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„The link between the dog-human relationship
and dogs' (*Canis familiaris*) performance
in socio-cognitive tasks“

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*“No hunt can have a sweeter reward, a more admirable goal,
than the excitement of thoroughly revised understanding”*

STEPHEN J. GOULD,
The Mismeasure of Man (1996)

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Lisa Horn. Some of the content presented in this chapter has been used in project proposals to the Austrian Academy of Sciences (DOC-fFORTE) and the University of Vienna (Forschungsstipendium) by the author.

Chapter 2.

I designed the study with input from Friederike Range. I collected and analyzed the data and wrote the first draft of the manuscript. Friederike Range was involved in editing and revising the manuscript and Ludwig Huber gave helpful comments for finalizing the manuscript.

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Chapter 5.

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CHAPTER 1

Introduction

The relationship between humans and dogs (*Canis familiaris*) has a long history, since humans first started to tame dogs' ancestors about 15,000 years ago (Savolainen et al. 2002). As the first and one of the most successful domesticated species, the dog soon spread all over the world and can presently be found in practically every human society. While the early dogs were mainly used for hunting and guarding human settlements, dogs are nowadays used for a wide variety of tasks in human societies. One of the dog's most important roles however is to function as a companion for their human owners (Hart 1995). Therefore, interest in the dog-human relationship and its beneficial influence on human behaviour has been growing in recent years. For example, it has been shown that pet dogs can improve the social development of young children (e.g., Millot 1994) and contribute positively to the life satisfaction in elderly people (e.g., Miller & Lago, 1990). Compared to that, questions regarding the influence of the dog-human relationship on dogs' behaviour and cognitive abilities have largely been neglected. Therefore, the aim of this dissertation is to explore the link between the dog-human relationship and dogs' performance in socio-cognitive tasks in three studies. The studies investigate (i) the effect of the owner's presence and behaviour on dogs' performance in a problem-solving task, (ii) dogs' flexibility in directing their behaviour towards different humans when being faced with a problem, and (iii) dogs' attention towards different humans.

In the first part of the introduction I delineate the history of the dog-human relationship by elaborating on the domestication process and breed diversification. I then give an overview of the literature on the dog-human relationship as the owners perceive it and as it has been measured in the dogs. Furthermore, I relate the findings about dogs' relationships with their owners to the framework of Bowlby's attachment theory (1958; 1969), which is based on comparative principles. In this part, I also review studies showing a beneficial influence of the dog-human relationship on both humans and dogs. In the second part of the introduction I present an overview of studies focusing on the socio-cognitive abilities of dogs. Here, I concentrate on studies investigating dogs' social interactions with humans, which is most

relevant for this dissertation. Although there are many studies showing dogs' exceptional cognitive abilities when interacting with other dogs (e.g., selective imitation; Range et al. 2007), nowadays humans have replaced conspecifics as the main social partner for many dogs. Therefore, a set of well-developed socio-cognitive abilities in interactions with humans has become important for dogs. The final part of the introduction contains an overview of the specific aims and structures of the three studies included in this dissertation.

1.1 The dog-human relationship

1.1.1 The domestication process

Results from archaeological excavations and DNA analysis of modern dog breeds indicate that dogs were domesticated about 15,000 years ago (Benecke 1987; Savolainen et al. 2002; for a different estimation of the onset of domestication see Vilà et al. 1997). Although it is nowadays agreed upon that the dog's ancestor can be found among the subspecies of the wolf (*Canis lupus*), the point of origin of the first population of domestic dogs remains debated (Europe: Verginelli et al. 2005; the Middle East: Davis and Valla 1978; vonHoldt et al. 2010; Southeast Asia: Olson and Olson 1977; Pang et al. 2009). In all of these areas wolves shared the habitat with humans and it has been argued that less shy individuals probably remained close to the human settlements due to the abundant food resources that they could easily exploit (Coppinger & Coppinger 2001). This early step of an introduction to the human environment naturally favoured individuals lacking fear and aggressiveness towards humans and those traits were then further selected for during domestication. Corollary evidence for this mechanism underlying the process of domestication comes from a selective breeding experiment with foxes (*Vulpes vulpes*) that has been running in Siberia for more than five decades: a strand of foxes selected exclusively for their fearless and none-aggressive approach towards humans started to show dog-like phenotypes (e.g., floppy ears, short or curled tails, fur depigmentation; Belyaev 1978) and behaviours (e.g., being able to follow human cueing better than randomly bred foxes; Hare et al. 2005). Additionally, recent results from studies investigating dogs' ability to use human communicative signals (i.e., pointing) indicate that the domestication process established a predisposition for increased attention to and cooperativeness with their human partners in dogs (Gácsi et al. 2009c), which is not present in

extensively socialized wolves (Gácsi et al. 2009a). This enhanced attention and readiness to cooperate with humans can also be seen as a prerequisite for dogs to form highly individualized relationships with specific humans.

While in the first stages of the domestication process tameness and the lack of aggression probably were the most important features of early dogs and humans probably took advantage of their natural behaviour patterns (i.e., territorial defence of human settlements, joining human hunting parties; Coppinger & Coppinger 2001), gradually dogs started to be selected for more specific purposes. The greatest diversification happened in the late 19th century in Europe when official breed clubs were founded and new breeds were created by strict regimen of human-induced selective breeding (Malmström et al. 2008). Nowadays, the Fédération Cynologique Internationale (FCI; www.fci.be) that was founded in 1911 recognizes 343 breeds from 86 countries – with the number of recognized breeds increasing every year. The FCI classifies breeds into ten breed groups characterized by both ancestry and usage of dogs. By using molecular markers, Parker and colleagues (2004) investigated the genetic relationships between 85 of those breeds. Their data allowed them to group breeds into four genetic clusters. The first cluster was compatible – although not completely congruent – with the FCI breed group 5 (Spitz and Primitive types) and comprised sledge dogs (e.g., Alaskan Malamute, Siberian Husky), Asian breeds (e.g., Akita Inu, Chow Chow, Shar-pei), and primitive African breeds (e.g., Basenji, Afghan Hound). Those breeds genetically clustered with wolves and were therefore regarded as the most ancestral among the dog breeds. The remaining breeds were identified as modern breeds with European origin by the authors (Parker et al. 2004) and could further be clustered into three groups containing (i) mainly molossoid breeds, (ii) mainly herding dogs, and (iii) the remaining modern breeds (including dogs from all ten FCI breed groups).

Although dog breeds have been selected for very different work purposes (e.g., Border Collie: herding livestock in close cooperation with humans; Hungarian Kuvasz: guarding livestock independently from humans) it is not clear whether this selection also altered their general socio-cognitive abilities. To investigate these possible breed differences, studies often used questionnaires administered to owners (e.g., Serpell & Hsu 2005) or expert raters (i.e., dog handlers, veterinarians; e.g., Hart 1995). Results from such questionnaires point to breed differences in ratings of trainability and temperament (Hart 1995; Serpell & Hsu 2005). However, these differences have to be interpreted with caution, since they could also reflect

the rater's preconceived opinion about a specific breed or different rearing environments of different breeds. In contrast to the above-mentioned indirect methods, Scott and Fuller (1965) directly investigated the behaviour of five different breeds under standardized conditions from birth on in an elaborate study running for almost 20 years. They found that the observed breeds differed in emotional and motivational characteristics, but not in general problem-solving abilities. These results suggest that breeds do not differ consistently in their performances in cognitive tasks (see also Pongrácz et al. 2005 for an absence of breed differences in a social learning task). However, differences in emotional and motivational characteristics could potentially lead to variations in the relationships that different breeds form with their human partners.

1.1.2 The human's relationship with the dog

Dogs can nowadays be found in practically every human society and are present in a great number of households around the world (Austria: about 17% of the households; Kotrschal et al. 2004). Dogs are nowadays used for a wide variety of tasks in human societies – from herding livestock and guarding property to working as police dogs or as guide dogs for the blind. Additionally, a great number of dogs nowadays are kept not for work purposes but as companion animals. Reflecting this wide variety of usages, Miklósi (2007/2009) described three purposes for keeping dogs: (i) using dogs' meat and pelts, (ii) using dogs for work, and (iii) keeping dogs as companions. Consuming dog meat and using dog pelts for industrial processing is by now effectively restricted to East Asia. Therefore, dog-human relationships in most human societies are either work or companion relationships. Egenvall and colleagues (1999) showed that in Sweden a great majority of dogs are acquired to act as companions – a result, that is probably applicable to other European countries as well. According to Cain (1985), 68% of the dog owners in the US actually regard their dogs as full family members. The argument that humans mainly see their dogs as companions nowadays is supported by several studies from Europe and the US, which showed that owners talked to their dogs like they would talk to their children (Mitchell 2001; but see Prato-Previde et al. 2006 for differences between men and women), that they believed that their dogs understood them (Pongrácz et al. 2001a) and had thoughts and feelings similar to human beings (Sanders 1993).

In many cases the affectional bond between owners and their dogs can be so strong that it was argued to resemble an attachment bond comparable to that normally found between two humans (Kurdek 2008; Kurdek 2009). Bowlby's (1958; 1969) attachment theory was originally used to describe the unique affectional bond that human infants form with their primary caregiver – usually the mother. However, researchers building on Bowlby's theoretical framework later argued that attachment is relevant for relational behaviour across the life span, especially for relationships between peers and romantic partners (Ainsworth 1989). Four particular components can be used to discriminate a true attachment bond from other types of affectional bonds (Cassidy 1999): (i) proximity maintenance (i.e., staying near to and resisting separation from the attachment figure), (ii) separation distress (i.e., feeling distress upon involuntary separation from the attachment figure), (iii) secure base (i.e., using the attachment figure as a base for exploring the environment free of anxiety), and (iv) safe haven (i.e., seeking out the attachment figure for contact and assurance in times of emotional distress). Several studies have shown that all of these components can be identified in owners' relationships with their dogs: (i) owners feel that they have a close relationship with their pet and enjoy both this perceived "closeness" and physical proximity to the dog (e.g., Kurdek 2008; Prato-Previde et al. 2006); (ii) they feel distressed when losing their dog and go through stages of grief comparable to those after the loss of a human partner (e.g., Gerwolls & Labott 1994; Planchon et al. 2002); (iii) they regard their dog as a secure base from which they can interact with their environment (e.g., Cusak 1988; Kurdek 2008); (iv) they turn to their dogs in stressful situations or times of emotional distress (e.g., Kurdek 2008; Kurdek 2009). However, not all dog owners have an equally close relationship with their dogs. In a large-scale study in the US Albert & Bulcroft (1987; 1988) found that people living alone and couples without children felt closest to their dogs and showed the strongest anthropomorphic attitudes. Such differences in the strength of the relationship and the owner's attitude towards the dog certainly also have the potential to influence the dog's behaviour in social interactions differently.

Regarding dogs' influence on humans, many studies have shown that there are several forms of beneficial effects. For example, it has been shown that physical proximity with dogs and petting them has calming effects on adult humans by increasing oxytocin and decreasing cortisol (Handlin et al. 2011; Odendaal & Meintjes 2003). Beetz and colleagues (2011) further showed that for children in a stressful experimental setting a stress-reducing effect was only

elicited by a dog, but not by a friendly human or a toy dog. Additional evidence suggests that living with a dog can generally improve the social development of young children (e.g., Filiâtre et al. 1986; Millot 1994) and contribute positively to the life satisfaction in elderly people (e.g., Garrity et al. 1989; Miller & Lago 1990). Interestingly, Friedmann and co-workers (1980) argued that owning dogs as well as other pets also had direct health benefits for humans: they found a positive correlation between survival rates one year after being treated for coronary heart diseases and owning a dog or another pet. Especially in dogs however, this effect could be rather indirect, because keeping a dog requires a considerable amount of care and encourages outdoor activities (for a review see Cutt et al. 2007). Another important indirect effect of dogs in human societies is that they facilitate social interactions between humans. Such effects have for example been shown in psychotherapy (e.g., Lapp 1991), among elderly people in a care institution (e.g., Winkler et al. 1989), and for people walking a dog (e.g., Wells 2004). Interestingly, in the latter study the facilitative effect depended on the type of dog that accompanied the person: a dog breed that was perceived as friendly (i.e., Labrador Retriever) elicited more positive interactions than a breed perceived as dangerous (i.e., Rottweiler).

