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Domestic Dogs (*Canis familiaris*) Use Human and Conspecific Social Cues to Locate Hidden Food

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Ten domestic dogs (*Canis familiaris*) of different breeds and ages were exposed to 2 different social cues indicating the location of hidden food, each provided by both a human informant and a conspecific informant (for a total of 4 different social cues). For the local enhancement cue, the informant approached the location where food was hidden and then stayed beside it. For the gaze and point cue, the informant stood equidistant between 2 hiding locations and bodily oriented and gazed toward the 1 in which food was hidden (the human informant also pointed). Eight of the 10 subjects, including the one 6-month-old juvenile, were above chance with 2 or more cues. Results are discussed in terms of the phylogenetic and ontogenetic processes by means of which dogs come to use social cues to locate food.

The use of social cues to locate food and other important entities in the environment is a skill with obvious adaptive benefits. For example, an "informant" may look toward an entity, and this look may be accompanied by both head and body orientation to the same location and sometimes by other behaviors such as vocalizations or travel toward the target location. The ability of observer individuals to exploit social cues of this type enables them to benefit from knowledge possessed only by specific groupmates. Despite the potential importance of this social ability for the foraging of many highly social species such as mammals, there has been very little systematic research in this area.

Virtually all of the relevant research has been conducted with nonhuman primates and their skills of gaze following. There are two basic experimental paradigms, and these have produced different sets of results. The first paradigm is simple gaze following in which 1 individual orients its head and eyes in a certain direction (sometimes accompanied by gestures), and another individual either does or does not orient itself similarly. For example, Itakura (1996) had a human approach nonhuman primate individuals and either look or look and manually point to the right or left. Many of the 11 different nonhuman primate species tested visually tracked the pointing gesture, but only 1 (an orangutan) visually followed gaze direction by itself. Using a similar methodology, Povinelli and Eddy (1996a) also found positive results for 6 juvenile chimpanzees following the gaze of a human experimenter. In the one study of nonhuman primates following the gaze direction of conspecifics, Tomasello, Call, and Hare (1998) found that all five species tested were very skillful. Because some of these species were the same as or very closely related to those that did not follow human gaze in Itakura's (1996) study, it is possible that it is more natural for nonhuman primates to follow the gaze of conspecifics than it is for them to follow the gaze of humans.

The other experimental paradigm involves an informant looking toward (or pointing and looking toward) the location of food hidden under one of two opaque containers; this paradigm is called the *object-choice paradigm.* In this case, there are no clear cases of success in nonhuman primates. Anderson, Sallaberry, and Barbier (1995) found that capuchin monkeys (*Cebus apella*) did not use human gaze direction to find food in this paradigm; the only effective cue was when the human placed his hand directly next to the baited container. Tomasello, Call, and Gluckman (1997) found that chimpanzees and orangutans did not use human gaze direction with an associated pointing gesture to locate food in an object-choice procedure. Povinelli and Eddy (1996b) and Call, Hare, and Tomasello (1998) also found negative results when chimpanzees were given gaze direction cues without a pointing gesture. Itakura, Agnetta, Hare, and Tomasello (in press) found no better results when the informant doing the looking was a chimpanzee conspecific, although subjects were successful in this study when the informant actually approached, sat in front of, and looked at the correct container (the local enhancement cue).

Perhaps surprisingly, domestic dogs have been found to be quite skillful in using human gaze to locate food in the object-choice paradigm. Hare, Call, and Tomasello (in press) tested 2 domestic dogs (*Canis familiaris*) in a variety of object-choice situations using a variety of social cues. In the most straightforward situation—and the one most comparable to that in which primates have been tested—a human informant stood equidistant between two opaque containers, and then turned his head and eyes to look at one of them (sometimes with a pointing gesture). Both canine subjects were well above chance in choosing the baited container in

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these conditions (and not in control conditions). They were also quite good in several variations; for example, both subjects were still above chance when the informant stood in front of the incorrect container and looked and/or pointed across to the correct container. (For the documentation of some other social–communicative skills of domestic dogs, see Filiatre, Millot, & Montagner, 1986; McConnell & Baylis, 1985; Mitchell & Thompson, 1993; and Warden & Warner, 1928.)

