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Visual perspective taking in dogs (*Canis familiaris*) in the presence of barriers

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Abstract

Previous studies have shown that dogs have developed a special sensitivity to the communicative signals and attentional states of humans. The aim of the current study was to further investigate what dogs know about the visual perception of humans and themselves. In the first two experiments we investigated whether dogs were sensitive to the properties of barriers as blocking the visual access of humans. We presented dogs with a situation in which a human forbade them to take a piece of food, but the type and orientation of the barrier allowed the dog to take the food undetected in some conditions. Dogs differentiated between effective and ineffective barriers, based on their orientation or the particular features of the barriers such as size or the presence of window. In the third study we investigated whether dogs know about what they themselves have seen. We presented subjects with two boxes and placed food in one of them. In the Seen condition the location of the food was shown to the dogs while in the Unseen condition dogs were prevented from seeing the destination of the food. Before selecting one of the boxes by pressing a lever, dogs had the opportunity to seek extra information regarding the contents of the boxes, which would be particularly useful in the condition in which they had not seen where the food was hidden. Dogs rarely used the opportunity to seek information about the contents of the box before making their choice in any condition. Therefore, we found no evidence suggesting that dogs have access to what they themselves have seen, which contrasts with the positive evidence about visual perspective taking in others from the first two experiments and previous studies.

Keywords: Dogs; Visual perspective taking; Metacognition

1. Introduction

Knowing and exploiting what others can and cannot see may provide several advantages for animals living in social groups. First, knowing what others can see may help

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individuals scrounge information from conspecifics. For example, following the gaze of another may lead an individual to discover interesting sights such as food, predators, and other group mates. Second, in competitive situations over limited resources, knowing what others can see may be advantageous, particularly for subordinates, when deciding whether to approach and take a piece of food in the presence of a dominant. Third, in addition to knowing what others can see, another aspect that may enhance an individual's problem solving skills is having access to what they themselves have or have not seen. This ability may, for instance, enable subjects to deploy more flexible foraging skills by focusing on seeking information that is currently missing. These three aspects regarding the visual access of others and the self have been documented in nonhuman primates, mostly in chimpanzees.

However, there is no reason why other non-primate species that also live in a complex social field should not develop such social cognitive skills (Rowell, 1999). Indeed, recent studies point to quite sophisticated skills in some animals like dolphins (Herman et al., 1999; Tschudin et al., 2001), scrub jays (Emery and Clayton, 2001), ravens (Bugnyar et al., in press), and dogs (Call et al., 2003; Cooper et al., 2003). According to Cooper et al. (2003) the study of dog cognition is particularly interesting for several reasons. First, Clutton-Brock (1977) suggested that wolves were domesticated because of their highly developed social structure. Therefore, some social cognitive skills are expected. Second, dogs have been domesticated by humans, and therefore, selectively bred by humans to perform certain tasks. Third, they live with humans their entire lives so that they may develop specific social cognitive skills that enable them to interact effectively with humans (Cooper et al., 2003).

Previous studies have shown that dogs can use human gaze as a cue to locate hidden food (Agnetta et al., 2000; McKinley and Sambrook, 2000; Miklosi et al., 1998; Soproni et al., 2001). In these experiments dogs were put in an object-choice situation where they had to choose between two or more containers. The human oriented her head and eyes toward the target. The majority of the dogs chose the correct container at above chance level. And this ability is not simply learned because they do not use gaze above the container as a cue (Soproni et al., 2001). These skills are independent of the age of the tested dogs (Agnetta et al., 2000) and human contact (Hare et al., 2002). Moreover, wolves, even if they are hand reared, are not as proficient as dogs in the same experimental design to locate hidden food (Hare et al., 2002). This suggests that this is a skill that was evolved in dogs during the long time they have been living with humans (Hare et al., 2002).

Dogs are also sensitive to the attentional state of humans. Call et al. (2003) presented dogs with a situation in which a human put a piece of food on the ground and forbade the dog to eat it. In the different conditions the human left the room, turned her back to the dog, engaged in a distracting activity or closed her eyes. In the control condition she looked at the dog. Call et al. found that the dogs took more of the forbidden food in the experimental conditions where the human could not see (Call et al., 2003; see also Freedman, 1958). Similarly, Cooper et al. (2003) found that dogs may be able to perceive the distinction between one experimenter that has seen an event and an experimenter that has not seen an event.

Thus, dogs seem to have some knowledge about visual perception in others. However, the mechanism for this ability, whether the dogs just responded to a specific cue or whether they used their past experience to derive some knowledge about what the human could and could not see is not clear. One way to find out whether this is a fixed skill as opposed to a broader understanding consists of testing them in different situations. In fact, one of the things that makes the case for chimpanzees convincing is that there is convergent evidence from various sources and various skills (Call, 2001). Thus, chimpanzees follow the gaze of others around barriers and past distracters, use visual gestures when others can see them, and can also infer what others can and cannot see based on the position of barriers (Hare et al., 2000). Moreover, chimpanzees knowledge extends into knowledge about what they themselves have seen, not just what others can or cannot see (Call and Carpenter, 2001). This research is related to recent efforts to investigate the metacognitive abilities in animals (see Smith et al., 2003). These studies have shown that humans, dolphins, and rhesus macaques opt for escaping those trials that present difficult discriminations between two stimuli (thus avoiding making mistakes and not receiving a reward and earning a time-out period), but respond to one of the stimuli if the discrimination is easy (Smith et al., 1995, 1997). These results can be interpreted as evidence showing that these species know when they are likely to succeed and when they are likely to fail, and adjust their behavior accordingly. Similarly, Hampton (2001) tested rhesus macaques in a delayed matching to sample paradigm and found that subjects declined to take tests after long delays or when no sample had been offered to the animals—so that they could not know what alternative was correct. Hampton concluded that rhesus macaques knew what they remember (Hampton, 2001). In contrast, pigeons tested in a similar paradigm produced no evidence that they knew what they remembered (Inman and Shettleworth, 1999).