1.1.3 The dog's relationship with the human

Also domestic dogs form close and individualized relationships with their human owners. It has been argued that even in adult dogs these relationships bear a remarkable resemblance to the bond between children and their parents because dogs are dependent on human care and their behaviour seems to be adapted to engage their owners' care-giving system (Archer 1997; Askew 1996). Therefore, it has been suggested that the relationship between the dog and the owner might represent an infant-like attachment bond as it had been described by Bowlby (1958; 1969). Ainsworth and Wittig (1969) developed a standardized experimental procedure aimed at characterizing attachment relationships in human infants based on Bowlby's theories (i.e., the Strange Situation Test). Given the broad comparative framework of Bowlby's original attachment theory, several researchers adapted the methodology of the Strange Situation Test to investigate whether the relationship between adult dogs and their human owners represents an attachment bond (e.g., Palmer and Custance 2008; Prato-Previde et al. 2003; Topál et al. 1998). During this experiment, dogs were confronted with an unfamiliar setting, an unfamiliar person entering the room and two brief separations from the owner. By subjecting

dogs to this mildly stressful setting, researchers tried to discover whether dogs displayed the four behavioural components characterizing the attachment system (i.e., proximity maintenance, separation distress, secure base, safe haven). The first two studies (Prato-Previde et al. 2003; Topál et al. 1998) found clear evidence for proximity seeking and separation distress in the dogs. Moreover, they also found indications of a secure base effect characterized by more exploration of the environment in the presence of the owner than in the subsequent absence of the owner. However, Prato-Previde and colleagues (2003) concluded that due to the strong sequence effect inherent to the test procedure this apparent secure base effect could have also been due to other factors such as the tiring of the dog. Consequently, Palmer and Custance (2008) carried out a counterbalanced version of the Strange Situation Test and still found the same secure base effect independently of the sequence. The only component of the attachment system not observed in any of the studies was turning to the owner as a point of safety upon the entrance of the unfamiliar human (i.e., safe haven). However, this lack of fearful behaviour towards the stranger can be explained by dogs' good socialization with unknown humans, which is required for living in the human environment. Corollary evidence for owners' function as a safe haven however comes from an experiment in which dogs were confronted with a human stranger approaching them in a threatening manner (Gácsi et al. 2009b). When dogs were tested in the absence of their owners, the threatening approach was more stressful for them than when their owner was present and provided some safety. Therefore, the experimental evidence strongly supports the argument that the dog-human relationship shows many similarities with the infant-caregiver relationship. There are however findings that suggest that not all dog-human relationships are the same and that a dog can even form different relationships with different humans from their household (Mariti et al. 2011).

In children it is known, that the interaction style of the caregiver has a strong influence on their relationship, which – in turn – influences many aspects of the child's later life (for a review see Steele 2002). In dogs, research has largely focused on the potential influence of owners' relationships and interaction styles on problem behaviour in dogs (e.g., human-directed aggression, separation anxiety; Jagoe & Serpell 1996; Voith et al. 1992). But several studies also documented a beneficial influence with owners having a similar calming effect on their dogs as their dogs have on them. There is an increase in oxytocin when dogs are in physical contact with a person (Odendaal & Meintjes 2003) and this effect seems to be more

pronounced when the person is the owner instead of an unknown person (Handlin et al. 2011). McGreevy and colleagues (2005) also found a reduced heart rate in dogs when being groomed by a person. Apart from these short-term physiological effects of interacting with a human, the specific relationship that dogs have with their owners has the potential to also influence dogs' behaviour long-term. Topál and colleagues (1997) showed that dogs, whose owners treated them as companions and had anthropomorphic attitudes towards them, behaved dependently during a problem-solving task (i.e., they looked back at their owners frequently) and were less successful in solving the task than dogs kept outside of the house. These results are compelling and point towards a possible link between the dog-human relationship and dogs' performance in cognitive tasks – especially tasks involving human participants. Therefore, in the next part I review the existing literature on dogs' abilities in the socio-cognitive domain when interacting with a human.

1.2 The dog's abilities in the socio-cognitive domain

1.2.1 Communicative abilities

Communication can be broadly defined as an action of one organism that influences the probability of a certain behaviour to emerge in another organism (Wilson 1975). Since dogs come into contact with humans on a daily basis, it has been essential for them to develop communicative abilities in interaction with their heterospecific partners. Dogs have been found to both utilize human communicative signals (e.g., gesturing, gazing) as well as initialize human-directed behaviour (e.g., gazing at the human, gaze alternation).

Utilizing human communicative signals

While dogs can be trained to use human verbal communication and learn to associated labels with objects or actions (e.g., Kaminski et al. 2004; Pilley & Reid 2011), the outstanding example of dogs' exceptional socio-cognitive abilities is their proficiency in following a wide variety of human bodily communicative cues. This has mainly been tested in two-way object choice tasks, where the human indicates the correct location (i.e., where a reward has been placed) to the dog with a certain type of cue. Dogs can follow conspicuous as well as subtle cues, including pointing at varying distances and for different durations, gazing (i.e., turning

the head to look at the location), and even glancing (i.e., not moving the head, but looking at the location with only the eyes; for a review see Miklósi & Soproni 2006). The essential component influencing the dogs' choices in these tasks seems to be the human action. This is suggested by the findings that dogs can succeed in finding the reward when they can observe a human placing an artificial marker to indicate the right location, but not when they just see the marker without the placing action (Agnetta et al 2000). The preference to follow a human gesture can be so strong that pointing to the wrong location can overshadow the dog's knowledge of the correct hiding place and lead them to an incorrect choice (Szetei et al. 2003). However – in the experimental setting – dogs do not follow the pointing gesture outside the context of finding a reward, indicating that they do not perceive the pointing gesture as imperative but rather as informative (i.e., indicating the location of the reward; Scheider et al. 2011). Further, several studies have shown that dogs can already follow human cues from very early ages on (e.g., Riedel et al 2008, Gácsi et al 2009a), even when raised in a kennel with limited contact to humans (Hare et al. 2002). Hand-raised wolves on the other hand do not follow more difficult human cues (e.g., distal pointing) deliberately at young age and can only succeed in the task as adults after years of socialization and training (Gácsi et al. 2009a). Therefore, Gácsi and colleagues (2009a) suggested that dogs had an exceptional predisposition to attend to and cooperate with humans, which allowed them to excel in communicative tasks. A recent study (Téglás et al. 2012) showed that dogs only follow a human's gaze to the indicated location, when they were addressed with ostensive-communicative cues, which human adults normally use to address infants and children in teaching contexts (i.e., speaking in a high-pitched voice, establishing eye contact). A similar effect has been found in human infants in a gaze following task (Senju & Csibra 2008). In this study, the authors suggested that for human infants the ostensive-communicative cue acted as an indicator that the communicative act – the gazing – was meant to provide information for them. Ostensive-communicative cues have also been found to influence dogs and human infants alike in the A-not-B task (Topál et al. 2009). In this task, the reward was hidden in the (novel) B location after previously hiding it in the A location several times. When a human demonstrator performed the hiding with ostensive-communicative cues, infants and dogs – but not hand-raised wolves – continued to search for the reward in the A location. Although the authors of both studies (Téglás et al. 2012; Topál et al. 2009) do not suggest the same cognitive mechanisms underlying the effects of ostensive-communicative cues in human infants and

domestic dogs, these results are another indication of how sensitive dogs are to human communicative signals.

Initializing human-directed communicative behaviour

Beside dogs' evident abilities to utilize human communicative cues, dogs have also been shown to actively initiate communicative interactions with humans: either when begging for food or when a reward is hidden out of their reach. In these situations, dogs have also been found to take the human's attentional state into account. They were – for example – shown to beg less from a person oriented away from them or blindfolded than from a person facing them (Cooper et al. 2003; Gácsi et al. 2004). Miklósi and colleagues (2000) found that dogs – when observing the hiding of a food reward or toy in an out-of-reach location in the absence of their owners – increasingly looked at their owners when they returned to the room and also alternated their gaze between the hiding place and the owner. The authors termed this behaviour “showing behaviour”, most notably because of its functionally communicative result: at the end of the test, owners could reliably locate the position of the reward among several possible hiding locations in the room. Apart from showing the location of an out-of-reach reward dogs have also been found to direct their gaze at their owners when they could not solve a manipulative task (e.g., Marshall-Pescini et al. 2008; Topál et al. 1997). This behaviour was found to be even more pronounced when the dog was initially allowed to solve the task and was later prevented from doing so by blocking the apparatus (Marshall-Pescini et al. 2009; Miklósi et al. 2003; Miklósi et al. 2005). To investigate whether this behaviour of looking back at the owner emerged during domestication or was shaped by dogs' socialization and interaction with humans, Miklósi and colleagues (2003; 2005) conducted comparative experiments with two additional species: hand-raised and well socialized wolves (Miklósi et al. 2003) and domestic cats kept as pets (*Felis catus*; Miklósi et al. 2005). Interestingly, neither wolves nor cats looked back at their owners when they were faced with an unsolvable problem. Therefore, it seems that neither socialization and close contact with humans alone, nor domestication alone can explain the unique behaviour exhibited by the dogs. This is another indication that in dogs the domestication process led to an increased sensitivity to social interactions with humans, which then allowed them to learn the most effective ways to interact with them from their daily experiences. Further evidence for this comes from a recent study (Passalacqua et al. 2011) showing that young puppies – before being adopted by their

owners – directed their gaze only briefly at the humans close by when they were faced with an unsolvable task. Moreover, Marshall-Pescini and colleagues (2009) found that the type of training that a dog received could also influence this behaviour. Dogs participating in interactive dog sports with their owners (i.e., agility: the owner directs the dog through an obstacle course with verbal commands and/or gestures) looked back at their owners for longer durations when faced with an unsolvable task than untrained dogs or dogs receiving another type of training. However, it remains to be tested whether also owners' relationship and interaction styles can influence dogs' human-directed behaviour.

