Dogs Do Not Change Their Problem Solving Strategies After Receiving Pedagogical Cues

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Abstract

Ostensive cues – signals that indicate an intent to communicate (e.g., pointing) – affect how humans interpret and attend to information. For example, when presented with ostensive cues, young human children are more likely to generalize the information they receive. Humans, however, are not alone in their sensitivity to ostensive cues. Another species – the domesticated dog (*Canis familiaris*) – shows a great degree of similarity to humans in their sensitivity to ostensive cues. To what degree does ostensive cueing affect a dog's problem solving behavior in a learning situation? We attempt to ascertain whether ostensive cueing influences dogs' problem solving in a puzzle task. We find evidence that ostensive cues did not change dogs' puzzle solving abilities. These findings underscore conflicting accounts of instrumental imitation in domesticated dogs and suggest ostensive cueing, at least in some tasks, has little effect on a dog's problem solving.

Keywords: ostensive cues, social learning, canine cognition, problem solving

Dogs Do Not Change Their Problem Solving Strategies After Receiving Pedagogical Cues

From books to fashion trends, humans demonstrate an incredible array of cultural knowledge. Some researchers argue that humans have such an expanse of cultural knowledge because of special cognitive mechanisms that support efficient learning from others. According to “natural pedagogy”, a social communicative learning mechanism, humans have the capacity to easily learn information that does not have an immediate, apparent cause and to generalize learned information in social learning situations (Csibra & Gergely, 2006; Csibra & Gergely, 2009). For instance, when a child is taught how to tie her shoe, she might not understand all of the movements associated with tying the knot, but natural pedagogy argues she is geared to learn the movements despite not completely comprehending them. In addition, it argues that she will be able generalize and might try tying a knot in a variety of other situations, such as with rope or dog leashes. If the child had figured out shoe-tying on her own, she might not apply the knot tying to such a wide array of other situations. Natural pedagogy argues that the child did not have to rely on being taught in different contexts to generalize how to tie knots. Instead, Csibra and Gergely (2009) argue that learning mechanisms cause more efficient encoding in social learning situations.

Based on research with human infants, Csbira and Gergely (2009) proposed three processes underlie natural pedagogy: i) a sensitivity to social cues that tell an infant he is being communicated with, ii) an expectation that the communicator will be referencing information after social cues, and iii) an expectation that this social referential communication refers to a generalizable interpretation of what is communicated. The first process (i) underlying natural pedagogy asserts infants should be sensitive to a particular type of social cue, ostensive cues. Ostensive cues are social cues that indicate an intention to communicate with a subject

(McKinley & Sambrook, 2000; Sperber & Wilson, 1986). Examples of ostensive cues include visual and auditory cues like eye contact, eyebrow raising, directed speech, name calling, gaze alternation, and 'ostensive' pointing (Moore, Liebal, & Tomasello, 2013; Senju & Csibra, 2008; Schmidt, Rakoczy, & Tomasello, 2011). Natural pedagogy argues that humans should be sensitive to ostensive cues in order to infer communicative intent and understand who the intended recipient is. Moreover, Csibra and Gergly (2009) argue that the different expectations that support natural pedagogy (such as the referential and generalizable nature of communication) are activated during ostensive communication.

There is some evidence in favor of the idea that human learners pay special attention to ostensive cues. For example, human infants direct their attention based on ostensive cues (Blass & Camp, 2001; Farroni et al., 2002). Ostensive cues also change what an infant learns from a demonstration. When ostensively cued, infants imitated irrelevant "involuntary" head touches, whereas without ostensive cues they did not, indicating that infants encode different information as relevant when communication is ostensive (Király, Csibra, & Gergely, 2013). When presented with ostensive cues, infants also expect they will be provided with generalizable knowledge. For instance, 10-month-olds, when ostensively cued, devote more memory to the identity of objects, whereas without ostensive cues, they preferentially memorize the location of the objects (which is less-generalizable, see Yoon, Johnson, & Csibra, 2008). Another study found that, in an A not B task, ostensive cueing causes 10-month-old infants to generalize about where an object is hidden. In this task, an experimenter hides an object under one of two accessible places (i.e., Location A) and continues to hide it in that location, allowing the subject to retrieve the object, until the final trial, in which the experimenter hides the object under Location B. In the final trial, seven to ten-month-old infants perseverate and look under place A, rather than choose the correct location of the object (Clearfield, Diedrich, Smith, & Thelen, 2006; Smith, Thelen, Titzner, & McLin, 1999). In this pedagogical task, infants seem to think they are receiving generalizable information on the location of the object (Topál, Gergely, Miklósi, Erdőhegyi, & Csibra, 2008). Thus, ostensive cues play an important role in information transfer in infants: aiding attention, distinguishing what is relevant, and changing how information is interpreted.

