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Ontogenetic effects on gazing behaviour: a case study of kennel dogs (Labrador Retrievers) in the impossible task paradigm

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Abstract Life experiences and living conditions can influence the problem-solving strategies and the communicative abilities of dogs with humans. The goals of this study were to determine any behavioural differences between Labrador Retrievers living in a kennel and those living in a house as pets and to assess whether kennel dogs show preferences in social behaviours for their caretaker relative to a stranger when they are faced with an unsolvable task. Nine Labrador Retrievers living in a kennel from birth and ten Labrador Retrievers living in a family as pets were tested. The experimental procedure consisted of three "solvable" tasks in which the dogs could easily retrieve food from a container followed by an "unsolvable" task in which the container was hermetically locked. Dogs of both groups spent the same amount of time interacting with the experimental apparatus. Kennel dogs gazed towards people for less time and with higher latency than pet dogs; however, there were no significant preferences in gazing towards the stranger versus the caretaker in both groups. These findings demonstrated that kennel dogs are less prone to use human-directed gazing behaviour when they are faced with an unsolvable problem, taking the humans into account to solve a task less than do the pet dogs.

Keywords Dog–human communication · Cognitive test · Gazing behaviour · Kennel dog · Shelter dog · Unsolvable task

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Introduction

Dogs exhibit an acute sensitivity for human social cues (see Hare and Tomasello 2005 for a review), but how these skills developed is a highly disputed subject. The "Domestication Hypothesis" proposes that the processes of natural and artificial selection of the wild progenitor of dogs caused genetic changes that allowed the animals to understand human signals using advanced socio-cognitive skills (Agnetta et al. 2000; Miklósi et al. 2003; Hare and Tomasello 2005; Hare et al. 2002, 2010). Such a theory is largely based on studies demonstrating that dogs outperformed wolves raised by humans in certain cue-following tasks (Hare et al. 2002). Furthermore, domesticated fox puppies are as skilful as dog puppies in using human gestures and, at the same time, they are also more skilled than foxes not specifically selected for tameness (Hare et al. 2005). Alternatively, the "Two-Stage Hypothesis" suggests that the capacity to follow human cues is acquired during life after having accepted humans as companions in early ontogeny and being given the opportunity to learn from them during life (Udell and Wynne 2008, 2010; Wynne et al. 2008; Udell et al. 2010). Indeed, when wolves were raised with intensive socialization with humans, they outperformed dogs in following human social cues (Udell et al. 2008).

The ability of dogs to follow human signals to obtain useful information indicates that they consider humans to be important reference points for reaching their goals. Thus, in light of the above controversies, how much this assessment depends on domestication or on life experience remains unclear.

In task studies that involve following cues, dogs can obtain a reward by following human signals where the activity of researchers inevitably catches the dog's

attention. Experimental conditions in which the experimenter is inactive leave considerably more freedom for dogs to choose whether to refer to humans when they are in difficulty. This condition is observed with the impossible task paradigm; an initially accessible apparatus containing food becomes impossible to access (see Miklósi et al. 2003). This paradigm is a useful tool for assessing the relevance of humans to dogs, assessing human-directed behaviours as a help request in an attempt to solve a task and the dog's independent decision-making when they encounter a problem that violates their expectations (Cooper et al. 2003; Hare 2004).

Within a homogeneous dog population of beagles, the impossible task demonstrated that social interactions, which include frequency and duration of both looking and physical contact with the test leader, were significantly heritable tracts (Persson et al. 2015), suggesting that there are genetic components of such behaviours. Moreover, an association between owner-directed gazing behaviour in the unsolvable task and polymorphisms in the dopamine receptor D4 gene was demonstrated; dogs carrying a shorter allele looked at their owner more frequently, for longer periods of time, and earlier than dogs carrying a longer allele (Hori et al. 2013). Miklósi et al. (2003) showed that dogs in an impossible task test gazed at the human face more than socialized wolves, which may indicate that the tendency to refer to humans by gazing may be the result of genetic selection through the domestication processes.