The aim of the current study was to further our knowledge on dogs' perspective taking abilities in two different domains. In the first two studies we investigated their knowledge about barriers as blocking others' perception. We adapted the Call et al. (2003) setup in which the experimenter forbade the dog to take a piece of food but added a barrier so that dogs in some conditions would be able to take the food undetected (Call et al., 2003). In the first experiment the orientation of the barrier varied. If the dogs were able to take the visual perspective of a human they should prefer to eat the food, when the experimenter's visual access was really blocked by the barrier. The second experiment investigated which of the two components in food retrieval (i.e., approach or food taking) was more important in controlling the dogs' behavior. In some trials, a barrier with a window only blocked the human's visual access to the dog's approach to the food and in other trials the approach to the food was visible but the food taking was hidden from the human experimenter by a small barrier. So, these two experiments did not test the sensitivity to the attentional state of the human, but knowledge about the humans' ability to observe the dog when different kinds of barriers were present.

In the third study we investigated dogs' social cognitive skills about vision, not in relation to others' visual access but the visual access of the self. In particular, we raised the question of what dogs know about what they themselves had seen. In order to test dogs' metacognitive abilities, we adapted the seeking-information paradigm that we had previously used with apes and children (Call and Carpenter, 2001). The dogs had to chose between two boxes only one of which held a piece of food. In some trials, the experimenter showed the dogs how she baited the box while in other trials the dog was prevented from seeing which one of the two boxes was baited. Before dogs selected one of the boxes by pressing a lever they were given they opportunity to explore the boxes. Thus, once dogs were released they could either choose one of the boxes or explore and then choose one of the boxes. If they knew what they had seen, they should seek for extra information in the situation in which the baiting process was hidden from them.

2. Experiment 1: the barrier test

2.1. Methods

2.1.1. Subjects

Ten dogs (3 males and 7 females) of various breeds and ages (range 1–9 years old) participated in this study (see Table 1). All subjects had been living as pets with their owners all of their lives. These dogs had received the normal obedience training typical for domestic dogs, but none had attended any training school. Dog owners were not present during the test and only the owners who expressed an interest in the design of the study were informed about it. As a precondition to participate in this study, dogs had to be interested in food and obey the experimenter when she forbade them to take a piece of food. The females were tested when they were not in estrous.

Table 1
Subjects included in Experiments 1 and 2

Dog	Breed	Gender	Age (years)	Participated in experiment
Alischa	Mongrel (Rottweiler × Doberman)	f	5	The window
Arco	Mongrel (Doberman × Fox terrier)	m (neutered)	5	The barrier
Aslan	Mongrel (Labrador × Munsterlander)	m (neutered)	5	The barrier
Auguste	Mongrel (German Shepherd)	f	1	The barrier, the window
Ben	Mongrel (Briard)	m (neutered)	3	The barrier the window
Bora	Labrador Retriever	f	0.5	The window
Jonas	Mongrel	m	9	The window
Lea	Mongrel (German Shepherd × Rottweiler)	f	4	The window
Linda	Mongrel	f	9	The barrier, the window
Lotte	Mongrel (Labrador Retriever)	f	1	The window
Lucy	Golden Retriever	f (neutered)	4	The barrier
Luna	White Shepherd	f	3	The barrier
Lupo	Mongrel (German Shepherd × Alaskan Malamute)	m	5	The window
Mogly	Sheltie	m	1	The window
Mora	Mongrel (German Shepherd × Mongrel)	f	4	The barrier
Pauline	Portuguese Water dog	f	1	The barrier
Rex	Mongrel (German Shepherd × Collie)	m (neutered)	4	The window
Senta	Saint Bernard	f (neutered)	7	The window
Shiva	Rottweiler	f	2	The barrier
Tia	Mongrel (German Shepherd × Rottweiler)	f	2	The window
Toby	Australian Cattle dog	m (neutered)	4	The window
Tommy	Mongrel (Labrador × Golden Retriever)	m	2	The window

2.1.2. Materials

The test took place in a quiet room (4.8 m × 3.6 m × 2.6 m) in which there were was a chair near to the wall to the right of the entrance where the experimenter 1 (E1) sat during the trial. One small piece of dry dog food was used as reward and placed on the floor at a predetermined position 1.2 m in front of the chair. An opaque wooden barrier (2.0 m × 1.2 m × 0.01 m) was placed either 0.2 m away and to the left of the food or between food and experimenter. All trials were filmed with a video camera, which was positioned to the right of the experimenter opposite the door.

2.1.3. Procedure

At the beginning of each testing session, E entered the room with the dog, placed a piece of food on the predetermined place and let the dog eat it. This was done to make sure that the dog was hungry and would not associate the prohibition with the predetermined location. Then the test proper started. E took another piece of food and showed it to the dog. While saying “Aus!” (in German for dogs: “Do not take it!”), calling the name of the dog and repeating “Aus!” she put the food on its predetermined position. During this command the dog was always attentive and looked at the person or the food. E made sure that the dog would not eat the food while she said “Aus!”. Then E immediately went to the chair and sat down always following the same route from the food location. The dog was able to move freely in the room during the whole trial, something that many of the dogs did. There were two conditions depending on the orientation of the barrier in relation to the E (see Fig. 1):

Visible condition: the barrier was perpendicular to the E (and to the left of the food) so that the E had unrestricted visual access to the food. During the trial, E stared at the food.

Hidden condition: the barrier was parallel to the E (and in front of the food) so that it blocked the E’s visual access to the food. During the trial E stared at the place on the barrier corresponding to the food location, which was behind the barrier.

