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A Simple but Powerful Test of Perseverative Search in Dogs and Toddlers

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Abstract

Perseverative (A-not-B) errors during the search of a hidden object were recently described in both dogs and 10 month old infants. It was found that ostensive cues indicating a communicative intent of the person who hides the object played a major role in eliciting perseverative errors in both species. However, the employed experimental setup gave rise to several alternative explanations regarding the source of these errors. Here we present a simplified protocol that eliminates the ambiguities present in the original design. Using five consecutive object hiding events to one of two locations in a fixed order ("AABBA"), we tested adult companion dogs and human children (24 months old).The experimenter performed the hiding actions while giving ostensive cues in each trial and moved the target object to the given location in a straight line. Our results show that in the B trials, both 24 month old children and dogs could not reliably find the hidden object, and their performance in the first B trials was significantly below that of any of the A trials. These results are the first to show that the tendency for perseverative errors in an ostensive-communicative context is a robust phenomenon among 2 year old children and dogs, and not the by-product of a topographically elaborate hiding event.

Keywords: perseveration, A-not-B error, visible displacement, dog, toddler

A Simple but Powerful Test of Perseverative Search in Dogs and Toddlers

The term "perseverative error" is used when a subject, engaged in a string of repetitive tasks involving more than one option, continues to perform the previously successful solution that is erroneous in the actual context. This phenomenon is known as the "A-not-B error" when referring to a two location search task. Here the perseverative error manifests when the subject searches at the previously chosen and rewarded "A" location, while the object has clearly been placed at a second "B" location.

Recently it was found that in a social context (where the object was hidden by a human), 10 month old infants commit more perseverative errors if the hiding event was performed in an ostensive-communicative manner (Topál, Gergely, Miklósi, Erdőhegyi, & Csibra, 2008). However, when the target was hidden by the experimenter without using ostensive signals, infants persevered significantly less. Based on the concept of "natural pedagogy" (Gergely, Egyed, & Király, 2007) the authors concluded that ostensive-communicative signals induce a receptive learning attitude in infants who are generally sensitive to the "teaching aspect" of the actions of adults. As a consequence, infants tend to (mis)interpret the repeated hiding events at location A (that were highlighted in ostensive context) as manifestations of generalizable knowledge (*"This kind of object is to be found in container A"*) and/or demonstrations of a particular desired behaviour (*"Search here!"*).

In their next study Topál, Gergely, et al. (2009) found that if one location is misleadingly indicated by the human's ostensive signals dogs, but not the extensively socialized wolves, were prone to commit A-not-B errors in an ostensive-communicative context. These findings have led to the conclusion that dogs are prone to show special sensitivity to these kinds of communicative signals, which are otherwise often and adaptively used in human-human (Csibra & Gergely, 2009) and human-dog interactions (e.g., Pongrácz, Miklósi, Timár-Geng, & Csányi, 2004).

These findings on the role of ostensive communication in inducing dogs' and infants' (but not wolves') perseverative search error (Topál, Gergely, et al., 2009; Topál et al., 2008) have triggered a vivid debate about how do dogs (as compared to wolves and infants) 'interpret' human ostensive signals. In human communication ostensive cues serve as a means to indicate the signaller's communicative intention and as obvious signal for the recipient that (s)he is the intended addressee of the communication. These signals consist of a set of verbal and non-verbal cues (e.g. verbal addressing, eye contact with the addressee) providing evidence of the communicator's intention to convey information (Csibra, 2010).

Many assume, however that dogs' (and preverbal infants') receptivity to ostensive-communicative signals are not necessarily tied to complex mental processing. Ostensive signals may work in communicative interactions merely due to their ability to grasp attention. Evidence suggests that verbal (and visual – e.g. gaze shifts) cues attract and direct dogs' attention efficiently (e.g. Téglás, Gergely, Kupán, Miklósi, & Topál, 2012) and dogs' sensitivity to human communication is unprecedented among nonhuman animals in the sense of being able to learn efficiently from communication-guided interactions (see Miklósi & Topál, 2013; Topál, Kis, & Oláh, 2014 for reviews). The finding that ostensive signals have the potential to elicit positive affective responses from dogs (as well as from young infants) may be based on that for them human ostensive signals act as reliable signs for anticipating further informative stimuli. Thus, although human communication signals, such as eye contact and verbal addressing are ostensive in terms of their intended function, and help the addressee to pay attention to the communicative exchange, it is not necessary to suppose dogs' ability to infer the mental state of communicative intent.