Ostensive cues appear to have a powerful effect on pedagogical situations, but it is unclear whether ostensive cues are crucial for natural pedagogy. Is a baseline sensitivity to ostensive cues enough to create natural pedagogy-like learning mechanisms? Csibra and Gergely (2009) suggest ostensive cues a critical element of natural pedagogy, yet ostensive cues may just be associated with pedagogical demonstrations. Ostensive cues may not be necessary for a child to generalize within the context of a pedagogical demonstration (Bonawitz et al., 2011).

The domesticated dog (*Canis familiaris*) shares a variety of social learning traits with humans, such as learning from ostensive cues (Kaminski et al., 2012; Range et al., 2009; Téglás, Gergely, Kupán, Miklósi, & Topál, 2012). Studying dogs may help distinguish between different hypotheses related to the evolution of pedagogy, particularly what evolutionary pressures have led to the similarities dogs share with human learners (Johnston, McAuliffe, & Santos, 2015). Dogs have lived in the same environment as humans for over 10,000 years and have evolved to live and work with humans. During the domestication process, dogs are thought to have developed their sensitivity to ostensive cues (Topál, Gergely, Erdőhegyi, Csibra, & Miklósi, 2009; Virányi et al., 2008). Recent research has found that, among non-human animals, dogs are particularly adept in their use of ostensive cues. For example, in contrast with non-human primates, dogs follow ostensive pointing to retrieve an object requested by the experimenter (Kirchhofer, Zimmermann, Kaminski, & Tomasello, 2012).

In addition to merely attending to ostensive cues, dogs also appear to show preference for and use ostensive cues to understand intention (Kaminski et al., 2012; Tauzin, Csík, Kis, Kovács, & Topál, 2015; Téglás et al., 2012). For example, dogs use information from humans to detour around a fence only when the demonstration is paired with calling of the dog's name and eye contact (Pongrácz, Miklósi, Timár-Geng, & Csányi, 2004). Like human newborns (Farroni, 2002), dogs have an early preference for eye contact. From four weeks onward, dog puppies have a greater preference to eye contact with humans than hand-raised, wolf puppies (Gácsi et al., 2005). Dogs also follow ostensive pointing (Riedel, Schumann, Kaminski, Call, & Tomasello, 2008), and like humans, in some situations do not consider pointing intentional without accompanying eye contact (an ostensive cue; Kaminski et al., 2012).

Dogs are also sensitive to when the cues are presented, following referential signals (like pointing) when they are preceded by ostensive cues. Dogs were found to be significantly more likely to follow pointing when pointing followed ostensive name calling and eye contact compared to when the order was reversed (Tauzin et al., 2015). In this way, dogs use ostensive cues similarly to infants (Csibra, 2010; Senju & Csibra, 2008), suggesting that for domesticated dogs, ostensive cueing can prime the dogs for information uptake or following.

Although there are many similarities between dogs and humans' sensitivity to ostensive cues, there is a notable difference between dogs' and infants' use of social information. In scenarios of informative communication, dogs have been found to view ostensive communication as a command or an imperative, when, for instance, the demonstrator stays in the room (Kupán, Miklósi, Gergely, & Topál, 2011). However, regardless of the fact that ostensive cueing may result in command-following behavior in dogs, the results from the studies of

Pongrácz et al. (2004), Tauzin et al. (2015), and Topál et al. (2009) nevertheless provide consistent evidence that dogs may share a basic, human-like sensitivity to ostensive cueing.