The main limitation of Hare et al.'s (in press) study was that there were only 2 subjects, and they both had grown up with the human experimenter. This fact means that these dogs might be special in some way or that there might be something special about dogs' ability to use social cues produced by their masters as opposed to those produced by less familiar humans. What is needed, therefore, is a study using a larger sample of dogs and a human experimenter who is unfamiliar to the dogs. In addition, however, there is the interesting question of whether dogs can only use social cues produced by humans and not those produced by conspecifics. There is some evidence in the primate literature that so-called enculturated individuals—those raised and trained by humans in human-like cultural environments—may develop and use social cognitive skills in interaction with humans that they do not use with their conspecifics (Call & Tomasello, 1996). Domestic dogs are by definition raised in human-like cultural environments, sometimes with very little contact with conspecifics, and of course domestic dogs have also been selectively bred for their ability to relate socially to humans. It is thus possible that domestic dogs are skillful at using the social cues produced by humans but not at using those produced by conspecifics.

In the current study, therefore, we had three goals. First, we sought to replicate the main findings of Hare et al. (in press), but with a larger sample of dogs and a human informant unfamiliar to them. Second, and most importantly, we also used a conspecific informant to see if the dogs could use social cues produced by a conspecific to locate food in an object-choice task. Third, we exposed the subjects to two different kinds of cues: a gaze direction cue (involving also body orientation and sometimes a pointing gesture) and a richer local enhancement cue; both types of cues were used by both species of informant.

Method

Subjects

Subjects were 10 domestic dogs (*Canis familiaris*) that were regularly boarded at a commercial dog care facility but that otherwise spent their time with their human families. None of the dogs had ever received any special training beyond the normal obedience training typical for domestic dogs. One dog, Daisy, had participated in Hare et al.'s (in press) study and had been raised by Brian Hare. The other 9 dogs were completely naive to any form of experimentation and completely unfamiliar with the human experimenter. See Table 1 for a list of subjects along with their breeds, sexes, and ages.

Table 1
Subjects and Their Breeds, Sexes, and Ages

Subject	Breed	Sex	Age (in years)
Boo	Mongrel	F	3
Max	Mongrel	M	2
Daisy	Mongrel	F	4
Uma	Labrador retriever	F	1/2
Prudence	Labrador retriever	F	3
Maggie	Labrador retriever	F	4
Tiger	English bull mastiff	M	2
Patience	English setter	F	3
Giligan	Burmese mountain	M	1
Zena	Border collie	F	1

Note. F = female; M = male.

Materials and Design

Each subject was individually tested for its ability to follow social cues to food (dog treats) hidden behind small, curvilinear cardboard barriers (20 cm^2). Testing took place in a 10 m^2 room that was familiar to the subjects. In each trial, there were two barriers positioned 2–3 m apart with food hidden behind one only. The distance was 2 m for the human informant because he gave his gaze cue standing upright, whereas the distance was 3 m for the dog informant so that, given her horizontal stance, her eyes would be about the same distance from the target as the human informant's. The subject began each trial positioned 2 m from the midpoint between the two barriers, as illustrated in Figure 1.

There were 4 different types of experimental trials resulting from the factorial combination of two dimensions. First was the type of informant: human or dog. Second was type of cue: local enhancement or gaze and point. There was also a control condition in which no cue was given that was associated with each experimental condition. Each subject participated in 24 experimental trials and 6 control trials in each of these four conditions, with each condition run as a block (control trials randomly interspersed), for a total of 120 trials per subject. Four different orders of conditions were used, with either 2 or 3 subjects assigned to each order, so that approximately equal numbers of subjects began with each cue. All trials for a given subject were administered within a 1 month period, with daily sessions comprising one or more rounds of 15

