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Following human pointing: Where do dogs (*Canis familiaris*) look at to find food?

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ABSTRACT

Domestic dogs (*Canis familiaris*) are notably skillful in following cues from people (e.g., pointing gestures). However, not much is known about the processing of information available during such tasks. We here focus on one of the earliest of such processes, namely attention. The goal of the present work was to describe variations in dogs' attention towards diverse targets while they solve an object choice task with human pointing. The direction of subjects' gaze was measured in the period comprising one second before and two seconds after the experimenter called the dog and simultaneously performed a static distal pointing gesture towards the correct bowl. We did two consecutive training phases: acquisition and extinction. Dogs spent more time watching the pointer than the pointing gesture itself and the correct than the incorrect bowl. Indeed, the time spent watching the correct bowl was the best predictor of correct choices across phases. We discuss the relevance of these findings for the process of local enhancement.

1. Introduction

Attentional processes involve the ability to focus perception in a particular stimulus while other items are filtered out (e.g., Posner et al., 1980). Gaze direction and pointing, as social stimuli, are of special importance to coordinate shared attention on a relevant object (Porciello et al., 2014). Moreover, this ability could be the basis of more complex socio-cognitive skills (Emery, 2000).

Domestic dogs (*Canis familiaris*) share many social contexts with humans and they are notably skillful in following cues from people (e.g., pointing gestures) to solve diverse problems and acquire access to reinforcers (e.g., Elgier et al., 2009).

The object choice task (OCT) is one of the most used tests to study dogs' capacity to follow human pointing. In it, the experimenter hides food in one of two or more recipients, and the dog has to find the reward by following the human signal. Dogs are capable to use several cues such as proximal pointing and body position (e.g., Miklósi et al., 1998; Braüer et al., 2006).

Despite this evidence, not much is known about the cognitive processing of information available during the OCT. We here focus on one of the earliest of such processes, namely attention. Attentional processes would play a key role in determining which information is processed and used to solve the task.

Studies with humans showed that pointing triggers reflex changes in the observer's attentional state (Ariga and Watanabe, 2009; Langton and Bruce, 2000). Nonetheless, researchers have rarely focused on the role of attentional processes in socio-cognitive tests in studies of dog-human communication (Range et al., 2009), although some evidence point to their relevance. For example, Pongracz et al. (2004) showed that dogs performed better in an observational learning task if the experimenter continuously talked to the animal during demonstrations, suggesting that calling the dog's attention played an important role in its capacity to learn the task. In addition, Range et al. (2009) showed that during an observational learning task the use of human ostensive cues to increase subjects' attention impaired dogs' performance compared with another condition without ostensive cues. This result suggests that dogs could have been distracted by the ostensive cues, which impaired their ability to solve the task. In sum, these investigations suggest that understanding where dogs direct their attention in socio-cognitive tasks may help explaining disparities in their performance (e.g. Range and Huber, 2007).

The aim of the present work is to describe variations in dogs' attention towards diverse targets while they solve an OCT with human pointing. With this goal in mind, we registered the direction of dogs' gaze towards the main elements in the situation as

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a measure of their attentional focus (Mongillo et al., 2010). This behavior was registered one second before and two seconds after the experimenter called the dog and simultaneously performed a static distal pointing gesture towards the correct bowl. We did two training phases: 1) an acquisition phase in which the dog was reinforced for choosing the correct bowl; and 2) an extinction phase in which neither bowl had food.

2. Methods

2.1. Subjects

We evaluated 24 adult dogs (mean ±1 SD: 5.32 ± 4.04 years old). Twelve subjects had to be discarded because: 2 showed signs of excessive fear, and 10 did not reach learning criteria (see *Procedure*). The definitive sample comprised 12 subjects (1 Bloodhound, 2 German Shepherds, 1 Border Collie, 1 Retriever, 1 Poodle and 6 dogs of mixed breeds) of which half were females. All subjects lived with their owners as pets and did not have any specific training. Only one of them had previously participated in a problem solving task that did not involve human cues (Barrera et al., 2015).

