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Pointing gestures modulate domestic dogs' search behavior for hidden objects in a spatial rotation problem

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ABSTRACT

In the spatial domain, domestic dogs are highly inclined to search at the last location where they saw an object disappear and cannot infer that a hidden object has moved imperceptibly from one location to another. In the current study, we examined whether exposure to human social cues modulates dogs' search behavior for hidden objects. In Experiment 1, twenty dogs were first trained to find an object they saw disappear inside a stationary container in the presence (social group) or absence (non-social group) of pointing gestures. In tests, the containers were rotated 180° around a central axis. The dogs in the non-social group systematically searched at the initial (now incorrect) hiding location, whereas the dogs in the social group chose correctly significantly above chance. In Experiment 2, we tested whether pre-exposure to human pointing has an impact on dogs' use of gestures. No gestures were given during training and both the social and non-social conditions were administered to each of the ten dogs. In contrast to Experiment 1, the performance of dogs in the social condition dropped significantly and varied substantially from one dog to another. Overall, this study suggests that dogs' tendency to use human signals is so strong that it even outweighs their spatial bias to search where they saw an object disappear; however, this penchant to use human gestures appears to be dependent on the degree of familiarity of the dog with these signals.

In the last decades, comparative researchers have extensively investigated spatial cognition in animals, that is, how they encode, organize, utilize and revise their knowledge about the spatial environment and the location of objects (Freska, 2004). In domestic dogs, however, the study of spatial cognition is still young (for a review see Macpherson & Roberts, 2010) and additional work is needed to understand how dogs perceive and encode their surrounding environment and what they know about the physical laws that govern the displacement of objects inside that environment.

The ability to track and locate moving objects that have momentarily disappeared from sight is one spatial problem in dogs that has been the subject of many investigations over the past 20 years (e.g. Fiset, Gagnon, & Beaulieu, 2000; Fiset, Landry, & Ouellette, 2006; Fiset, Beaulieu, LeBlanc, & Dube, 2007). This interest in investigating spatial memory of hidden objects in domestic dogs is partially attributable to Piaget, who provided a theoretical and methodological framework that allows the study of spatial cognition from a comparative perspective. Indeed, the search tasks developed by Piaget (1954) in children can easily be adapted to all species that interact with moving objects to survive. For example, since dogs regularly

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need to represent the location of a prey or social partner that has momentarily disappeared from sight behind a rock or a tree, the study of search behavior for disappearing objects is very well adapted to the natural behavior of dogs.

According to Piaget (1954), object permanence gradually develops during ontogeny through the interaction between an organism and its surrounding physical world. Most specifically, the search for hidden objects develops across six distinct stages. In the first stages, successful retrieval of hidden objects depends on perceptual cues or previous motor responses. The understanding of object permanence truly begins in Stage 5 where the organism can solve visible displacement problems. In these problems, an object is visibly moved and hidden behind one or several hiding locations (e.g. screens and boxes). In Stage 6, the organism is able to solve invisible displacement problems where an object is deposited inside an opaque transport container (e.g. hand, cup) which is then moved to a new spatial hiding location. Thereafter, the object is imperceptibly transferred from the container to the hiding location and the empty transport container is shown to the subject. Although the first studies conducted by Gagnon and Doré (1992, 1993, 1994) suggested that domestic dogs understood invisible displacement problems, the general consensus now is that the dog does not reach a complete understanding of object permanence. Recent studies demonstrated that dogs can easily succeed at Stage 5 visible displacement problems but systematically fail invisible displacement problems at Stage 6 (Collier-Baker, Davis, & Suddendorf, 2004; Fiset & Leblanc, 2007; Fiset & Plourde, 2012; Watson et al., 2001). Collier-Baker et al. (2004) and Fiset and Leblanc (2007) also found that in a Piagetian invisible problem, dogs primarily search for the disappearing object either inside the transport container or at the first adjacent box to the transport container, that is, where they have seen the object last.

