to interrupt participation during the study and none of the dogs showed signs of stress during the session. The authors complied with ARRIVE guidelines.

Subjects

One hundred and twenty pet dogs (56 females) were tested (Table S1 for more demographic and counterbalancing information). Their mean age was 70.34 months (± 40.62), range: 9-180 months. The European association of dog breeders (Fédération Cynologique Internationale, FCI) classifies dog breeds based on their function, i.e., the activity they were bred to perform in human society, their morphology and geographical origin. We classified the specific breeds we recruited (which did not include companion and toy dogs, FCI group 9, nor Dachshunds, FCI group 4) in two breed types (cooperative and independent) based on the classification operated in previous studies (Gácsi et al., 2009; Heberlein et al., 2017) and, if a new breed was available to us but not included in previous studies, we assigned it the same breed type of other breeds in the same FCI group. Accordingly, 72 dogs in our sample belonged to FCI groups 1 (shepherds, N = 27), 2 (guard dogs, N = 8), 7 (pointers, N = 14) or 8 (retrievers and water dogs, N = 23) and were therefore classified as “cooperative”; 48 dogs belonged to FCI groups 3 (terriers, N = 33), 5 (spitzes, N = 5), 6 (scent hounds, N = 9) and 10 (sight hounds, N = 1) and were therefore classified as independent.

Of the tested dogs, 72 did not have formal training experience (i.e., had never participated in individual or group training/sport activities with a professional dog trainer) while 48 had this experience. Training and breed type were not collinear: of the dogs belonging to cooperative breeds, 44 did not have professional training while 28 did. Of the dogs belonging to independent breeds, 28 did not have professional training and 20 did. None of the dogs had previous experience in studies testing experience-projection, so the visual barriers we used were effectively novel to them.

Additional 67 dogs came to the lab to participate in this experiment but were excluded for various reasons: for not meeting the inclusion criteria (see supplementary materials) in familiarisation phase 1 (17 dogs); in familiarisation phase 2 (30 dogs) and in familiarisation phase 3 (6 dogs); for having being released too soon during the test trial (4 dogs); for not being motivated enough to open the bucket lids independently (4 dogs); for breaking through the fence separating the room in two during the manipulation check (1 dog); experimenter’s mistake (2 dogs); discovery upon arrival to the lab that the dog was not pure-bred or did not belong to a cooperative or independent breed (2 dogs); and video loss (1 dog).

Set-up and materials

The experiment took place in a 606 x 705 cm room of the Clever Dog Lab, Vienna (Fig. S1). The room was divided in two sides (the dog’s side and the communicator’s side) by a series of fences including a blue, wooden tunnel (all 110 cm high; Fig. 1 and S1). The tunnel, approx. perpendicular to the other fences, was 60 cm long. For dogs in the TB group, the tunnel contained a transparent barrier, allowing visual access between the two sides of the room. For dogs in the FB group, on the contrary, the tunnel contained an opaque barrier which prevented visual access between the two sides of the room. On the dog’s side of the room, two 12.5 cm high opaque plastic buckets (flowerpots, diameter: 13.7 cm), one light blue, the other dark grey, were placed equidistant (163 cm away) from the dog’s starting position. The side of the buckets was kept constant across dogs (blue on the dogs’ left side), but which bucket

was baited first (i.e., which one was bucket A for a dog) was fully counterbalanced across dogs. Both buckets contained a rubber foam padding on the bottom, to prevent the food from making noise when it was dropped in the buckets. Moreover, both buckets were rubbed with the food used during the experiment, to prevent dogs from being able to locate the hidden food based on olfactory cues alone. Mostly, the food used were slices of Frankfurter, but for a minority of dogs the caregivers provided different treats, due to dietary restrictions.

The dog was held on its collar or harness in its starting position by its seated and blindfolded caregiver. Importantly, being perpendicular to the tunnel, from their starting position dogs could not see the barrier contained in the tunnel, but only its outer wooden structure, which was the same between conditions (Fig. 1a). Half of the dogs were tested with the set-up shown in Fig. 1, in which the tunnel is closer to the grey bucket, while the other half with its specular version, in which the tunnel was closer to the blue bucket (Fig. S1).