2.2. Materials

We used two opaque bowls (20 cm in diameter, 8 cm high) with a double bottom where five pieces of chicken were hidden to control for odor cues. The bowls were placed on the seat of two chairs in between which the experimenter (E) stood. For the proximal pointing task, the E was at a distance of 20 cm from each bowl, whereas, for the distal pointing task, the chairs were moved away from the E so that the E stood at a distance of 50 cm from each bowl. At the beginning of all trials, the subject stayed with a handler 1.5 m from the E, facing the two bowls. Two video cameras (SONY DCR-SR88) were placed behind and above each bowl to register the subject's gaze during the task. A third camera (SONY DCS-W35) was placed in front of the other two cameras, next to the handler, to register the pointing gesture and the subject's choice.

2.3. Procedure

The procedure comprised four phases.

1) *Pre-training*: the E showed the dog a piece of chicken, placed it in a bowl, and made a static pointing gesture towards it until the dog approached the bowl and ate the food. This was done twice in each side to show subjects that bowls could contain food.
2) *Proximal pointing*: immediately after *pre-training* trials, we did a 10-trials proximal pointing session. Each trial began with the E saying the dog's name for a maximum of three times, and simultaneously doing the pointing gesture towards the correct bowl (i.e., the bowl with a food reward). Then, the handler released the dog, which could access the food if it chose the correct bowl; otherwise, it did not eat chicken on that trial. If the subject did not make a choice within 15 s from the moment the pointing gesture started on the trial, we registered a "no choice" response and this response was coded as an incorrect choice. Whether the correct bowl was on the right or on the left of the E was determined randomly, with the restriction that the same side was not repeated more than twice in a row. We established a criterion of 8 successful choices out of 10 for a subject to move to the next phase. Eight subjects did not reach this criterion and were thus discarded.
3) *Distal pointing, acquisition*: this phase was similar to the previous one with the following exceptions; a. bowls were at a distance of 50 cm from the E; b. after the initiation of the pointing gesture, the handler retained the subject for 3 s before releasing (this was done to be able to register the direction of the dog's gaze during the first 2 s after the call); and c. if the subject made three incorrect choices (not necessarily consecutive) or two consecutive "no choices", two recovery trials, identical to pre-training trials, were done. We established a criterion of three recovery instances (each involving two trials) as maximum per subject. Two subjects were discarded for exceeding this limit. All subjects reached the criterion of 8 correct choices out of the last 10 during the first 10 trials, except for one subject which needed 12 trials.
4) *Distal pointing, extinction*: 1 min after the acquisition phase, the E was replaced by another E of the same gender who repeated the procedure of the previous phase, though without placing food inside the correct or any bowl.

In all cases, the inter-trial interval was set at 20 s.

3. Data analyses

The main dependent variable was the time subjects spent watching each of four possible targets (experimenter, pointing gesture, correct bowl, and incorrect bowl) during the one second before and two seconds after the experimenter pointed to the bowl,both in the acquisition and the extinction phases of the distal pointing protocol. This measure involved a frame by frame analysis of the videos. Each second of recorded video comprised 5 still frames. For the analyses and figures, frames per second were re-transformed into seconds. To analyze the time subjects spent watching each target across acquisition and extinction, for each target, we averaged the seconds spent watching that target for the first five trials of acquisition phase (ACQ1), for the last five trials of the acquisition phase (ACQ2), for the first five trials of the extinction phase (EXT1), and for the last five trials of the extinction phase (EXT2). To make comparisons between watching times we used Wilcoxon Matched Pairs tests. To assess changes in watching times in the acquisition phase, we compared ACQ1 vs. ACQ2 for each target. To assess changes in watching times from acquisition to extinction, we compared ACQ2 vs. EXT2 for each target. We compared differences in watching times among different targets in the acquisition phase using the variable ACQ2. The same was done with the variable EXT2 to compare watching times among targets in the extinction phase. Last, we also recorded whether subjects chose the correct bowl, the incorrect bowl or made a no-choice response in each trial. We used Wilcoxon Matched Pairs tests to compare the frequency of correct, incorrect and no-choice responses between phases (acquisition vs. extinction). All data was codified by one of the authors (FC) twice, whereas 100% of the data was also codified by another co-author (MB). Intra- and inter-observer reliabilities were both high (Pearson correlation coefficients, 0.94 and 0.93, respectively). We also registered the number of correct choices. All tests were two-tailed and we did Bonferroni corrections for all multiple comparisons among targets.