Before introducing some critical points to the debate about the role human ostensive communication played in dogs' tendency to make search errors in Topál, Gergely, et al. (2009) study, it is useful to briefly summarize the experimental protocol they followed. Each dog and wolf participated in a seven-trial test session, where the target was hidden at first four times to location A, then three times to location B. The subjects were allowed to retrieve the target in each trial. Three experimental groups were formed: social-communicative (SC), social-non-communicative (SNC), and non-social (NS). In the SC and the SNC group a human experimenter carried the target, while in the NS group the target was moved from behind a screen. In the SC group the experimenter used verbal and visual (gaze alternating) ostensive addressing cues, while in the SNC group she did not. One of the main peculiarities of the trials was the asymmetry of the ostension: these cues were given only during the A trials. Marshall-Pescini, Passalacqua, Valsecchi, & Prato-Previde (2010) criticized the original finding of Topál, Gergely, et al. (2009) because of the 'unbalanced' presentation of attention getting signals. In their response, Topál et al. (2010) demonstrated that dogs kept on persevering even after hiding the toy at location B was accompanied by non-verbal acoustic cues (squeezing a rubber toy). We should note however, that ostensive addressing (calling a dogs' name) may be a more powerful attention grabbing cue than the sound of a toy. Although in a more recent study, Kis, Topál, et al. (2012) provided further support for the significant effect of socio-communicative cues in the emergence of A-not-B error in dogs, these studies did not directly test whether ostensive and non-ostensive cues elicited a comparable level of attention. Another asymmetrical feature of the original study of Topál, Gergely, et al. (2009) was caused by the experimenter's route: first she always approached location A with the target in her hand, and then she passed behind location A, and then proceeded to go towards location B. Regarding this asymmetry Fiset (2010) suggested, that moving the target behind location A before it would arrive to location B, could mislead the dogs. In their next paper however, Topál, Miklósi, Sümegi, & Kis (2010) provided evidence that dogs tend to commit the error even if the target has not been moved behind location A on its way to location B.

Many of the aforementioned concerns regarding the original method of (Topál, Gergely, et al., 2009; Topál et al., 2008) could have been avoided by using a traditional version of the Piagetian A-not-B task. Therefore with the intention of taking a "more classic" approach (c.f., Piaget 1954) we devised a two-way visible displacement task. Unlike the method used in the previous studies (Topál, Gergely, et al., 2009; Topál et al., 2008, 2010), our object hiding procedure was characterized by high levels of symmetry (with respect to the cueing procedure). We also avoided the use of training trials prior to the test trials and kept the number of initial A trials to a minimum (2 trials). This was done to reduce the chance of the high number of initial A trials (training or test) being the cause of perseveration (Smith, Thelen, Titzer, & McLin, 1999). For similar reasons we did not set a performance criterion in the A trials, because we did not want to bias our sample by excluding subjects with a lower propensity of choosing location A.

Our question was whether adult dogs (that have reached cognitive maturity) and two year old children (who have not yet reached cognitive maturity), would still commit A-not-B errors in an ostensive-communicative hiding context, if the sole factor to elicit this was the asymmetric order of hiding at the two locations (AABBA). We expected that if two year old children are not affected by ostensive cues in our experiment, then they should perform above chance level in their first B trial, however, if they are influenced then their performance should be close to that predicted by chance. Similarly to our first prediction with children, if the ostensive cues do not affect dogs' choices, then we can expect that dogs will most likely also master the task without showing perseverative search bias. However, if A-not-B errors can be induced by human ostensive communication, then we would not expect a total elimination of perseverative errors in our task. More specifically, if the phenomenon is caused by social facilitation in the dog and a tendency in children to misinterpret the hiding action at location A as a potential teaching demonstration, (Kis, Topál, et al., 2012; Topál, Gergely, et al., 2009; Topál et al., 2008, 2010; Topál, Tóth, Gergely, & Csibra, 2009), then we expect a search bias toward location A in the first B trial (due to the unbalanced ostensive reinforcement history of the two locations). In the second B trial, however, after the reinforcement of A and B locations were balanced, a significant elimination of this search bias can be expected.

Methods

The experiment consisted of two experimental groups. The principal arrangement and test procedure was the same in both groups. Two hiding locations were used (A and B) and the test consisted of five trials. In trials 1 and 2 the target object was placed to location A. In trials 3 and 4 the object was placed to location B. In trial 5 the object was again placed to location A. For half of the subjects location A was on the left, for the other half it was on the right.