The understanding of invisible displacement problems, however, is not limited to the Piagetian invisible displacement task. New paradigms have been developed in the last decade (Barth & Call, 2006). The spatial rotation problem, initially tested on human infants (Bremner, Knowles, & Andreasen, 1994; Bremner, 1978; Lasky, Romano, & Wenters, 1980), is one of them, and it is well adapted for investigating invisible displacement understanding in animals. The rotation task consists of an invisible displacement in which an attractive object is visibly hidden in one of the containers (usually two) placed at the opposite ends of a platform. While the participant remains stationary, the platform and the containers are visibly rotated around its center (from 0° to 360°, by increments of 90°). The hidden object therefore is subjected to an invisible displacement, and the participant's task is to visually track the target container to find the object that has invisibly changed its location.

The rotational problem, however, has not received a lot of attention in the animal literature yet and until now its use has been restricted to the great apes and domestic dogs. Using a three-container array, Beran and Minahan (2000) reported that chimpanzees and bonobos can track and retrieve an object that has been invisibly rotated by 180° well above chance level. Beran, Beran, and Mendel (2005) generalized those results to a five-container array in chimpanzees. Call (2003) administered 0°, 180° and 360° rotation problems to chimpanzees and orangutans using a two-container array. Although those species performed better in the no-rotation trials, their performance in the 180° and 360° rotation trials was significantly above chance level. Based on these studies, it seems reasonable to conclude that great apes are able to track invisible displacement of an object in a rotation task.

Fiset (2007) and Miller, Gipson, Vaughan, Rayburn-Reeves, and Zentall (2009) investigated dogs' capacity to track invisible displacements of objects in a spatial rotation problem and obtained different results from the above mentioned studies on great apes. In both studies, dogs systematically failed the task and performed below the chance level in the 180° rotations. Most interestingly, dogs showed a strong spatial bias in the rotation problem: they searched for the hidden object in the container located at the spatial position where they had seen the object disappear. This observation of dogs' spatial bias in a rotation task corroborates previous works using different search tasks (e.g. transposition problem) that have also demonstrated the tendency of dogs to search at the last location where they saw an object disappear (Doré, Fiset, Goulet, Dumas, & Gagnon, 1996; Fiset & Plourde, 2012).

Although previous studies that have investigated dogs' understanding of invisible displacements have reduced to the bare minimum the presence of uncontrolled visual cues in the search tasks, Fiset and Leblanc (2007) recently found that dogs, not knowing where to search for the hidden object in a Piagetian invisible displacement problem, partially attempt to use the experimenter's position to find the object. Agnetta, Hare, and Tomasello (2000) and Riedel, Buttelmann, Call, and Tomasello (2006) have also shown that dogs' ability to find a hidden object is higher when the hiding location is marked by the presence of an experimenter than when it is not. These results therefore suggest that the simple presence of a human in a search task can have an impact on dogs' search behavior.

Dogs' ability to locate hidden objects is also influenced by explicit human social cues (e.g. pointing, gestures, gaze), as demonstrated by the numerous studies that used an object-choice task – an object is hidden beforehand inside one of two potential hiding locations and an experimenter points at the actual hiding location – to investigate point comprehension in dogs. These studies revealed that dogs can use various forms of human communicative gestures to find food rewards, including pointing (Bräuer, Kaminski, Riedel, Call, & Tomasello, 2006; Dorey, Udell, & Wynne, 2010; Hare & Tomasello, 1999, 2005; Lakatos, Soproni, Dóka, & Miklósi, 2009; Miklósi, Polgárdi, Topál, & Csányi, 1998; Soproni, Miklósi, Topál, & Csányi, 2001; Soproni, Miklósi, Topál, & Csányi, 2002), bowing, nodding, head-turning and glancing (Miklósi et al., 1998; Soproni et al., 2002). Studies that used contradictory pointing (the non-rewarded container is pointed at by an experimenter) also revealed that dogs rely on these signals to attempt to find a reward (Marshall-Pescini, Valsecchi, & Prato-Previde, 2011; Prato Previde, Marshall-Pescini, & Valsecchi, 2008; Szetei, Miklósi, Topál, & Csányi, 2003), reinforcing the view that dogs are highly inclined to follow human gestures.

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