Design and procedure

Data were collected in a single session of approximately 30 minutes. In a between-subject design, half of the dogs were tested in the FB group and the other half in the TB group. Notably, the only difference between these two groups was the barrier inserted in the tunnel. Except for this, the procedure was identical between the two groups.

After undergoing three familiarisation phases (familiarisation phases 1–3), dogs were given firsthand experience with the visual properties of the barrier inserted in the tunnel (experience phase). Afterwards we checked whether our manipulation produced the expected learning outcome (manipulation check phase) and immediately afterwards tested the dogs in a single trial (FB or TB test, shown in Fig. 1). The aim of the familiarisation phases was not only to acclimate dogs to the novel situation and experimenters, but also to ensure we only tested dogs who: 1) understood visible food displacements spontaneously; 2) were willing to follow the communicator's novel communicative cue (no pointing gestures were used in this study) spontaneously when they had not witnessed the food hiding themselves and 3) were attentive enough to find the food immediately when they had the chance to observe the hiding and received a correct suggestion. In the manipulation check phase, dogs were shown that one experimenter, the hider, kept food on a chopping board. The hider then sat down behind an opaque partition (a series of fences, including the tunnel), that divided the room in two sides and that prevented the dogs from seeing or approaching the hider (Fig. S3). While the hider was hidden, dogs could hear chopping sounds made on the chopping board but, from the position in the room where their caregiver held them, they could not see through the tunnel, they could only see its outer wooden contour. If dogs were curious to check on the hider preparing food, the only way they could have gained visual access to this was by approaching the tunnel, once released by their caregiver upon the hider's signal, but only in the TB condition, in which the barrier in the tunnel would have allowed them to see through the tunnel. In the FB condition, dogs could have not gained visual access to the hider because the whole partition, including the tunnel containing an opaque barrier, was opaque. All familiarisation, experience

and manipulation check phases are described in detail in the SM (supplementary text and Fig. S2-S3) and closely followed the procedures of Lonardo et al. (2021, 2024).

During test trials, dogs would see the hider hide food in one bucket first (bucket A, colour counterbalanced across dogs; Fig. 1a). A second experimenter, the communicator, would then leave her initial position, equidistant from both buckets and in front of the dogs, she would open a small gate in the fences and cross it to walk over to the communicator's side of the room (Fig. 1b). There, she would crouch down behind the tunnel, insert her face inside the tunnel, leaving only her side body visible to the dogs, clear her throat to catch the dogs' attention. Upon hearing this, the hider would silently remove the food from bucket A and relocate it to bucket B (Fig. 1c). Next, the hider would leave the room, closing the door behind, and the communicator would stand up, cross the gate once more and would walk back to the dog's side of the room, where she suggested bucket A without pointing at it, but using ostensive cues already validated for dogs in previous studies (Lonardo et al., 2021; Lonardo, Berndt, et al., 2026; Marshall-Pescini et al., 2012). These cues consisted of approaching bucket A (in both conditions; empty), picking it up, alternating gaze between the bucket and the dog while uttering "look, this is good, this is very good" with a positive tone of voice and facial expression (Fig. 1d). The communicators, who during familiarisation trials would always suggest the correct (baited) bucket using the same communicative cues just described for the test, would always speak in English to avoid accidentally using any command words known to the dogs. After giving her suggestion, the communicator would walk back to her starting position, look down to the floor and say "ok" to signal to the caregiver to release the dog.

The tests were conducted by five experimenters (two men, three women), whose identity and role (hider or communicator) were counterbalanced as much as possible between conditions. The largest difference between conditions were two experimenters having tested four more dogs in one condition than in the other as hider and four experimenters having tested one more dog in one condition than in the other as a communicator.

During test trials, we scored whether dogs first crossed the line marked on the floor, 40 cm away from the dog's starting position (purple lines in Fig. S1), corresponding to bucket A or B and whether they first touched, with their nose or front paw, bucket A or B. We considered both these variables important to assess whether dogs might have changed their mind after starting to approach one bucket, because they could see the barrier inside the tunnel, after walking 40 cm away from their starting position. These two variables largely coincided with only one exception: a 10-month-old female Parson Russel terrier tested in the TB group, who appeared to start approaching on the side of bucket B but ended up choosing (i.e., touching) first bucket A. Due to this large overlap between the two variables, we only analysed the first touch variable for similarity with previous studies (Lonardo et al., 2021). As a manipulation check, we scored the latency it took dogs to go look through the tunnel from the moment they were released during the manipulation check and whether they exhibited this behaviour or not.