Group 1: Dogs (*Canis familiaris*)

Subjects. Dogs ($N = 20$; 9 females and 11 males) and their owners were recruited from clients of various dog training schools and participants of competitions for dogs. Owners were instructed in advance how to behave and what to do during the test, however, they were unaware of the hypothesis of the study. Only dogs older than 1 year were tested (M = 2.8, SD = 1.5), and various breeds were included (1 Airedale Terrier, 4 Border Collies, 2 German Shepherd Dogs, 2 Golden Retrievers, 1 Groenendael, 1 Vizsla, 1 Labrador Retriever, 2 Miniature Poodles, 1 mixed breed, 1 Mudi, 4 Belgian Tervuerens). The dogs had to be motivated to retrieve a ball or rubber toy. This was tested by throwing a toy three times and observing whether the dog retrieved it.

Apparatus. The hiding locations (2 plastic panels, 40cm × 40cm with two bent 10cm extensions on each side) were placed 2m from each other and 15m from the starting position. A plastic flower pot (diameter 16cm) was placed behind each panel. The pots were used to hold the target object during the trials and ensured that the dogs had to look into one of them to find the object. We used a rubber squeezable toy or a tennis ball as the target, depending on the preference of the dog. All tests were performed outdoors at the same Hungarian dog training school. The subjects and their owners were regular attendants of the dog school, and they were familiar with the location of the test – therefore no additional warm-up or familiarization with the testing conditions was necessary in their case.

Procedure. The procedure was the same in both the A and B trials. Owners were given a general explanation about what will happen during the test (“A ball will be hidden behind one of the two locations, and the dog will be given the chance to find it. While the experimenter performs the hiding of the ball, the owner should keep the dog at the starting position and ensure that the dog watches the experimenter’s action. Owner should release the dog only after the experimenter returned to the starting location.”) Each trial started with the owner, the dog and the experimenter (the first author, A.P.) standing at the starting position. The owner was standing behind the dog and restricted the animal’s movements by holding its collar. The experimenter took the target object, showed it to the dog and walked straight towards the actual hiding location without passing behind the other screen. While walking, the experimenter maintained the dogs' attention on himself by frequently turning his head toward the dog, calling the dog's name and waving the target object. After reaching the actual location, the experimenter placed the object behind the plastic panel into the pot, then displayed his empty hands and returned to the starting position. While walking back the experimenter continued talking to the dog and displaying his empty hands. After the experimenter returned to the starting position, the dog was released and encouraged to search for the target object, however, neither the owner, nor the experimenter gave any hints about the location of the target.

The average (± *SD*) time interval between the disappearance of the object and the start of the search was 9.7 ± 1.9s. The dog was allowed to search for the object until it was found. After finding the object the dog was praised by the owner and the experimenter, and recalled to the starting position. Finally the owner took the object from the dog, handed it to the experimenter and the next trial began.

Group 2: Two year old Children

Subjects. Two year old (± 14 days) children (N =20; 10 boys and 10 girls) and their parents were recruited from a database at the Institute of Cognitive Neuroscience and Psychology, Hungarian Academy of Sciences (ICNS HAS). The parents of all participants gave informed consent, however they were unaware of the hypothesis of the study.

Apparatus. The equipment and its arrangement during the test trials was similar to that used by Topál et al. (2008). Two identical brown plastic pots served as containers and were placed upside down on a rectangular table 40cm apart. We used one of 4 small toys (a toy train, a plastic cube containing a crocodile and rattling balls, a toy plane and a plush mouse) as target objects based on the child's preference. Experiments were conducted in a test room (5m x 4m) of the ICNS HAS.

Procedure. The experimental procedure included a warm-up and a test phase. During the experiment only the child, the parent and the experimenter (the second author, A.G.) were present in the room.

Warm up. Before the test trials, the parent put the child on a blanket on the floor, and the experimenter attracted the child's attention to the objects placed there (the 2 plastic pots and the 4 small toys). The child was allowed to explore the objects freely for one minute. Then the experimenter initiated playing with the objects (approx. 1-2 min). This procedure was designed to give a chance to the child to become familiar with the environment, the objects and the experimenter, and to select one of the toys, which could be used as the target in the test trials.

Test trials. The child sat on the parent's lap on one side of the table, equidistant (70cm) from the two containers. Before each trial, the parent was instructed to close his/her eyes during the entire object hiding sequence.

