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Training for eye contact modulates gaze following in dogs

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Following human gaze in dogs and human infants can be considered a socially facilitated orientation response, which in object choice tasks is modulated by human-given ostensive cues. Despite their similarities to human infants, and extensive skills in reading human cues in foraging contexts, no evidence that dogs follow gaze into distant space has been found. We re-examined this question, and additionally whether dogs' propensity to follow gaze was affected by age and/or training to pay attention to humans. We tested a cross-sectional sample of 145 border collies aged 6 months to 14 years with different amounts of training over their lives. The dogs' gaze-following response in test and control conditions before and after training for initiating eye contact with the experimenter was compared with that of a second group of 13 border collies trained to touch a ball with their paw. Our results provide the first evidence that dogs can follow human gaze into distant space. Although we found no age effect on gaze following, the youngest and oldest age groups were more distractible, which resulted in a higher number of looks in the test and control conditions. Extensive lifelong formal training as well as short-term training for eye contact decreased dogs' tendency to follow gaze and increased their duration of gaze to the face. The reduction in gaze following after training for eye contact cannot be explained by fatigue or short-term habituation, as in the second group gaze following increased after a different training of the same length. Training for eye contact created a competing tendency to fixate the face, which prevented the dogs from following the directional cues. We conclude that following human gaze into distant space in dogs is modulated by training, which may explain why dogs perform poorly in comparison to other species in this task.

In humans, a crucial feature of social life and communication is eye gaze, which plays a central role in social cognition. Gaze following, the ability to monitor and match another's head and eye orientation by following gaze direction into distant space, has been extensively studied in human infants. The first such study by Scaife and Bruner (1975) tested infants (of different ages) seated across from an adult experimenter who addressed the infant before turning to look to the side of the room for a few seconds. This and many subsequent studies indicate that the ability to follow gaze improves as the infant develops. This process is influenced by various factors such as perceptual skills and preferences, habituation, reward-driven learning, social environment and spatial layout (Moore, 2008; Triesch, Teuscher, Deák, & Carlson, 2006).

Although several studies have highlighted the importance of investigating age differences in social cognition, especially in elderly humans, for whom reduced social communication and interaction skills have been found in comparison to middle-aged subjects (Henry, von Hippel, & Baynes, 2009; Slessor, Laird, Phillips, Bull, & Filippou, 2010), there are few life span studies of gaze following. The human literature has focused almost entirely on infants in their first 18 months of life, but also studies testing gaze following in chimpanzees, *Pan troglodytes*, have focused mostly on juvenile or adult animals (Teufel, Gutmann, Pirow, & Fischer, 2010).

Comparative studies in nonhuman animal species can help to shed some light on the evolutionary origins and mechanisms of gaze following (Gómez, 2005). A species of particular interest for comparative studies is the domestic dog, *Canis familiaris*. Dogs share an evolutionary and developmental history with humans as a result of their domestication, and there is ample evidence that dogs have specialized skills in reading human-given cues (Kaminski, 2009). Dogs outperform nonhuman primates in following human

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gaze in object choice tasks (Cooper et al., 2003; Hare, Brown, Williamson, & Tomasello, 2002), and their gaze following, as is that of preverbal infants, is modulated by ostensive cuing such as direct gaze and addressing by the person, who then indicates with her gaze one of two objects or which of two containers is baited with food (Téglás, Gergely, Kupán, Miklósi, & Topál, 2012).

However, despite the human-like performance of dogs in following human-given cues in object choice tasks, there is conflicting evidence of whether dogs follow human gaze in non-foraging contexts. Recently, Met, Miklósi, and Lakatos (2014) found evidence that some dogs follow gaze to and around a barrier, even in nonforaging situations; however, as a group, dogs performed below chance. Additionally Agnetta, Hare, and Tomasello (2000) found no indication that dogs follow human gaze into distant space.

Since gaze following into distant space has been documented in many species such as apes (Bräuer, Call, & Tomasello, 2005; Povinelli & Eddy, 1997), domesticated goats, *Capra aegagrus hircus* (Kaminski, Riedel, Call, & Tomasello, 2005), several bird species (Kehmeier, Schloegl, Scheiber, & Weiss, 2011; Loretto, Schloegl, & Bugnyar, 2010), the red-footed tortoise, *Chelonoidis carbonaria* (Wilkinson, Mandl, Bugnyar, & Huber, 2010) and wolves, *Canis lupus* (Range & Virányi, 2011), we would expect the gaze-following response to be present also in dogs. So why do we find so little evidence that dogs follow gaze outside of object choice situations?