Analyses

All statistical analyses were conducted in R (R Core Team, 2025; version 4.2.2). All inferences were drawn based on p -values $< .05$.

Influence of condition and breed type on first choice

To analyse the effect of the communicator's belief on dogs' choice of the empty bucket, we fitted a GLMM with binomial error structure and logit link function, using the function `glmer` of the package `lme4` (Bates et al., 2015). The only test predictors, with fixed effect, were condition (a factor with 2 levels: TB and FB), breed type (a factor with 2 levels: cooperative and independent) and their interaction. As control predictors with fixed effect, we included dogs' age (in months, z-transformed), sex and first baited bucket identity (blue or grey). Additionally, we included the random slope of condition, sex, first baited box (all dummy coded and centred) and age (z-transformed) within the random intercept of breed, to account for repeated observations of the same breeds. Correlation parameters between each random slope and the random intercept were included too (Barr et al., 2013). We assessed the significance of the individual fixed effects by conducting likelihood ratio tests.

Influence of training experience on first choice

In addition to the pre-registered analysis reported above, we further explored whether having received any form of training by a professional dog trainer (yes, coded as 1 or no, coded as 0) influenced the dogs' first choice in this task. To analyse the effect of training on dogs' tendency to follow human misleading communicative cues, we fitted a binomial model similar to the one described in the section above but with the addition of: 1) the fixed effects of training (factor with two levels: yes and no) and of the interaction between training and condition and 2) of the random slope of training (dummy coded and centred) within breed. Correlations parameters between random slopes and intercept had to be removed from this model due to converge issues.

Manipulation check

To assess the validity of our experimental manipulation, during the manipulation check phase, we measured dogs' latency and probability to approach the tunnel. As preregistered, we expected that the dogs in the TB group should have been faster or more likely to approach the tunnel than the dogs in the FB group, because we assumed that dogs would have been motivated to observe what happened on the other side of the room when hearing chopping sounds and remembered that they could do so through the tunnel in the TB but not in the FB group.

Dogs who never approached the tunnel were given a value very close to the maximum trial duration (30 s), but not exactly the maximum because the latency was scored from the moment the owner released the dog (which typically took a fraction of second) until the end of the trial, hence all latencies were shorter than the maximum trial duration. To analyse dogs' latency to approach the tunnel we used a two-

independent-samples t-test and we controlled also that the duration of the manipulation check trials was not significantly different between experimental groups using the same method. We compared dogs' probability to approach the tunnel at all during the manipulation check between the two groups by using a binomial test (comparing the probability to approach in one group to the probability to approach in the other group, one observation per subject).

A second, naive coder watched 36 (30% of our total) videos and scored: the dogs' first touched bucket during test trials; their latencies and probabilities to approach the tunnel during the manipulation check. All variables demonstrated substantial to almost-perfect inter-observer reliability. For the binary variables, we calculated Cohen's kappa and found that inter-observer agreement was 97.22% (Kappa = 0.93 $z = 5.61, p < .001$) for the first touched bucket, and 88.89% (Kappa = 0.71, $z = 4.28, p < .001$) for the probability to approach the tunnel. For the latencies, we calculated an intraclass correlation coefficient (ICC = 1; 95% confidence interval: [.99 – 1]; $F_{(35,36)} = 464, p < .001$).

Results

Influence of condition and breed type on first choice

Overall, 74% of the dogs followed the communicator's misleading suggestion to the empty bucket A; in the false belief condition 80% of the cooperative and 60% of the independent dogs chose bucket A while in the true belief condition 86% of the cooperative and 61% of the independent dogs chose bucket A (Fig. S4). The interaction between condition and breed type was not significant ($\chi^2_{(1)} < 0.01, p = .952$), hence we refitted the model without the interaction term but kept both main effects. To avoid multiple testing, we compared the fit of the full model to a null model lacking the fixed effects of the test predictors (condition and breed type). The full-null model comparison was significant ($\chi^2_{(2)} = 6.56, p = .038$), indicating that at least one of the two test predictors had a significant main effect on dogs' first choice. The communicator's apparent belief did not influence dogs' choices significantly ($\chi^2_{(1)} = 0.86, p = .353$; Fig. 2A). Instead, irrespective of condition, dogs' willingness to choose first the empty but suggested bucket significantly depended on their breed type. Specifically, on average across conditions, 83% of the cooperative dogs followed the communicator's misleading communication, while 60% of the independent breeds did so. Hence, dogs of cooperative breeds were more likely than the independent ones to follow the communicator's misleading suggestion to a bucket they knew to be empty ($\chi^2_{(1)} = 6.08, p = .014$). Dogs were more likely to choose bucket A when this was grey, or on their right side, compared to blue, or on their left side ($\chi^2_{(1)} = 6.48, p = .011$). The results of the full model are reported in Table S2 and Fig. 2B.