The experimenter, sitting opposite to the child, placed the target object to the starting position, between container A and B (20cm from each). The experimenter attracted the child's attention verbally ("[Name]! + Look!") and by making a conspicuous noise with the target object (tapping the toy on the table). Then the experimenter started to move the object slowly towards the actual container while talking to the child ("Look at the nice toy, now it moves here."), lifted the container and then lowered it onto the toy. At this point the experimenter established eye contact with the child and addressed him/her ("Look!") while looking back and forth twice between the container and the child. During this procedure the experimenter ensured that the child was following the movement of the object and repeated any step that the child was not attending.

After lowering the container, the experimenter waited for 4s before pushing the containers simultaneously towards the child by means of an 80cm long stick. When the containers arrived within the child's reach, the experimenter withdrew the stick and lowered it below the table. At this point the parent was allowed to open his/her eyes but was not allowed to interact with the child.

The average (± *SD*) time interval between the hiding (disappearance of the toy) and the start of the search was 8.72 ± 1.13s. The child was allowed to search for the object until finding it. Finding the toy was defined as the child lifting the pot that covered the toy. In some cases the children did not lift the pots, but only touched them and then withdrew their hands. If after touching the pot the child still did not lift the pot after several seconds, the experimenter lifted the pot and displayed its contents to him/her. After finding the toy the child was allowed to play with it for a short time. During this time, the experimenter moved the containers to their original position. Finally the experimenter took the object from the child, placed the toy to the starting position and the next trial began.

Data Collection and Analysis

All experiments were video recorded and analysed later. For the analyses, we coded subjects' first choices between the two locations. First choices have been defined in the two groups accordingly to the specific behavioural characteristics (speed of movement, tendency for hesitation, variability of the reaction) of the subjects. In group 1 (dogs) the first inspected location was regarded as the subject's choice and a choice was scored as correct if the dog lowered its head behind the baited plastic panel and looked into the pot behind it. In group 2 (two year old children) three different aspects of the participants' choice behaviour were recorded: looking at, touching and lifting either of the containers. A trial was regarded as correct if the subject (1) looked at, and/or (2) touched and/or (3) lifted the baited pot. These behaviours represent different levels of executive functioning and did not coincide in all trials, therefore we analysed these behaviours separately. In all groups a trial was terminated when the subject selected and inspected the baited location.

Subjects' first choices were analysed with the help of IBM® SPSS® Statistics 20. We used nonparametric tests because our data were not normally distributed. When comparing the number of correct choices to that expected by chance we used binomial tests. To account for the increased chance of type I errors due to multiple comparisons, we adjusted the p values in each test battery using the method by Hochberg (1988) as was described by Wright (1992). The adjusted *p* values are marked as p_{Hoch}. When comparing the number of correct choices between trials in group 1 we used the related-samples Cohran's Q test. When comparing the number of correct choices between trials and between choice behaviour types (look, touch, lift) in group 2 we used a generalized linear mixed model. The model used a binary logistic link, correct/incorrect choices as the target variable, number of trial, type of choice behaviour and their interaction as fixed effects. We allowed the degree of freedom to vary between tests due to the relatively moderate sample size. Also to compensate for potential deviations from the models assumptions we used robust covariance estimates (White, 1980).

Results

Group 1: Dogs

Using binomial tests we compared the number of correct and incorrect choices to the ratio expected by chance in each trial (Figure 1). The results showed that dogs chose the correct location above chance in every A trial (A1: $p_{Hoch} < .001$; A2 $p_{Hoch} < .001$; A3 $p_{Hoch} < .01$). In contrast, they chose the correct location significantly below chance in trial B1 ($p_{Hoch} < .05$) whereas in trial B2 the ratio of correct choices did not differ from chance performance ($p_{Hoch} = .503$). When comparing the number of correct choices between trials with a related-samples Cohran's Q test we found a significant overall difference ($N = 20$, $Q(4) = 42.61$, $p < .001$). The post-hoc pairwise comparison showed that in the first B trial dogs made significantly fewer correct choices than in either of the A trials (Figure 1).