First, we can hypothesize that as gaze following is likely to be a product of both reflexive and learnt mechanisms (Ricciardelli, Carcagno, Vallar, & Bricolo, 2013), one explanation could be that dogs may lose their reflexive responding to human gaze cues through long-term habituation over an individual's lifetime living with human companions (the long-term habituation hypothesis). Owners often turn and gaze at objects and stimuli that are irrelevant to dogs in their daily lives, which may lead to a gradual loss of the dogs' gaze-following response. Thus we could expect young dogs' gaze-following response to be more automatic and therefore more frequent than in adult dogs, which have been affected more strongly by learnt gaze responses.

Second, dogs' lack of response to human gaze to distant space may be explained by their training. One of the first training exercises recommended for owners when getting a puppy is to condition the dog's name as an orienting cue, and to develop eye contact with the owner (Howell & Bennett, 2011). Dogs receive this training in various forms of formal training, such as in puppy school, and during obedience, agility and trick training. After giving relevant ostensive cues, which encourages the dog to pay attention, the owner then gives the next specific verbal command or visual signal usual for that training context (e.g. 'Muffin' and 'come'). Dogs may pay attention to the whole of the owner's body, hand or face when anticipating the next cue (for example body orientation (used in agility), specific hand signals (used in obedience tasks) and so on). Therefore, the effects of such formal training may increase the dog's frequency and duration of fixations to the owner (while waiting for the next cue typical for the given training context), which may then interfere with the dog's response when humans present directional gaze cues that are not part of the formal training. Hereafter we refer to this explanation as the formal training hypothesis.

On the other hand, in their daily lives dogs are repeatedly asked to look at humans in many different situations in which dogs may need more flexibility in detecting the relevant communicative cues of their human partners. Such informal training for increased attention to humans is, therefore, likely to increase the chances that dogs will be able to detect human cues, such as gaze cues, and thus may increase the likelihood that the dog may follow human gaze. Since dogs have the opportunity to learn about these cues and to generalize them to different contexts over their lives, we refer to this explanation as the lifelong learning hypothesis.

There is experimental evidence that even short-term training can affect dogs' human-directed attention (Bentosela, Barrera, Jakovcevic, Elgier, & Mustaca, 2008; Wallis et al., 2014). Short-term training for initiating eye contact (depending on the details and the context of the training) may have a two-fold effect on gaze following: either facilitating it, as proposed by the lifelong learning hypothesis, or hindering it, according to the formal training hypothesis. To examine how such short-term training affects dogs' readiness to follow human gaze cues, we tested the dogs' gaze-following response twice, before and after training to initiate eye contact with the experimenter. On the one hand this training may serve to increase the dogs' attention to the experimenter and thus may confirm the lifelong learning hypothesis, if we find that after such training, the dogs' gaze-following propensity increases. Or, on the other hand, since our short-term training to initiate eye contact follows a specific sequence of events (dog looks up at the experimenter's face, the experimenter uses a clicker to mark the behaviour and then rewards the dog with food), the effect of this training may support the formal training hypothesis, where we would expect that the dogs would follow gaze less after than before the training.

The aims of this study were to re-examine the question whether dogs are capable of following human gaze into distant space and, if so, to investigate through age effects whether the propensity to follow gaze is affected by long-term habituation to directional gaze cues and/or training to focus their attention on humans. Thus, we tested dogs of different ages that had a shorter or longer time to habituate to human gaze cues or to learn to pay attention to relevant human-given cues. We also addressed the potential effect of formal training by examining the influence of lifelong training of different intensity. Finally, we aimed to experimentally test the effects of formal training and of learning to pay attention to humans, by comparing the gaze-following propensity of the dogs before and after training to initiate eye contact with the experimenter. To examine the effects of fatigue and/or short-term habituation during repeated testing, an additional group of dogs was tested using the same procedure, but without being trained for eye contact (instead they were trained to touch a tennis ball with their paw). Our predictions were that if long-term habituation was a key factor, older dogs would follow the gaze of the experimenter less than younger dogs. If, however, lifelong learning to pay attention to humans was important, older dogs would follow gaze more than younger ones, and also short-term training for initiating eye contact would increase gaze following. And finally, if formal training had an influence, highly trained dogs would follow gaze less than dogs with little training experience, and also short-term training for initiating eye contact would decrease the propensity of the dogs to follow gaze.

METHODS

Subjects

One hundred and forty-five dogs ranging in age from 6 months to 13 years and 10 months were divided into seven groups according to age (Table 1). All recruited dogs were border collies kept as family pets to exclude effects of different developmental and ageing speeds of different breeds. The age groups were chosen according to the timing of the main life span developmental stages in the border collie (late puppyhood, adolescence, early adulthood, middle age, late adulthood, senior and geriatric, Siegal & Barlough, 1995). Dogs that were reported by the owner (via questionnaire) as suffering from any detrimental behavioural or cognitive effects of old age consistent with a diagnosis of canine cognitive dysfunction