On the other hand, it has been shown that in the impossible task paradigm, the tendency to gaze at humans was correlated with age; older dogs expressed this behaviour more than younger dogs did (Passalacqua et al. 2011; Persson et al. 2015). Furthermore, dogs trained for certain social jobs differed in their human-directed gazing behaviour; agility and water rescue-trained dogs gazed towards humans more than did search-and-rescue and untrained dogs (Marshall-Pescini et al. 2009; D'Aniello et al. 2015). Thus, in addition to a genetic base, gazing behaviour also has a strong ontogenetic component. In this context, kennel-reared dogs can provide useful information because their lifetime is well known (i.e. they have limited social interactions with humans and have never experienced a life in a human family). We are differentiating kennel dogs from shelter dogs. Shelter dogs indeed include stray and/or abandoned dogs, which previous life experiences before coming to the shelter are unknown. Probably most of them come from a family and so they are less appropriate.

Before being delivered to a visually impaired person, trained guide dogs live in the school kennel and engage in training with a trainer for two hours per day. The interactions with other people are restricted to the guests of the school. Scandurra et al. (2015) found that, during this period, trained guide dogs have exhibited a very low gazing interest towards humans in the impossible task paradigm while preferring to attempt to solve the task independently. Guide dogs are trained to be highly autonomous in their choices when they work. Indeed, the dogs learn to be the initiators of actions and attain a certain degree of independence from their human partners (see Naderi et al. 2001). Accordingly, the dogs' limited consideration of humans in trying to individually resolve the task could be a by-product of their specific training. Therefore, in this paper, we decided to study the impossible task paradigm using dogs of the same breed born in a kennel, which had never experienced a life in a family or training, and have been living in conditions of limited social interaction with humans. The only human contact was with a caretaker once a day and occasionally with the veterinarian. The first goal of this study was to evaluate any behavioural differences between kennel dogs and those that had grown up in a family since they were puppies. This experimental approach, in addition to providing information on ontogenetic acquired behaviours, will also disentangle whether our previous outcomes in guide dogs (Scandurra et al. 2015) were the result of training or of living conditions.

In the impossible task paradigm, several studies have reported preferences for the owner, rather than a stranger, in dogs without formal training (Miklósi et al. 2005), agility dogs (Marshall-Pescini et al. 2009) and water rescue dogs (D'Aniello et al. 2015), whereas search-and-rescue dogs did not differentiate between the owner and a stranger (Marshall-Pescini et al. 2009). Thus, our second goal was to assess whether kennel dogs would differentiate their caretaker from a stranger when they are faced with an unsolvable task. We introduced a stranger into the test who was compared with the dogs' putative reference figure.

Materials and methods

Subjects

A total of 19 Labrador Retrievers (four males and 15 females) were tested: nine kennel dogs (two males and seven females; mean age ± SD, 3.5 ± 0.8 years) and ten control pet dogs which had lived with their owners since they were puppies (three males and seven females; mean age ± SD, 3.8 ± 0.5 years); none of the kennel or control dogs had formal training (i.e. neither basic obedience nor specific training). One female dog in the kennel group did not show interest in food during the solvable tasks and was excluded from the sample.

Pet dogs were recruited through personal contacts and advertisements on the internet and in parks and at

veterinary surgeries; all lived in a single house hold within a family of two/four people. All kennel dogs came from the FOOF dog museum (Caserta, Italy), which holds many breeds for exhibition purposes. Visitors are only allowed to observe the dogs; any interaction is forbidden. All animals had never experienced mistreatment and were reared in conditions that respected their primary physical needs. Labrador Retrievers live in kennels (24 m^2) chilled by a cooling system in the floor and spray in summer and heated in winter, with covered (8 m^2) and opened (16 m^2) areas. Each kennel held two dogs, except for one kennel with three dogs. These dogs had a recreational area where they could run and play freely for approximately 20 min a day. Dogs were cared for by the same caretaker for feeding and cleaning activities once a day, for 10–15 min. During this time, the caretaker does not attract the attention of the dogs and interacts with the dogs only when requested.

Apparatus and procedure

The apparatus consisted of a glass food container (10.5 × 10.5 cm) placed on a rectangular wooden platform (77 × 34.5 cm), as described previously (D'Aniello et al. 2015). The lid was fixed on the platform, and the container was placed upside down on the tracks of the lid during the solvable phases of the test and was locked onto the lid during the unsolvable phase. The wooden platform was fixed to the floor by double-sided adhesive tape. After each test, the apparatus and the container were washed with a slightly perfumed, non-toxic disinfectant.

