Anim Cogn (2014) 17:461–470
DOI 10.1007/s10071-013-0677-0

ORIGINAL PAPER

My owner, right or wrong: the effect of familiarity on the domestic dog's behavior in a food-choice task

Amy Cook · Jennifer Arter · Lucia F. Jacobs

Received: 18 June 2013 / Revised: 17 August 2013 / Accepted: 19 August 2013 / Published online: 31 August 2013

Abstract Dogs are strongly influenced by human behavior, and they readily form bonds with specific humans. Yet these lines of inquiry are not often combined. The goal of this study was to investigate whether such bonds would play a role in how dogs behave in response to human signals. Using various types of signals, we compared dogs' use of information from a familiar human (their owner) versus an unfamiliar human when choosing between two food containers. In some conditions, the owner indicated a container that gave food and a stranger indicated a container that did not; in other conditions, this was reversed. Dogs more often chose the container indicated by or nearest to their owner, even when this container never yielded a food reward. In two conditions, dogs chose at chance: a control condition in which both pointers were strangers and a condition in which the owner and stranger sat reading books and provided no social signal. This is the first study to directly compare owners to strangers in a single food-choice situation. Our results suggest that dogs make decisions by attending preferentially to social signals from humans with whom they have become familiar.

Keywords Domestic dog · Pointing · Canis familiaris · Social cognition · Attachment

Introduction

Estimates are that dogs first began to diverge from wolves (*Canis lupus*) and to live near early humans approximately 130,000 years ago (Vilà et al. 1997). By at least 15,000 years ago, they had diverged morphologically from wolves (Clutton-Brock 1995; Gray et al. 2010; Wayne and vonHoldt 2012) and evidence of their importance to humans has been found in their appearance in cave art and human burials at approximately the same time (see Udell et al. 2010a). During this time, the dog's natural foraging niche has centered on humans (Coppinger and Coppinger 2001). Behaviors in dogs that may stem from human provisioning have been well documented: dogs look to, rely on, and defer to humans when confronted with food-acquisition tasks (Marshall-Pescini et al. 2009; Miklósi et al. 2003; Topál et al. 1997, 2009), and they will even follow the same travel trajectory that they have seen a human follow (Kubinyi et al. 2003; Pongrácz et al. 2003).

The dog's ability to follow the human pointing gesture to find hidden food (Miklósi and Soproni 2006; Reid 2009) is perhaps the most well-studied example of the influence of humans on dogs' foraging behavior. The origin and function of this behavior has been the subject of much research. It has been established that dogs can follow points when the human's hand is up to 80 cm away from the indicated object (Soproni et al. 2002; Miklósi et al. 2005) and that they can follow the gesture whether they see that the human's arm is moving or is entirely still during the trial (Reid 2009). They can also accurately follow a point when the pointer is moving away from the correct object while pointing at it (McKinley and Sambrook 2000). It appears that this ability emerges in early puppyhood (Hare and Tomasello 2005; Riedel et al. 2008), although there is also evidence that experience affects it. In one sample, shelter dogs were unable to follow more difficult types of points until they had received specific training in the ability (Udell et al. 2010). Another study found that dogs performed well when a human pointed and used a helpful tone

A. Cook (✉) · J. Arter · L. F. Jacobs
Psychology Department, University of California,
3210 Tolman Hall #1650, Berkeley, CA 94720, USA
e-mail: doggeek@berkeley.edu

of voice, but performed at chance when the human held out a hand in a prohibitive gesture and used a discouraging tone of voice (Pettersson et al. 2011). This suggests that dogs may be attuned to the social tone of humans' gestures. Regardless of the mechanism by which this happens, such findings show that dogs find human social gestures especially salient. All of this is ample evidence that human social gestures are of particular interest to dogs in the context of foraging.

There is also strong evidence that dogs come to form specific bonds with specific people. Dogs begin to show a preference for a familiar human over a stranger by 4 weeks of age (Gácsi et al. 2005). Adult dogs show behaviors toward familiar human adults that are similar to the behaviors of human infants toward caregivers. For example, dogs' cortisol levels are lower when exploring a novel environment with a familiar human, compared to when alone or with a familiar dog (Tuber et al. 1996). Also, when placed in an unfamiliar room, they show more exploration and a higher activity level when in the presence of their owner compared to the presence of a stranger; their activity levels with the stranger are comparable to those seen when the dog is alone. Dogs also tend to show "seeking" behavior when left in an unfamiliar room with an unfamiliar human (e.g., standing by the door; Palestrini et al. 2005). Dogs even display social referencing behavior, looking to the owner when confronted with an unfamiliar object (Merola et al. 2012). One intriguing finding showed that when owners reported a closer relationship with their dog (e.g., talked to and played with their dog more often), the dog displayed more "dependent" behavior in a problem-solving task: looked to the owner more and made fewer attempts to solve the problem on its own (Topál et al. 1997).

Thus, there is evidence that dogs follow human points and that dogs form preferences for specific humans. This suggests that a long-term relationship with a particular human should result in a dog having a preference for the pointing gesture provided by this human over that of an unfamiliar human. Yet the few pointing studies that have examined this effect thus far have not supported this prediction. One study that compared owners to experimenters as pointers, in separate testing sessions, found no difference in the dogs' performance (Miklósi et al. 1998). However, in this case, the dogs already tended to be at ceiling on the task, and thus, any preference for the owner would be masked by dogs' general high performance in the task. In fact, the majority of dogs across all studies are able to use a single pointer's gesture to find hidden food, so familiarity is probably not being adequately tested in a single-pointer task (for a review of single-pointer studies, see Reid 2009). Another study found that simple measures of closeness to the owner (i.e., how much time the dog spent with the owner and whether the dog spent more time indoors or outdoors) did not relate to performance on a pointing task when an unfamiliar human was the pointer (Gácsi et al. 2009). However, this study did not assess dogs' performance with owners as pointers. Thus, neither study has conclusively excluded the effects of familiarity on the ability to follow a point.