1.2.2 Social learning abilities

Being able to learn from a reliable demonstrator is important for animals living in social groups, because it allows faster acquisition of adaptive behaviours than individual learning (Rendell et al. 2011). Broadly, social learning can be defined as “any situation in which the behaviour, or presence, or the products of the behaviour, of one individual influence the learning of another” (Caldwell & Whiten, 2002; p.193). It has been shown that dogs can readily learn from a human demonstrator in tasks that require rather simple social learning mechanisms like social facilitation or enhancement (e.g., detouring a V-shaped fence: Pongrácz et al. 2001b; Pongrácz et al. 2004; manipulating an apparatus: Kubinyi 2003). Dogs can also be influenced to choose against their own preference when either an experimenter or the owner displays a preference for a smaller rather than a larger amount of food (Marshall-Pescini et al. 2011; Prato-Previde et al. 2008). Further, recent studies have shown that specially trained dogs are also capable of more complex social learning mechanisms when learning from a human demonstrator, such as imitating a human in the “Do-as-I-do” paradigm (i.e., the dog has to copy the human's action after hearing the command “Do it!”; Huber et al. 2009; Topál et al. 2006). Range and colleagues (2011) also showed that dogs seem to have a preference to copy human actions by using the equivalent body part (i.e., hand/paw vs. head/muzzle), which is comparable to the same preference found in humans observing the actions of a human demonstrator (Brass et al. 2001). One essential factor influencing a dog's performance in a social learning task however is the attention towards the demonstrator. Particularly when complex behaviours or sequences of actions have to be learned socially, the individual has to observe the actions of a demonstrator for an extended period of time. Range and colleagues (2009) showed that while dogs' attention span was shorter than that of human children, dogs

looked for longer durations at the actions of a human than a conspecific demonstrator. Interestingly, a recent study also showed that dogs paid more attention to their owner than to an unfamiliar demonstrator (Mongillo et al. 2010). Although the authors did not control effects of different levels of social familiarity with the two human demonstrators, it is possible that the relationship that dogs have with a human can influence their attention towards this human.

1.3 Aims and structures of the included studies

In the existing literature there are many indications that the dog-human relationship might affect dogs' behaviour and performance in socio-cognitive tasks. However, few studies have directly compared these effects experimentally. Therefore, the aim of the three studies included in this dissertation was to specifically investigate the link between the dog-owner relationship or the owner's behaviour towards the dog on the one side and the dogs' behaviour in different tasks on the other side. A different sample of dogs was used in each study and details on the participating dogs can be found in Appendix I.

It has already been shown that a dog's relationship with its owners resembles human infants' attachment relationship with their caregivers, including the presence of a secure base effect influencing their interactions with the environment (Palmer & Custance 2008). In children, this effect has been found to influence their problem-solving performance (Matas et al. 1978) but it is not known whether the same is true for dogs. Therefore, in the study "*The Importance of the Secure Base Effect for Domestic Dogs – Evidence from a Manipulative Problem-Solving Task*" (Chapter 2) dogs' persistence and success in a manipulative task was tested in three conditions: (i) the owner was absent, (ii) the owner was present but not interacting with the dog, (iii) the owner was present and encouraging the dog verbally.

Further, while it was shown that the type of training influenced dogs' human-directed behaviour when faced with an unsolvable (Marshall-Pescini et al. 2009), it is not clear whether they also adjust this behaviour to the interaction style of their partner. In the study "*Domestic dogs (Canis familiaris) flexibly adjust their human-directed behaviour to the actions of their human partners in a problem situation*" (Chapter 3), dogs were confronted with unsolvable problems. In Experiment 1, we manipulated owners' interactions with their dogs and reactions to their human-directed behaviour in order to investigate the influence of these interactions.

In Experiment 2, we provided the dogs with two experimenters and allowed them to learn through an initial phase that each of the experimenters could solve one of the two problems and tested whether the dogs would direct their behaviour to the appropriate experimenter when faced with the respective problem.

Finally, a recent study showed that dogs attended more to their owners than to an unfamiliar experimenter (Mongillo et al. 2010) without controlling whether this preference was mediated by mere familiarity with the owner or by their specific relationship. Therefore, the study “*Dogs’ attention towards humans depends on their relationship, not on social familiarity*” (Chapter 4) investigated how long dogs attended to the manipulative actions of two familiar humans and one unfamiliar experimenter, while varying whether dogs had a close relationship with only one or both familiar humans.

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CHAPTER 2

The Importance of the Secure Base Effect for Domestic Dogs – Evidence from a Manipulative Problem-Solving Task

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Abstract

Background: It has been shown that dogs display a secure base effect similar to that found in human children (i.e., using the owner as a secure base for interacting with the environment). In children, this effect influences their daily lives and importantly also their performance in cognitive testing. Here, we investigate the importance of the secure base effect for dogs in a problem-solving task.

Methodology/Principal Findings: Using a manipulative task, we tested each dog in three conditions, in which we varied the owner's presence and behavior (Conditions: "Absent owner", "Silent owner", "Encouraging owner"). We found that the dogs' duration of manipulating the apparatus was shorter when their owner was absent than when their owner was present, irrespective of the owner's behavior when present in the room. Furthermore, the reduced manipulation during the absence of the owner was not connected to the dog's degree of separation distress scored in a preceding attachment experiment.

Conclusions/Significance: Our study is an important piece of evidence for the similarity between the secure base effect in dogs and in human children and shows that the secure base effect can manifest itself during a problem-solving task. These results also have important implications for behavioral testing in dogs, because the presence or absence of the owner during a test situation might substantially influence dogs' motivation and therefore the outcome of the test.

Keywords

Dog-human relationship • Attachment • Secure base effect

Introduction

Based on ethological and evolutionary principles, Bowlby [1,2] claimed that for the healthy development of humans as well as non-human animals it is essential for infants to develop a strong affectional bond with their primary caregiver – usually the mother. Separation from the attachment figure activates the infant's attachment system, which aims at restoring and maintaining proximity with this specific individual [1]. Four particular components can be used to discriminate a true attachment bond from other affectional bonds [3]: a) staying near to and resisting separation from the attachment figure (proximity maintenance), b) feeling distress upon involuntary separation from the attachment figure (separation distress), c) using the attachment figure as a base for exploring the environment free of anxiety (secure base), d) seeking out the attachment figure for contact and assurance in times of emotional distress (safe haven). Ainsworth [4] argued that the secure base effect is the most important component of the attachment system, because it is crucial for balancing the maturing infants' exploration of the world with maintaining proximity to the caregiver. In line with this, Matas et al. [5] showed that the secure base effect also had an influence on children's performance in an experimental problem-solving task. They found that children, who were able to use their mother as a secure base for exploring the environment, were also more persistent and enthusiastic while solving the task than children for whom the mother was no secure base. Based on Bowlby's theoretical framework, Ainsworth and Wittig [6] developed an experimental procedure, where children were confronted with an unfamiliar setting, an unfamiliar person entering the room and two brief separations from the attachment figure in a fixed sequence – Ainsworth's Strange Situation Test (ASST). This mildly stressful setting was geared to activate the child's attachment system in order to measure each of its behavioral components (e.g., crying at the exit of the parent (separation distress), exploring more in the presence of the parent than in the absence (secure base)).

Dogs have been closely associated with humans for about 15,000 years [7]. Nowadays, the domestic dog is well adapted to its niche in the human society and in general the owner has replaced conspecifics as the main social partner of the dog. It has been argued that the relationship between adult dogs and their human owners bears a remarkable resemblance to the bond between children and their parents: dogs are dependent on human care and their behavior seems specifically geared to engage their owners' care-giving system [8,9]. Given the broad comparative framework of Bowlby's original attachment theory, several researchers have used his concepts and the methodology of the ASST to investigate whether the relationship between adult dogs and their human owners conforms to the characteristics of an attachment bond (e.g., [10-12]). Using a modified version of the ASST adapted for testing dogs, two studies [10,11] found clear evidence for proximity seeking and separation distress in dogs. Further, they also found indications of a secure base effect characterized by more exploration in the presence of the owner than in the subsequent absence of the owner, which was however confounded with a strong sequence effect inherent to the procedure. To control for this factor, Palmer and Custance [12] carried out a counterbalanced version of the ASST and found the same secure base effect independently from the sequence. Despite of the attachment system, dogs can normally cope well with short separations from their attachment figure – like it is the case for human children in the home environment [13]. However, in some dogs the separation from the owner can generate anxiety, which manifests itself in separation-related behavior (SRB: e.g., excessive vocalizing, destructive behavior, defecation/urination; [14]). While originally some authors argued that separation anxiety is a form of "hyperattachment" to the owner (e.g., [15]), recent studies showed that this anxiety disorder is not related to the strength of dogs' attachment [16,17] but may be linked to a generally more negative cognitive bias in these dogs [18].

Since the dog has emerged as a model species for behavioral and cognitive research in recent years, it is vital to understand whether the attachment to their owners – particularly the secure base effect, which is mediating their interactions with the environment – is also relevant for their performance in cognitive tasks as it has been shown for human children [5]. Therefore, the aim of our study was to investigate the importance of the secure base effect for dogs by confronting them with a problem-solving task (i.e., manipulating an apparatus in order to obtain a food reward) in the presence and the absence of their owner. We predicted that if the owner acts as a secure base for the dog, the dog's performance should be poorer in

the owner's absence (Condition "Absent owner"). To control for the possibility that the difference in performance was brought about by the absence of behavioral cues from the owners, each dog was tested in two different conditions with the owner present: a) the owner was blindfolded and did not interact with the dog (Condition "Silent owner") and b) the owner was allowed to encourage the dog verbally (Condition "Encouraging owner"). To further examine the effects of dogs' potential anxiety during separation from the owner, all dogs were independently tested in a shortened version of the ASST and their degree of separation distress was compared to their performance in the task.

Materials and Methods

Ethics statement

The owners and their dogs participated in this study voluntarily. The testing procedure was entirely non-invasive. No special permission for the use of animals (dogs) in socio-cognitive research such as this study is required in Hungary. The relevant committee that allows research on animals without special permission is the University Institutional Animal Care and Use Committee (Hungary).

Participants

Twenty-two dogs were recruited from a database of volunteer participants of the Family Dog Research Program at the Department of Ethology of the Eötvös Loránd University in Budapest, Hungary. Only dogs living permanently in the owner's household as pets were selected and all dogs had at least basic obedience training. All dogs were highly food-motivated. Two dogs had to be excluded because they failed the pre-test (see procedures section below). Therefore, 20 dogs (12M/8F; mean age $\pm$ SD=2.7 $\pm$ 2.36 years) completed the experiment. The sample consisted of 14 purebred dogs from three different FCI (Fédération Cynologique Internationale) breed groups (Sheepdogs: N=9; Toy dogs: N=3; Primitive types: N=2) and 6 mixed-breed dogs.

Experimental design

Dogs first had to pass a pre-test to ensure that they were motivated to manipulate an apparatus to get food and that they were willing to consume food even in the absence of the owner. Dogs that passed the pre-test by taking food in the absence of the owner progressed to the test phase. In the test phase, we used three different test conditions, in which we varied the presence of the owner and the owner's behavior:

- *Condition "Absent owner" (cAO)*: The owner is not present in the experimental room during the trial.
- *Condition "Silent owner" (cSO)*: The owner is present in the experimental room during the trial, but remains silent.
- *Condition "Encouraging owner" (cEO)*: The owner is present in the experimental room during the trial and is encouraging the dog verbally.

We used a within-subject design so that each dog received one trial in each of the three test conditions. The sequence of the conditions was counterbalanced across dogs.

Apparatuses

For the pre-test we used a folded cotton towel (13cm x 29cm x 2cm) under which the food reward was placed. As apparatuses for the test we used four types of commercial interactive dog toys, which could be filled with food rewards: Nina Ottosson© Dog Pyramid (aDP, 13cm x 13cm x 17cm), Hunter© Snack Bottle (aSB, 9cm x 20cm x 9cm), Hunter© Snack Cactus (aSC, 20cm x 20cm x 20cm), and Hunter© Rolling Snack (aRS, Figure 1). The latter toy was available in a smaller (10cm x 10cm x 7cm) and a larger version (13cm x 13cm x 10cm) and thus the size was adjusted to the size of the dog. All toys had to be manipulated persistently with either the paw or the muzzle to receive the food rewards placed inside. The food rewards were of high quality (i.e., dog sausage) and consisted of 5 pieces per trial. Before the experiment started we asked owners whether their dogs had already interacted with toys that were the same or similar to any of the four toys presented. For each dog we selected three toys that were unknown to the dog. Otherwise, toys were selected randomly.