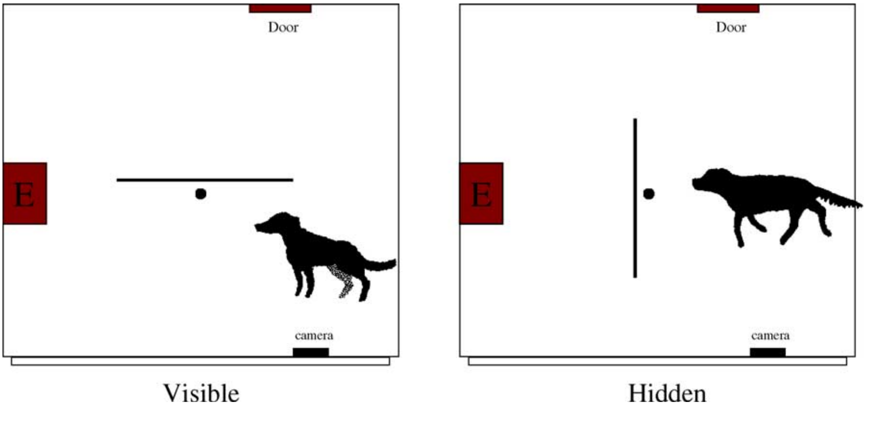

Fig. 1. Design of the two conditions in Experiment 1.

The trial ended after 120 s had elapsed at which point E got up and took the food if it was still there and led the dog outside of the room. At no point during the test or after the trial was over did E react to the dog's actions. That is, she neither praised the dog for not taking the food nor punished him/her for taking it.

Dogs received eight test trials per condition, with two trials each condition occurring each day. There was an inter-trial interval of at least 10 min, in which dogs could do what they wanted. The order of presentation of the conditions was counterbalanced across sessions and changed each day. Thus, four sessions were needed to complete the experiment.

In order to avoid the situation that dogs would learn to take the food regardless of whether it was forbidden (because there was no punishment during the test), one training trial was implemented at the end of each testing session. The training consisted of a single 120 s trial in which there was no barrier at all. E placed a piece of food on the floor and forbade the dog to take it ("Aus!"). If the dog attempted to take the food during the trial, E punished him/her verbally and physically prevented him/her from taking it. After the 120 s had elapsed, the dog was verbally encouraged to take the food. So, overall each dog received four experimental trials and one training trial per session.

2.1.4. Data analysis

We scored two variables for each trial: (1) whether the subject took the food and (2) the latency to take the food from the second "Aus!" to food retrieval. Only those trials in which the food was taken were included in the latency analysis. The determination of whether dogs took the food was completely unambiguous so no inter-observer reliability was calculated. For the latency data, one of the authors (JB) scored all trials from the videotapes and a second independent observer who did not know the purpose of the study scored a randomly selected sample of trials (25%). Reliability was excellent (Pearson correlation $r = 0.99$, $N = 73$). We used the Wilcoxon-signed-ranks test (two-tailed) to analyze the differences between conditions.

2.2. Results

Fig. 2 presents the mean number of food pieces taken in the two conditions. Dogs ate the forbidden food significantly more often in the Hidden condition than in the Visible condition (Wilcoxon $T = 34.5$, $N = 8$, $P = 0.02$).

Since training trials at the end of every session may have fostered learning to take less food in the Visible condition, we compared the number of food pieces taken in the first two sessions to the number of food pieces taken in the last two sessions. There were no significant differences in the Visible condition (Wilcoxon $T = 17.5$, $N = 7$, $P = 0.30$, NS) or the Hidden condition (Wilcoxon $T = 4.5$, $N = 3$, $P = 0.30$, NS).

Focusing on the dogs that took food in both conditions, we analyzed whether there were differences in latency to take the food between the hidden and Visible conditions. This analysis revealed no significant differences between conditions (Wilcoxon $T = 17.5$, $N = 9$, $P = 0.17$). Six dogs waited longer in the visible than in the Hidden condition whereas three showed the reverse pattern.

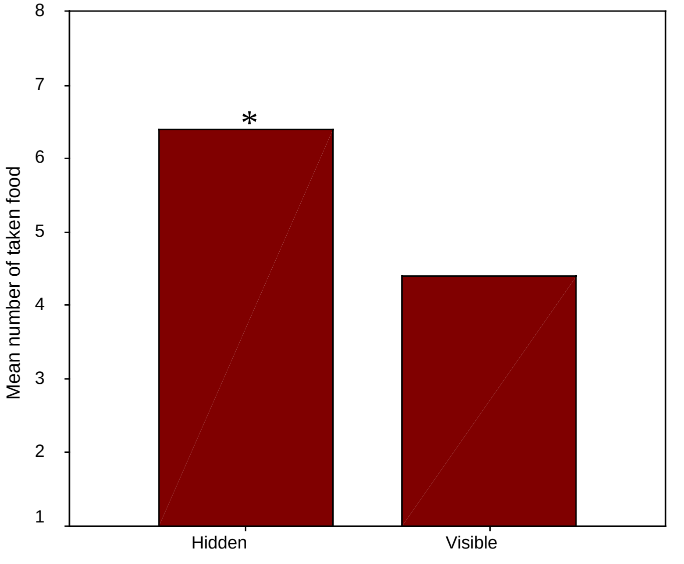

Fig. 2. Mean number of the taken food in the two conditions Hidden and Visible (* $P < 0.05$).

2.3. Discussion

Dogs took more pieces of the forbidden food when the barrier was in front of the food (so that the experimenter was unable to see the food) rather than to the side of it. There was no indication that dogs learned during the test to take more food in the situation where the food was hidden behind the barrier. Whatever skills they showed they brought to the experiment.