Group 2: Two year old Children

In the case of two year old children, we analysed three behaviours indicating choice: looking at, touching and raising one of the two pots. With binomial tests we compared the number of correct and incorrect choices to the ratio expected by chance in each trial for the three choice behaviours (Figure 2). On the basis of their first look children selected the baited location in all A trials as well as in the second B trial significantly more often than expected by chance (A1: $p_{Hoch} < .01$; A2 $p_{Hoch} < .001$; B1 $p_{Hoch} = .26$; B2 $p_{Hoch} < .01$; A3 $p_{Hoch} < .05$). In contrast, the analysis of their more explicit responses (first touch: A1: $p_{Hoch} < .01$; A2 $p_{Hoch} < .001$; B1 $p_{Hoch} = .50$; B2 $p_{Hoch} = .08$; A3 $p_{Hoch} < .01$; lifting the pot: A1: $p_{Hoch} < .001$; A2 $p_{Hoch} < .001$; B1 $p_{Hoch} = .50$; B2 $p_{Hoch} = .08$; A3 $p_{Hoch} < .01$), suggest a somewhat different picture of their performance:

subjects did not show a preferential bias towards the baited location in either of the B trials (Figure 2).

We also tested whether the number of correct choices differed between trials, and whether the different choice behaviours yielded different numbers of correct choices. The generalized linear mixed model indicated a significant effect of choice behaviour type ($F(2, 33) = 4.46$, $p < .05$) and number of trial ($F(4, 21) = 6.15$, $p < .01$) but no significant interaction between choice behaviour type and number of trial ($F(7, 285) = 1.87$, $p = .074$). Calculating the pairwise contrasts for the estimated means of the choice behaviour types yielded no significant differences (look vs. touch: $t(20) = 0.54$, $p = .122$; look vs. lift: $t(28) = 1.96$, $p = .059$; touch vs. lift: $t(25) = 1.56$, $p = .133$). However, by calculating the pairwise contrasts for the estimated means of the trial numbers we found significant differences between the first B trial and all other trials, and between the second B trial and the second A trial (Figure 2).

We also analysed whether children showed an ambivalent choice behaviour. For this we calculated the number of trials in which children looked at the incorrect location but subsequently touched or lifted the pot at the correct location (Figure 3). Next we compared the sum of ambivalent choices in the five trials to each other with a related-samples Cochran's Q test. We found no significant difference when ambivalent choice was defined as looking at the incorrect location and touching the correct one ($N = 20$, $Q(4) = 2.29$, $p = .683$), however, in the case when we examined the number of events when children looked at the incorrect location but lifted the pot at the correct one, we found a significant difference between the trials ($N = 20$, $Q(4) = 10.40$, $p < .05$). Post-hoc tests revealed that children showed significantly more ambivalent choice behaviour in the B1 trial than in the A2 trial.

Discussion

In this study we investigated whether dogs and children commit perseverative errors if they are tested in similar, single visible displacement tasks with an identical hiding sequence to one of two locations (AABBA) and identical ostensive cues from the experimenter during each trial. We found that two year old children and adult companion dogs show a similar error pattern: their overall performance in response to hiding the object at location A was markedly above chance, unlike the first and second B trials. Both the dog's and the children's performance dropped significantly in the first B trial and did not differ from the chance level in the second B trial.

Perseveration-like behaviour in two year old children

One of the most striking results of our study was that the two year old children did not choose the correct location above the chance level in the B trials of this simple visible displacement task and that their performance in the first B trial was significantly lower than the success rate of all the other trials. Children of this age are considered to have a fully developed object permanence ability (Piaget, 1954), therefore their inability to reliably locate the object cannot be due to a deficit of this capacity. So far it has been suggested that A-not-B errors are typical in infants younger than one year of age (e.g., Sophian & Wellman, 1983), while 12 month old children require 10s or longer delays between the hiding event and the beginning of the search to commit A-not-B errors (Diamond, 1985). Sixteen month olds have been found to choose the correct location in their first B trial with a rate around 80% in a non-ostensive context

(Sophian & Sage, 1985; Sophian & Wellman, 1983). Since it has been demonstrated that children's perseverative errors decrease with age in A-not-B tasks (Espy, Kaufmann, McDiarmid, & Glisky, 1999; Marcovitch & Zelazo, 1999) it is reasonable to expect that 24 month old children should have an even higher correct choice rate in a simple non-ostensive setup.

Compared to the experiment of Topál et al. (2008), our design lacked "sham baiting" to location A in B trials, ostensive cues were not limited to A trials, and **fewer** initial A trials were performed. The older age of the children in addition to all of these other factors should have contributed to further increase the children's performance in B trials. The finding that only 40% of two year old children selected (touched) the correct location in the first B trial in a communicative setup supports the hypothesis that the ostensive context was the factor affecting their choices. The children's random choices in the B trials might reflect a conflict between their more developed representational skills and the teaching aspect of the situation brought about by the ostensive cues.