Finally, we assessed whether the time spent watching each target showed any association with choice performance. We did a stepwise logistic regression using the seconds attended to each target as predictive variables for correct choices in each trial of both phases. We followed a procedure of backward elimination starting with all watching targets as predictors and eliminating those that did not contribute significantly to explaining correct choices. All analyses were done using a α-value of 0.05 and the statistical software package SPSS v.19.

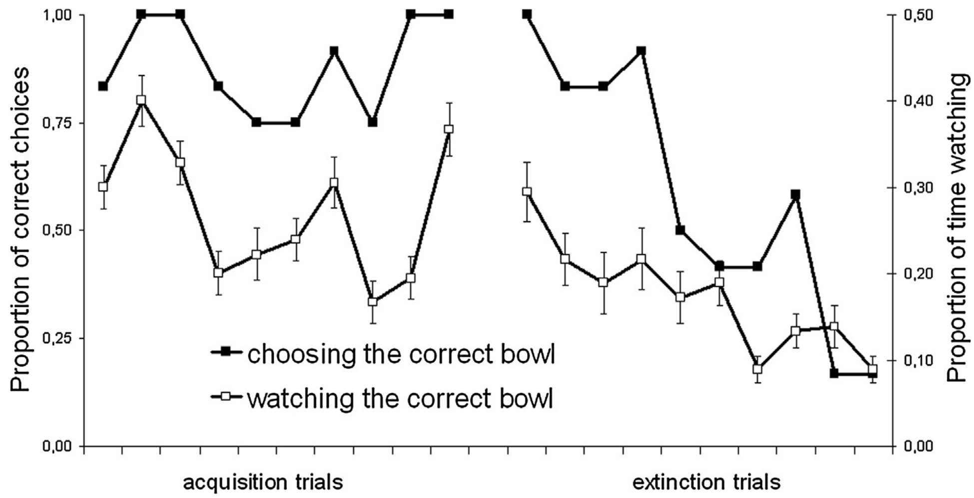

Fig. 1. Filled squares: Proportion of dogs that chose the correct bowl in each trial of the acquisition and the extinction phases. White squares: Proportion of time spent watching the correct bowl (±1 sem) in each trial of the acquisition and the extinction phases. The left y-axis indicates the proportion of correct responses and the right y-axis indicates the proportion of time looking at the correct bowl.

Table 1
Amount of seconds (mean ± 1 SD) subjects spent watching each target in the acquisition and the extinction sessions.

Target	Acquisition	Extinction
Experimenter	1.01 (±0.56)	1.26 (±0.7)
Pointing gesture	0.61 (±0.3)	0.67 (±0.4)
Correct bowl	0.82 (±0.6)	0.52 (±0.57)
Incorrect bowl	0.17 (±0.39)	0.11 (±0.26)

4. Results

4.1. Watching times in the acquisition phase

First, we evaluated whether the time spent watching each target changed across this phase. We found evidence of a significant decrease in the time spent watching the incorrect bowl from ACQ1 to ACQ2 (N = 12, Z = 1.94, p = 0.05). Watching times for the remaining targets did not significantly change (all p-values > 0.24). Second, we compared the time spent watching each target in the last trials of this phase (ACQ2). Subjects spent significantly more seconds watching the E than the pointing gesture (N = 12, Z = 2.84, p = 0.004) and the incorrect bowl (N = 12, Z = 3.06, p = 0.002), and more seconds watching the pointing gesture and the correct bowl than the incorrect bowl (N = 12, Z = 3.06, p = 0.002; N = 12, Z = 2.93, p = 0.003, respectively). All other comparisons were non-significant (all p-values > 0.028; the Bonferroni adjusted $\alpha = 0.0083$).

4.2. Watching times in the extinction phase

First, we evaluated whether the time spent watching each target changed across this phase. We found evidence of a significant decrease in the time spent watching the correct bowl from EXT1 to EXT2 (N = 12, Z = 2.27, p = 0.02). Watching times for the remaining targets did not significantly changed (all p-values > 0.62). Second, we compared the time spent watching each target in the last trials of this phase (EXT2). Subjects spent significantly more seconds watching the E than the correct bowl (N = 12, Z = 2.82, p = 0.005) and the incorrect bowl (N = 12, Z = 2.98, p = 0.003), and more seconds watching the pointing gesture and the correct bowl than the incorrect bowl (N = 12, Z = 3.06, p = 0.002; N = 12, Z = 2.82, p = 0.005, respectively; see Table 1). All other comparisons were non-significant (all p-values > 0.015; the Bonferroni adjusted $\alpha = 0.0083$).