One possibility is that dogs learned to avoid taking food during the experiment because of the training trials and they generalized to the test situation. However, note that during the training trials, unlike the test trials, there was no barrier present, and therefore their differential response in test trials cannot be explained by some general tendency to avoid taking the food. Therefore, these results suggest that dogs take into account the orientation of the barrier in relation to the food and the experimenter. In other words, dogs took more pieces when the experimenter's visual access was blocked than when it was not blocked.

Another possibility is that with the barrier they felt more protected-like when E was absent. However this does not explain the Call et al.'s (2003) results. Nevertheless we conducted the next experiment to rule out that presence and absence determine the behavior of the dogs.

Note that our results are silent regarding the precise feature that controls dogs' differential responding in the current experiment. It seems likely that dogs are concealing the act of food retrieval, because the experimenter forbade them to take the food. On the other hand it is possible that they especially conceal their approach to the food. This explanation has some credence because dogs took circuitous approaches to food when they were being observed in a previous experiment (Call et al., 2003). In the next experiment we investigated the influence of each of these two factors on the behavior of the dogs.

3. Experiment 2: the barrier with window test

This experiment investigated which of the two components in food retrieval (i.e., approach or food taking) was more important in controlling the dogs' behavior. We presented dogs with a situation in which we manipulated these two components. In some trials (Window condition), a barrier blocked the human's visual access to the dog's approach to the food but a window cut on the barrier left the food-taking act in the open. In other trials (Small barrier condition), the situation was reversed so that the approach to the food was visible but the food taking was hidden from the human experiment by a small barrier. If dogs perceived the taking of the food as the critical component, they should take less food in Window condition than in the Small barrier condition because in the former the human was able to witness the act of taking to food. In contrast, if the approach to the food was critical, then it is expected that they will take less food in the Small barrier because the approach is blocked in the Window condition.

3.1. Methods

3.1.1. Subjects

Seventeen dogs (7 males and 10 females) of various breeds and ages (range 0.5–9 years old) and with rearing backgrounds similar to those of the previous experiment participated in the current experiment. Five of them had previously participated in Experiment 1 (see Table 1). The preconditions for the dogs to participate in this experiment were identical to those of Experiment 1.

3.1.2. Materials

The test took place in one of two quiet rooms ($4.8\,m \times 3.6\,m \times 2.6\,m$ and $4.0\,m \times 3.5\,m \times 2.9\,m$) depending on the dogs. The rooms were furnished in the same way as in Experiment 1 except that we used three barriers corresponding to the three experimental conditions. The large barrier ($2.0\,m \times 1.2\,m \times 0.01\,m$, opaque surface: $2.4\,m^2$) and the small barrier ($0.65\,m \times 0.4\,m \times 0.02\,m$, opaque surface: $0.26\,m^2$) were made of opaque wooden panels. The barrier with the window was also made of an opaque wooden panel ($2.0\,m \times 1.2\,m \times 0.01\,m$, opaque surface: $2.14\,m^2$) but with a rectangular opening ($0.65\,m \times 0.4\,m$) cut in its bottom center part. This opening, which was identical in size to the small barrier, was covered with a transparent Plexiglas panel that allowed dogs to see through it but prevented them from going through it (see Fig. 3). The barriers always stood between the experimenter and the food.

3.1.3. Procedure

Before the test started, dogs were made familiar with the window barrier. They had to sit in front of the barrier, and E moved around it and tried to get the attention of the dog through the window. After this familiarization, the procedure was exactly the same as in

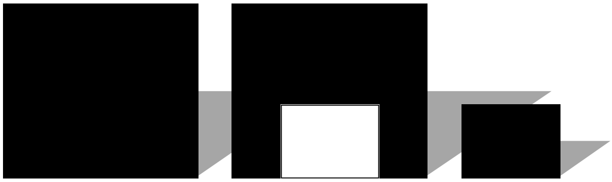

Fig. 3. Design of the three conditions Large barrier, Small barrier and Window, in Experiment 2.

Experiment 1 except that the barriers always stood between the experimenter and the food in each of the following three conditions.

Large barrier: with the large barrier in place, E could see neither the dog's approach nor its food retrieval. This condition is similar to the Hidden condition in the barrier test.

Small barrier: with the small barrier in place, E could see the dog's approach but not the food retrieval.

Window: with the window in place, E could see the dog's food retrieval but not its approach.

Dogs received eight trials per condition, with each condition occurring once per day. There was an inter-trial interval of at least 10 min, in which dogs stayed in another room and could do what they wanted. The order of presentation of the conditions was counterbalanced across sessions and changed each day. Thus, eight sessions were needed to complete each experiment. We also administered training trials in this experiment identical to those used during Experiment 1. Overall each dog received three experimental trials and one training trial per session.

3.1.4. Data analysis

We scored the same variables as in Experiment 1 and used the same non-parametric statistics to analyze the data. We followed the same inter-observer reliability procedures. Inter-observer-reliability was excellent for the latency (Pearson correlation $r = 0.99$, $N = 73$). In addition, we coded whether the dogs would hesitate while approaching the food. We scored hesitation if the dog started approaching the food and once it was within 1 m of it, the dog stopped and waited for more than 1 s or turned back and withdrew from the food. Inter-observer reliability was excellent (Cohen's kappa $= 0.79$, $N = 110$).