By analysing the ambiguous choices of children we found that significantly more subjects looked at the incorrect location before raising the pot at the correct location in the B1 trial than in the previous A2 trial. This finding is in contrast with previous results where children showed better performance in a violation of expectancy paradigm (with looking time as response variable) than in an A-not-B task where they chose by reaching (Ahmed & Ruffman, 1998). However, looking in our case could be an indicator of a tendency to choose location A that was established in previous A trials but was successfully inhibited in favour of choosing location B.

Dogs do persevere even in a 'skeletonized' A-not-B task

Dogs, in contrast, displayed a perseverative search bias to location A in the B1 trials. With the presently used experimental design the earlier mentioned alternative hypotheses for dogs' A-not-B errors can easily be ruled out. First, there was no asymmetry between the usage of ostensive cues at locations A and B (as Marshall-Pescini et al. (2010) suggested earlier), because in our case the experimenter kept on maintaining the dogs' attention with identical verbal cueing while hiding the ball at both locations. Second, the alternative hypothesis mentioned by Fiset (2010), namely that the difference between the performances at A and B locations was the result of the asymmetrical route the experimenter followed, is unlikely here because the experimenter approached both locations directly, without moving behind location A while heading to location B. Therefore, perseverative errors in the B1 trials were most likely caused by location A being repeatedly enhanced by the experimenter's ostensive communication. In the B2 trial however, dogs selected randomly – possibly because by then, both A and B locations were already enhanced equally.

It was shown earlier that dogs rely heavily on verbal ostensive cues during detour tasks involving social learning from a human demonstrator (Pongrácz et al., 2004). As dogs learned from the experimenter only when she provided ostensive cues during the demonstration, it was concluded that ostensive signalling may help dogs to pay attention to those contexts in which humans aim to teach or direct dogs' attention to something. Our experiment on perseverative errors, caused by the combination of hiding order asymmetry and ostensive cues, provides a new insight into how quickly episodic instructions can influence the choice preference of dogs. Even without stating that dogs are influenced by the intentional and referential nature of communicative signals the same way as young children are, we still find a striking analogy between the phenotypically similar behavioural responses of children and dogs elicited by human ostension. The strong sensitivity of dogs to human ostensive signals has already been highlighted in several studies. In fact, many argue that socially provided information is particularly effective in influencing the behaviour of dogs; they prefer to select an empty container despite having seen the correct one being baited (Erdőhegyi, Topál, Virányi, & Miklósi, 2007) and adopt inefficient responses as a result of repeated observations of human action demonstrations (Kupán, Miklósi, Gergely, & Topál, 2011). Moreover Prato-Previde, Marshall-Pescini, & Valsecchi (2008) found that after having seen a human's ostensively cued preference for a smaller amount of food, dogs change their baseline preference for the larger quantity and show a selection bias towards the smaller one.

Possible explanations for perseveration in children and dogs

The results of the present study suggest that the communicative version of a standard A-not-B task can be perceived by both dogs and human children as an ambiguous situation which can be perceived not only as indicating actual information in the here-and-now about the location of the toy, but also as communicating information about some generalizable property of the situation. That is, subjects' search behaviour may not only be guided by the actual location of the target object, but may also be influenced by their tendency to obey rules of a social game (ostensive communication during repeated A trials can act as highly effective social cues with the function of performing search behaviour at location A). Based on these results, in agreement with earlier studies (Kis, Topál, et al., 2012; Topál, Gergely, et al., 2009; Topál et al., 2008, 2010; Topál, Tóth, et al., 2009), we propose that ostensive communication plays a significant role in the emergence of A-not-B error in both dogs and children. Whether or not this effect is mediated by the same or homologous cognitive processes in children and dogs remains unclear. A parsimonious explanation could be that while a two year old child's reaction may be caused by the ostensive-communicative 'pedagogical' aspect of human's action in a new task, dogs may react with a response to "episodic instruction" from the human.

As an alternative explanation we can also presume that ostensive cues act as distractors for the dogs and young children, who probably rely on these more likely than adults or the wolves that have a more mature decision making system related to simple spatial tests like two-choice task. Every companion dog experiences massive amount of human signalling (intended and not-intended) during its development and everyday life in the human environment, and they learn the importance and/or relevance of these signals as cues to reward and adaptive behaviour (Wynne, Udell, & Lord, 2008). Therefore one may assume that dogs' susceptibility to human ostensive communication is merely a by-product of their (learned) preferential attention to signals which may carry important informative value. If so, eye contact and ostensive addressing may have a strong attention capturing effect and, in our A-not-B error task, may have a strong distracting effect (i.e. it distracts the subjects' attention from the location of the target object).When these strong cues are removed dogs can focus on the actual problem and solve the problem at that level, which is more successful. This could also be occurring in the children. Infants will eventually develop a more effective spatio-cognitive system, while dogs will not, instead they will keep on relying on human-given cues.