A single-pointer paradigm may be inadequate as a test of dogs' preference for familiar humans' information. Here, we propose a simple modification of the procedure that could reveal such an effect. Specifically, we asked dogs to choose directly between two human pointers in a single testing session. Because dogs ignore olfactory and visual cues in favor of human gestures when choosing between food sources and will even continue to follow a human's point when the point ceases to provide accurate information (Kundey et al. 2010; Szetei et al. 2003), we hypothesized that dogs would follow a familiar over an unfamiliar human's point even when the familiar pointer's gesture consistently failed to yield a reward. Additionally, to rule out the possibility that this effect might be due to a dog's simply being drawn toward the owner when the owner is present, and then only subsequently choosing a nearby container, we included conditions designed to control for this possibility. Specifically, we hypothesized that dogs would choose a container that the owner had indicated to the dog (i.e., by shaking it while looking at the dog) over one similarly indicated by a stranger, after both humans had left the room; and that, reciprocally, dogs would not prefer a container placed nearer the owner over one placed nearer a stranger, when there was no clear indication by either human of involvement in the choice task.

Method

Rationale

The goal of this study was to present dogs with two possible food sources, one of which was indicated by a familiar person and the other of which was indicated by an unfamiliar person. We wanted to test whether dogs would prefer a container indicated by the familiar person. For each dog, only one of the two containers it could choose to investigate would yield a food reward. For some dogs, the owner consistently pointed to this container (the "owner-correct" condition), and for others, the stranger pointed to this container and the owner pointed to a container that would not yield a food reward (the "stranger-correct" condition). We hypothesized that the dogs in the owner-correct condition would choose the correct container more often than the dogs in the stranger-correct condition. In other words, we predicted that regardless of condition, dogs would tend to rely preferentially on the

owner's point, causing dogs in the stranger-correct condition to repeatedly choose the sham-baited container. We compared these two groups to a number of other conditions. In the first, the "two-stranger" condition, both pointers were strangers. We hypothesized that dogs in this condition would perform at chance: Being unfamiliar with both pointers, they would not have a preference for either container. The two-stranger condition was also included to ensure that dogs were not learning whose point to follow during the course of the procedure. We also included a "no-point" condition in which the owner and a stranger each stood near a container, but neither pointed, to establish whether a pointing gesture, in particular, is a crucial determinant of dogs' behavior. Finally, we included two conditions to control for possible effects of simple presence of the owner. In the first, the "leave" condition, the owner and stranger each held and shook their respective containers, while looking at the dog, and then left the room. In the second, the "read" condition, the owner and stranger sat at the two far ends of a rectangular table and read books, and a handler placed containers near each of them and then released the dog to make a choice. In the leave condition, we hypothesized that the dog would choose the container indicated by the owner, even though the owner was no longer in the room. In the read condition, we hypothesized that dogs' performance would be at chance, because the owner was not supplying any form of social information to the dog.

Subjects

Thirty dog–owner dyads were recruited from local dog trainers. (An additional three dogs were recruited but are not included in analyses. Two of these dogs were unable to consistently retrieve food from beneath the containers. The third completed testing but due to experimenter error the containers were not baited correctly, and thus, data from this dog's performance could not be included.) The design was between-subjects; each dog was tested only once. Each dog was assigned at random to only one of the conditions described below. The sample consisted of a roughly equal distribution of male and female dogs (17 males), whose ages ranged from 2 to 12 years (mean = 6.16 years, SD = 2.91). Twelve dogs were mixed breed and 18 were purebred (see Appendix for breed list). All the dogs met our inclusion criteria: that they were at least one year old, were kept as pets and lived in their owner's household, and had lived in their current household for at least one year.

Materials

Two identical opaque plastic cylindrical containers, 20 cm in height, were used to contain the bait. These were presented to the dogs upside-down so that the lids were set against the floor. There were two tight-fitting lids for these containers; one of these had a hole in the middle such that a food reward would drop out when the dog tipped the container, and the other had no hole. In this way, both containers appeared visually identical to the dog during testing. For all trials, food was placed in both containers but was only available in one container for each trial. By switching lids, we were able to alternate which container was the "correct" choice. Dog treats of a type preferred by each individual dog were used as bait. For the "read" condition, a rectangular table 76 cm deep by 183 cm long was placed in the testing space. Two standard metal folding chairs were set at each end of the table, and 16 books were spread out along the length of the table.

Procedure

The room was familiar to 14 of the 30 dogs. Upon arrival, each dog was given a warm-up period in the room prior to testing and was able to explore the room at liberty while the owner completed paperwork. During this period, the dog was invited to greet and become familiar with all researchers (there were either two or three researchers present, depending on the condition), establishing that the dog was not fearful of the researchers. One researcher served as the stranger and another handled the dog. For the two-stranger condition, two researchers served as the two strangers and the third handled the dog. Neither the stranger(s) nor the owner gave the dog any food rewards during the course of the procedure. The entire procedure took no longer than one hour, including habituation and testing, for each dog.