3.2. Results

Fig. 4 presents the mean number of food pieces eaten by the dogs across conditions. Overall, there were significant differences between conditions (Friedman $X^2_2 = 10.0$, $N = 17$, $P = 0.007$). Dogs took the forbidden food significantly more often in the Large barrier condition compared to the Small barrier (Wilcoxon $T = 45$, $N = 9$, $P = 0.007$) and Window conditions (Wilcoxon $T = 41$, $N = 9$, $P = 0.021$). There was no significant difference between the Small barrier and the Window condition (Wilcoxon $T = 33$, $N = 9$, $P = 0.20$). There were no significant differences in the number of food items taken between

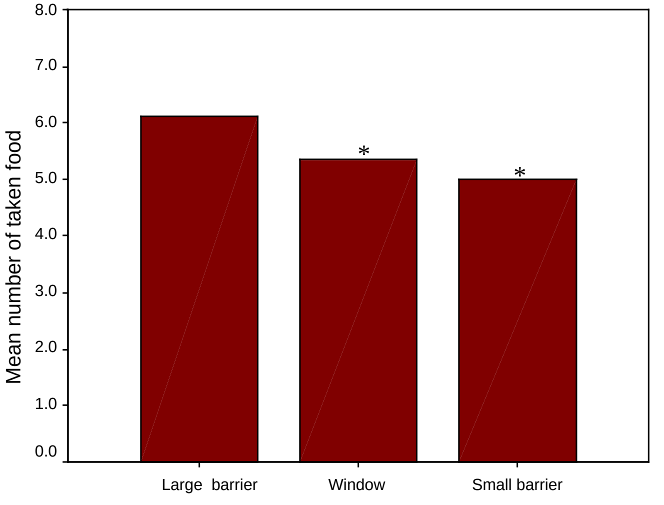

Fig. 4. Mean number of the taken food in the three conditions Large barrier, Small barrier and Window.

the first four sessions and the last four sessions in the Large barrier condition (Wilcoxon $T = 5$, $N = 4$, $P = 1.0$), Small barrier condition (Wilcoxon $T = 31.5$, $N = 9$, $P = 0.27$), or the Window condition (Wilcoxon $T = 27$, $N = 9$, $P = 0.56$).

Some of the individuals did not show any differences in the number of food pieces they took in the different conditions. Therefore, we investigated whether their latency to retrieve food pieces varied depending on the condition. The seven dogs (Auguste, Bora, Jonas, Lupo, Mora, Shiva, Tommy) that did not distinguish between the Large barrier and the Window conditions also did not show a difference in the latency to take the food (Wilcoxon $T = 14$, $N = 6$, $P = 0.46$). The same was true in the comparison between the latencies of the Small barrier and the Window conditions for the six dogs (Bora, Jonas, Linda, Lupo, Mora, Rex) that took the same number of food pieces in these two conditions (Wilcoxon $T = 14$, $N = 6$, $P = 0.46$). In contrast, the seven dogs (Bora, Jonas, Lotte, Lupo, Mogli, Mora, Tia) that took the same number of food items in the Large barrier and the Small barrier conditions took longer to retrieve the food in the Small barrier compared to the Large barrier condition (Wilcoxon $T = 28$, $N = 7$, $P = 0.018$).

The analysis of hesitation during the approach to the food indicated that the dogs rarely hesitated (5 out of 136 times in the Large barrier condition, 4 out of 136 times in the Small barrier condition, 3 out of 136 times in the Window condition). This produced no significant differences across conditions (Friedman $X_2^2 = 1.37$, $N = 17$, $P = 0.50$, NS).

Finally, we compared the performance of the five dogs (Auguste, Ben, Linda, Mora, Shiva) that participated in Experiments 1 and 2. This analysis revealed significant differences between the Window and Visible conditions (Wilcoxon $T = 15$, $N = 5$, $P = 0.041$) but no differences between the Small barrier and Visible conditions (Wilcoxon $T = 11$, $N = 5$, NS). This lends some support to the idea that dogs were hiding their approach because they treated the Small barrier (but not the Window condition) as being equivalent to the Visible condition.

3.3. Discussion

Dogs took more pieces of the forbidden food if there was a large opaque barrier between them and the human compared to the conditions where the barrier was small or had a window. This is not surprising because the large opaque barrier prevented visual access both the approach and the food retrieval act. The current results revealed no significant differences in the percentage of food taken (or the latency to take it) between the Window and the Small barrier conditions. Therefore, we conclude that dogs seem sensitive both to the approach to the food and the food retrieval act in deciding whether to take a forbidden piece of food.

As it was the case in the previous experiment, the results indicated that there was no evidence of learning during the present experiment. One could still argue that dogs may have learned in the past that punishment is unlikely if there is a large object between them and the human without any sensitivity to the attentional state of the human. This explanation, however, cannot account for the reduced retrieval rate in the Window condition compared to the Large barrier condition because the size of the barrier is identical in both conditions. Moreover, even if an explanation based on the total size of the opaque surface available is invoked to explain the difference between the Large and the Window conditions (i.e., the more opaque surface the more food they should retrieve), this cannot explain the lack of difference between the Window condition and the Small barrier condition, which has a substantially smaller opaque surface than the barrier in the Window condition.

One of the limitations of previous studies regarding the sensitivity to attentional states in humans (Call et al., 2003) is that those studies were vulnerable because the presence of certain features such as the open eyes directed at the subject could be taken as the control stimuli for those results. In other words, the dogs could have learned not to take forbidden food when the human eyes are directed at them. However, the current experiments undermine this explanation. Dogs took less food when the window cut in the barrier (Window condition) permitted the human to witness the act of snatching the food compared to the identical barrier without a window (Large barrier condition). One could argue that the difference between those conditions was produced by the dogs inhibiting their food snatching response at the last moment once they saw the human eyes throughout the window. However, results indicated that dogs very rarely stopped taking the food once they had decided to approach it. Moreover this hesitation did not differ between the conditions meaning that the dogs did not change their behavior when they had decided to take the food. Conversely, it is unlikely that our current results can solely be explained by arguing that dogs simply forgot that the human was there during the trial. Recall that the human was present and visible, albeit in different attentional conditions (e.g., back turned, distracted, or her eyes were closed) in a previous study (Call et al., 2003).