The domesticated dog's unique use of human social information, such as ostensive cueing, led Johnston, Holden, and Santos (2016) to investigate whether dogs shared the human tendency to over-copy in scenarios where a demonstrator presents a solution to problem-solving task with both relevant and irrelevant actions. Despite ignoring the irrelevant action when solving the problem on their own, human children after demonstration copy both the relevant *and* the irrelevant actions (Lyons, Young, & Keil, 2007). This tendency, the faithful copying of a demonstrator's unnecessary actions, is termed *overimitation*. Overimitation may be a product of the same learning mechanisms involved in natural pedagogy (Nielsen & Tomaselli, 2010). For instance, it has been proposed that infant's preferential use of ostensively cued information facilitates the transfer of cultural information (Csibra & Gergely, 2011; Jaswal, Croft, Setia & Cole, 2010), and limits the amount of time children have to learn by trial and error in social learning situations (Shafto, Goodman & Frank, 2012). This preferential use of ostensive cues may cause children to assume all of the presented actions are purposeful (Csibra & Gergely, 2009) and lead children to overimitate (Lyons, Damrosch, Lin, Macris, & Keil, 2011). Overimitaiton is thought to be unique to humans, as no evidence of overimitation has been found outside of humans (Horner & Whiten, 2005).

Johnston et al., (2016) proposed that as domesticated dogs exhibit human-like social learning traits they may be an ideal model to learn about the origin of overimitation. They hypothesized that social learning (like sensitivity to ostensive cues) may cause overimitation. Dogs may overimitate due to their similarities in social learning they share with humans, which developed over the domestication process. To consider the domestication hypothesis, the researchers also examined the Australian wild dog, the dingo (*Canis dingo*). The dingo lies somewhere between dogs and wolves in the domestication process (Smith, 2015). Should dogs show signs of overimitation and not dingoes, then it would be initial evidence that overimitaton is caused by basic social learning traits developed during the domestication process. However, if both dogs and dingoes show signs of overimitation, it would suggest that canines might share this trait with humans for some other reason. Subjects saw a demonstration of a puzzle, in which, after getting the subject's attention, an irrelevant lever was first moved then the relevant lid was opened (the ultimate solution). The experimenter then picked up the food-reward and showed it to the subject. Both dogs and dingoes learned to ignore the irrelevant lever and solved the puzzle efficiently. They did not overimitate.

Although neither dogs nor dingoes overimitated, dogs used the irrelevant lever more often than dingoes. As the use of the irrelevant lever could be a sign of overimitation, an alternative explanation for this difference was examined. As dogs have been shown to be more sensitive to ostensive cues than dingoes when using ostensive cues to locate hidden food (Smith & Litchfield, 2010), it was possible that dogs were more likely to copy the actions of the presenter than the dingoes. As a follow-up experiment, Johnston and colleagues ran the same demonstration, but in order to determine how the demonstration affected dogs' puzzle solution, researchers blocked the dogs' view of the puzzle. As in the original condition, the experimenter ostensively called the dog's name and made eye contact with the dog. If ostensive cues made dogs more likely to copy the experimenter via imitation or another form of social learning, than the dogs would use the irrelevant lever less frequently, as this action was no longer shown. However, if the dogs were not using information from the demonstration to learn how to operate the puzzle, then they would continue to use the irrelevant lever. Johnston and colleagues found that dogs, regardless of seeing the demonstration or not, were equally likely to use the lever. Similarly, they did not find evidence that dogs were using information from a demonstration to change their solution of a puzzle. These results ruled out a species difference, showing that dogs were not using information from the demonstration differently than dingoes (Johnston et al., 2016).

However, given the role that ostensive cues play in other dog studies (Kaminski et al., 2012; Marshall-Pescini et al., 2012; Pongrácz et al., 2004; Range et al., 2009; Tauzin et al., 2015; Topál et al., 2009), there remains the possibility that the presence of ostensive cues in the demonstration of both conditions in fact could account for the increased use of the irrelevant lever in dogs compared to dingoes. In both conditions the presenter ostensively called the dog's name and made eye contact. Given that dogs are more sensitive to ostensive cues in some situations (Smith & Litchfield, 2010), the mere use of ostensive cues may have changed dog's problem-solving approach. For example, ostensive cues might increase dog's interest in the puzzle as previous research has shown ostensive cues to affect a dog's preference (Marshall-Pescini et al., 2012; Prato-Previde, Marshall-Pescini, & Valsecchi, 2008). Similar research has not been conducted in dingoes. When presented with ostensive cues, dogs might have changed how they approached the box (in terms of general interest, motivation, or problem-solving approach), whereas ostensive cues might not have had the same impact on dingoes. This would explain why dogs used the irrelevant lever more frequently the dingoes. Alternatively, if the ostensive cues had no effect on the dog's approach or interest in the puzzle, dogs may just have a greater predisposition to explore more parts of a novel object.