Influence of training experience on first choice

The interaction between condition and training was not significant ($\chi^2_{(1)} = 0.01, p = .921$), hence we refitted the model without the interaction term but kept both main effects. To avoid multiple testing, we

compared the fit of the full model to a null model lacking the fixed effects of training, condition and breed type (but retaining all other fixed and all random effects of the full model). This comparison was significant, revealing that at least one of these test predictors had a significant main effect on dogs' first choice ($\chi^2_{(4)} = 11.44, p = .022$). Of the dogs with professional training experience, 85% followed the communicator's misleading suggestion, while 67% of the dogs without training experience did so. Hence, dogs with professional training experience were more likely than dogs without such experience to follow the communicator's misleading communicative cue, irrespective of condition and breed type ($\chi^2_{(1)} = 5.42, p = .02$). This model also confirmed that breed type significantly explained the dogs' willingness to choose the empty but suggested bucket, with cooperative breeds being more likely than independent ones to choose the empty, suggested bucket irrespective of training and condition ($\chi^2_{(1)} = 4.85, p = .028$). Dogs were more likely to choose bucket A when this was grey, or on their right side, compared to blue, or on their left side ($\chi^2_{(1)} = 6.51, p = .011$). The results of the full model are reported in Table S3 and Fig. 2C.

Manipulation check

Dogs in the TB group took on average 12.87 (SD $\pm$ 11.27) s to approach the tunnel during the manipulation check, while dogs in the FB took on average 19.05 ($\pm$ 10.62) s. As predicted, dogs in the TB group were significantly faster to approach the tunnel during the manipulation check than dogs in the FB group ($t = 3.09, df = 117.58, p = 0.002$; Fig. 3A).

Of the 60 dogs tested in each experimental group, 45 (75%) in the TB group approached the tunnel during the manipulation check, while 33 (55%) did so in the FB group. As predicted, dogs in the TB group were significantly more likely than dogs in the FB group to approach the tunnel (Fig. 3B; binomial test: $p = .001$).

Discussion

The aim of this study was to disentangle whether dogs' performance in perspective-taking tasks relies on behaviour-reading or mind-reading. Further, we assessed the effect of functional breed selection (cooperative vs independent breeds) and training experience on dogs' tendency to follow human misleading communicative cues. To achieve the first aim, we presented dogs with a novel, simplified, experience-projection test. In this, dogs had to project their first-person previous experience with a novel barrier (i.e., whether it was possible to see through it or not) onto a third person, the communicator, in a cooperative, communicative task. When dogs themselves were motivated to gain visual access to the other side of the tunnel, they remembered the visual property of the barrier, even when the barrier was no longer directly visible from the dogs' point of view. Despite remembering the visual affordance of the barrier hidden in the tunnel, we found no evidence that dogs projected the mental state "has visual access" onto a third person, as dogs did not react differently to the human communicator's suggestion between conditions.