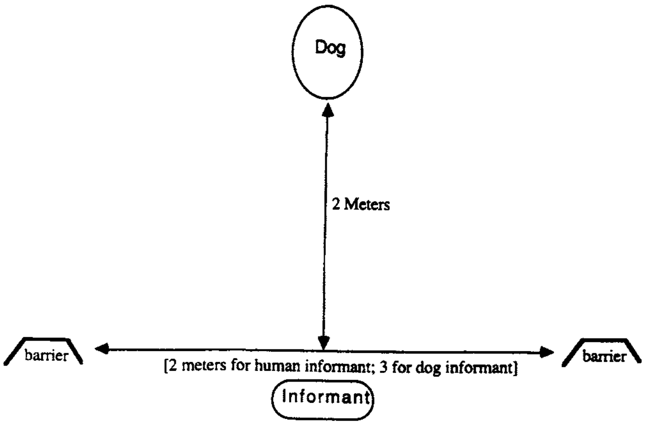

Figure 1. Experimental arrangement of object-choice task.

trials (with 10-min breaks in between). For 9 subjects, the conspecific informant was Maggie; however, when Maggie was the subject, the informant was Giligan. Food placement was randomized so that each cup was baited an equal number of times in each experimental or control condition for each subject, with the same cup never baited 3 times in a row. All trials were videotaped from behind the location of the first experimenter (E1).

Procedure

For all trials, the subject was exposed to either a human informant (E1) or a dog informant giving a cue for approximately 5 s. A second human experimenter (E2) controlled the subject during this procedure and then released him or her to make a choice. Each subject on each trial went straight to a barrier and searched behind it. If correct, they were allowed to eat the food. If incorrect, they were shown where the food was located as E1 retrieved it from behind the other barrier, but they were not allowed to eat it.

Subjects began with a series of 6 warm-up trials in which they saw the food being hidden behind one of the barriers (three times for each barrier). Eight of the 10 subjects were successful on all of these trials, whereas 2 subjects required 10 additional trials to become reliably successful. Experimental trials were then administered as follows (with the order counterbalanced as specified above):

Human—local enhance. E1 baited one barrier and sham baited the other (in random order) while the subject watched. He then stood equidistant between the two barriers and obtained the subject's attention. He then approached and squatted beside the correct barrier, as he looked back and forth between it and the subject.

Human—gaze and point. The procedure for these trials was identical to that in the human—local enhance trials except that, for the social cue, E1 stayed in position equidistant between the barriers, gazing at the correct barrier and pointing to it using the contralateral hand.

Dog—local enhance. The subject was kept outside of visual contact by E2 while E1 baited a barrier, prepared the dog informant, and hid behind a partition (this was necessary to ensure that the only cues the subject saw came from the dog informant). The subject was then released to see the dog informant standing right next to (within 30 cm of) one of the barriers. The informant's attraction to the food and a leash attached to the opposite wall ensured that she stayed basically in the same place throughout the trial.

Dog—gaze and point. The procedure for these trials was identical to that in the dog—local enhance trials except that, for the social cue, the dog informant stood equidistant between the two barriers (i.e., her horizontal midpoint was at the midpoint), looking at the correct barrier—again attracted to the food but restrained by a leash attached to the opposite wall. In both of the dog-informant conditions, the dog informant remained basically still and silent throughout the trial (she was, in fact, chosen for her ability to do this).

Control. For the two sets of trials with a human informant, the corresponding control trials were identical to these except that, for the cue, E1 simply turned his back to the subject. For the two sets of trials with a dog informant, the corresponding control trials were identical to these except that, for the cue, no dog was present when the subject emerged (all that was present was the leash attached to the opposite wall and laid out as in the corresponding experimental trials).

Scoring

A subject's choice for a given trial was the first barrier it searched behind. Responses were totally unambiguous (and subjects searched on every trial), so E1 and E2 simply noted independently after each trial which barrier the subject had chosen. Agreement between E1 and E2 was 100%.