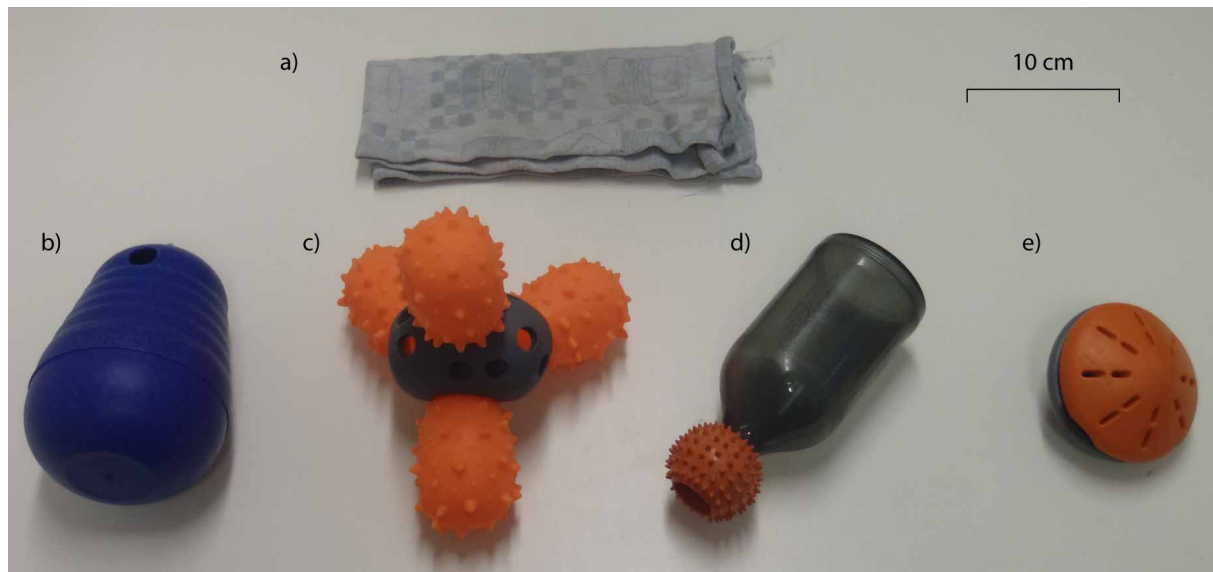


Figure 1. Apparatuses used in the experiment. a) Folded cotton towel used in the pre-test, b) Nina Ottosson© Dog Pyramid (aDP), c) Hunter© Snack Cactus (aSC), d) Hunter© Snack Bottle (aSB), e) the smaller version of the Hunter© Rolling Snack (aRS).

Experimental set-up

The experiments were carried out between February and June 2010 in a quiet experimental room (3m x 5m) at the department. The room was equipped with two doors: Door 1 could be used to enter the experimental room from the hallway, Door 2 led to an adjacent room. A chair for the owner was placed on the left side of Door 1. The experimenter was positioned on the right side of Door 1 during the pre-test and test trials. Tape markings on the floor indicated a circular area ($r=1\text{m}$) around the owner's chair and the experimenter's position, respectively. A clock on the opposite wall was used by the experimenter to time the trials. A line on the floor marked the dog's release point. The apparatus was placed 2.5 m away from this line. The room was equipped with four cameras linked to monitoring and recording equipment in the adjacent room (Figure 2).

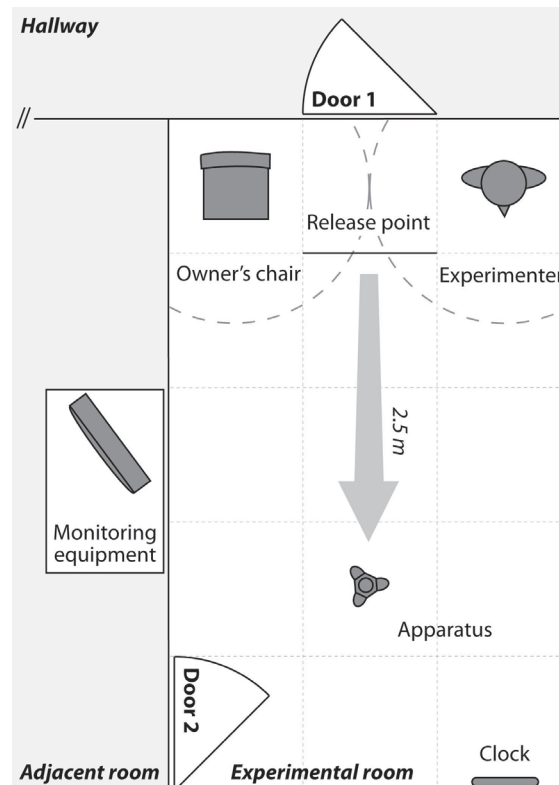


Figure 2. Schematic representation of the experimental set-up. The experimental room was equipped with two doors, one connecting it to the hallway (Door 1) and one connecting it to an adjacent room with monitoring and recording equipment (Door 2). At the beginning of each trial, the dog was released by the experimenter from the release point, which was 2.5 m away from the apparatus. During each trial the experimenter stood on the right side of Door 1 – timing the trial with a clock on the opposite wall. The owner either sat on the designated chair on the left side of Door 1 or was in the adjacent room – depending on the pre-test trial or the condition of the test trial. The dashed lines indicate the floor markings around the owner’s chair and the experimenter’s position, which were used for later video coding.

Procedures

All dogs participating in this experiment had previously been tested in a modified version of the ASST aimed at characterizing their relationship with their owners. This test consisted of several episodes in which either the owner, an unfamiliar human or both were present in the room with the dog. The test also comprised two separation episodes, which allowed us to assign an SRB score to every dog (see supplementary material for a detailed description¹).

¹ Supplementary material provided in Appendix II

In the main experiment, the general procedure was the same for each trial of both the pre-test and the test phase. Before each trial, the dog always observed the handling of the food reward (pre-test trials, test trials) and/or the baiting of the apparatus (test trials) in the hallway outside the experimental room. The experimenter then entered the room through Door 1 and placed the food reward or the apparatus on the designated position (see Figure 2). After that, the experimenter returned to the hallway. Right before each trial the owner entered the experimental room through Door 1 while the dog waited in the hallway with the experimenter. The owner then took position depending on the pre-test trial or the condition of the test trial. In each trial, the owner had to wear dark sunglasses (either opaque or normal), which allowed us to manipulate the owner's visual access to the dog's actions depending on the condition. After waiting for 10 s, the experimenter entered the room together with the dog on a leash. She directed the dog to the line indicating the release point and released it with one command (i.e., "You can go, it's yours!"). Then she took her position next to the door. During the trial the experimenter never looked at the actions of the dog but kept looking at the clock on the opposite wall. After a pre-defined time (see detailed descriptions below) the trial ended and the experimenter called the dog back, put it on leash and walked it out of the experimental room. The owner waited for 10 s and then also left the room through Door 1. There was a break of 5 to 10 min between trials.

Pre-test phase

The pre-test phase consisted of four trials that were administered in a fixed order:

- *Trial 1:* Owner present, food reward on the floor
- *Trial 2:* Owner present, food reward under the towel
- *Trial 3:* Owner absent, food reward on the floor
- *Trial 4:* Owner absent, food reward under the towel

In the first two trials of the pre-test phase the owner sat down on the chair and put on opaque sunglasses. The food had either been placed in the location of the apparatus directly on the floor (Trial 1) or under the towel (Trial 2). Trial 1 ended when the dog had consumed all five pieces of food or after a maximum of one minute. Since it was not possible for the experimenter to assess whether the dog had retrieved all pieces of food from underneath the

towel, Trial 2 ended after exactly one minute. In Trial 3 and Trial 4 the owner – after first entering the experimental room through Door 1 – left the room through Door 2 and remained in the adjacent room during the trial. The rest of the procedure was the same as in Trial 1 and Trial 2, respectively. In the adjacent room the owner could observe the events in the experimental room via monitoring equipment. The owner therefore knew when the trial was over and he or she had to leave this room and exit the experimental room through Door 1 again.

Two dogs were not motivated to consume any piece of food from the floor in the absence of the owner (Trial 3) and could therefore not proceed to the test phase. Two further dogs failed to retrieve any piece of food from under the towel in the absence of the owner (Trial 4). However, these dogs were motivated to retrieve the food and actively manipulated the towel during this trial. Therefore we decided to include them in the test phase.

Test phase

In the test phase, we administered three trials, each of which lasted 5 min.

In a trial of the condition “Absent owner” (cAO) the owner left the room in the same way as in the trials 3 and 4 of the pre-test phase. In a trial of the condition “Silent owner” (cSO) the owner sat down on the chair, put on opaque sunglasses and remained silent and passive throughout the trial. In a trial of the condition “Encouraging owner” (cEO) the owner sat down on the chair, put on normal sunglasses and was allowed to encourage the dog verbally and to point at the apparatus throughout the trial. The owner had to remain seated on the chair but was allowed to pet the dog when it came close. However, the owner was not allowed to touch the apparatus.

Data Analysis

All experimental sessions were videotaped for later behavioral coding with Solomon Coder beta (©2006-2011 András Péter). All statistical analyses were carried out with SPSS Statistics 17.0.0 (©2008 SPSS Inc.).

In the test trials, we used continuous coding to code three behaviors of the dog. “Manipulating” was recorded whenever the dog was interacting with the apparatus with its muzzle or paw. “Staying close to the owner” and “staying close to the experimenter” was

recorded whenever the dog was with at least one paw and the head within the area marked by the circle around each respective person. A second coder blind to the aim of the experiment and to the experimental conditions coded 20% of the videos of the test trials and Cronbach's alpha was calculated as a measure of inter-observer reliability. Cronbach's alpha was greater than $\alpha=0.9$ for all behavioral variables. The number of food pieces retrieved by the dog was assessed immediately after each trial by the experimenter.

A linear mixed model (LMM) with main effects and two-way interactions was used to investigate the effect of the factors "sequence of conditions" (1st, 2nd, 3rd), "type of apparatus" (aDP, aSB, aSC, aRS), and "condition" (cAO, cSO, cEO) on the variable "duration of manipulation". To investigate whether the duration that dogs spent manipulating the apparatus when the owner was absent (cAO) was correlated with the degree of SRB scored during the ASST, we used Spearman's rank correlation. To control for individual variation in general manipulation durations, we calculated a "relative duration of manipulation in cAO" by dividing the absolute duration of manipulation in cAO by the dog's average duration of manipulation across all three trials and correlated this score with the dog's SRB score.

Additionally we calculated two separate LMMs (main effects, two-way interactions) where we investigated the effects of the same factors as above on the variable "duration spent in the proximity of the owner" in those conditions where the owner was present in the room (cSO, cEO) and on the variable "duration spent in the proximity of the experimenter" in all three conditions.

Analyses of the residuals confirmed normal distribution for all variables in the three LMMs. Post-hoc comparisons of estimated marginal means (EM means) were carried out with LSD confidence interval adjustment.

Pearson's Chi-Square test was used to examine the distribution of whether dogs retrieved a food reward (yes/no) in the three conditions (cAO, cSO, cEO) and with the different types of apparatuses (aDP, aSB, aSC, aRS).