Reacting differently between conditions in this task required mainly three cognitive abilities. First, it required dogs to be sensitive to the precise timing of the communicator's moving behind the tunnel (after having seen food being hidden in A but before food was relocated to B). A previous study using the same change-of-location logic suggests that dogs should be capable of reacting to this timing cue appropriately (Lonardo et al., 2021). However, this previous study used a much more obvious manipulation (the communicator being present or absent from the room during the food relocation) than the present study and hence could not rule out that dogs' performance was explainable in terms of behaviour-reading. By contrast, the second cognitive ability required for the present task is the understanding that, when their heads were in the tunnel, the communicators could only see the food being relocated if the barrier inside the tunnel was transparent. Third, the task hinges on the assumption that dogs remembered the visual affordance of the barrier inside the tunnel (see-through or opaque) even when they could no longer see it directly themselves. Our manipulation check, which happened right before the test trial, confirmed that dogs indeed remembered such affordance, as evidenced by dogs being more likely and faster to approach and look through the tunnel when the tunnel was transparent (TB) compared to opaque (FB), when they themselves wanted to check what is happening on the other side of the room. Hence, given that dogs likely possess the other two cognitive abilities required for passing this task, we suggest that, in the current set up, they might have lacked the ability to project their own previous experience onto a third person (the communicator's) to infer their visual perspective. This conclusion is supported by previous studies using experience-projection methods to study perspective-taking with dogs across a variety of cooperative and competitive contexts (Lonardo et al., 2024; West-Brownbill et al., 2024). Nevertheless, it should be noted that a limitation of the present task is that it requires experience-projection across species, i.e., the ability to generalise from dogs' sensory system to that of humans, which might pose additional challenges compared to projecting one's own experience onto a conspecific; but see Kano et al. (2019) and Karg et al. (2015) for evidence that great apes are capable of projecting their own experience, across species, onto humans.

Nevertheless, one additional possibility to explain the present results is that experience-projection tests, as they have been implemented so far, are too demanding for assessing dogs' perspective-taking abilities, since they not only require the ability to attribute mental states, but they additionally require the ability to project (i.e., generalise) one's first-person past experience onto heterospecific others. Currently, the hypothesis that dogs are capable of generalising from a first-person observation to a third-person perspective is lacking support (e.g., Jim et al., 2020; Kaminski et al., 2012). Hence, it remains possible that dogs are capable of perspective-taking based on mind-reading but that the present test is not suitable to showcase this ability due to dogs' limitations in generalising from a first-person to a third-person perspective. Nevertheless, another methodology has been developed to disentangle between behaviour-reading and mind-reading in dogs, based on auditory cues, and not requiring experience projection (Lonardo, Berndt, et al., 2026). However, the dogs did not significantly discriminate between conditions in that task either. Still, their performance in the latter task did not differ significantly from that in the visual false belief task (Lonardo et al. 2021), even though there were no behavioural differences between the two communicators in the auditory false belief task.

Dogs' ability to discriminate between the visual properties of an opaque and a transparent barrier, when this information is useful to the dogs themselves, is consistent with the findings of previous studies leaving the barriers directly visible from the dogs' point of view (Bräuer et al., 2004; Heberlein et al., 2017; Huber et al., 2025; Kaminski et al., 2009) and additionally confirms that dogs can remember the properties of visual barriers even when they are afterwards hidden (Lonardo et al., 2024). What the present study, together with previous ones using experience-projection methods (Lonardo et al., 2024; West-Brownbill et al., 2024), seems to suggest is that although dogs react appropriately to transparent and opaque barriers when they can use this information from a first-person perspective, they fail to expect that others will have similar visual access as the dogs did, when looking through the same barrier. That is, dogs do not use their own previous mental state as a model to simulate what others' mental state in the same situation will be (or dogs do not generalise their own visual abilities to another species).

Using this test allowed us to evaluate breed type differences in response to human misleading communicative cues (already reported in previous studies; Barnard et al., 2019; Lonardo et al., 2021). It has been advanced that modern dog breeds' functional selection history might have shaped dogs' socio-cognitive abilities towards more or less reliance on human-given communicative cues (Gácsi et al., 2009; Pongrácz & Dobos, 2025). Our classification of cooperative and independent breeds was based on the breeds' functional selection history as done in previous studies (Bognár et al., 2021; Gácsi et al., 2009; Heberlein et al., 2017; Lonardo et al., 2021, 2025; Lugosi et al., 2024; and Pongrácz & Dobos, 2025 for a review). Specifically, cooperative breeds (in this study: shepherds, retrievers and water dogs, pointers, watch dogs) have been selected for cooperating with humans while keeping visual attention on their handler, such as when herding cattle. In contrast, independent breeds (in this study: terriers, sight hounds, scent hounds, spitzes) were selected for cooperating with humans in a more independent way, that relies less on visual attention to the human handler, such as when hunting underground (Gácsi et al., 2009). Although we did not find the interaction between breed type and condition that we had predicted prior to collecting the data, we did find that breed type had a main effect on dogs' tendency to follow human misleading communicative cues. Accordingly, independent breeds were less likely to follow the communicator's misleading suggestion than cooperative breeds, irrespective of condition. This finding is consistent with previous studies (Gácsi et al., 2009; Morrill et al., 2022).