Ostensive communication, however, is not the only factor that can induce A-not-B errors. It has been shown that delay between hiding and start of search, and age, and number of A trials can increase the chance that children commit A-not-B errors (Marcovitch & Zelazo, 1999; Wellman, Cross, & Bartsch, 1987). Moreover, perseveration can arise in the absence of ostension given the right combination of these other factors (e.g., Diamond, Cruttenden, & Neiderman, 1994; Kis, Gácsi, Range, & Virányi, 2012). What our experiment together with the results of Topál et al. (2008) demonstrate is that children of a relatively old age, with short delay and a minimal number of A trials, commit perseverative errors if an ostensive context is used. The notion that ostensive communication can serve as an important factor in eliciting perseverative errors is not in direct opposition to other existing theories explaining perseverative errors (e.g., based on memory or inhibition: Marcovitch & Zelazo, 2009; Munakata, 1998).

Future research directions

It is still an open question how the effect of ostensive-communicative context and natural pedagogy interacts with other mechanisms that have been shown to induce perseveration (Vorms, 2012). For example a generalized social rule formed by the ostensive context could be more difficult to inhibit than a motor pattern formed by previous interaction with the hiding location. Alternatively ostension might highlight the action performed by the demonstrator, which would lead to more persistent memory traces /representations; this phenomenon is regarded as the basis of natural pedagogy in children and could be the basis of a phenotypically infant-analogue communicative receptivity in dogs. It should be the topic of future studies to investigate the interaction of the effects of ostensive-communicative context and that of memory or inhibition, e.g., by determining whether ostension affects children by enhancing the memory of the location, the search action or the retrieval.

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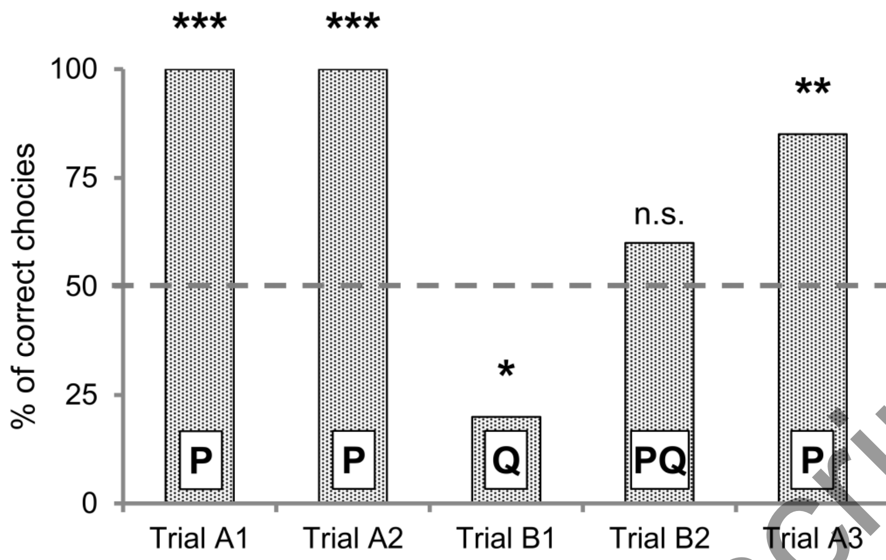
Figure captions

Figure 1. Ratio of correctly choosing individuals (looking into the pot) in group 1 (companion dogs). Binomial tests comparing the number of correct choices to the ratio predicted by chance (n.s.: $p_{Hoch} \geq .05$, *: $p_{Hoch} < .05$, **: $p_{Hoch} < .01$, ***: $p_{Hoch} < .001$; dashed horizontal line marks the ratio of correct choices expected by chance (50%)). Related-samples Cohran's Q test comparing the number of correct choices between trials (capital letters P and Q mark the trials that differ from each other significantly according to the post-hoc pairwise comparison, trials with the same letter do not differ significantly).