Results

We found that the condition in which the dogs were tested had a highly significant effect on how long the dogs manipulated the apparatus (LMM, $F_{1,36}=12.478$, $P\leq 0.001$, Figure 3). The

dogs manipulated the apparatus shorter when the owner was absent (EM means, cAO-cSO: $P=0.001$, cAO-cEO: $P\leq 0.001$), while there was no significant difference between the two conditions when the owner was present (EM means, cSO-cEO: $P=0.540$). Neither the sequence, nor the type of apparatus, nor any of the interactions had an effect on how long the dogs continued to manipulate the apparatus. When analyzing the correlation between the dogs' relative duration of manipulating when the owner was absent and their SRB score assigned in the ASST, we found no negative correlation (Spearman's rank correlation, $N=20$, $\rho=-0.140$, $P=0.557$), indicating that the effect observed in the LMM was not only present in those dogs with separation problems but in all dogs of the sample.

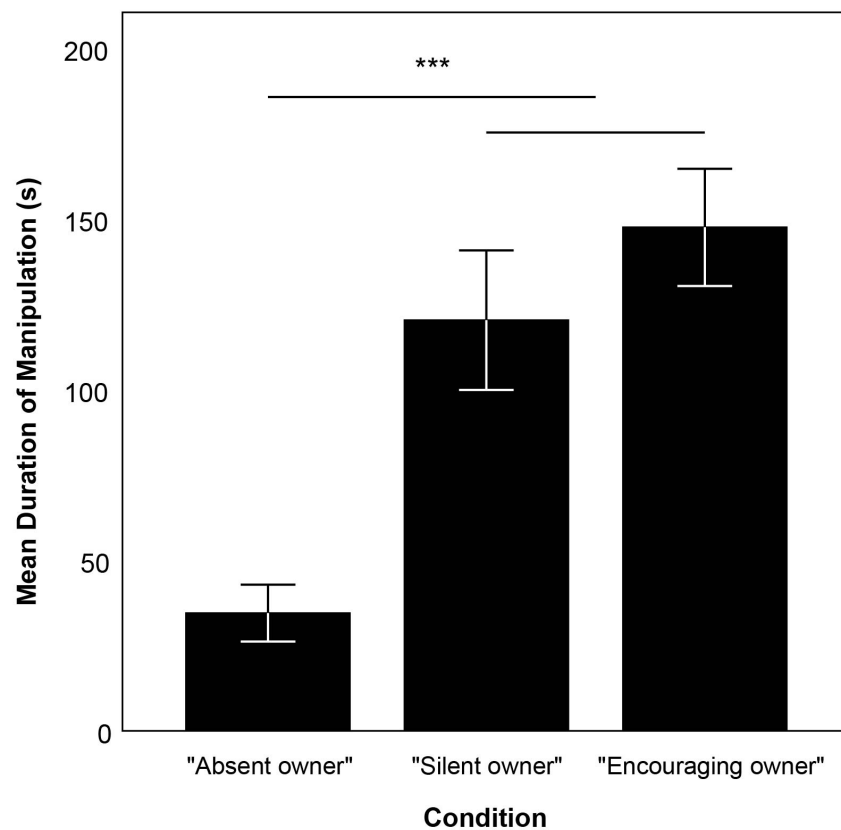


Figure 3. Duration of manipulating the apparatus. Mean duration of manipulating the apparatus in the conditions "Absent owner" (cAO), "Silent owner" (cSO), and "Encouraging owner" (cEO). Shown are mean $\pm$ s.e.m.

There was also an effect of the condition on whether the dogs successfully retrieved food out of the apparatus or not (Pearson's Chi-Square test, $X^2=6.652$, $P=0.033$). In this case however, the dogs were more successful than expected by chance in retrieving food when their

owner was encouraging them, and less than expected by chance when their owner was absent (Table 1). The type of apparatus used in the trial on the other hand had no effect on whether the dogs were able to retrieve food or not (Pearson's Chi-Square test, $X^2=4.695$, $P=0.196$).

Table 1. Total number of trials in which dogs either retrieved or did not retrieve food, grouped by condition.

Food retrieved	Absent owner	Silent owner	Encouraging owner
yes	5	8	13
no	15	12	7

When investigating the time that the dogs spent in proximity of the two humans we found that the dogs spent overall equal amounts of time close to their owner in both conditions when the owner was present. Also, the sequence and the type of apparatus had no effect on this behavior. However, when looking at the duration that the dogs spent close to the experimenter, we found a highly significant effect of the condition. When the owner was absent, the dogs spent more time close to the experimenter than in both conditions when the owner was present (LMM, $F_{1,36}=17.221$, $P\leq 0.001$; EM means, cAO-cSO: $P\leq 0.001$, cAO-cEO: $P\leq 0.001$, cSO-cEO: $P=0.593$, Figure 4). Further, there was a significant main effect of the sequence (LMM, $F_{1,36}=4.611$, $P=0.016$) and a significant interaction term between condition and sequence (LMM, $F_{1,36}=2.923$, $P=0.034$), indicating that the effect of sequence on the time spent close to the experimenter varied according to the test condition. We therefore split the data into the three conditions. We found that in the condition “Absent owner” the dogs spent significantly more time close to the experimenter when they received this condition in their second trial than when receiving it in either their first or their third trial (pairwise comparisons, Mann Whitney U test; 1st–2nd: $Z=2.429$, $P=0.015$; 2nd–3rd: $Z=-1.981$, $P=0.048$; 1st–3rd: $Z=1.000$, $P=0.317$). In the other two conditions there was no effect of sequence (Figure 4).

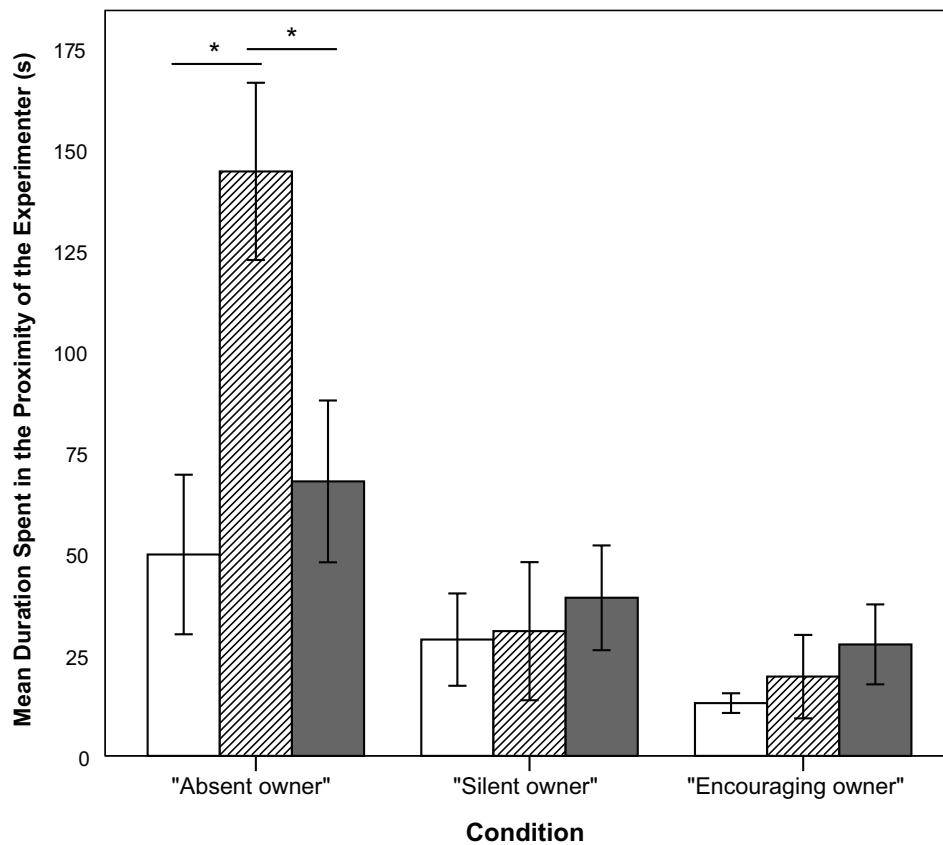


Figure 4. Duration spent in the proximity of the experimenter. Mean duration spent in the proximity of the experimenter in the conditions “Absent owner” (cAO), “Silent owner” (cSO), and “Encouraging owner” (cEO). White bars represent the 1st trials, striped bars represent the 2nd trials, grey bars represent the 3rd trials. Shown are mean $\pm$ s.e.m.

Discussion

In this study we found that in a problem-solving task the dogs’ duration of manipulating an apparatus for retrieving food was shorter when their owner was absent than when the owner was present, irrespective of the owner’s behavior when present in the room. This significant decrease in manipulation in the absence of the owner was not only evident in dogs with separation problems, since the duration of manipulation was not negatively correlated with the dogs’ degree of separation-related behavior scored in the ASST. However – independently of the duration of manipulation – the dogs were most successful in retrieving food from the apparatus when their owner was verbally encouraging them and least successful when their owner was absent. The dogs’ proximity to their owner during the experiment did

not depend on the owner's behavior, whereas the dogs spent most time in the proximity of the experimenter when the owner was absent – especially when they received this condition as their second trial.

The effect of reduced manipulation in the absence of the owner found in this experiment cannot be attributed to a lack of food motivation in the absence of the owner or to the surprise of not finding the owner in the experimental room because we controlled for these factors in the pre-test. With the pre-test we made sure that all dogs were familiarized with the owner's potential absence from the room and that they were ready to consume food also when separated from the owner. Additionally, the decrease of manipulation can also not be attributed to a lack of behavioral cueing or encouragement from the absent owner. In the condition "Encouraging owner" the owner was constantly encouraging the dog to manipulate the apparatus, while in the condition "Silent owner" the owner could not see the actions of the dog due to being blindfolded and did not interact with the dog at all. Despite these substantial differences in the owner's cueing and encouragement, there was no significant effect on how long dogs persisted in manipulating the apparatus in these two conditions. Therefore, the factor influencing the dogs' duration of manipulation was the absence of the owner. This points to the owner's function as a secure base for the dogs, influencing their persistency to manipulate the apparatus in this cognitive task. A comparable effect has been shown in human children when they were confronted with a problem-solving task: those children that were able to use their mother as a secure base were found to be more enthusiastic and persistent in solving the task compared to children for whom the mother was no secure base [5].

In our study we also controlled for the possibility that the dog's degree of separation distress lead to a decreased duration of manipulation in the owner's absence. However, since the dogs' duration of manipulation was not negatively correlated with their individual SRB score, this points to an influence of the secure base effect on all dogs. This is an additional indication that dogs exhibiting separation anxiety are not more attached to their owners than dogs without this disorder, since the other components of the attachment system do not seem to differ between these two groups of dogs (see also [16,17]).

Since the dog was never completely alone during the experiment because the experimenter was present in each trial, the dogs' secure base effect observed in this study was – like in human children – clearly specific for their attachment figure. However, we found that the dogs spent more time in the proximity of the experimenter in the absence of the owner, possibly

indicating that the experimenter nevertheless had the potential to provide social support to the dog in this stressful situation. Also in human children it has been observed that they can seek social support from non-attachment figures with whom they had been familiarized prior to the ASST [19]. Although in adult dogs it has so far mainly been shown that owners are the ones who provide social support for their dogs [20,21], in dog puppies social support can also be provided by an unfamiliar human [22]. It is also interesting that the effect of searching the experimenter's proximity was strongest when the dogs received the condition "Absent owner" as their second trial. This cannot be attributed to the stronger insecurity about the absence of the owner after a trial with the owner present in the room because in that case the same effect should have also been found in the third trial. Additionally, in the pre-test all dogs were familiarized with the potential absence of the owner and therefore it should not have been an unexpected event for the dogs. Although the observed effect is very robust with an equal variation across the dogs in all three trials, our experiment does not allow us to draw final conclusions and therefore further research will be needed to explain these findings.