The current experiment was designed to detect whether dogs solve a puzzle differently when presented with ostensive cues. In two conditions where the experimenter's solution was blocked, we compared dogs' behavior when the experimenter solely differed in his use of ostensive cues. In this study, dogs were given the same demonstration as in Johnston et al. (2016), but with ostensive cueing removed.

If ostensive cues increase a dog's interest in the puzzle or motivate the dog, then the dogs may solve the puzzle more quickly or frequently in the ostensive condition. In addition, if ostensive cues increase a dog's general interest or motivation, a dog may be more likely to use the lever when ostensively cued. On the other hand, if dogs do not use any form of pedagogical information on this instrumental learning task, then there may not be a difference between ostensive and non-ostensive conditions in how quickly the puzzle is solved, how frequently it is solved, or how frequently the lever is used.

Method

Subjects

We tested a group of 20 dogs (12 males; $M_{age} = 5.85$; $SD_{Age} = 3.25$; see Table 2). One dog was excluded because the dog flipped over the puzzle box. All dogs were pets whose owners volunteered for participation by entering their dogs' information into an online database. Subjects were required to show no aggressive tendencies, be up to date on all their vaccinations, and be older than 4 months of age. Before participation, all dogs visited the center at least once before testing to become familiar with the center. None of the dogs tested in Experiment 1 or 2 from Johnston et al. (2016) were tested in this experiment.

Apparatus and testing setup

We used the same puzzle box used in Johnston et al. (2016). The box (15.25*cm x* 15.25*cm x* 12.7*cm* height) included a red lid on hinges that can be opened (which extends 1.25*cm* from the side of the box) and a lever that can be moved horizontally (a plastic toy shaped as a stick with a diameter of 5*cm* and extended 15.25*cm* from the side of the box). To solve the puzzle, dogs simply needed to open the red lid. The lever was fully irrelevant and had no effect on the solution of the puzzle. In line with previous research (Horner & Whiten, 2005), the sides of the box were transparent and paper shredding was placed inside the box to cover the treat. We used $1cm^3$ cubes of Natural Balance beef sausage as the food reward for all subjects (see Figure 1).

As in Johnston et al. (2016), the study was conducted in a large room (*3.5m* x *3.15m*), with the box situated in the middle of the room, approximately 1*m* from the dog. Owners were the handlers of the dogs and sat behind them. The dogs were attached to a leash (approximately *2.5m* long), which gave dogs full access to the box, and the leash was fixed underneath the owners. Two cameras recorded the dogs' behavior from two different angles (see Figure 2).

Design and procedure

The method of this experiment was nearly identical to that used in Experiment 2 of Johnston et al. (2016). Overall, the experiment was conducted in two phases. To verify subjects' motivation and comfort with the treats and puzzle apparatus, we first tested dogs on a warm-up phase.

Warm-up trials. During the *warm-up phase* dogs were given four easily accessible treats. The warm-up phase was conducted to insure that dogs were motived by treats and comfortable with the puzzle box. The first was placed on a plate, the second in an empty bucket, the third in a bucket filled with paper shredding, and the fourth in the opened, empty puzzle box (which had been opened outside of the subject's view). If the subject did not retrieve the treat from the open puzzle box, both the handler and the experimenter encouraged the dog to retrieve it. If the subject did not then retrieve the treat, the subject was excluded from the study. No dogs were excluded based on this criterion.