The caretaker and a stranger were present during the test. They did not touch either the container or the food. The tests were conducted indoors. Before the experimental phase, the dogs were allowed to move freely around the room to explore and familiarize themselves with the room and with the members of the research group for about 5 min, except for the stranger, who entered only at the moment of the test. The tests were conducted in two different locations: at the University of Naples "Federico II" in Naples (room 14 m^2) and at the FOOF dog museum (Caserta) in a delimited indoor space of approximately 15 m^2. Both places were unknown to the dogs. The kennel staff and owners were asked not to feed the dogs during the 4 h prior to testing; the dog's interest in the food was ascertained by administering a limited amount of food to the dog before the test and by assessing whether the dog was willing to follow the experimenter with the food.

During all trials, a stranger and the caretaker of kennel dogs or the owner of pet dogs was present in the testing area (for simplicity, henceforth, the term caretaker will be used for both human reference figures). Prior to testing, the stranger and caretaker were instructed to maintain the same position on opposite sides of the room, situated approximately 30 cm from the wooden table on which the container was located. Throughout the test period, the two people looked straight ahead, ignoring the dog. Two researchers interacted with the dog: one held the dog while the other placed the food beneath the glass container, ensuring that the dog observed the procedure. Subsequently, the dog was let free to recover the food. After the three "solvable" trials, the two researchers left the room after locking the container covering the food and left the dog free to operate during the unsolvable phase. The duration of the unsolvable trial was 60 s (see supplementary material in Scandurra et al. 2015 for a movie).

Data analysis

The entire experimental procedure was recorded using two Sony Handycam video cameras (HDR-CX115 and HDR-PJ260VE). We focused on specific behaviours, particularly the human-directed and the task-directed behaviours listed in Table 1.

We analysed the data collected during the 1 min unsolvable trial. The duration and latency of each behaviour were recorded using Solomon Coder beta® 14.05.19 (ELTE TTK, Hungary). A second independent coder analysed a random sample of nine dogs (approximately 50 % of the sample), and inter-observer reliability on the duration of the behaviours was calculated using Spearman correlations (interaction with people: $r_s = 0.94$, $P = 0.03$; gazing at people: $r_s = 0.92$, $P = 0.04$; interaction with apparatus: $r_s = 0.96$, $P = 0.01$). Statistical analyses were carried out using nonparametric tests. The Mann–Whitney U test was used to compare the duration and latency of the behaviours between kennel and control groups. The Wilcoxon test was performed to compare the duration and latency of behaviours towards the caretaker and the stranger within the two groups. All statistical tests were performed using SPSS 21 software.

Results

All dogs, except one in the kennel group, succeeded in obtaining food in the three solvable trials and were exposed to the unsolvable trial.

Gazing behaviour was shown by all dogs tested to at least one of the two people present. In the kennel group, five of the eight dogs (63 %) gazed at their caretaker first and later at the stranger, whereas in the control group, four of the ten dogs (40 %) exhibited this behaviour towards the caretaker first. The Mann–Whitney U test showed a significant difference in the duration and latency of gazing at the people, with kennel dogs gazing at people for less time and later than the control group ($N_{kennel} = 8$, $N_{control} = 10$,

**Table 1** Behaviours recorded in our impossible task test

Categories	Behaviours	Definitions
Apparatus-directed behaviours	Interaction with the apparatus	Any behaviour involving the dog being related to the glass bowl or the wooden platform, e.g. rubbing, nosing, licking, smelling, pawing, scratching or gazing at the apparatus
People-directed behaviours	Interaction with people	The dog establishes physical contact with the caretaker or stranger, e.g. rubbing, nosing, licking, pawing a hand or leg or jumping up
	Gaze at the people	From a stationary position, dog turns/lifts its head towards the caretaker or stranger faces, without approach
Other	Mixed	Includes all behaviours mutually exclusive to the above categories that were not useful for our goal and/or expressed to very low level (i.e. moving and gazing towards the door; exploring; locomotion; passivity)