Although it was not the main focus of the present study, this task also allowed us to explore the effect of formal training on dogs' tendency to follow human misleading directions. Dogs with prior experience with a professional dog trainer were more likely to follow the communicator's suggestion than dogs without formal training experience. This finding partly contrasts with earlier work suggesting that training level (competitive vs basic) does not necessarily improve dogs' performance in following human-given communicative cues (Cunningham & Ramos, 2014). Interestingly, our findings show that dogs who had previous experience participating in an activity with a professional dog trainer were more likely to follow human misleading communicative cues, even though we had several different types of training (and their combinations) in our sample (obedience, agility, scent detection, assistance dogs, etc...) and irrespective

of dogs' breed group, suggesting that training can affect even independent dogs' tendency to rely less on human-given cues.

In conclusion, in this setting we found no evidence that dogs use mind-reading to solve perspective-taking tasks. Rather, it seems more likely that their performance in previous perspective-taking tasks can be explained with the use of an egocentric strategy and behaviour-reading. However, the possibility remains that dogs are capable of perspective-taking, but not of experience-projection and this selective inability to generalise observations from first- to third- person (or from one species to another) might explain dogs' performance in this task. Further, this study advances our understanding of canine social cognition through the finding that cooperative breeds are more likely than independent ones to follow human misleading communicative cues. The result that training increases dogs' tendency to follow misleading human cues supports the use of dogs as a model species for investigating the behavioural foundations of obedience and responsiveness to human social cues.

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Author Contribution

LL: Conceptualization, Methodology, Data curation, Formal analysis, Project administration, Resources, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing. JH: Investigation, Data curation, Project administration. JS: Investigation, Data curation, Project administration. JD: Investigation, Data curation, Project administration. CJV: Conceptualization, Methodology, Writing – review & editing. LH: Conceptualization, Methodology, Resources, Supervision, Writing – review & editing.

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Data availability

The raw data and R code for the analyses described in this paper are available at Zenodo:
<https://doi.org/10.5281/zenodo.20555809> (Lonardo, Hasenöhl, et al., 2026).

Additional information

The authors declare no competing interests.