Test trials. After completing the warm-up, the experimenter left the room and returned with paper shredding, which was placed in the puzzle box along with a treat, out of the view of the subject. The experimenter then provided instructions to the handler. Handlers were told to close their eyes during the demonstration, encourage their dogs if they so choose, and not point (see Figure 2). Crouching next to the puzzle box, the experimenter then began the demonstration. First, the occluder, an opaque screen, was positioned so that the subject could not see the puzzle. The occluder was used to control for any effect eye-contact or other social factors that could affect the subject's general motivation when solving the box. To get the subject's attention without use of ostensive cues, the experimenter (PH) clicked his tongue twice, rather than calling the subject's name as in Johnston et al. (2016). The experimenter did not make any eye-contact during the demonstration as this is an ostensive cue; his gaze was purely focused on the puzzle, behind the occluder. These changes were made to directly compare this ostensive cue-removed study with the results of Experiment 2 of Johnston et al. 2016 (which included ostensive cues). After clicking his tongue, the experimenter operated the box, first moving the lever horizontal in two directions and then opening the lid and removing the treat (see Figure 3). Keeping visual access to the treats consistent to Experiments 1 and 2, the experimenter held the treat over the occluder for the dog to see; the experimenter maintained his gaze on the box. Finally, to allow for direct comparison with Experiment 2, we used the transparent box. After the demonstration, the experimenter left the room and watched the dogs on a monitor outside the room, waiting for a minute or until the dog solved the puzzle before returning to the room.

Coding and analyses

We coded *solve outcome*, *solve latency*, and *lever use*. As in Johnston et al., (2016), solve outcome was defined as whether the subject lifted the puzzle's lid high enough to obtain the treat, solve latency was defined as the amount of time it took the subject to solve the puzzle after the moment of release, and lever use was defined as whether the subject moved the lever via direct contact at any point before solving the puzzle. Solve outcome, latency to solve, and lever use were each fully coded by the author (PH) and an additional coder (JS) who was blind to hypothesis. Reliability was high for each of the outcome variables (r = 100% for solve outcome, r = 99.8% for latency to solve, r = 100% for lever use). In all analyses, PH's codes were used. Latency to solve was only included for trials on which the subject solved the puzzle.

Statistical analyses were conducted in the same way as Johnston et al. (2016), using R statistical software (version 3.2.1, R Foundation for Statistical Computing, Vienna, Austria). Both solve outcome and lever use were analyzed using generalized linear mixed models (GLMMs) with a binary response term (for solve outcome: solved = 1 and did not solve = 0; for lever use: used lever = 1 and did not use lever = 0). Solve latency was log transformed and analyzed using linear mixed models (LMMs), as the transformed response variable had a normal error distribution. In these analyses, we included the full data set from Experiment 2 and the full data set from the current experiment. This allowed us to compare demonstration trials (in Experiment 2) and no demonstration with no ostensive cues (from this experiment) in order to determine whether dogs interacted with the puzzle differently when they did not receive any ostensive cues. The between-subjects predictor of interest was experiment (Experiment 2: ostensive cues and no demonstration of the current experiment: neither ostensive cues nor demonstration) and the within-subjects predictor of interest was trial number (trial 1 or 2). Subject identity was included as a random effect to control for repeated measures. All mixed models were run using R package ‘lme4’ (Bates, Maechler & Bolker, 2012).

In mixed model analyses, we first examined a null model, which included only subject identity. We then compared the null models with full models that included all predictor variables and their interactions. Model comparisons were conducted with likelihood ratio tests.

Results

Our full models for irrelevant lever use and solve outcome were no better at predicting lever use or solve outcome than our null models (*p*s > .428). In other words, dogs did not use the lever more often or solve the puzzle more frequently in either the ostensive condition ($M_{lever\ use}$ = 1.50, $M_{solution}$ = 1.05; from Johnston et al., 2016) or the non-ostensive condition ($M_{lever\ use}$ = 1.40, $M_{solution}$ = 0.55). Thus, we found no evidence that the presence of ostensive cues had an effect on how the dogs solved the puzzle. However, our model for solve latency revealed that trial was a significant predictor of dogs’ latency to solve the puzzle (LRT: $\chi^2 = 22.18$, $p < .001$; see Table 2 for all model output), indicating that dogs solved the puzzle more quickly across trials (trial 1: *M* = 27.68s, *SE* = 3.85s; trial 2: *M* = 8.27s, *SE* = 1.74s). No other factors or interactions were significant predictors for latency to solve the puzzle (LRT: *ps* > .262).