Figure 2. Ratio of correctly choosing individuals in group 2 (two years old children). Correct choices are coded either as looking at, touching or raising the pot covering the target object. Binomial tests comparing the number of correct choices to the ratio predicted by chance (n.s.: $p_{Hoch} \geq .05$, *: $p_{Hoch} < .05$, **: $p_{Hoch} < .01$, ***: $p_{Hoch} < .001$; dashed horizontal line marks the ratio of correct choices expected by chance (50%)). Generalized linear mixed model comparing the number of correct choices between trials (capital letters P, Q and R mark the trials that differ from each other significantly according to the pairwise contrasts of the estimated means, trials with the same letter do not differ significantly).

Figure 3. Ratio of ambivalent choices in group 2 (two years old children). Ambivalent choices are defined as looking at the incorrect location first and then either touching (Look vs. Touch) or raising (Look vs. Lift) the pot at the correct location. Related-samples Cohran's Q test comparing the number of ambivalent choices between trials for the two cases (solid lines mark the result of the two tests: n.s.: $p \geq .05$, *: $p < .05$; horizontal bracket marks the result of the post hoc tests: *: $p < .05$).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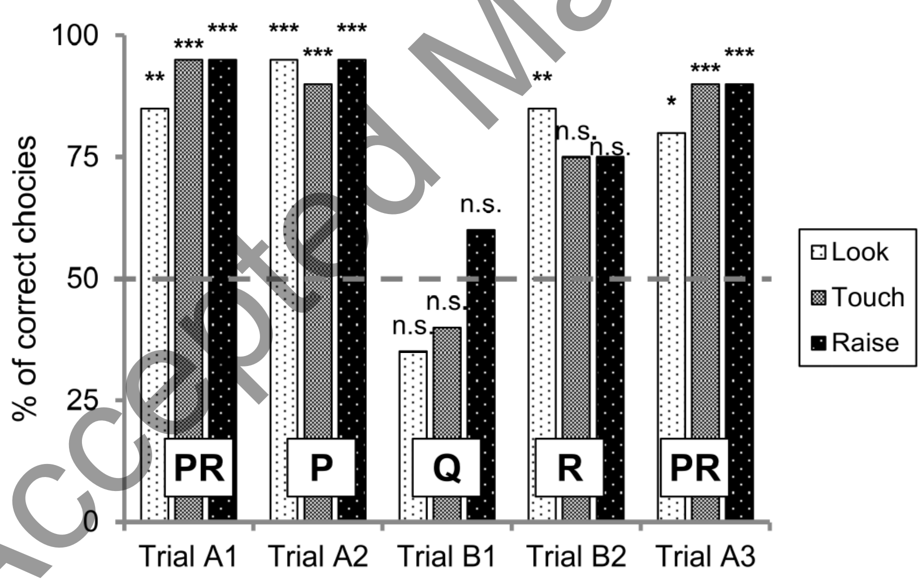
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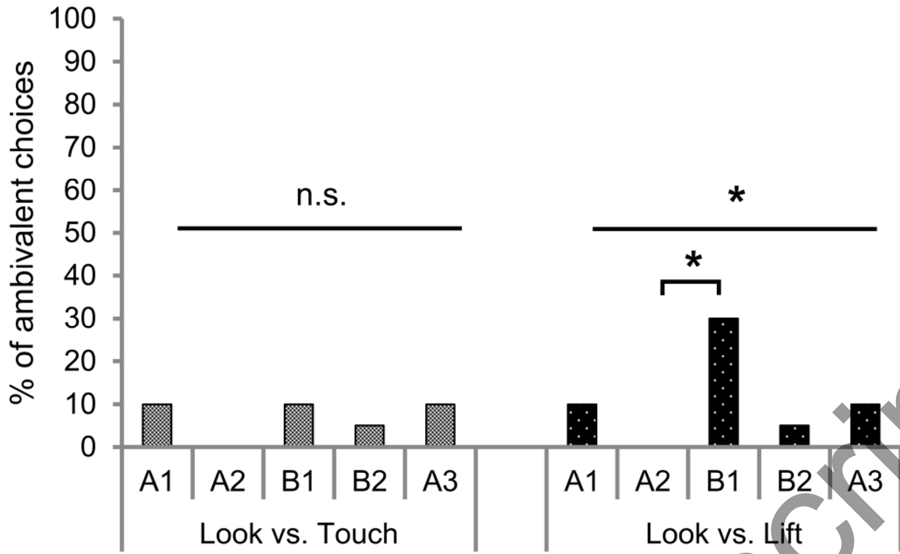

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