4.3. Comparison of watching times between acquisition and extinction

We evaluated whether the time spent watching each target changed from the final trials of the acquisition phase to the final trials of the extinction phase (ACQ2 vs. EXT2). These comparisons showed that subjects significantly decreased the time spent watching the correct bowl from acquisition to extinction (N = 12, Z = 2.67, p = 0.007). A similar test for the remaining targets showed non-significant differences (all ps > 0.20).

4.4. Choices

In terms of dogs' choices, subjects had 88% and 58% correct responses in acquisition and extinction, respectively. The comparison of correct responses (choice of the signaled bowl) between phases showed a significant decrease from acquisition to extinction (N = 12, Z = 2.93, p = 0.003). Furthermore, dogs presented significantly more "no choice" responses in extinction than in acquisition (mean ±1 sem: 3.42 ± 0.7 vs. 0.08 ± 0.1; N = 12, Z = 2.66, p < 0.008). We found no statistical evidence of differences in the number of incorrect responses between phases (mean ±1 sem: 1.08 ± 0.2 in acquisition vs. 0.75 ± 0.2 in extinction; N = 12, Z = 1.07, p = 0.29).

In order to test for attentional predictors of correct choices, we did backward elimination of variables (watching targets) in logistic regression models. We found that the only variables that significantly contributed to predicting choices were the time spent watching the correct and the incorrect bowls. The final model also included phases and trials as nested variables and subjects as a random factor ($X^2_{15} = 99.26$, p< 0.001, −2LL = 179.09), showing a good fit (Hosmer and Lemeshow's test, $X^2_8 = 0.502$), and predicting 86.3% of choices. In this model, seconds spent watching the correct and incorrect bowls significantly increased and decreased the probability of a correct choice, respectively ($\beta = 0.99$, Wald $X^2_1 = 4.83$, p = 0.028); ($\beta = -2.08$, Wald $X^2_1 = 10.23$, p = 0.001, respectively; see Fig. 1).

5. Discussion

The goal of the present study was to describe variations in dogs' attentional focus while following a distal pointing gesture in an object choice task. We looked forward to better understanding which information dogs used to solve the task (Range and Huber, 2007).

In the acquisition phase, dogs spent more time watching the pointer than the pointing gesture itself or the incorrect bowl, and more time watching and the correct bowl and the pointing gesture than the incorrect bowl. The time watching the person could indicate dogs' understanding of the communicative nature of the task, meaning that they recognized the experimenter as the main source of information. Nevertheless, this measure was probably affected by the fact that the experimenter called the dog by its name in the beginning of each trial, thus inciting the animal to orient towards him or her.

An interesting result was that dogs spent relatively little time watching the pointing gesture. Indeed, this variable was more or less stable across trials. In addition to the fact that the pointing gesture was the only informative cue to the food, this result indicates that dogs do not need to pay much attention to it to use it successfully. This could be taken to suggest that the pointing gesture may be a very familiar, easily processed, cue to dogs.

In turn, the time spent watching the correct bowl was the best predictor of correct choices. This indicates that to solve the present communicative task dogs used social as well as non-social stimuli. It could be that dogs focused on the bowl because it was the cue with the closest (spatially and temporarily) association with the food, thus leading it to become a very salient signal. Evidence for this comes from the fact that subjects watched the correct bowl for longer in acquisition than in extinction, when they could learn that bowls had no food anymore.

Moreover, the fact that attention to the signaled bowl predicted choices could be related with the phenomenon of local enhancement, in which subjects pay attention to a place indicated by another individual's behavior or location (Rendell et al., 2011). This process might contribute to explain how animals find food by observing others, without the need to assume any communicative intent or understanding (Heyes, 2012). This perspective aligns with the evidence showing that learning may play an important role in the process through which dogs use human cues (e.g., Dorey et al., 2010; Elgier et al., 2012). Nevertheless, if dogs understand the human pointing referentially it would also be expected that they look longer at the signaled location. Unfortunately with the current design we could not response to this question. Further investigations need to be done in order to fully understand dogs' ability to follow human pointing.

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