Results

Performance for each subject in each condition is presented in Table 2. The most straightforward data analysis compared the number of correct choices against chance for each subject for each of the four experimental conditions separately (and one combined control condition that included all 24 control trials). Given a 50% chance probability, 17/24 correct was greater than would be expected by chance (one-tailed binomial probability). Results of this analysis showed that for human—local enhance, there were 8 subjects above chance; for human—gaze and point, there were 5 subjects above chance; for dog—local enhance, there were 6 subjects above chance; for dog—gaze and point,

Table 2
Number Correct (out of 24) by Each Subject in Each Experimental Condition (Control Conditions Combined)

Subject	Human—local enhance	Human—gaze and point	Dog—local enhance	Dog—gaze and point	Controls
Boo	23*	23*	19*	18*	12
Max	20*	17*	22*	17*	12
Daisy	19*	24*	7	11	10
Uma	16	12	18*	21*	12
Prudence	13	12	20*	23*	12
Maggie	23*	20*	16	13	14
Tiger	17*	13	14	13	9
Patience	21*	13	17*	14	10
Giligan	22*	14	16	15	9
Zena	21*	21*	20*	16	12
Average	19.5	16.9	16.9	16.1	11.2

*$p < .05$.

there were 4 subjects above chance; and for the control condition, there were no subjects above chance.

Group performance was assessed in two ways. First, each condition was compared with performance in the combined control condition using a one-sample *t* test. In all cases, the experimental group was higher: for human—local enhance, $t(9) = 7.50, p < .0001$; for human—gaze and point, $t(9) = 3.99, p < .01$; for dog—local enhance, $t(9) = 4.85, p < .001$; and for dog—gaze and point, $t(9) = 4.45, p < .001$. Second, performance in the four different experimental conditions was compared. For this analysis, an initial test for the order of conditions was run (a one-way analysis of variance, or ANOVA, with four possible orders). No effect of order was found. Consequently, a two-way ANOVA was run with type of informant (human or dog) and type of cue (local enhance or gaze and point) as variables. No significant differences were found for either variable, nor did the two variables produce a significant interaction. Thus, the overall conclusion is that all four cues were used effectively by the subjects as a group, and they were all used equally well.

Patterns of individual performance showed much variability. Two subjects were good with all four cues; 2 subjects were good with the two cues produced by the human informant only; 2 subjects were good with the two cues produced by the dog informant only; and 1 subject was good with the two local enhancement cues only (regardless of informant). Each of the other 3 subjects was above chance on at least one cue, but without a clear pattern. There are thus no interesting overall patterns in the individual analyses, except that no subject was good on the two gaze and point cues only (regardless of informant). Analysis of errors revealed that of the 8 subjects that were at chance in at least one experimental condition, all showed a relatively pronounced side bias (consistently choosing either the right or left barrier at least twice as often as the other) in most of the conditions in which they were performing poorly (15/17). Four subjects also showed a side bias in the combined control condition.

Finally, there were no obvious relationships between the breed, gender, or age of the subjects and their performance. Quantitatively, the correlation of age with the subjects' overall performance was not significant ($r = -.23$). Importantly, however, the one 6-month old juvenile (Uma) was above chance on both dog cues but below chance on both human cues. In contrast, the 2 oldest subjects (Maggie and Daisy, both 4 years old) were above chance on both human cues but below chance on both dog cues.

Discussion

The current findings replicate and extend those of Hare et al. (in press). In the current study, 8 of 10 domestic dogs of various breeds and ages were able to use a human local enhancement cue, and 5 of these were able to use a human gaze plus pointing cue to locate food in an object-choice task. They did this even though the human experimenter was completely unfamiliar to them (with one exception), and they did this from a very young age. The current study did not explore the range of cues that dogs can exploit in this situation, but there is no reason to believe that these subjects are any different from those in the Hare et al. (in press) study. In that study, the 2 dogs responded generally well to gaze direction cues whether they were given dynamically or statically, whether they were consistent with or discrepant with distance cues, and whether they were or were not accompanied by a pointing gesture. (Note that these subjects did not respond skillfully to eye direction when it was discrepant with head direction.) In both studies, control conditions ruled out the possibility that the dogs were using other kinds of cues, such as olfactory cues, to find the food.