Fig. 1 Significant differences in the duration (**a**, $P < 0.01$) and latency (**b**, $P < 0.01$) of the gazing behaviour towards people in the unsolvable trial
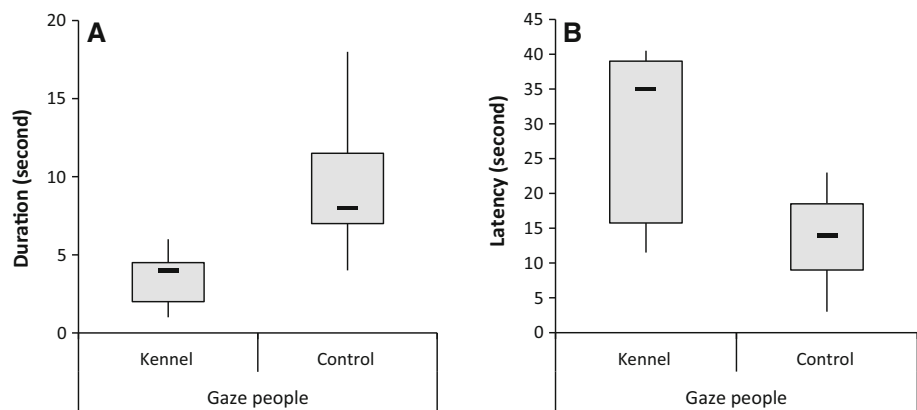
duration: $U = 3$, $P = 0.007$, Fig. 1a; latency: $U = 3$, $P = 0.007$, Fig. 1b). The duration of gazing towards the stranger was significantly lower in the kennel group than in the control ($N_{kennel} = 8$, $N_{control} = 10$, $U = 6$, $P = 0.02$); a similar trend was observed in gazing at the caretaker ($N_{kennel} = 8$, $N_{control} = 10$, $U = 9.5$, $P = 0.04$). However, no significant differences were recorded for the latency towards the stranger ($N_{kennel} = 8$, $N_{control} = 10$, $U = 13.5$, $P = 0.18$) or the caretaker ($N_{kennel} = 8$, $N_{control} = 10$, $U = 22.5$, $P = 0.85$).

Within-group comparisons did not reveal any significant differences in either group in the duration of gazing at the caretaker versus the stranger (Wilcoxon test: kennel: $N = 8$, $W = 17$, $P = 0.69$; control: $N = 10$, $W = 14.5$, $P = 0.50$, Fig. 2) or in latency (Wilcoxon test: kennel: $N = 8$, $W = 21$, $P = 0.24$; control: $N = 10$, $W = 24$, $P = 0.09$).

The amount of time that dogs spent interacting with the apparatus did not differ between the kennel and control groups ($N_{kennel} = 8$, $N_{control} = 10$, $U = 14$, $P = 0.20$). The latency to interact with the apparatus was not analysed since this behaviour was initiated immediately.
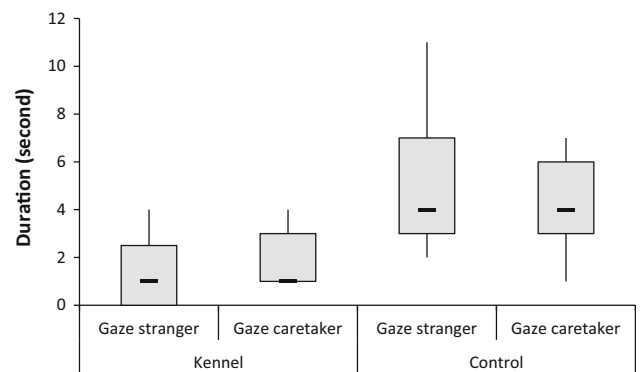
Fig. 2 Within-group comparisons of the duration of gazing at the caretaker versus the stranger did not reveal any significant differences in either group

Discussion

We studied the behaviour of kennel dogs when they were faced with an unsolvable task with the primary goal of detecting any behavioural differences from pet dogs, which live in different environmental and social stimuli. Kennel

dogs have exhibited a lower level of gazing interest towards humans compared to pet dogs, while no differences were recorded in interacting with the apparatus.