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Figures

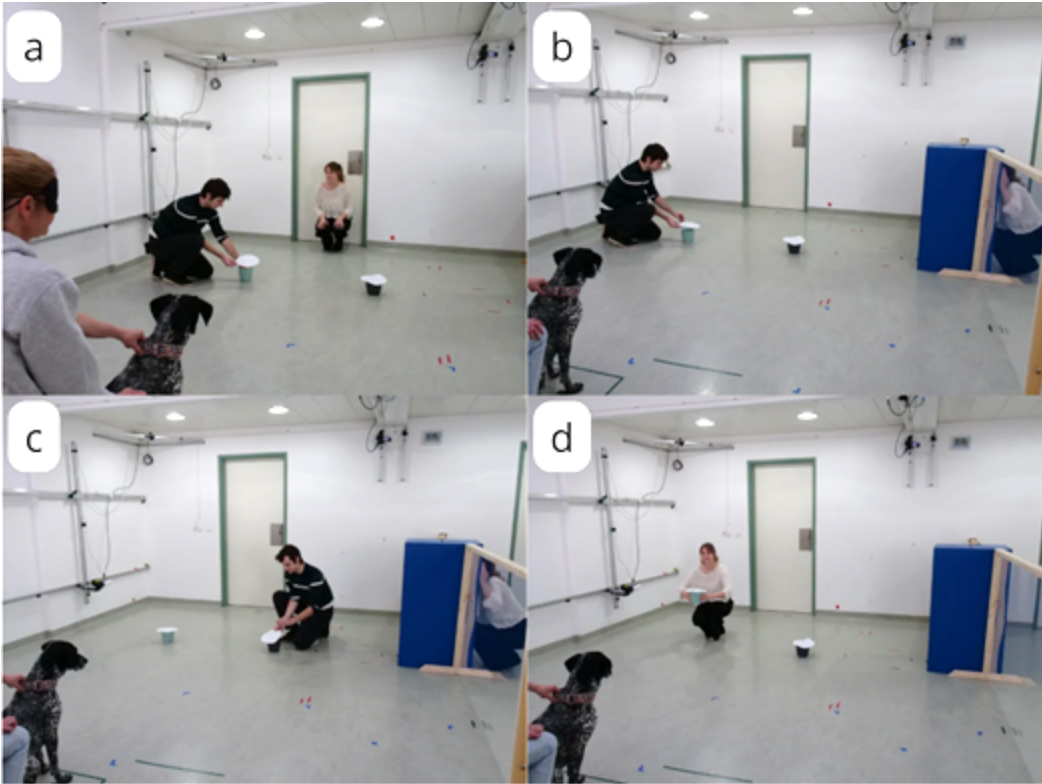


Figure 1

The experimental room and set-up/the procedure. In (a) the hider hides the treat in bucket A, while the communicator and the dog watch; (b) the communicator moves behind the tunnel; (c) the hider displaces the treat to bucket B, while the communicator observes from behind the tunnel; (d) after the hider has left the room, the communicator comes back and suggests container A. The dog in the pictures was not one of the participants.

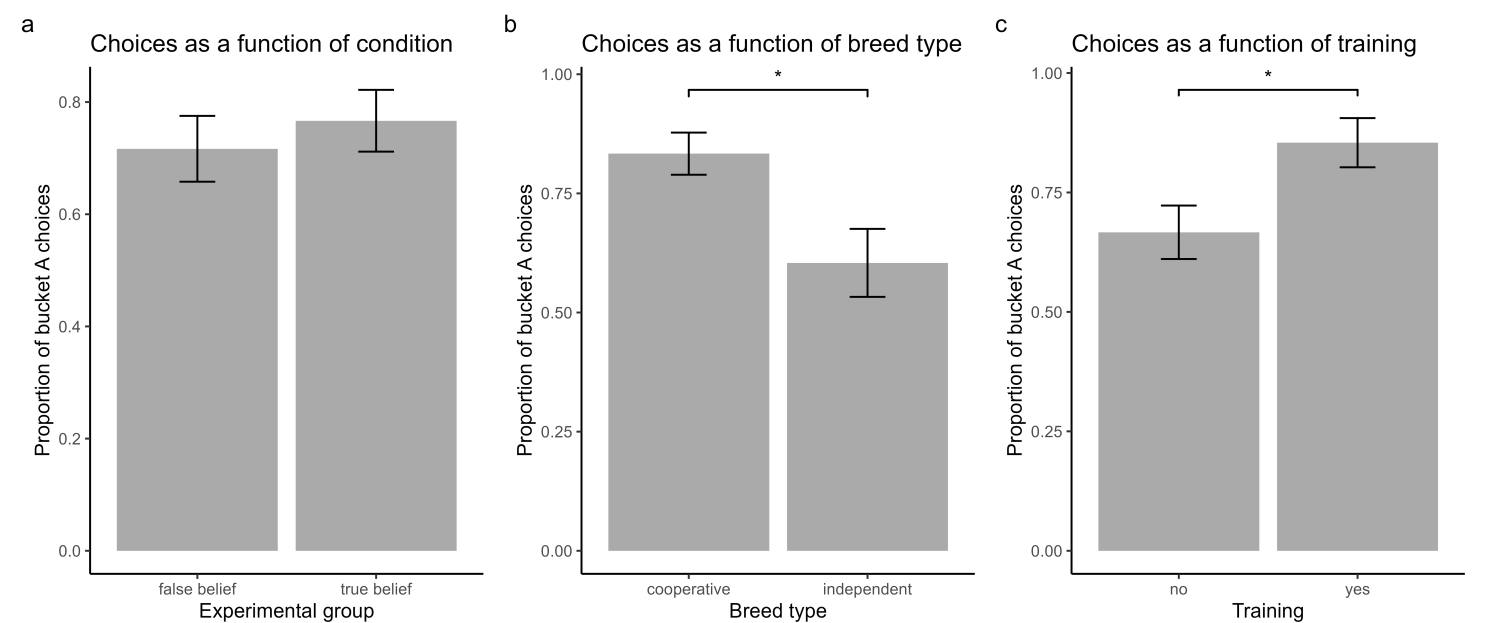


Figure 2

Bar plots showing dogs' average proportion of choosing the empty but suggested bucket A first as a function of experimental condition (a), breed type (b) and training experience (c). Error bars represent standard errors. Significance bars reflect the results of a binomial GLMM (likelihood ratio test).