The novel finding of the current study was that domestic dogs are also quite good at using social cues provided by a conspecific. Six of 10 subjects used a conspecific local enhancement cue skillfully, and 4 of 10 used a conspecific gaze direction cue skillfully. Both of these conspecific cues were given statically—the subject emerged to see the informant oriented in one way or another—and the gaze cue was independent of distance as well. This skill with conspecifics is somewhat surprising because many of these domestic dogs had had only limited experience with other dogs. Indeed, the one intriguing developmental finding was that the 6-month-old juvenile was only able to use cues produced by conspecifics, whereas the two 4-year-olds (the oldest in the sample) were only able to use human cues. Given the small number of subjects involved, this finding is extremely tentative. But it does suggest the hypothesis that many dogs are able to use conspecific gaze cues from very early in life without extensive experience with conspecifics, and then, ontogenetically, they extend this ability to humans (to some degree on the basis of similarities in human and dog facial features) as they interact with them—perhaps in some cases to the point that they lose their ability with conspecifics.

The comparison of our subjects' abilities with nonhuman primates is an interesting one. Whereas a number of primate species are skillful at following gaze in a neutral context (Tomasello et al., 1998), in the object-choice task they do not use the gaze or pointing cues of another being, either human or conspecific, to guide their choice (Call et al., 1998; Povinelli & Eddy, 1996b; Tomasello et al., 1997). They do better when there are additional cues suggesting food—such things as local enhancement and vocalizations (Itakura et al., in press)—but either gaze or pointing alone or both gazing and pointing are not sufficient to reveal to them the location of the food as these actions are for dogs. There is currently no clear explanation for this species difference, but one speculation is that wolves in general evolved as social carnivores that hunt in groups (with dogs descended directly from wolves; Vila et al., 1997), and in group hunting, monitoring conspecific gaze and body direction is often necessary for effective coordination. Primates evolved mostly as herbivores and frugivores, and so their group foraging does not require the same kind of coordination of movements as the group hunting of members of the wolf family. The demonstrated ability of primates to follow gaze in neutral contexts may derive from a need to monitor the social activities, not feeding activities, of conspecifics. Primates can only use gaze to locate food when other food cues are also available.

It is also interesting in the current context that in Itakura et al.'s (in press) study, there were 2 chimpanzee subjects that used human gaze to locate food in the absence of other food-related cues in an object-choice task. These were the 2 subjects that had previously had extensive experience in a human-like cultural environment. (See Call & Tomasello, 1994, for a similar finding involving orangutans and the following of a pointing gesture in an object-choice task.) This finding suggests the possibility that with appropriate experience, some primates may, like dogs, come to use the gaze direction of others to locate food without additional food-related cues. (See also Itakura & Anderson, 1996, for a successful attempt to train, using over 100 discrimination learning trials, a capuchin monkey to follow human gaze direction.)

Much current theorizing in the field of human cognitive development links skills of gaze following to more complex social–cognitive skills, such as understanding intentions or "theory of mind" (e.g., Baron-Cohen, 1995). The current study did not address the question of how domestic dogs understand the visual gaze of others—for example, whether they use it to infer something of another's intentional or mental states. Nevertheless, the current results should contribute to the discussion by documenting gaze-following skills in a species many millions of years removed from primates and humans, suggesting the possibility that skills of gaze following may have evolved more than once, possibly to meet very different ecological demands. Currently, it is not possible to assess this theory because researchers do not know anything about the gaze-following skills of mammals more closely related to primates than dogs (e.g., insectivores).

What researchers do know is that recent studies have shown that domestic dogs have many of the same cognitive skills as nonhuman primates, including skills of object permanence (Gagnon & Doré, 1992; 1993), cognitive mapping (Chapius & Varlet, 1987), and now, gaze following. Unfortunately, there is currently very little research on the cognitive skills of other nonprimate mammals (Cords, 1997; Tomasello & Call, 1997), and so it is not possible to place the current findings in a broader evolutionary perspective. In general, much more research with nonprimate species is necessary to make progress in understanding in its broadest perspective the evolution of mammalian cognition.

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