Consistent with our results, an ontogenetic effect on gazing behaviour in dogs has also been demonstrated in a different testing paradigm (i.e. problem-solving task) in which dogs with limited exposure to humans, such as those living outside the home, interacted using gazing behaviour towards humans less than those living as an integral member of a human family (Topál et al. 1997). Nevertheless, in an experimental setting in which the food was out of the dog's reach, shelter dogs gazed at human as a help request for the same duration as pet dogs (Barrera et al. 2011, 2012). Furthermore, when the food was no longer present in a problem-solving apparatus, shelter dogs gazed at humans more than pet dogs (Barrera et al. 2015). These discrepancies with our data might be attributable to the different experimental settings and/or the breeds used. Alternatively, because of the impossibility of studying dogs with aggressive behaviour or excessive fear (Barrera et al. 2012; personal observation), mixed breeds force the study of only the more sociable dogs from a shelter, and such animals usually express more gazing behaviour at human faces than less sociable individuals (Jakovcevic et al. 2012). In our paper, we selected only Labrador Retrievers, which rank very high in sociability (Svartberg 2006), thus avoiding the need for preselection. Furthermore, all of our kennel dogs were raised and had lived in the kennel since they were puppies, whereas the background histories of shelter dogs in Barrera et al. (2011, 2012, 2015) were not available. For example, certain of the shelter dogs could have been in a family for a long time before arriving at the shelter, thereby being more likely to have learned to use gazing behaviour.

Unlike our shelter trained guide dogs (Scandurra et al. 2015), we did not find intergroup differences in interactions with the apparatus in attempts to resolve the task, but only in the gazing behaviour. Thus, our current data support the view that the "independent" behaviour shown by guide dogs is gained by their specific training and not solely the result of living in the kennel. Interestingly, while social behaviour (e.g. gazing towards the human) was shaped by living in the kennel, non-social behaviour (e.g. interacting with the apparatus) was not affected by the lack of training. Conversely, guide dogs that had lived with a visual impaired person for at least one year interacted with humans in the impossible task in a manner similar to pet dogs (Gaunet 2008; Scandurra et al. 2015), which reflects their plasticity in using humans as a reference point for a resolution task following changes in their social environment.

We observed no significant preference between the stranger and the caretaker in both experimental groups. Such result not necessarily means that no such preference

exists; our sample size was small, so an overt preference could not reach the significance. Indeed, in the impossible task paradigm, preferences for the owner have emerged (Marshall-Pescini et al. 2009; D'Aniello et al. 2015) as a result of specific training. In certain training regimes and living contexts, the social cognition of the dog may provide a preferred reference figure while in other cases any human partner might be seen as potential support for task resolution (Marshall-Pescini et al. 2009; Scandurra et al. 2015).

Lower gazing behaviour, observed here in kennel dogs relative to pet dogs, was also observed in wolves (Miklósi et al. 2003) reared like dogs and tested in the same testing paradigm. Very low gazing behaviour related to the task (i.e. they do not look back at humans for assistance) in the impossible task paradigm was also observed in captive-born and socialized dingoes (Smith and Litchfield 2013), thereby supporting the importance of the domestication process on this behaviour (Miklósi et al. 2003; Smith and Litchfield 2013). However, it should be noted that dingoes originated from domesticated dogs coming from East Asia less than 5000 years ago, as evidenced by mitochondrial DNA (Savolainen et al. 2004). Recent molecular dating suggests an onset of dog domestication from 18,800 to 32,100 years ago (Thalmann et al. 2013) which implies that dingoes originated from dogs that had already undergone the domestication process for a long time. If the predisposition to gaze towards humans emerged as a specifically selected process during domestication, because of the semi-domestic state of the dingoes, we should expect that they would perform in this behaviour, if not exactly like dogs, at least to a greater extent than wolves, which have never experienced a domestication. Thus, data on dingoes are inconclusive as supporting evidence that the gazing behaviour has been affected by domestication process. In conclusion, our results indicate that, although gazing behaviour towards humans in dogs was possibly shaped by the domestication process (Miklósi et al. 2003), it is not fully revealed if not appropriately stimulated by living with humans. Thus, while data from socialized wolves support a genetic selection for the trait of referring to humans by gazing (Miklósi et al. 2003), our results on kennel dogs also highlight the relevance of ontogenetic experiences.

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