It is unclear, what is the most important factor in determining dogs' likelihood to take the forbidden food. On the one hand, it seems reasonable to take more food in Small barrier condition (compared to the Window condition) because there the human cannot see the dogs eating the forbidden food. On the other hand, concealing the approach to the food is reasonable as well. In the Window condition the dogs can get close to the food without being watched. In the moment when the dogs are visible in the window and snap for the food it is already too late for the human to intervene. Indeed it is likely that dogs are often punished already during their approach of a forbidden object. Our current results do not allow us to decide between these two factors because there were no significant differences between these two conditions. One possibility for the lack of differences may be that the window was too large, thus offering information not just about the food retrieval act but also about the approach. Future experiments could use a smaller window that leaves the food visible but totally covers the approach to it has the window cut on an irrelevant location such as one of the upper corners so that dogs can still approach and take the food undetected.

4. Experiment 3: checking before choosing

Previous experiments have revealed sophisticated skills in dogs' sensitivity to what others can or cannot see, and they make decisions based on that knowledge. One question is whether dogs are also sensitive to the information that they themselves have or have not seen. We investigated this issue by presenting dogs with an object-choice paradigm previously used with apes and children. We placed food in one of two boxes and subjects had to select one of them. In some trials (Seen condition) we showed the dogs the location of the food while in other trials (Unseen condition) we prevented dogs from seeing the destination of the food. We investigated whether subjects sought information regarding the contents of the boxes, particularly in the Unseen condition, before selecting one of the boxes by pressing a lever.

4.1. Methods

4.1.1. Subjects

Ten dogs (8 females and 2 males) of various breeds and ages (range 0.5–9 years old) participated in this experiment (see Table 2) with backgrounds similar to those of previous experiments. The precondition to be included in the study was that the dog was interested in food and able to learn to press a lever on a box to designate it as its choice.

Table 2
Subjects included in the study box

Dog	Breed	Gender	Age (years)	Participated in
Auguste	Mongrel (Shepherd)	Female	1	Part 1
Eva	German wire haired pointer	Female	6	Parts 1, 2
Jule	Labrador Retriever	Female	2	Parts 1, 2
Klausi	Mongrel (Giant Schnauzer × Dalmatian)	Male (neutered)	1	Part 1
Linda	Mongrel	Female	9	Parts 1, 2
Luna	White Shepherd	Female	3	Parts 1, 2
Mora	Mongrel (Shepherd × Mongrel mix)	Female	4	Pilotpart, Parts 1, 2
Penny	Mongrel	Female	5	Pilotpart, Parts 1, 2
Salim	Mongrel (Giant Schnauzer × Dalmatian)	Male	2	Part 1
Sissi	German Shepherd	Female	2	Part 1

4.1.2. Materials

The experiment took place in a quiet room (4.8 m × 3.6 m × 2.6 m) in which there were two identical wooden boxes (30 cm × 20 cm × 14 cm) on the floor ca. 105 cm apart. On one side of the box there was a transparent Plexiglas window with 13 small holes that allowed subjects unrestricted visual and olfactory access to the box's content. The dog could look and/or smell through that window to check whether the food was in that box or not. On the opposite side there was a lever that dogs pressed down to indicate their choice for one of the boxes. Upon pressing the lever, it made a clicking noise. During the trial the two boxes stood left and right from E who was kneeling on the floor. The dog stood at a marked place 1.5 m away and in front from the experimenter. We used two wooden barriers (0.65 m × 0.4 m × 0.02 m) to occlude the baiting process in the Hidden condition trials. All trials were videotaped from a location to the right of the experimenter. Small pieces of dry dog food were used as reward.

4.1.3. Procedure

Training: dogs learned to press the lever with its paw to choose a box on the basis of instrumental conditioning. This procedure was implemented to make sure that inspection could be clearly distinguished from choosing a particular box.

Test: the dog stayed at a predetermined place oriented toward the human (and the boxes). Before the baiting, the boxes were placed in a way that the dog was able to see that both were empty. E held up a piece of food to show it to the subject. Then she placed the food under one of the boxes in one of two ways corresponding to the two different conditions:

Unseen: the experimenter placed two occluding barriers in front of the boxes to block visual access to the baiting process and baited one of the boxes. E always put her hands first under the left, and then under the right box. Thus, in this condition the dog did not see the location of the reward.

Seen: the experimenter baited one of the boxes in full view of the dog (i.e., without any occluding barriers) and left the other box untouched. Thus, in this condition the dog knew the precise location of the reward.

After the baiting process was completed, the E turned towards the dog and closed her eyes to avoid seeing the box selected by the dog (so not to give cues about the correct choice) and issued a verbal command to release the dog from its starting position. Once the E heard the noise of the lever she turned to that side and lifted the box so that the dog could eat the food, if it was there. Then she lifted the other box. If the dog was wrong in its first choice, the E prevented it from eating the food. Then the dog was brought to the starting position again and a new trial began.