Differently from the motivation to manipulate the apparatus, the success in retrieving a food reward was also influenced by the owner's behavior. The success rate was lowest when the owner was absent and there were generally short durations of manipulation. Independently from the equal durations of manipulation when the owner was present however, the dogs were more successful when their owners were verbally encouraging them. Although a previous study showed no effect of owners' encouragement on dogs' success in a relatively difficult problem-solving task [23], in the current experiment – where a much simpler manipulation was needed – owners might have indicated the right solution with simple commands known to the dogs or might have simply consistently reinforced the dogs' behavior when they were manipulating the apparatus in the right way.

Our study presents a further important piece of evidence for the similarity between the secure base effect found in the dog-owner relationship and that present in human infants. Further, our study is the first to show that the secure base effect in dogs extends from the ASST to other areas of dogs' lives and that it can also manifest in cognitive testing. This also has important implications for behavioral testing in dogs, because the presence or absence of the owner during a test situation might substantially influence dogs' motivation and therefore the outcome of the test.

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CHAPTER 3

Domestic dogs (*Canis familiaris*) flexibly adjust their human-directed behavior to the actions of their human partners in a problem situation

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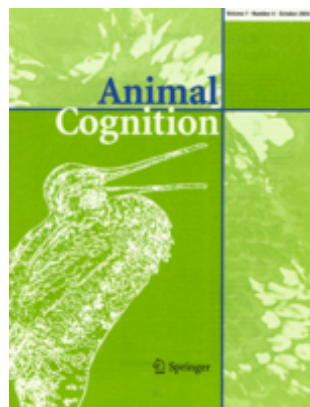
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Domestic dogs (*Canis familiaris*) flexibly adjust their human-directed behavior to the actions of their human partners in a problem situation

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Abstract

Domestic dogs (*Canis familiaris*) have been shown to actively initiate triadic communicative interactions by looking at a human partner or by alternating their gaze between the human and an object when being faced with an out-of-reach reward or an unsolvable problem. It has hardly been investigated, however, whether dogs flexibly adjust their human-directed behavior to the actions of their partners, which indicate their willingness and abilities to help them when they are faced with a problem. Here, in two experiments, we confronted dogs – after initially allowing them to learn how to manipulate an apparatus – with two problem situations: with an empty apparatus and a blocked apparatus. In Experiment 1, we showed that dogs looked back at their owners more when the owners had previously encouraged them, independently from the problem they faced. In Experiment 2, we provided dogs with two experimenters and allowed them to learn through an initial phase that each of the experimenters could solve one of the two problems: the Filler re-baited the empty apparatus and the Helper unblocked the blocked apparatus. We found that dogs could learn to recognize the ability of the Filler and spent time close to her when the apparatus was empty. Independently from the problem, however, they always approached the Helper first. The results of the present study indicate that dogs may have a limited understanding of physical problems and how they can be solved by a human partner. Nevertheless, dogs are able to adjust their behavior to situation-specific characteristics of their human partner's behavior.

Keywords

Dog–human interaction • Communication • Gazing • Learning • Problem-solving • Help-requesting behavior

Introduction

Changes in the pattern of looking at others are a main characteristic of the socio-cognitive development of human infants in their first year of life (Rochat and Striano 1999). Genetic predispositions like inborn preferences for face-like patterns and eye contact (Batki et al. 2000; Farroni et al. 2002) have been suggested to facilitate infants' learning about others as well as about objects at this early age (Csibra and Gergely 2006; Johnson and Morton 1991). By the end of the first year of life, children's gazing pattern associated with triadic situations involving child, adult, and objects gets more sophisticated. They flexibly and reliably direct adult attention to outside entities using communicative gestures and check whether the adult is paying attention to them by precisely coordinating their gazing between their partner, the object, and their manipulative actions (Carpenter et al. 1998). These joint attentional skills of children are thought to be the precursors of their later representational theories of mind (Wellman 1993) and may already reflect recognizing others' attention and intentions (Tomasello 1995). Other authors emphasize the role of associative learning processes during regular infant–adult interactions that may – simply by rewarding the infant when looking at the adult or at the object – increase the frequency of these behaviors without any deep understanding of others' intentions (Corkum and Moore 1998; Perner 1993). In support of both theories, it has been found that 7-month-olds, when encountering a novel object, repeatedly looked at an adult, but they did so independently from whether the adult was engaging in interaction with them or not. Only ten-month-old infants took into account whether the adult was paying attention to them (Striano and Rochat 2000). Accordingly, gazing of the older infants seems to reflect sensitivity to the partner's direction of gaze, whereas the younger infants' looking at the adult can be explained by less fine-tuned conditioning in earlier similar situations when they could profit from monitoring others' faces. Apparently, genetic predispositions facilitate learning about others and objects across early human development. Through these learning processes, older infants come to a better

understanding of when to expect certain actions from others in social interactions and are subsequently able to adjust their own behavior in a more sophisticated way to their partner's engagement.

Dogs have also been reported to actively initiate triadic communicative interactions by looking at a human partner or alternating their gaze between the human and an object – either when indicating a reward hidden in a location out of their reach (Gaunet 2008, 2010; Hare et al. 1998; Miklósi et al. 2000) or when facing an instrumental problem difficult or unsolvable for them (Marshall-Pescini et al. 2008; Miklósi et al. 2003). Regarding the underlying mechanisms of this behavior, studies comparing its occurrence in domestic dogs and human-reared wolves have led authors to propose that – during the course of domestication – dogs evolved a genetic predisposition to look at humans or to quickly learn to do so, which is not present in wolves (Gácsi et al. 2009; Virányi et al. 2008). Additionally, dogs' experiences with their human partners from early age on might also contribute to their preference to look back at them. Various studies have demonstrated that keeping conditions, general training, and reinforcement schedule can strongly influence the dog's human-directed gazing behavior (Bentosela et al. 2008; Marshall-Pescini et al. 2009; Topál et al. 1997). Accordingly, associative learning processes are likely to play a crucial role in dogs' readiness to look at humans in problem situations, which does not exclude, however, that through these learning processes, dogs also develop skills to adjust their behavior flexibly to others' direction of attention and engagement in a given problem (Call 2001).

Regarding this fine-tuned behavioral coordination of dogs, it has been shown that dogs preferentially beg from a person who can see them in contrast to another one who turns away or whose eyes are covered (Gácsi et al. 2004). They alternate their gaze between a human partner and an out-of-reach toy more often if the person was not present when the toy was hidden and therefore does not know where the object is (Virányi et al. 2006). Apparently, guide dogs of blind owners – despite ample experience that their owners cannot see – cannot resist looking back at their owners when faced with a problem. However, in this situation, they additionally use sonorous mouth licking – a behavior, which is perceivable for their blind owners (Gaunet 2008). Moreover, Gaunet (2010) showed that dogs continued to produce their human-directed behavior when they did not receive the solicited object from their human partner. Also, dogs that are used to cooperating with their owners in interactive dog sports look back at their owners more persistently when they cannot solve a problem on their own

compared to pet dogs without such training (Marshall-Pescini et al. 2009). To what extent the above-described flexible use of human-directed gaze in dogs reflects cue-driven conditioned responses and to what extent it relies on understanding of the human's intentions and other psychological states is hard to disentangle – just as it is in case of human infants. Still, investigating to what features of their partners' actions dogs adjust their gazing behavior can inform us about their cognition and behavioral flexibility. The aim of our study was to investigate whether dogs would adapt their human-directed behavior to the actions of their human partners.

Experiment 1

In our first experiment, we tested whether dogs would adjust their human-directed gazing behavior to their owners' previous encouragement, indicating owners' attention and interaction in the problem-solving situation. In two groups of dogs, we systematically manipulated owners' responses to their dogs' looks while the dogs learned to manipulate an apparatus. During an initial training phase, half of the owners were asked to encourage their dogs each time they looked back at them in the same way they usually use in daily interactions with their dogs to ensure them about their agreement and support. In the other group, the owners did not respond to the dog's behavior in any way. Based on their experience in the initial training trials, we expected that if dogs learned about their owners' responsiveness in this specific situation, previously encouraged dogs would look at their owners more often in the test trials than non-encouraged dogs, although not receiving encouragement anymore in those trials. If the dogs were insensitive to the owner's behavior or their looking at the owner resulted from earlier experiences gained with their owners prior to the experiment (e.g., associating the owner with food, checking the owner's reactions to ongoing events), they should equally look at the owner after both types of training.

Furthermore, we also investigated whether dogs would distinguish between two different problem situations. We examined whether they would look at their owners more often when faced with a novel problem situation that their owner could potentially solve (i.e., the apparatus was getting blocked during manipulation and thus the previously learned solution of the problem was not applicable anymore) in contrast to another problem situation with the same apparatus that the owner could not solve in the experimental setting (i.e., finding the

apparatus empty when the owner had no food to fill it). If dogs perceived that in the one situation, there was a greater probability that the owner would interfere – because dogs might have experienced their owners providing inaccessible items (e.g., toys) during their everyday interactions – they should look at the owner more often when the apparatus was blocked compared to when it was merely empty. If, however, the dogs did not perceive that the owner was more likely to solve one specific problem, no difference would be expected in the looking behavior between the two test trials.

Materials and methods

Subjects

Forty-three dog–owner pairs were recruited from the list of volunteer participants of the Family Dog Research Program at the Department of Ethology of the Eötvös Loránd University in Budapest, Hungary. Only adult dogs permanently living together with the owner in the same household as pets were selected. All dogs had at least basic obedience training, and training levels were balanced across experimental groups. Seventeen dogs had to be excluded because they failed the pretest (see procedures section below), and one dog had to be excluded during testing because it attempted to damage the apparatus and the experiment had to be aborted. Therefore, 25 dogs completed the experiment. They comprised 17 males and 8 females ranging from 1.1 to 10.4 years of age ($\text{Mean} \pm \text{SD} = 4.50 \pm 2.36$ years). Dogs were 14 purebred dogs from six different FCI (Fédération Cynologique Internationale) breed groups (7 Sheepdogs, 1 Molosoid breed, 1 Terrier, 1 Scenthound, 2 Pointing dogs, 2 Retrievers) and 11 mixed-breed dogs. Two owners were men and 19 were women; four owners had two dogs participating in the experiment.

Apparatus

The apparatus consisted of two wooden discs screwed on top of each other (80 cm in diameter, upper disc 11 cm from the ground, see Fig. 1). Six round food containers (10 cm in diameter) were built into the lower disk with equal distance to each other. The upper disc could

be rotated in one direction. A hole of the same size as the food containers in the upper disk allowed access to the food reward if the hole aligned with a food container on the lower disc. All odor cues were controlled for by fixing one piece of food to the backside of each container – out of reach for the dogs. The apparatus also comprised a blocking mechanism that – when activated – blocked the rotation of the upper disk after it had been turned 180° and fixed it in that position.

