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I saw where you have been—The topography of human demonstration affects dogs' search patterns and perseverative errors

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ABSTRACT

Performance in object search tasks is not only influenced by the subjects' object permanence ability. For example, ostensive cues of the human manipulating the target markedly affect dogs' choices. However, the interference between the target's location and the spatial cues of the human hiding the object is still unknown.

In a five-location visible displacement task, the experimental groups differed in the hiding route of the experimenter. In the 'direct' condition he moved straight towards the actual location, hid the object and returned to the dog. In the 'indirect' conditions, he additionally walked behind each screen before returning. The two 'indirect' conditions differed from each other in that the human either visited the previously baited locations before (proactive interference) or after (retroactive interference) hiding the object.

In the 'indirect' groups, dogs' performance was significantly lower than in the 'direct' group, demonstrating that for dogs, in an ostensive context, spatial cues of the hider are as important as the observed location of the target. Based on their incorrect choices, dogs were most attracted to the previously baited locations that the human visited after hiding the object in the actual trial. This underlines the importance of retroactive interference in multiple choice tasks.

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1. Introduction

Dogs' (*Canis familiaris*) object permanence ability has been the subject of extensive investigation over the past few decades. Numerous studies have shown that dogs are capable of solving tasks involving simple visible displacement (Triana and Pasnak, 1981; Gagnon and Doré, 1992, 1994). Dogs can reliably find a hidden object if a delay of 20 s (Gagnon and Doré, 1993) or even 4 min (Fiset et al., 2003) is introduced between the hiding event and the start of the search. There is some evidence suggesting that dogs are capable of simple invisible displacement (Gagnon and Doré, 1992). However more recent findings indicate that dogs' search behavior in an invisible displacement task is guided by the final position of the displacement device (Collier-Baker et al., 2004) or by the position of the experimenter (Fiset and LeBlanc, 2007).

Studies regarding how dogs encode the position of hidden objects show that they can use several sources of spatial information. In a series of experiments, Fiset et al. (2000, 2007) found that dogs primarily rely on egocentric information to encode the position of a hidden object; however if the egocentric information was made irrelevant, dogs were able to use allocentric information and dead reckoning as well to orient themselves (Fiset et al., 2007).

Geometric relationship of landmarks is not the only source of information that can guide an animal's choice when searching for hidden objects. Findings suggest that in object search tasks the position or the route taken by the experimenter (who hides the object) can also influence dogs' choices. In an invisible displacement task, where dogs had no information about the exact location of the target object, dogs tended to start searching at the location which was last passed by the experimenter whilst hiding the object (Watson et al., 2001). In an experiment of Fiset and LeBlanc (2007) the target object was not visible during the hiding, but was inside a container and this container was moved by a human experimenter. In one of the experimental conditions during the whole test the experimenter was standing behind the hiding locations (closer to the two middle locations). In this situation dogs searched for the object more often at the locations close to the experimenter who hid the

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target object than at locations further away. Thus it seems that if dogs have insufficient information about the location of the target object they rely on local enhancement to solve the tasks.

These findings reveal a potentially important factor for the dogs' search performance: the information gained from social partners that until recently has been largely ignored in object search tasks. Human communicative signals can also guide the dogs' attention and influence their inferences and interpretations in object search tasks. For example, in a two-way choice task when dogs had no direct information about the location of the target they selected the location indicated by the human's ostensive-communicative referential cues (Erdőhegyi et al., 2007). In another two choice object search task Topál et al. (2009) found that dogs commit perseverative search errors when (and only when) the hiding events are presented in an ostensive communicative context.

Numerous studies suggest that dogs could be subject to proactive and retroactive interference. Positive evidence that proactive interference could have an effect on dogs' performance to our knowledge has been found in one study only (Tapp et al., 2003). In this experiment dogs had to solve a spatial list learning task. On the other hand Fiset et al. (2003) found no evidence for proactive interference in a delayed visible displacement task. On the other hand it was shown that in a radial maze dogs performance in a spatial memory task decreases due to the retroactive interference caused by the arms of the maze that have been already visited by the dog (Macpherson and Roberts, 2010). Gagnon and Doré (1993) found that dogs' errors in an invisible displacement task can be partially attributed to retroactive interference caused by the post disappearance movement of the container. At the same study the researchers also found that dogs also seem to be subject to retroactive interference in a visible displacement task.