We conducted two variations on this test in succession depending on the arrangement of the boxes. First, we tested all dogs with the boxes placed in a way that the lever was 45° from the dog's starting position (and the window was at 225°). The distance between the levers was 1.75 m, and the smallest distance between the corners of the boxes was 1 m (see Fig. 5). So if dogs wanted to inspect the box's contents before pressing the lever, they had to come around the box while suppressing their tendency to press the lever. Second, we tested six of the dogs again with an arrangement in which the lever was on the opposite side of their

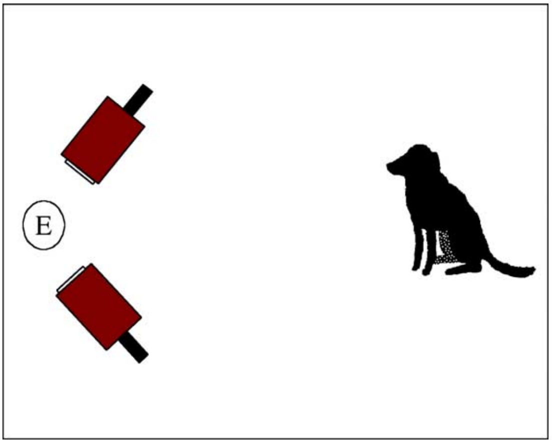

Fig. 5. Design of the Experiment 3 (first arrangement).

starting point (180°) and the window was directed towards the dogs and with its lower part covered with tape, so that the dogs could see the piece of food only if they were standing in front of the box. This arrangement presumably reduced the costs of checking by decreasing the tendency to press the lever right away because dogs had to come around the box to do so.

Every dog received 24 trials per condition in each of the two arrangements. Each condition occurred six times per session, and there were not more than two sessions per day separated at least by a 30-min interval. Thus, every dog received four sessions with 12 trials in one part of the experiment. The order of presentation of the conditions was counterbalanced across sessions, but the food was hidden on one side not more than three times in a row.

The following variables were scored for each trial: (1) whether the subject selected the baited box; (2) the latency to choose a box; and (3) how often the dog checked through the Plexiglas window before choosing. Choosing the baited box consisted of pressing the lever of the baited box and the latency to choose consisted of the time elapsed from the issue of the releasing command and the first sound produced by the lever once the dog pressed it. Checking consisted of moving to the box so that the dog's mouth was less than 10 cm away from the window for at least 0.5 s. One of the authors scored all trials from the videotapes. A second independent observer who did not know the purpose of the studies scored a randomly selected sample of trials (25%) to assess inter-observer reliability for the latency to take the food. Reliability was excellent for the latency (Pearson correlation $r = 0.99$, $N = 156$), and also for the checking behavior (Cohen's kappa $= 0.82$, $N = 156$). We conducted no reliability analysis for which box they selected because this variable could be determined unambiguously. For the statistical analyses a two-tailed Wilcoxon-signed-ranks test and a binomial test were used.

4.2. Results

Fig. 6 presents the percentage of correct responses across conditions in the first arrangement. There was a significant difference between conditions (Wilcoxon $T = 55$, $N = 10$,

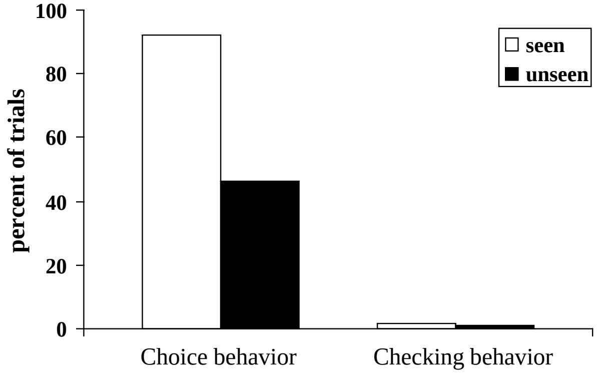

Fig. 6. Mean percent of trials with correct choices and checking behavior in the two conditions Seen and Unseen in the first arrangement.

$P = 0.01$). All dogs except Auguste were above chance in the Seen condition (binomial test: $P = 0.02$, $N = 24$), with four of them selecting the correct box in all trials, whereas none of the dogs were above chance level in the Unseen condition (binomial test: NS, $N = 24$).

In contrast, there were no significant differences in the number of trials in which dogs checked the contents of the box between conditions (Wilcoxon $T = 4$, $N = 3$, $P = 0.56$, NS; Fig. 6). Only four dogs used the opportunity of looking and/or smelling in a few trials and they did not differ between conditions. The same was true for the latencies the dogs needed to make their decision. There was also no difference between the Seen and the Unseen conditions (Wilcoxon $T = 29$, $N = 8$, $P = 0.12$).

The results with the second arrangement were comparable to those of the first arrangement. Dogs selected the correct box in 96% of the trials in the Seen condition but only in 56% of trials in the Unseen condition (Wilcoxon $T = 21$, $N = 6$, $P = 0.03$). In this arrangement all dogs checked at least once, but there was no significant difference between conditions (Wilcoxon $T = 4.5$, $N = 3$, $P = 0.41$, NS). The only difference was found in the latencies the dogs needed to make their decision. Five of the six tested dogs needed more time to choose in the Unseen compared to the Seen condition (Wilcoxon $T = 15$, $N = 5$, $P = 0.04$).

4.3. Discussion

Dogs were capable of selecting the correct box with great accuracy if they had witnessed the baiting process, but were at chance level if they were prevented from seeing the location of the food. In regard to checking behavior, dogs rarely used the opportunity to check the contents of the box before making their choice. Most importantly, dogs did not show a difference in checking behavior between the Unseen and the Seen condition. This means that they did not check more often if they had not seen where the food was located.

These results on checking behavior contrast with those of apes and children (Call and Carpenter, 2001), which unlike dogs, differentially check the contents of the box before choosing depending on whether they have seen the location of the food. It is true that there was a slight difference between the latencies the dogs needed to make their decision in the two conditions in the second arrangement. But it is unclear how to interpret this result. For instance, taking less time to choose in the Seen condition may merely reflect that subjects are more willing to walk toward the boxes when they have seen the food under one of them. Watson et al. (2001) found that dogs would decrease their speed of checking in an object permanence task with three screens after failing to find the object behind the first two screens. They argue that dogs rely on associative guidance meaning that each failure to find the object is an extinction trial for the association (Watson et al., 2001). Similarly in the Unseen condition the dogs might not really "expect" the food because they sometimes failed to get the food in the Unseen trials before.