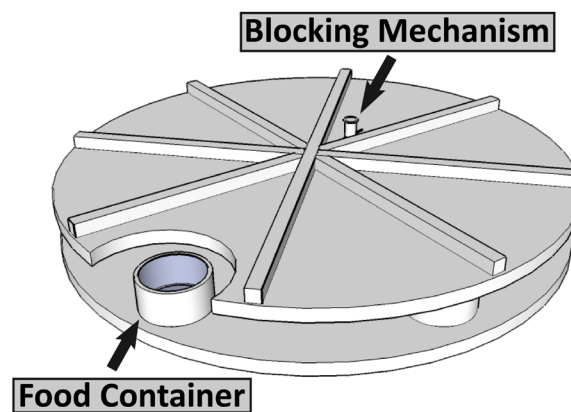


Fig. 1 Schematic drawing of the apparatus used in Experiment 1 and Experiment 2, showing one of the six food containers on the lower disk and the blocking mechanism. Engaging the blocking mechanism would render the upper disk immobile after turning it 180°

Experimental setup

Testing took place in a quiet experimental room (3 m x 5 m) at the department. The experiments were carried out between January and March 2008. The experimental room was empty except for the apparatus and a chair for the owner. A grid on the floor marked sections of 1 x 1 m each. The chair on which the owner was seated throughout the experiment was situated approximately one meter away from the apparatus and facing it. Throughout the experiment, owners had to wear dark sunglasses but their head was always oriented to the apparatus. The door that was used by the owner to enter with the dog as well as by the experimenter to enter and exit the experimental room during trials was located behind the owner. The experimental room was equipped with four cameras connected to monitoring and

recording equipment in the adjacent room, from where the experimenter could observe the dog and the owner during all phases of the experiment.

Procedures

All dogs had to pass a pretest in which they could manipulate the apparatus to ensure that they were motivated and not stressed in the experimental setting. Dogs that passed the pretest progressed to two experimental sessions on two different days. Each session consisted of a training phase and one test trial (see Fig. 2). The interval between the two sessions was between 1 and 11 days ($\text{Mean} \pm \text{SD} = 5.21 \pm 3.16$ days) for all dogs except for one. This dog could only be tested in the second session after 30 days due to an accident. Nevertheless, this dog reached the criterion in the second training phase equally fast as the other dogs; therefore, we did not exclude it from our sample.

Pretest

In the pretest, the owner entered the experimental room together with the dog on the leash. Inside the room, the apparatus was already set up and filled with food rewards and the experimenter was not present during the pretest. The owner sat down and let the dog off the leash, so that it could explore the room and manipulate the apparatus for 10 min. Owners were allowed to encourage their dogs to approach the apparatus with one command in the beginning of the pretest (e.g., “Get it!”, “It’s yours!”) and to comfort their dogs when they seemed stressed by the experimental setting. The pretest was passed successfully when the dog obtained at least one piece of food reward on its own within 10 min.

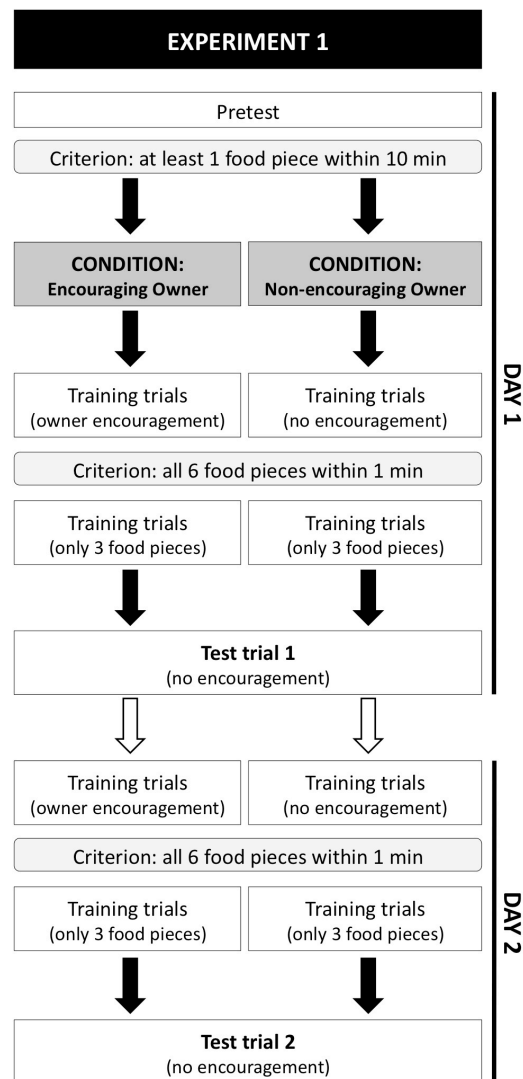


Fig. 2 Testing schedule of Experiment 1

Training phase

The training allowed the dogs to learn how to effectively manipulate the apparatus to obtain the food reward and to give them experience about their owners' behavior in this task. To systematically manipulate the dogs' experience, they were randomly assigned to one of two experimental groups: "Encouraging owner" ($N = 13$ dogs) or "Non-encouraging owner" ($N = 12$ dogs). In the "Encouraging owner" group, owners were asked to encourage their dogs verbally whenever the dogs looked back at them (e.g., "Good dog!", "Keep trying!"). They

were, however, not allowed to make any gestures or point at the apparatus, and they were wearing common sunglasses that prevented the dogs from having eye contact with the owners, while the owners could still see what their dogs were doing. In the “Non-encouraging owner” group, the owners were wearing dark sunglasses that were opaque, so that they could not see the actions of their dogs. These owners were asked to sit passively during the training phase.

Each training trial started with the dog being allowed to observe the experimenter entering the room and hiding six food pieces in the apparatus. In the first trial, the dogs could run free and watch the hiding of the food in the apparatus closely to increase their motivation. In every other trial, the dogs observed the hiding of the food from a position next to their owner, where they were gently restrained by the owner. After the experimenter hid the last piece of food, she touched but did not engage the blocking mechanism and then left the room inconspicuously. Once the experimenter left, the dog was released by the owner with one command that allowed it to manipulate the apparatus to obtain the food and that was known to the dog (e.g., “Get it!”, “It’s yours!”). During each training trial, the dog received either encouragement or no encouragement, depending on the assigned condition. A training trial ended after the dog had obtained all food pieces or after it gave up manipulating the apparatus for longer than 1 min. Training trials were repeated until the dog reached the criterion of obtaining all six food pieces hidden in the apparatus within 1 min. After reaching the criterion, two more training trials were carried out to familiarize the dog with a situation where not every container was baited. In these trials, the procedure was exactly the same as in the other training trials with the exception that the experimenter pretended to hide six pieces of food while she actually only hid three pieces of the reward.

Test trials

After each training phase, one test trial was conducted. Each dog was tested twice with two different test trials: “Apparatus empty” or “Apparatus blocked”. The sequence of test trials was counterbalanced across dogs.

In the test trials, owners of dogs of both groups were asked to wear opaque sunglasses and sit passively. In the test trial “Apparatus empty”, the experimenter pretended to hide food in the apparatus as before, but no food was actually placed into the containers. In the test trial

“Apparatus blocked”, however, the experimenter hid six food pieces in the apparatus but then engaged the blocking mechanism, which would render the apparatus immobile after half a turn, so that the dog could only obtain three pieces of food. After the experimenter left the room, the dogs were allowed to manipulate the apparatus as in the training trials. A test trial ended after a dog gave up manipulating the apparatus for more than 1 min or after a maximum of 5 min. The second test trial took place on another day after a second session of identical training trials.

Data analysis

All experimental sessions were videotaped for later behavioral coding with Solomon Coder beta (©2006–2009 András Péter). All statistical analyses were carried out with SPSS Statistics 17.0.0 (©2008 SPSS Inc.).

The dogs’ learning rate was investigated by analyzing the number of trials needed to reach criterion in the first training phase. The effect of encouragement during training on the learning rate was tested using a Mann–Whitney U test (Encouraging owner, Non-encouraging owner). Additionally, a Spearman’s rank correlation was carried out to investigate whether the age of the dog influenced the learning rate.

For statistical reasons, we decided to include only continuous variables in our analysis. The following behavioral variables were recorded during test trials at 0.1 s time resolution:

- Manipulating the apparatus (duration, latency): The dog interacts with the apparatus using its muzzle or paws.
- Looking at the owner (duration, latency): The dog directs its head and eyes (if visible) to the owner.
- Looking at the door (duration, latency): The dog directs its head and eyes (if visible) to the door.

Since the length of the test trials varied, raw data of the durations were converted into relative durations. A second coder blind to the aim of the experiment and to the experimental conditions coded 20% of the videos of the test trials, and Cronbach’s alpha was calculated as a measure of interobserver reliability. Cronbach’s alpha was greater than $\alpha = 0.84$ for all behavioral variables.

Linear mixed models (LMM) were used to investigate the effect of experimental groups (Encouraging owner, Non-encouraging owner), types of test (Apparatus empty, Apparatus blocked), and sequence of test sessions (First session, Second session) on latency and relative duration of manipulating the apparatus and the gazing behavior of the dog during test trials. Analyses of the residuals of the LMMs confirmed normal distribution for all variables but “latency to look at the owner.” Therefore, this variable was log-transformed and a new LMM was calculated.

Results

No difference in the number of trials the dogs needed to reach criterion was found between dogs whose owners had encouraged them during training trials and dogs whose owners had remained silent (Mann–Whitney U test: $N = 25$, $Z = -0.891$, $P = 0.373$). Further, there was no correlation between age of the dog and learning rate (Spearman’s rank correlation: $N = 25$, $\rho = 0.146$, $P = 0.487$).

Since the dogs – independently from the owners’ encouragement – were similarly successful in their first training session, it is not surprising that their latency to approach the apparatus in the test trials was the same in both groups (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Group} = 1.019$, $P = 0.318$). Similarly, in both types of test trials, they approached the apparatus equally fast (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Test} = 1.085$, $P = 0.304$), suggesting that they were equally motivated in both tests. Despite this, dogs continued to manipulate the apparatus considerably longer when it was blocked than when it was empty (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Test} = 18.587$, $P = 0.001$).

The dogs that had been encouraged during the preceding training trials generally stopped manipulating the apparatus after a shorter time than the dogs that had not been encouraged (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Group} = 4.437$, $P = 0.041$). Also, the amount of looking at their owners depended on the encouragement received during the training trials. Dogs that had been encouraged looked at their owners longer than dogs that had not been encouraged (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Group} = 4.328$, $P = 0.044$). Additionally, there was an effect of the sequence of the test trials on the duration of looking at the owner, with dogs of both groups looking for shorter periods in the second session

($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 25, df = 42, F_{\text{Session}} = 6.144, P = 0.017$). This difference was more pronounced in dogs with encouraging owners, where the duration of looking at the owner dropped almost to the levels of non-encouraged dogs in the second session, although this trend was not significant ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 25, df = 42, F_{\text{Group} \times \text{Session}} = 3.263, P = 0.078$; Fig. 3a). The type of test trial had no effect on how much dogs looked at their owners but did influence when they first looked at them. Dogs looked at their owners later when the apparatus was blocked ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 25, df = 42, F_{\text{Test}} = 9.136, P = 0.004$), although this effect was only found in the first session ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 25, df = 42, F_{\text{Test} \times \text{Session}} = 8.667, P = 0.005$; Fig. 3b). Importantly, independently from previous encouragement by the owner, dogs in both groups looked at the owner and did so with a similar latency ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 25, df = 42, F_{\text{Group}} = 1.612, P = 0.211$).