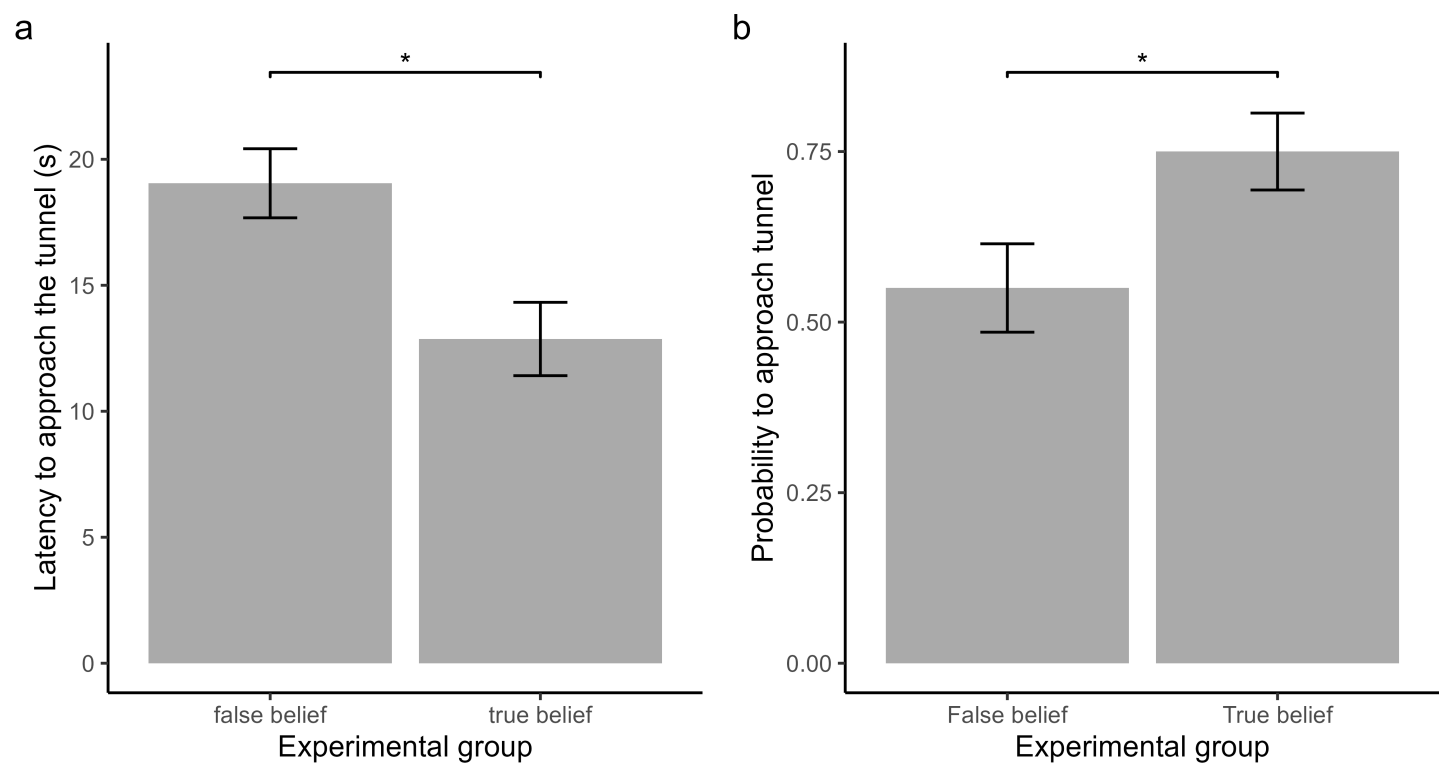


Figure 3

Bar plots showing dogs' behaviour during the manipulation check. Panel a) shows dogs' latency (in s) to approach the tunnel as a function of experimental group. Panel b) shows dogs' average probability to approach the tunnel at all. Error bars represent standard errors. Significance bars reflect the results of an independent-samples t-test (a) and a binomial test (b).

Supplementary Files

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- [SupplementaryMaterialTunnelFBvers29092026.docx](#)