Habituation

Following the warm-up period, the dog was given four practice trials, two with each container, during which the dog learned how to tip the containers to retrieve rewards. During these trials, no gestures were used, and the stranger and owner were not present in the testing room. Any dog that showed difficulty during this pre-training phase was not included in the study. After this, the dog was taken to an outer room separated from the testing room by a 1.2-meter-high wall for all conditions except the leave condition, in which the owner and stranger went to the outer room, while the dog and handler remained in the testing room.

Testing

Dogs were quasi-randomly assigned to one of six conditions, each of which had 20 trials. In all conditions, it was determined that the dog had chosen a container when the

dog made physical contact with that container. Each dog in each condition completed 20 trials, with a brief pause between trials 10 and 11 so that dogs could drink water and rest. In all conditions, the owner and stranger, or the two strangers, changed positions such that each appeared 10 times on the dog's right, and thus, also the correct container appeared 10 times on the dog's right. The two people switched positions in the same way for all dogs, and the same side was never correct more than twice in a row. To control for the possible influence of odor, the container designated as "correct" switched each time the dog made a correct choice (i.e., touched the correct container). The dog was not present in the testing room while the containers were being reset, and the people were changing positions.

Owner-correct condition

In the owner-correct condition, the owner pointed to the correct container during all 20 trials (i.e., the one with the open lid, which would deliver the reward). During testing in this condition (as in all pointing conditions), the two humans stood 122 cm apart in the testing room, each pointing to a container located 56 cm away, on a diagonal, such that the two containers were 142 cm apart (Fig. 1). Each container was located approximately 64 cm from the tip of the respective pointer's finger (varying somewhat depending on the height of the pointer). The two humans were positioned between the two containers, and they matched their gestures as closely as possible. Both humans looked up at the line where the wall and ceiling met, to avoid any differences in eye contact with the dog, as dogs are sensitive to humans' gaze direction (Bräuer et al. 2006; Call et al. 2003). Both humans in all pointing conditions made identical static, distal points, meaning that the point was in position when the dog was brought in, and remained in position until the dog chose a container (In the descriptions below, note that in each case, the determination of which human would be nearer to or indicate the correct container was designed to provide the most stringent test of the hypotheses). For all pointing conditions, the handler brought the dog in and released it from a point equidistant from the two containers. The handler watched the dog and released it at a time when the dog was not looking at either container or either person. Containers were never handled by the stranger or owner during any of the pointing trials.

Stranger-correct condition

In the stranger-correct condition, the stranger always pointed to the correct container; other than this, the arrangement was the same as in the owner-correct condition. As in all pointing conditions, the two humans were 122 cm apart and pointed to containers 142 cm apart.

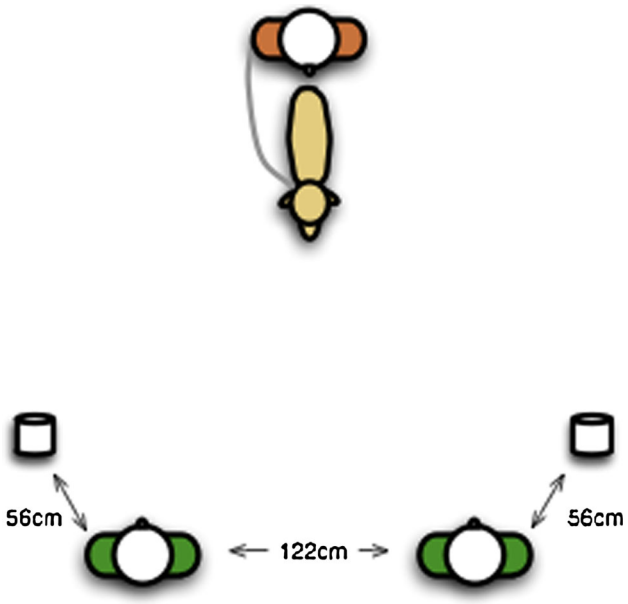

Fig. 1 Schematic illustration of the physical layout of the two-pointer paradigm

Two-stranger condition

In the two-stranger condition, the owner was not in the testing room, and instead, two strangers pointed to the two containers; in each of the two-stranger trials, one stranger would consistently point to the correct container. Other than this, the arrangement was the same as in the owner-correct and stranger-correct conditions. As in all pointing conditions, the two humans were 122 cm apart, pointing to containers placed 142 cm apart.

No-point condition

In the no-point condition, the two humans kept their arms behind their backs. Other than this, the testing setup was the same as in all pointing conditions, with the humans 122 cm apart and the containers 142 cm apart. In the no-point condition, the owner always stood next to the incorrect container.

Read condition

In the read condition, the owner always sat nearer the correct container. In this condition, the owner and stranger sat in the folding chairs, facing diagonally away from the dog's position (Fig. 2) and read books continuously during all trials. The containers were placed 142 cm from each other, and each container was placed 30 cm from the edge of each chair, on the side of the table nearest the dog's entry point. As in all pointing conditions, the handler brought the dog in and released it from a point equidistant