Discussion

When subjects saw the full puzzle demonstration with social cues in Johnston and colleagues’ (2016) first experiment, dogs initially used the lever more than dingoes did on the same task. To better understand what factors contributed to dogs’ initial approach of the puzzle, Johnston et al. (2016) ran another experiment that precluded dogs from seeing any manipulation of the puzzle, but kept all other cues consistent with the first experiment. They found the dogs continued to operate the puzzle in the same manner when exploring it on their own, eliminating the possibility that dogs were using the direct puzzle demonstration information differently than the dingoes. However, there remained the possibility that solely the presence of ostensive cues had an effect in causing dogs to use the lever more frequently than dingoes. The present study removed the social cues that were present in the second Johnston et al. experiment. The results of this study show that between two conditions that only differed by ostensive cueing, there was no difference in dogs' pattern of lever use or success rate. Thus the three conditions of demonstration (full demonstration with ostensive cues, occluded demonstration with ostensive cues, and occluded demonstration without ostensive cues), did not change dogs' use of the lever nor their puzzle solution times. Taken together with Johnston et al. (2016), it appears that dogs who observed a human demonstrator did not even use more basic forms of social learning (e.g., stimulus enhancement). In contrast, dogs relied on individual exploration to solve a puzzle task. Despite previous work showing that ostensive cues change how dogs interpret information (Kaminski et al., 2012; Topál et al., 2009), we did not find evidence that dogs were using information from the human demonstration to change how they interacted with a puzzle.

There is one notable limitation to this study and an alternative explanation for these results, however. It is possible that the behavior we coded failed to capture some aspects of behavior that may have differed between conditions. For instance, a dog's motivation to engage with the puzzle may have varied across the different conditions. With an increased motivation, dogs may have spent more time trying to solve the puzzle. We hoped to account for this difference in motivation through coding time until solution – under the hypothesis that more motivated dogs would solve the puzzle more quickly – but if motivation did not result in shorter solution times, motivation would have escaped the latency measure. Latency time to solution of the puzzle is likely to be affected by at least two factors: motivation and the dog's ability to solve the problem. An increase in motivation after ostensive cueing would have been in line with findings like those of Marshall-Pescini and colleagues (2012), where dogs changed their preferences after ostensive cueing. However, if motivation varies between conditions (though not detected in our measures), an additional confound would exist: owner encouragement. In the current study, owners were asked to not point (an ostensive cue), whereas in the other two experiments in Johnston et al. (2016) owners were not explicitly asked to avoid pointing. As we found no difference in measured behavior across trials, no analysis of pointing was warranted to account for this potential confound. Future studies should account for differences in motivation due to owners, but more importantly, develop other metrics to detect subtler differences in motivation; for example, total time spent attempting to solve the puzzle.

Although evidence suggests dogs treat information differently after ostensive cueing (Tauzin et al., 2015; Topál et al., 2009), we did not measure a difference in dogs' problem solving between conditions. However, though we found no evidence of social learning, it's possible that dogs are less prone to use 'higher' forms of social learning in some tasks. For example, in instrumental tasks that lack ecological relevance for dogs, dogs may be less likely to imitate, as imitation learning requires some understanding of the demonstrator's goals and actions (Whiten & Ham, 1992). This could partially explain some mixed findings in canine imitation. Though there is some consensus that dogs imitate human behavior in a *Do as I Do* task involving imitation of body motion (Fugazza & Miklósi, 2014; Fugazza, Pogány & Miklósi, 2016), there is conflicting evidence as to whether dogs imitate in instrumental learning tasks (Kubinyi, Topál, Miklósi, & Csányi, 2003; Mersmann, Tomasello, Call, Kaminski, & Taborsky, 2011; Miller, Rayburn-Reeves, & Zentall, 2009; Pongrácz, Bánhegyi, & Miklósi, 2012). In some instrumental learning tasks used to measure imitation, researchers concluded that less sophisticated forms of social learning explain imitative behavior (Kubibyi et al., 2003;

Mersmann et al., 2011). Another study found that dogs imitated conspecifics, but not humans in a lever instrumental task (Miller et al., 2009). In light of dog's ability to imitate (Fugazza et al., 2016), there may be scenarios in which dogs are less prone to exhibit this form of social learning, perhaps due to ecological reasons. Accordingly, in this study the nature of the task may have lent itself to individual exploration.

