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Domesticated dogs (*Canis familiaris*) react to what others can and cannot hear

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ABSTRACT

Recent research suggests some nonhuman primates (e.g., chimpanzees, rhesus macaques) consider what others hear when acting in competitive situations. We explored whether dogs living in private homes or sourced from an animal shelter would show this same predilection. Following an inhibition task where dogs (*Canis familiaris*) were commanded not to take a treat left on a plate by a human, we presented subjects with the opportunity to take food from one of two containers. These containers were located within the proximity of a human gatekeeper who was either looking straight ahead or not looking at the time of choice. One container was silent when food was inserted or removed while the other was noisy. Among pet dogs (20 total; 10 in each condition) randomly assigned to the Looking or Not Looking condition, four subjects approached the silent container in the Looking condition (binomial test: $P = 0.8$) while 10 approached the silent container in the Not Looking condition (binomial test: $P = 0.004$). We compared pet dogs' pattern of performance between conditions using a chi-square test for independence, which indicated that dogs significantly preferred the silent container only in the Not Looking condition ($\chi^2_1 = 8.8$, $P = 0.003$). This outcome suggests dogs preferentially attempted to retrieve food silently only when silence was germane to obtaining food unobserved by the human gatekeeper. Interestingly, dogs sourced from a local animal shelter evidenced similar outcomes. Among shelter dogs (20 total; 10 in each condition) randomly assigned to the Looking or Not Looking condition, four subjects approached the silent container in the Looking condition (binomial test: $P = 0.8$) while nine approached the silent container in the Not Looking condition (binomial test: $P = 0.02$). We compared shelter dogs' pattern of performance between conditions using a chi-square test for independence, which indicated that dogs significantly preferred the silent container only in the Not Looking condition ($\chi^2_1 = 5.5$, $P = 0.02$). This result suggests shelter dogs, like pet dogs, preferentially tried to retrieve food silently only if silence was relevant to obtaining food unobserved by a human gatekeeper. This result conflicts with other recent data suggesting that shelter dogs perform more poorly than pet dogs in tasks involving human social cues.

1. Introduction

Researchers curious about the cognitive capacities of nonhuman animals typically have studied nonhuman primates (hereafter, primates). Due to our shared ancestry, primates have been considered by many the likeliest

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contenders to display basic forms of human cognitive skills. However, recent research with domestic dogs (*Canis familiaris*) suggests dogs' skills in social cognitive tasks frequently appear more flexible and similar to those of humans than species more closely (e.g., Horowitz, 2009) or distantly (e.g., Schloegl et al., 2008) related to humans phylogenetically. Some have posited that this may be due to dogs' close association with humans through domestication (e.g., Vilà et al., 1997; Clutton-Brock, 1999). Indeed, many investigations highlight dogs' acute sensitivity to humans' social and communicative cues (e.g., Agnetta et al., 2000; Hare and Tomasello, 2005; Lakatos et al., 2009).

Numerous studies note dogs' proficient use of humans' attentional state, as evidenced by their ability to modify their behaviour to accord with where humans are visually attending (e.g., Call et al., 2003; Schwab and Huber, 2006). For example, Call et al. (2003) presented dogs with trials in which a human forbid them to eat a piece of food. During some trials, the human maintained visual contact with the dog. In others, the human left the room, turned her back, engaged in a distracting activity, or closed her eyes. When the human visually attended to the dogs, they were less likely to retrieve food and approached the food in an indirect manner, suggesting dogs were sensitive to the human's attentional state.

While the issue of animals' sensitivities to human attentional states has not been explored at length within the canine literature, we can look to work with other species. For example, a variety of primates have shown skill in determining what a conspecific can see as they compete for a limited amount of food (e.g., Flombaum and Santos, 2005; Hare et al., 2006; Bräuer et al., 2007; but see e.g., Karin-d'Arcy and Povinelli, 2002; Hare et al., 2003). For example, Hare et al. (2006) provided evidence that some chimpanzees spontaneously chose to approach food items via a route hidden from a human competitor's view rather than a route from which they could be observed. Rhesus macaques also chose to take food from humans who could not see them in conditions where the humans' eyes were facing away or when the human's face was blocked by an opaque barrier (Flombaum and Santos, 2005). Similar results have been demonstrated with domestic goats (*Capra hircus*) using a competition paradigm (Kaminski et al., 2005). Ravens (*Corvus corax*) have also been shown to adjust their caching and foraging behaviour in the presence of conspecific competitors (e.g., Bugnyar and Heinrich, 2006; Bugnyar and Kotrschal, 2004).

The evaluation of what competitors know does not appear limited to information gleaned from the visual domain (Santos et al., 2006). Santos et al. presented rhesus macaques with the opportunity to take food from a human competitor who did or did not have visual access to baited containers. One container was noisy when manipulated while the other was not. Results indicated subjects took food from the silent container when the competitor was not looking and chose randomly when the competitor was looking. This suggests rhesus macaques preferred to try to obtain food silently only when silence was relevant to obtaining the food surreptitiously. Similar results were obtained by Melis et al. (2006) with chimpanzees. However, Bräuer et al. (2008) did not find evidence that chimpanzees considered what a conspecific could hear. In this paradigm, pairs of chimpanzees competed over two pieces of food. What the dominant individual heard relative to the food baiting varied over trials. Results indicated that subordinates did not consider what the dominant competitor had heard with respect to food baiting even though they themselves could find the hidden food based on the noise created by food placement.

Interestingly, similar results were recently obtained with a nonmammalian species. More specifically, Stulp et al. (2009) found that Western scrub-jays (*Aphelocoma californica*) attempt to reduce the auditory information available to competitors when caching. In their study, jays were given caching opportunities for two different trays. One tray was filled with a substrate that made noise when birds cached in it; the second tray was filled with a substrate that did not make noise when birds cached in it. Birds were allowed to cache under several conditions: caching behaviour could be heard but not seen by conspecific competitors, caching behaviour could be neither seen nor heard by conspecific competitors, or caching behaviour could be seen and heard by conspecific competitors. The results indicated that birds only cached fewer food items in the noisy substrate under conditions in which they could be heard but not seen. These results suggest that scrub-jays, like rhesus macaques (Santos et al., 2006) and chimpanzees (Melis et al., 2006; but see Bräuer et al., 2008) consider how auditory information can change a competitor's knowledge state.

Given evidence indicating dogs' predilection to modify their behaviour to accord with humans' visual attention in situations in which they have been prohibited from taking food (e.g., Call et al., 2003; Schwab and Huber, 2006), we queried whether dogs might show a connection between hearing and knowing. Importantly, Bräuer et al. (2006) indicate that dogs can use sound as a cue to locate food even though they may not possess an understanding of the causal relationships involved in the noise production. Additionally, we explored whether performance varied depending on whether the dog lived in a private home or resided at an animal shelter, as recent evidence suggests dogs from shelters may perform more poorly in tests involving human social cues (e.g., Udell et al., 2008).

2. Experiment

2.1. Animal, materials, and methods

2.1.1. Animals

We tested 22 dogs living in private homes from the local area. Dogs living in private homes were at least 1 year of age, had been obtained from a breeder, lacked advanced obedience training, and were free of major health problems. They had resided with their owner for at least the last 6 months and were not fed within 3–4 h prior to participation. Staff instructed owners that there were no correct behaviours and reminded them they were not to help their dog in any way. Short commands such as stay, sit, and release by the owner were permitted.

In addition to dogs living in private homes, we also tested 24 dogs from a local animal shelter. The shelter dogs