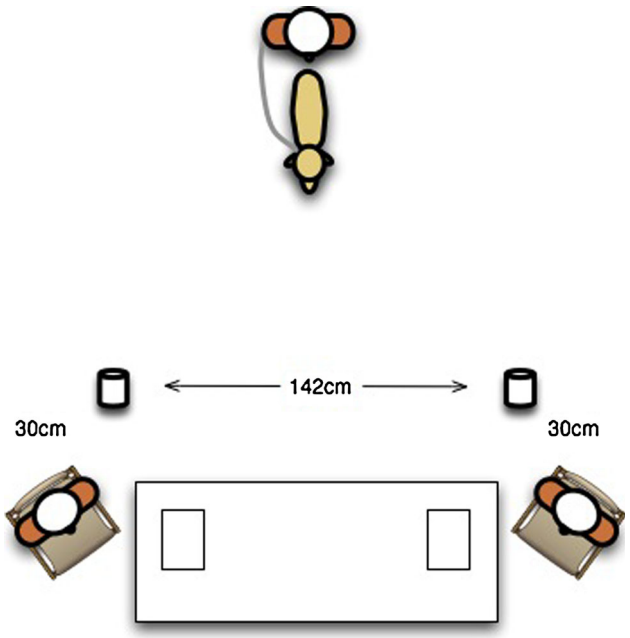

Fig. 2 Schematic illustration of the physical layout of the read condition

from the two containers, watching the dog and releasing it at a time when the dog was not looking at either container or either person. The containers were never handled by the stranger or owner during this condition.

Leave condition

In the leave condition, the handler held the dog in the testing location, while the owner and stranger entered the room and stood in marked positions 94 cm apart. (The distance between the owner and stranger was smaller in this condition due to the configuration of the room; in this latter condition, owner and stranger needed to enter from and stand near the outer door and thus needed to stand in a part of the room that was more narrow.) Each carried a container; the owner always held and shook the incorrect container. On the handler's mark, the owner and stranger looked at the dog and shook their containers for approximately one second, stopped on the handler's mark, looked at each other, placed their containers on marks on the floor at the same time, 15 cm from their feet, and then left the testing room. When they were out of sight and the door was closed, the handler released the dog to choose a container.

Analysis

For the conditions in which pointing occurred, we used ANOVA to determine whether the number of correct choices by the dog (i.e., choosing the container with food available) differed among these three conditions (owner-correct, stranger-correct, and two-stranger). We further tested dogs' performance against chance using one-sample *t* tests. We tested performance against chance in the no-point, read, and leave conditions using one-sample *t* tests. We analyzed these conditions separately because the absence of a point and the differences in experimental setup among these conditions made each a somewhat different task for the dog. We also tested dogs' tendency to choose the left- or right-side container (i.e., side bias) and their tendency to "wander" during trials using one-sample *t* tests and ANOVA. Finally, because each condition had a small sample size, we also analyzed each dog's performance individually using binomial tests. Criterion for significance was set at $p < 0.05$, and all *t* tests were one-tailed, in accordance with our directional hypotheses regarding dogs' preference for their owner's information.

Results

As predicted, there was a significant overall effect of condition (owner-correct, stranger-correct, or two-stranger) on number of correct choices, $F(2, 12) = 7.75$, $p = 0.007$. In the owner-correct condition, dogs made an average of 12.8 (SD = 2.6) correct choices (i.e., chose the owner's container). In the stranger-correct condition, dogs made an average of 8.2 (SD = 1.8) correct choices (i.e., chose the stranger's container). Thus, even when the owner's container was the incorrect choice, dogs chose it on average 11.8 (SD = 1.8) times out of 20. In the two-stranger condition, dogs chose correctly an average of 10.0 (SD = 0.7) times.

We tested whether performance in the owner-correct and stranger-correct conditions was significantly different in terms of how often the dog chose the owner's container. This difference was not significant, $t(8) = 0.71$, ns. Therefore, to increase power, we combined these two conditions and tested dogs' performance against chance. Dogs in these two conditions combined chose the owner's container on average 12.3 (SD = 2.2) times out of 20, significantly more often than chance, $t(9) = 3.36$, $p = 0.008$ (95 % CI 0.75–3.85). Indeed, no dog in these conditions ever chose the stranger's container more often than they chose the owner's container.

In the no-point condition, the stranger was always standing nearer to the correct container. Dogs chose correctly (i.e., the stranger's container) an average of 6.60 times (SD = 2.41) out of 20 trials, significantly less often than chance, $t(4) = 3.16$, $p = 0.034$ (i.e., they chose the owner's container significantly more often than chance; 95 % CI −6.39 to −0.41).

In the read condition, the owner was always sitting nearer to the correct container. Dogs chose correctly (i.e.,

the owner's container) an average of 10 times (SD = 1.22) out of 20, which was not significantly different from chance, $t(4) = 0.00$, ns.

In the leave condition, the stranger always indicated the correct container. Dogs chose correctly (i.e., the stranger's container) on average 7 times (SD = 2.00) out of 20, significantly less often than chance, $t(4) = -3.35$, $p = 0.028$ (i.e., again, they chose the owner's container significantly more often than chance; 95 % CI −5.48 to −0.52).

Dogs in all conditions also appeared to be using a second strategy for choosing between the containers. Many dogs appeared to be exhibiting a side bias: They preferred the container on the left or right. Combining dogs' preferences for either left or right, dogs chose one side or the other significantly more often than chance, $t(29) = 8.23$, $p < 0.001$ (95 % CI 3.73–6.20). There was a slight tendency for dogs to prefer the container on the left (mean = 10.77 out of 20 trials, SD = 5.99), but this effect was not significantly different from chance, $t(29) = 0.701$, ns. The side bias was not significantly stronger in any one test condition over the others, $F(5, 24) = 1.04$, ns.