These findings and the earlier presented studies raise the possibility that dogs' search performance in object hide-and-search tasks is fundamentally affected by both the ostensive communicative nature of the hiding event (by inducing perseverative errors) and the interference between the events perceived before or after witnessing the object disappear. Therefore we asked the question whether in a visible displacement task in a uniformly ostensive communicative context dogs' location choices would be affected by the hider's movement prior or after the disappearance of the object.

The object hide-and-search task in our study was designed so that dogs, after witnessing the placing of an object to one of five locations could search for the toy until they found it. A test consisted of five trials and the object was placed to all five locations once in a consecutive order. In the direct conditions the hider moved on a direct route (in a straight line towards the actual location) and dogs were either released right after the hiding (Direct group) or after 1 min distraction (Delayed Direct group). In the indirect conditions however, the hider walked behind each hiding location moving along an arc and the toy was placed behind one of the hiding locations. The hider's route was designed so that he either walked behind the previously baited locations before (Indirect group) or after (Reverse Indirect group) hiding the object. With this design we intended to discriminate the effects of the proactive interference caused by the hider's movement before hiding the object and the retroactive interference caused by the hider's movement after hiding the object. The hiding of the object was always performed in an ostensive communicative context. In the frame of this study by communicative context we mean that the hider expresses communicative intent by looking toward the dog while showing the ball (or his empty hands) and addressing the dog in a relatively high pitched voice, with the aim of attracting the dog's attention to himself and the task.

In our experiment the cues given by the hider can be categorized into two types. (1) The ostensive communicative cues that are intentional, uniformly present in all conditions throughout the entire hiding event and serve to direct dogs' attention to the hider and the task. (2) Spatial cues which refer to the position or the movement of the hider during the hiding event. These cues can be regarded as non-intentional and differ between the experimental conditions (except between the Direct and the Delayed Direct conditions where they are identical). The spatial cues of the hider could affect dogs in several ways. Based on the effect of these we can form four hypotheses and make the following predictions:

a If dogs rely exclusively on direct visual information about the location of the object in each condition, and ignore any other spatial cues of the hider (object location dominance hypothesis). In this case (hypothesis 1) we expect no difference in dogs choices between the Direct and the two indirect groups. Based on the experiments of Fiset et al. (2003), we expect a lower performance in the Delayed Direct group due to the one minute of delay introduced. However, according to hypothesis 1, no differences are expected among the trials in all groups(Table A1).
b If spatial cues act as a general distraction, then dogs in the two indirect conditions will encode the position of the correct location less accurately and this would result in a decrease of performance. Since the total amount of potentially distracting spatial cues are the same in the Indirect and Reverse Indirect groups we would expect no difference in performance, location choices or the distribution of erroneous choices between the two groups. In case of hypothesis 2 it is an open question, whether spatial distraction in the two indirect groups, or the higher requirement of working memory in the Delayed Direct group would cause lower performance. However, according to this hypothesis again, we do not expect any difference among the trials in all groups (Table A2).
c It is possible, however, that spatial cues act as attractors. Namely that in the indirect groups the hider by walking behind the locations does not simply distract dogs attention from the location where the object is hidden, but directs it towards the locations behind which he was walking.

One of the possible scenarios for the spatial cues (hypothesis 3A) is when the hider walks behind the locations before hiding the object, thus possibly causing proactive interference, or walking behind the locations after performing the hiding and causing retroactive interference.

The amount and localization of "proactive spatial cues" and the "retroactive spatial cues" differ in each of the corresponding trials between the two indirect groups (See Fig. 2; e.g., 2nd trial: Indirect group: the hider walks behind location 1 (proactive) and behind locations 3–5 (retroactive); Reverse Indirect group: the hider walks behind locations 5–3 (proactive) and behind location 1 (retroactive)). Because of this if there is a difference in the influence of the proactive and retroactive spatial cue types on dogs then that would cause a difference in overall location choices, correct choice distribution and the amount of perseverative and non-perseverative errors between the groups (Table A3).

According to a second option (hypothesis 3B—'the last spatial cue as attractor'), in line with the findings of earlier papers (Pongrácz et al., 2001; Watson et al., 2001) we could expect that dogs will show a preference for the location that the hider passed by last on his route and thus they will choose more often the location from where the hider returned to the starting position. This bias would lead to dogs having a lower ratio of correct choices in the two indirect groups, and a higher ratio of choosing the 1st or the 5th locations than expected by chance (Table A4).

Because the local enhancement caused by the hider's movement could interfere with the information about the location where the object disappeared, we could expect dogs to shift their choices towards the locations based on the interaction between their pre-

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