There is another difference between the current results and those of apes. Once apes started to check the contents of the containers before choosing, they continued to do so throughout the remaining trials (Call and Carpenter, 2001). Dogs, in contrast, if they checked, they did so at the beginning of the experiment and then stopped checking. Thus, dogs rarely checked before they chose, and if they did they stopped checking after a few trials. Only a single dog (Mora) checked frequently before choosing the correct box and was above chance in the Unseen condition. However, she always checked regardless of whether she had seen the location of the food or not. This means that dogs in principle are able to gather information to find the food, but we find no evidence that they deploy their search behavior depending on what they have witnessed.

It is conceivable that our negative results may be a consequence of the design of the present experiment. One main difference between the current and previous studies is that dogs had to learn by instrumental conditioning to press the lever to show their decision. This was necessary to clearly distinguish a choice response (pressing the lever) from a checking response (pawing the box). So, perhaps, dogs automatically pressed the lever to receive the reward regardless of the information they possessed about the food. In other words, dogs had problems inhibiting the pressing response despite their lack of information about the contents of the boxes. The fact that dogs checked more often in the new arrangement where the costs for looking and smelling were reduced due to the orientation of the boxes—recall that the lever was on the opposite side of the dog's starting position—lends some support to this interpretation. Interestingly, chimpanzees and orangutans check more often if there is a delay between baiting and choosing, when "they do not have to inhibit the powerful responses elicited by the prospect of getting the reward" (Call and Carpenter, 2001).

In sum, although dogs were able to accurately select the correct container when they had witnessed the baiting (and were at chance levels when they had not seen the baiting), they did not check differentially before choosing depending on whether they had or had not see the baiting. This raises the possibility that dogs like pigeons (Inman and Shettleworth, 1999), but unlike apes, monkeys, and dolphins (Hampton, 2001; Smith et al., 1995, 1997), do not have access to their own perceptual or knowledge states. However, future experiments should pursue this issue further by reducing the costs for checking and also increasing the potential benefits (e.g., the value or quantity of the food). Certainly it would be interesting to create a test based on another sensory modality (e.g., audition) that may be more important for the dogs than vision. As well escape-response experiments comparable to those used with other species.

5. General discussion

The current three experiments produced clear results regarding dogs' understanding of visual perception. The first two experiments showed that dogs are sensitive to the properties of barriers as blocking devices for visual access in humans. In particular, they differentiated between good and less good barriers based on their orientation (Experiment 1) or the particular features of the barriers such as size or the presence of window (Experiment 2). In contrast, the last experiment on their understanding of their own need for visual access produced no evidence that dogs are sensitive to their own visual experiences.

Focusing first on the barrier studies, these results complement previous investigations on this field and strengthen the case for a sophisticated system of perspective taking in dogs (Call et al., 2003). In the current experiments the open eyes could not be taken as the stimuli for the dogs because in some conditions the eyes of the experimenter were not visible for the subjects. It is also unlikely that our results can solely be explained by arguing that dogs simply forgot that the human was there during the trial because the human was present and visible in a previous study (Call et al., 2003). The dogs preferred to be blocked by a large barrier when they took forbidden food meaning that both components in food retrieval (i.e., approach and food taking) seem to be equally important in controlling their behavior.

All together, these results suggest that dogs seem to use an allocentric perspective rather than egocentric perspective to gauge the visual access of others under various conditions. In other words, their choices are based on what others can or cannot see rather than whether the subject can or cannot see others. Other recent studies have also indicated that dogs may know more about others' visual perspective than previously thought. For instance, Cooper et al. (2003) found that dogs prefer to select a container indicated by a human that had witnessed the baiting compared to a human who had not seen the baiting (Cooper et al., 2003). Miklosi et al. (unpublished data) also found that dogs are sensitive to the body orientation of humans when begging for food. Dogs preferred to beg food from humans whose face (and eyes) they could see rather than from those whose face and eyes were not visibly available. In another experiment the investigators found that two dogs would bring a toy in the visual field of the human, if he had turned away (Hare et al., 1998). These results are comparable to those found in chimpanzees and better than those in monkeys (Hare et al., 2003; Kummer et al., 1996).

In contrast to the previous evidence about visual perspective taking in others, we found no evidence suggesting that dogs have access to what they themselves have seen. Thus, dogs know what humans can and cannot see but do not know what they themselves have seen. This dissociation between the results on perspective taking about others and the self is puzzling. It is often assumed that information about the self may be basic for inferences about others' perspective. Yet, our data on dogs seem to call this assumption into question. One possibility is that dogs failed our task due to other reasons besides a metacognitive limitation. Indeed dogs may have known what they had seen but they were not able to deploy the appropriate search behavior to remedy this situation. In other words, they knew that they ignored the location of the food but they failed to seek information to make an informed choice. However, this idea is not well supported by our current data because some dogs sought information at the beginning of testing and then stopped their search attempts. Another possibility is that even though subjects are capable of deploying the search behavior, the urge to press the lever is so strong that they cannot resist approaching the lever and pressing it regardless of their state of information. This idea is partly supported by the observed increase in search responses in the second arrangement in which the lever was farther away from the dogs' starting point. Note however that the increase in search responses occurred both when the dogs had and had not seen the location of the food. This means that dogs still did not differentiate between the two types of trials despite of the different degree of success that they had in each condition.

6. Conclusion

We found that dogs take into account the orientation and the type of visual barriers when attempting to take forbidden food in the presence of a human. These results can be added to the mounting evidence showing that dogs have sophisticated knowledge about the visual perspective of others. Paradoxically, we found no evidence suggesting that dogs have access to what they themselves have seen.

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