We also examined each dog's performance against chance (Table 1). In total, 8 of 20 dogs had a significant preference for the owner's container in the four conditions in which the owner was present and gave a signal (i.e., the owner-correct, stranger-correct, no-point, and leave conditions). Of the 12 dogs in these conditions whose preference for the owner did not reach significance individually, 9 of these exhibited a significant side bias, preferring either the left-side or right-side container significantly more often than chance. In comparison, none of the 5 dogs in the read condition showed a significant preference for the owner's container, and none of the 5 dogs in the two-stranger condition chose the correct container more often than chance. Six of the 10 dogs in these two conditions showed a significant side bias.

Finally, we examined whether dogs' motivation was different among the different conditions, by examining the number of trials on which dogs "wandered" around the room (i.e., any behavior besides moving in a direct line toward a container, such as sniffing the floor, walking in a direction away from either container, standing still, or watching the handler) before choosing a container. When tested using an ANOVA comparing all conditions, dogs did not wander significantly more often in any one condition, $F(5, 24) = 1.94$, $p = 0.13$. In the owner-correct (pointing) condition, dogs wandered on 0.40 (SD = 0.89) trials; in the stranger-correct (pointing) condition, dogs wandered on 0.40 (SD = 0.55) trials; in the no-point condition, they wandered on 0.8 (SD = 1.79) trials; in the two-stranger condition, they wandered on 0.40 (SD = 0.89) trials; in the leave condition they wandered on 2.00 (SD = 3.46) trials; and in the read condition they wandered on 4.40 (SD = 4.72) trials. Moreover, four dogs wandered in the read condition, whereas no more than two dogs wandered in any of the other conditions. These results suggest that dogs may have had a somewhat greater tendency to wander in the read condition.

Table 1 Individual dogs' performance in each condition

Dog	Correct choices[a]	Side bias
Owner-correct condition		
P003	14*	12
P004	15*	15*
P006	15*	15*
P008	10	20*
P010	10	20*
Stranger-correct condition		
P001	6*	14*
P002	10	10
P005	7	13
P007	8	18*
P009	10	14*
Two-stranger condition		
C001	10	20*
C003	10	12
C004	9	13
C005	10	16*
C006	11	11
No-point condition		
NP001	4*	12
NP002	8	10
NP003	9	15*
NP004	4*	14*
NP005	8	16*
Leave condition		
L001	9	15*
L002	9	19*
L004	5*	11
L005	5*	13
L006	7	15*
Read condition		
R002	8	10
R003	10	18*
R004	10	20*
R005	11	19*
R006	11	19*

* $p < 0.05$

[a] "Correct choices" corresponds to choosing the owner's container for the owner-correct and read conditions; "correct choices" corresponds to choosing the stranger's container for the stranger-correct, no-point, and leave conditions. The owner was not present in the two-stranger condition

Discussion

The goal of our study was to investigate the influence of familiarity on the problem-solving behavior of domestic dogs. Our results show that various kinds of information provided by the dogs' owners affected the way that the dogs performed on a food-choice task. First, dogs did not attend to all humans equally; they preferentially focused on and were influenced more by familiar humans. When given the choice of a familiar versus an unfamiliar human information source, dogs preferred the familiar source, even when this source repeatedly provided information that led to no reward. These results were significant when analyzed both from the perspective of the number of correct choices and the strength of dogs' preference, compared to chance, for the owner's container. Regardless of whether the owner was providing accurate information, dogs in general continued to respond preferentially to this information. This was true whether or not the familiar human remained in the testing space when the dog was making a choice, as indicated by dogs' preference for the owner's container in all pointing conditions, the no-point condition, and the leave condition. However, notably, the preference for the owner's container disappeared in the read condition, when the owner was no longer providing any kind of social signal that could give the dog information regarding which container to choose. In the read condition, in spite of the owner's consistent proximity to the correct container, dogs chose at chance.

Although across conditions some dogs more strongly preferred the owner's container than others, no dog ever chose the stranger's container more often than chance, with the exception of one dog in the read condition that chose the stranger's container 12 times. However, dogs in this study did not rely entirely on human social signals when solving the task. They also relied on at least one non-social source of information in making their decisions: Specifically, our results revealed a side bias, in which dogs tended more often to choose either the container on the right side or the left side. Some dogs had a right-side preference and some had a left-side preference, and neither preference was seen significantly more often. Interestingly, many dogs that had a side bias would only choose the non-preferred side when the owner was standing on that side, revealing an apparent combined use of one social and one non-social strategy to solve the task. It is notable that, in spite of this strong source of noise in our results, the preference for the owner's container remained a robust finding. These results also demonstrate that dogs are not simply automatically deferring to a familiar human. Instead, they are actively engaging in attempts to solve the task, and one of their preferred strategies is to attend to the behavior and/or location of a familiar human.

This active reliance by dogs on both social and non-social strategies has been seen in other contexts (e.g., Erdohegyi et al. 2007; Pongrácz et al. 2008). Other pointing studies have similarly found that dogs tend to develop a side bias. For example, McKinley and Sambrook (2000) tested dogs' ability to use a variety of human gestures to find hidden food and found that when the cue was particularly subtle (e.g., the human gazed at the correct container), dogs that happened to get rewarded in one or another location would develop a preference for that location. They found that this effect was especially apparent in trials in which the dogs received no physical cuing from the experimenter. In a similar example, Gácsi et al. (2009) found that 53 % of their dogs that failed on a standard pointing task did so because of a strong side bias that developed after success in the first two trials. In a somewhat different paradigm, Szetei et al. (2003) found that dogs would override olfactory cues to follow a human point, except when the odor cues were extremely strong; that is, they would override a social strategy with a non-social one only when the non-social information was especially unambiguous. Thus, a side bias seems to be a common strategy that dogs adopt in food-finding tasks. However, dogs in this study were clearly relying on a social strategy as well, which involved a clear preference for the owner, and this preference appeared to be specific to social information that the dog was taking from the owner.