Despite the domesticated dog's sensitivity towards ostensive cues and evidence that they treat ostensive presentations differently from non-ostensive presentation (Pongrácz et al., 2004; Tauzin et al., 2015), we found no evidence that the presence of ostensive cues changed dogs' problem-solving behavior. The results suggest that for some tasks, particularly instrumental learning tasks, dogs may not use ostensive cues or any form of social learning. Consequently, ostensive cues may not impact problem solving; instead, dogs rely on individual learning. Despite the findings from the present study, dogs use ostensive cues in a variety of other situations and with striking similarity to humans. Though the current study served as a methodological study pertaining to Johnston et al., (2016), the findings help guide further research that utilizes dogs to examine the importance of sensitivity to ostensive cues in the theory of natural pedagogy in humans. Such future work will help reveal the processes behind social learning mechanisms that, ultimately, seek to explain human cultural knowledge and transmission.

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Table 1
Estimate of Fixed Effects in Generalized Linear and Linear Mixed Models Predicting Subjects' Lever Use, Solve Outcome, and Solve latency.

	Experiment		
	Lever Use	*Solve Outcome*	*Solve Latency*
Intercept	1.08 (0.35)**	-9.70 (1.95)***	4.57 (0.38)***
Trial Number			-1.38 (0.23)***
AIC	97.71	69.03	74.68
BIC	102.5	73.79	80.55
Log Likelihood	-46.86	-32.51	-33.34
Deviance	93.7	65.03	66.68
Number of Observations	80	80	32
Number of Groups: Subject ID	40	40	17
Variance: Subject ID	1.4	702.2	0.10
Variance: Residual			0.41
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{t}p < 0.1$			

Note: Table also shows goodness-of-fit statistics.

Table 2
List of Subjects, Including Owner-reported Breed, Sex, and Age (in years),

Name	Breed	Sex	Age
Maya	Miniature Lab, Sato, Pit Bull	Female	2
Sadie	Black Lab Mix	Female	3
Mr. Henry Jones	Daschund, Jack Russel Terrier	Male	6
Bodey	Goldendoodle	Male	2
Adina	Labrador Retriever	Female	5
Bo	Catahoula Leopard Dog	Female	1
Elinor	West Highland Whiter Terrier, Poodle	Female	5
Darby	Chesapeake Bay Retriever	Female	6
Fin	Chesapeake Bay Retriever	Male	10
Miles	Terrier Mix	Male	8
Chase	Golden Retriever	Male	9
Gus	Border Terrier Mix	Male	3
Nutmeg	Labrador Retriever, Whippet	Female	4
Moe	Basenji/ Chihuahua	Male	11
Denver	Cockapoo	Male	11
Bosco	French Bulldog	Male	4
Ben	Golden Retriever	Male	4
Tucker	Golden Retriever	Male	4
Tutu	Yorkshire Terrier	Male	2
Sarah	Lab, English Setter	Female	10

Figure 1: The puzzle, including a red flip lid and a plastic log lever.

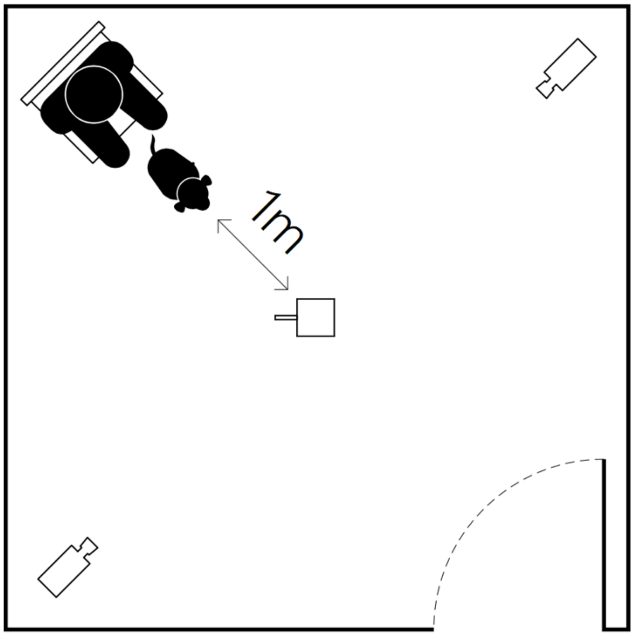

Figure 2: The experiment set-up.

Figure 3: The demonstration of the puzzle. Row 1 shows Johnston et al. (2016)'s experiment 1 procedure with the demonstration and ostensive cues. Row 2 shows Johnston et al. (2016)'s experiment 2 procedure with no demonstration and ostensive cues. Row 3 shows the current experiment's procedure with no demonstration and no ostensive cues.