Some specifics of how this reliance on social strategies may work in dogs become clear when comparing the various experimental conditions. The no-point condition demonstrated that a point was not necessary for a dog to choose the owner's container. In this condition, dogs preferred the container that the owner was merely standing nearer to. This result demonstrated that an explicit gesture by the human was not required; dogs seemed to be influenced by the owner's position in space in this condition. However, position in space was clearly not itself adequate to influence dogs: They performed at chance in the read condition, in which the owner sat near the correct container while facing away and reading. Thus, having the owner stand near the container while facing the dog induced dogs to choose the owner's container more; having the owner sit facing away, with attention on a book, did not. It is not entirely clear from these results which aspects of owners' behavior were required to cause a difference in dogs' performance, but it is likely that these aspects include the direction the owner was facing and whether the owner's attention was taken up with another task. Regardless of which aspects of the owner's behavior were most salient, the comparison of these two conditions strongly suggests that dogs were interpreting the humans' behavior as a social signal in all conditions except the read condition and that they demonstrated a preference not merely for the

owner's physical location but for the owner's *signal*. Indeed, our results reflect similar findings by both Cooper et al. (2003) and Udell et al. (2011) demonstrating that dogs also preferred to beg from (i.e., send a social signal *toward*) a human whose attention was free, compared to one whose attention was diverted (i.e., with back turned or while reading a book, both of which mirror the procedure used in the current study).

Results of the leave condition strengthen this interpretation by further demonstrating that the owner's immediate presence in the room was not required to induce dogs to choose the owner's container more often. When owners provided a clear social signal to dogs (i.e., held and shook the container while looking at the dog) and then left the room, dogs preferred that container. Notably, in this condition, the owner and stranger had to leave the room via a doorway that was positioned slightly to the dog's right; yet dogs continued to prefer the owner's container even when it was positioned on their left, meaning that they had to move away from the owner's last visible location to go to it.

On the basis of the no-point condition's results alone, it could have been argued that the observed preference for the owner's container was reducible to local enhancement: The dog being drawn toward the owner due to a history of reinforcement and then investigating the container that it incidentally finds there. However, we believe that dogs' performance in the read and leave conditions contradicts this interpretation. When the owner was present and thus his or her physical location might have provided a compelling cue for local enhancement, yet his or her attention was elsewhere, dogs chose at chance. On the other hand, when the owner was absent, and thus, the dog could not be drawn toward his or her location, but the owner had provided a clear signal to the dog before leaving, the dog preferred the owner's container. Anecdotally, it was only in the read condition that dogs would occasionally run first to the owner's location and then appear to subsequently "notice" one or the other container. Notably, even in these trials, the dog did not then necessarily choose the owner's container over the experimenter's.

However, regardless of the mechanism by which it operates, our main finding is that dogs seemed to clearly prefer social information taken from *specific*, *familiar* humans over that of strangers and, even more importantly, that they preferentially used information from this familiar person to make decisions in a foraging context, even when (in the experimenter-correct situations) this information consistently misled them. (Notably, the owner always indicated the incorrect container in the leave condition and sat nearer the correct container in the read condition; in this way, the experimental setup was not biased in favor of our hypotheses.) Thus, even if local enhancement could be considered a mechanism by which dogs' preference for their owner arose or was demonstrated, the salient result remains the fact that in no condition did dogs demonstrate preferential behavior toward the stranger. This result is not trivial; it could easily have been argued that dogs might prefer the stranger's container due to neophilia or that dogs might learn during the task which person was indicating the correct container. But they did not; dogs' tendency to rely on social information from their owners when finding food, regardless of its mechanism, was robust.

Conclusion

Why do dogs show this preference for social signals provided by a familiar human? Our results do not directly address the question of why dogs behave in this way; however, it seems likely that some evolutionary pressures have shaped dogs in this regard. Repeatedly choosing the owner's container in the stranger-correct condition never yielded a reward, and thus, in the short term, it was not a good strategy. But we speculate that it is likely to have been a successful strategy in the long term for most domestic dogs, throughout their shared evolutionary history with humans. We believe it is likely that the domestic dog has been shaped by evolution to attend to and rely on cues provided by humans (Kundey et al. 2010; Reid 2009; Pongrácz et al. 2003), to form an affinity for specific humans (Gácsi et al. 2001, 2005), and to maintain a persistent orientation toward or preference for cues provided by those familiar humans (Elgier et al. 2009; Prato-Previde et al. 2007; Topál et al. 1997). This suite of traits is likely to have led to fitness benefits in a variety of ways (Coppinger and Coppinger 2001) and thus could be influencing dogs' choice of strategies when they are faced with tasks that can be solved via both social and non-social means.

Although our study does not speak to the mechanism by which this strategy choice might operate, we advance one plausible explanation, which is consistent with our results as well as with prior evidence. Dogs persist in a state of general dependence on humans, and we suggest that they therefore show a suite of behaviors characteristic of and beneficial to dependents. For example, they have a tendency to attach to specific humans (i.e., form preferential, relatively long-lasting bonds with individual people; Palestrini et al. 2005; Topal et al. 1998, Tuber et al. 1996), to orient preferentially to these humans, and to look to these humans (or at a minimum, to humans in general) to solve various problems (see Topál et al. 1997, for a similar argument). This use of the social relationship in their problem-solving strategies, over other kinds of more non-social, independent strategies, is reflected in a variety of findings. For example, when faced with an unsolvable object-manipulation task, dogs quickly initiate and maintain a gaze toward the owner (Miklósi et al.

2003). Further, dogs will reposition themselves in order to view a human informant, but will not do so to view an inanimate information source (McMahon et al. 2010).

This dependence may also explain why dogs' performance in some tasks is hampered by the presence of humans (e.g., Erdohegyi et al. 2007; Topál et al. 2006, 2009). For example, dogs will choose a smaller over a larger pile of food, and a less desirable over a more desirable type of food, if their owner or an experimenter has shown interest in the smaller or less desirable food (Marshall-Pescini et al. 2011, 2012). Findings such as these have at times been considered to reflect a deficiency in the dog's cognitive or problem-solving ability. An alternative interpretation, however, is that the dog is choosing a human-oriented social strategy that, in the long run, has benefited the dog, which simply fails to benefit the dog in the specific setup of a given study. Poor performance in a given task may reflect a mismatch between dogs' preferred social means of solving that type of task, and the non-social strategy that would lead to a correct response in that particular experimental setup.

In conclusion, although dogs in the current study relied on both social and non-social strategies to solve the task, no dog ever used a social strategy that involved a preferential reliance on the information provided by a stranger, even when the stranger consistently indicated the accessible food source and the owner consistently did not. When dogs did not clearly prefer the owner's cue, this was often due to their use of a non-social strategy (i.e., a side bias), which indicates that dogs were actively attempting to solve the task, rather than simply deferring to humans. Our results support the claim that dogs not only strongly prefer familiar humans, but they also look to and are more strongly influenced by signals coming from these humans compared to those of strangers. A question for further research is whether this is an effect of domestication (and therefore would be seen in other domesticated species) or instead is perhaps specific to the dog–human relationship.

Acknowledgments We thank Kelly Dunbar, Sierra Eisen, Desiree Rogers, Susan Iyican, Anna Waismeyer, Mikel Delgado, and Aryn Hervel. We also thank the Committee on Research at the University of California, Berkeley; our dog participants and their people; and the University of California Chancellor's Fellowship awarded to AC.

Conflict of interest None.

Appendix

List of breeds.

French Bulldog.
Golden Retriever.
Labrador Retriever mix.
Beauceron.
Australian Cattle Dog mix.
Whippet mix.
German Shepherd.
Boston Terrier.
Rhodesian Ridgeback.
Australian Cattle Dog.
Australian Shepherd Labrador Retriever.
Mexican Hairless.
Rhodesian Ridgeback mix.
Rottweiler mix.
American Pit Bull Terrier mix.
Jack Russell Terrier mix.
Belgian Malinois.
Bearded Collie.
Cavalier King Charles Spaniel.
Cardigan Welsh Corgi.
Unidentifiable mixed breed.

We declare that these experiments comply with the current laws of the USA.

References

Bräuer J, Kaminski J, Riedel J, Call J, Tomasello M (2006) Making inferences about the location of hidden food: social dog, causal ape. J Comp Psychol 120(1):38–47

Call J, Bräuer J, Kaminski J, Tomasello M (2003) Domestic dogs (*Canis familiaris*) are sensitive to the attentional state of humans. J Comp Psychol 117(3):257–263

Clutton-Brock J (1995) Origins of the dog: domestication and early history. In: Serpell J (ed) The domestic dog: its evolution, behavior and interactions with people. Cambridge University Press, Cambridge

Cooper JJ, Ashton C, Bishop S, West R, Mills DS, Young RJ (2003) Clever hounds: social cognition in the domestic dog (*Canis familiaris*). Appl Anim Behav Psy 81(3):229–244

Coppinger R, Coppinger L (2001) Dogs: A startling new understanding of canine origin, behavior and evolution. NY, New York

Elgier A, Jakovcevic A, Barrera G, Mustaca A (2009) Communication between domestic dogs (*Canis familiaris*) and humans: dogs are good learners. Behav Proc 81:402–408

Erdohegyi Á, Topál J, Virányi Z, Miklósi Á (2007) Dog-logic: inferential reasoning in a two-way choice task and its restricted use. Anim Behav 74:725–737

Gácsi M, Kara E, Belényi B, Topál J, Miklósi Á (2009) The effect of development and individual differences in pointing comprehension of dogs. Anim Cogn 12:471–479

Gácsi M, Topál J, Miklósi A, Doka A, Csányi V (2001) Attachment behavior of adult dogs (*Canis familiaris*) living at rescue centers: forming new bonds. J Comp Psychol 114(4):423–431

Gácsi M, Győri B, Miklósi Á, Virányi Z, Kubinyi E, Topál J, Csányi V (2005) Species-specific differences and similarities in the behavior of hand-raised dog and wolf pups in social situations with humans. Dev Psychobiol 47:111–122

Gray MM, Sutter NB, Ostrander EA, Wayne RK (2010) The *IGF1* small dog haplotype is derived from Middle Eastern grey wolves. Biology 8(16). doi:10.1186/1741-7007-8-16

Hare B, Tomasello M (2005) Human-like social skills in dogs? Trend Cog Sci 9:463–464

Kubinyi E, Topál J, Miklósi A, Csányi V (2003) Dogs (*Canis familiaris*) learn from their owners via observation in a manipulation task. J Comp Psychol 117(2):156–165

Kundey S, De Los Reyes A, Arbuthnot J, Allen R (2010) Domesticated dogs'(*Canis familiaris*) response to dishonest human points. Inter J Comp Psychol 23:201–215

Marshall-Pescini S, Passalacqua C, Barnard S, Valsecchi P, Prato-Previde E (2009) Agility and search and rescue training differently affects pet dogs' behaviour in socio-cognitive tasks. Behav Proc 81:416–422

Marshall-Pescini S, Prato-Previde E, Valsecchi P (2011) Are dogs (*Canis familiaris*) misled more by their owners than by strangers in a food task? Anim Cog 14(1):137–142

Marshall-Pescini S, Passalacqua C, Miletto Petrazzini ME, Valsecchi P, Prato-Previde E (2012) Do Dogs (*Canis lupus familiaris*) make counterproductive choices because they are sensitive to human ostensive cues? PLoS ONE 7(4):e35437. doi:10.1371/journal.pone.0035437

McKinley J, Sambrook T (2000) Use of human-given cues by domestic dogs (*Canis familiaris*) and horses (*Equus caballus*). Anim Cogn 3:13–22

McMahon S, Macpherson K, Roberts W (2010) Dogs choose a human informant: metacognition in canines. Behav Proc 85:293–298

Merola I, Prato-Previde E, Marshall-Pescini S (2012) Social referencing in dog-owner dyads? Anim Cogn 15:175–185

Miklósi Á, Soproni K (2006) A comparative analysis of animals' understanding of the human pointing gesture. Anim Cogn 9:81–93

Miklósi Á, Polgárdi R, Topál J, Csányi V (1998) Use of experimenter-given cues in dogs. Anim Cogn 1:113–121

Miklósi Á, Kubinyi E, Topál J, Gácsi M, Virányi Z, Csányi V (2003) A simple reason for a big difference: wolves do not look back at humans, but dogs do. Curr Biol 13(9):763–766

Miklósi Á, Pongrácz P, Lakatos G, Topál J, Csányi V (2005) A comparative study of the use of visual communicative signals in interactions between dogs (*Canis familiaris*) and human and cats (*Felis catus*) and humans. J Comp Psychol 119(2):179–186

Palestrini C, Prato-Previde E, Spiezio C, Verga M (2005) Heart rate and behavioral responses of dogs in the Ainsworth's Strange Situation: a pilot study. Appl Anim Behav Sci 94:75–88

Pettersson H, Kaminski J, Herrmann E, Tomasello M (2011) Understanding of human communicative motives in domestic dogs. Appl Anim Behav Sci 133(3):235–245

Pongrácz P, Miklósi Á, Timar-Geng K, Csányi V (2003) Preference for copying unambiguous demonstrations in dogs (*Canis familiaris*). J Comp Psychol 117(3):337–343

Pongrácz P, Vida V, Bánhegyi P, Miklósi Á (2008) How does dominance rank status affect individual and social learning performance in the dog (*Canis familiaris*)? Anim Cogn 11(1):75–82. doi:10.1007/s10071-007-0090-7

Prato-Previde E, Marshall-Pescini S, Valsecchi P (2007) Is your choice my choice? The owners' effect on pet dogs' (*Canis lupus familiaris*) performance in a food choice task. Anim Cogn 11(1):167–174. doi:10.1007/s10071-007-0102-7

Reid PJ (2009) Adapting to the human world: dogs' responsiveness to our social cues. Behav Proc 80(3):325–333. doi:10.1016/j.beproc.2008.11.002

Riedel J, Schumann K, Kaminski J, Call J, Tomasello M (2008) The early ontogeny of human-dog communication. Anim Beh 75:1003–1014

Soproni K, Miklósi Á, Topál J, Csányi V (2002) Dogs' (*Canis familiaris*) responsiveness to human pointing gestures. J Comp Psychol 116(1):27–34

Szetei V, Miklósi Á, Topál J, Csányi V (2003) When dogs seem to lose their nose: an investigation on the use of visual and olfactory cues in communicative context between dog and owner. Appl Anim Behav Sci 83:141–152

Topal J, Miklósi Á, Csányi V, Dóka A (1998) A new application of Ainsworth's (1969) Strange Situation Test. J Comp Psychol 112(3):219–229

Topál J, Miklósi Á, Csányi V (1997) Dog-human relationship affects problem solving behavior in the dog. Anthrozoos 10(4):214–227

Topál J, Kubinyi E, Gácsi M, Miklósi Á (2006) Obeying social rules: a comparative study on dogs and humans. J Cult Evol Psychol 3(3–4):223–243

Topál J, Gergely G, Erdohegyi A, Csibra G, Miklósi Á (2009) Differential sensitivity to human communication in dogs, wolves and human infants. Science 325:1269–1272

Tuber D, Hennessy M, Sanders S, Miller J (1996) Behavioral and glucocorticoid responses of adult domestic dogs (*Canis familiaris*) to companionship and social separation. J Comp Psychol 110(1):103–108

Udell M, Dorey N, Wynne C (2010) The performance of stray dogs (*Canis familiaris*) living in a shelter on human-guided object-choice tasks. Anim Behav 79:717–725

Udell M, Dorey N, Wynne C (2011) Can your dog read your mind? Understanding the causes of canine perspective taking. Learn and Behav 39(4):289–302

Vilà C, Savolainen P, Maldonado JE, Amorim IR, Rice JE, Honeycutt RL, Crandall KA, Lundeberg J, Wayne RK (1997) Multiple and ancient origins of the domestic dog. Science 276(5319):1687–1689

Wayne RK, vonHoldt BM (2012) Evolutionary genomics of dog domestication. Mamm Genome 23:3–18