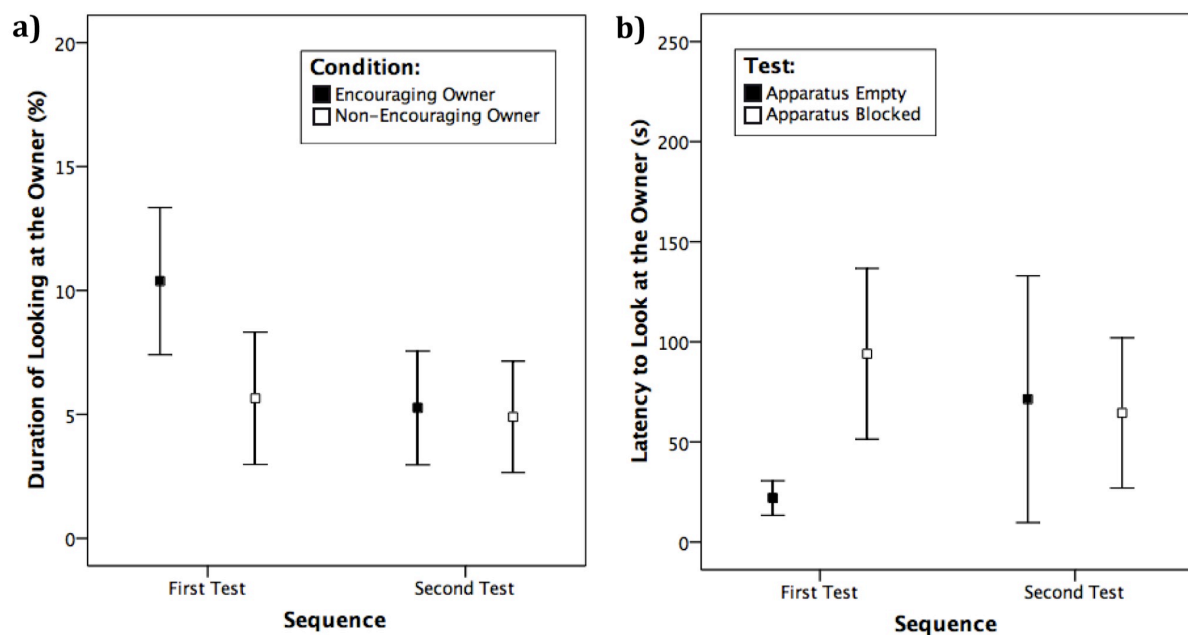


Fig. 3 a Means of the relative duration of looking at the owner (with 95% confidence intervals (CI)), grouped by testing sequence. **b** Means of the latency to look at the owner (with 95% CI), grouped by testing sequence

In the test trials, the dogs were also found to look repeatedly at the door. They looked at the door significantly longer in test trials, in which the apparatus was empty than when it was blocked ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 25, df = 42, F_{\text{Test}} = 14.164, P = 0.001$) and they did so

more in the second session (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Session} = 5.824$, $P = 0.020$; Fig. 4a). Previous encouragement on the other hand had no effect on how long the dogs looked at the door (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Group} = 1.082$, $P = 0.304$). However, the latency to look at the door was affected both by the type of test and by previous encouragement (LMM_{Group_x_Test_x_Session}: $N = 25$, $df = 42$, $F_{Test} = 36.575$, $P = 0.001$; $F_{Group} = 6.285$, $P = 0.016$; Fig. 4b) with dogs looking at the door considerably earlier when the apparatus was empty and dogs that had previously been encouraged by their owners looking at the door sooner than non-encouraged dogs.

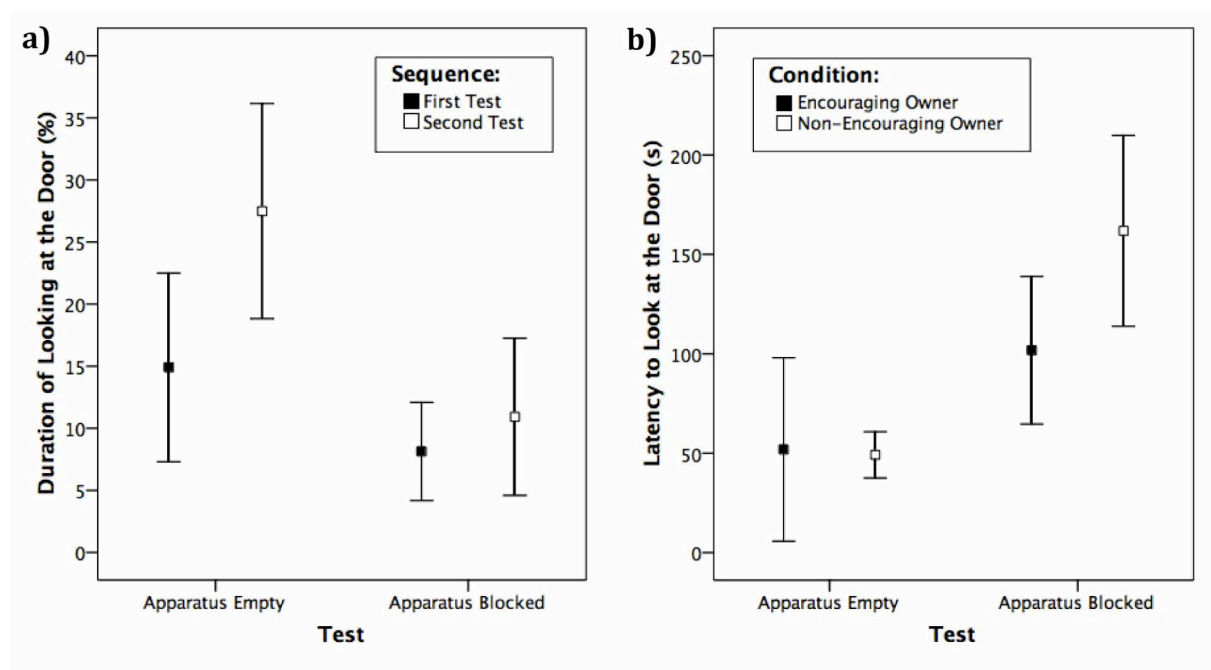


Fig. 4 a Means of the relative duration of looking at the door (with 95% CI), grouped by type of test. **b** Means of the latency to look at the door (with 95% CI), grouped by type of test

Discussion

In this experiment, we found that previously encouraged dogs looked longer at their owners than non-encouraged dogs, but this difference almost disappeared in the second test trial. The latency to look at the owner was the same for all dogs. Furthermore, while the dogs manipulated the apparatus longer when it was blocked than when it was empty, the latency to start manipulating was the same in both test types. Finally, the dogs looked longer at the door

through which they and the experimenter had entered the experimental room, when the apparatus was empty than when it was blocked.

While owner's encouragement during the training phase had no influence on how fast the dogs acquired the task, the behavior of the owner had an effect on how long the dogs continued to look back at them when they were faced with a problem in the test trials. Remarkably, the rather brief exposure to the owner's encouragement in our experiment (i.e., owners were only allowed to encourage their dogs during the initial training phase) was sufficient to cause a significant increase in owner-directed behavior in the test trials. Further emphasizing the flexibility of this behavior, we found that already in the second test trial, the rate of looking at the owner dropped down to almost the same level as in dogs that had never been encouraged, suggesting that the dogs learned in the first test trial that owners would not interfere when they were faced with a problem. However, we found that looking back at the owner occurred in the non-encouraged dogs as well and that the latency to look at the owner was the same for all dogs, independently from previous encouragement. This shows that at least the occurrence of looking at the owner is common in dogs, but its pattern can be flexibly adjusted to the situation.

Dogs from both groups, however, did not look at the owner longer or earlier in any of the two problem situations (i.e., blocked apparatus vs. empty apparatus). This cannot be explained by the dogs perceiving both test trials as similar problems because based on their manipulative behavior, it is clear that they differentiated between the two kinds of problems. When the apparatus was blocked, the dogs continued to manipulate the apparatus much longer than when the apparatus was empty. Also – since we controlled for odor cues – this result was not likely to be due to a lack of food odor, which could have led dogs to instantaneously perceive that the apparatus was empty. Confirming this, the latency to approach and manipulate the apparatus was the same in both test trials indicating that in the beginning of the trial, the dogs were equally motivated to manipulate the apparatus when it was empty as well as when it was filled. However, receiving no food reward in the empty condition – compared to the blocked condition in which dogs received three pieces of food before the apparatus got blocked – might have led dogs to give up sooner. Alternatively, continuing to manipulate the apparatus for a long time when it was blocked might have been caused by the novel experience of suddenly not being able to move the apparatus anymore and not realizing that the task was in fact unsolvable. Therefore, the dogs might have simply tried harder to solve the task.

Accordingly, it seems that the dogs did not take into account that one of the problems was more likely to be solved by the owner. This is not surprising since – although the dogs might have had experiences with their owners retrieving inaccessible items for them during their everyday interactions – in the experimental setting, the dogs could never experience the owner actually unblocking the blocked apparatus for them. They could, however, repeatedly experience the experimenter re-baiting the empty apparatus, and interestingly we found that – when the apparatus was empty – the dogs looked more at the door through which the experimenter had entered to bait the apparatus whenever it was empty. Based on this observation, one can hypothesize that the dogs might have indeed recognized the more active, refilling role of the experimenter, and when they were faced with the empty apparatus, they expected her to return in accordance with the usual sequence of the procedure. A confounding factor was, however, that the dogs also had entered the experimental room through the same door and as such, looking at the door may have merely reflected their expectation to leave the experimental room once the apparatus was empty. In Experiment 2, we therefore attempted to resolve the question of what dogs may learn about two experimenters' specific abilities to solve one specific problem each.

Experiment 2

In the second experiment, we changed two design features of the applied paradigm. Firstly, the dogs and the experimenters entered the room through different doors. Secondly, we introduced two experimenters, the Filler and the Helper. The Filler regularly re-baited the empty apparatus, whereas the Helper repeatedly entered to unblock the apparatus when it got blocked. In two test trials analogous to Experiment 1, we then examined whether dogs initiated interactions with the Filler more often when they found the apparatus empty and with the Helper more often when the apparatus was blocked. Further, any behavior directed to the door where the dogs had entered would indicate that the dogs expected to leave the room.

Materials and methods

Subjects

For this experiment, 36 new dog–owner pairs were recruited using the same criteria as in Experiment 1. Thirteen dogs had to be excluded because they failed the pretest, two dogs had to be excluded during testing because the experiment had to be aborted (one tried to damage the apparatus, one started to get too stressed by the experimenters in the room). The data of one dog could not be analyzed because video recording failed during the experiment. Therefore, the data of 20 dogs were analyzed. The sample consisted of eight males and twelve females ranging from 1.0 to 15.8 years of age ($\text{Mean} \pm \text{SD} = 4.78 \pm 3.72$ years). Dogs were 14 purebred dogs from four different FCI breed groups (10 Sheepdogs, 1 Terrier, 2 Pointing dogs, 1 Companion dog) and 6 mixed-breed dogs. Three owners were men and 15 were women; two owners had two dogs participating in the experiment.

Apparatus

The same apparatus as in Experiment 1 was used in this experiment.

Experimental setup

The experiment was carried out between September 2008 and February 2009. The testing location and setup were the same as in Experiment 1, but in this experiment, three different doors were used. The owner used the door on one side of the experimental room to enter and exit together with the dog. During the whole experiment, owners were asked to wear dark sunglasses and sit passively while being oriented to the apparatus. On the other side of the room, there were two opposing doors (Door1 and Door2; see Fig. 5), through which the two experimenters entered and left the experimental room. The two experimenters each acted out one specific role (i.e., Filler and Helper). Prior to the experiment, one of the two doors (Door1, Door2) was assigned to and used by one experimenter throughout the familiarization, the training, and the learning phases. The opposing door was used by the other experimenter. The sides of the assigned doors were counterbalanced across dogs. Five women acted as

experimenters in this study, and the roles were counterbalanced between experimenters, so that every experimenter played each of the two roles equally often.

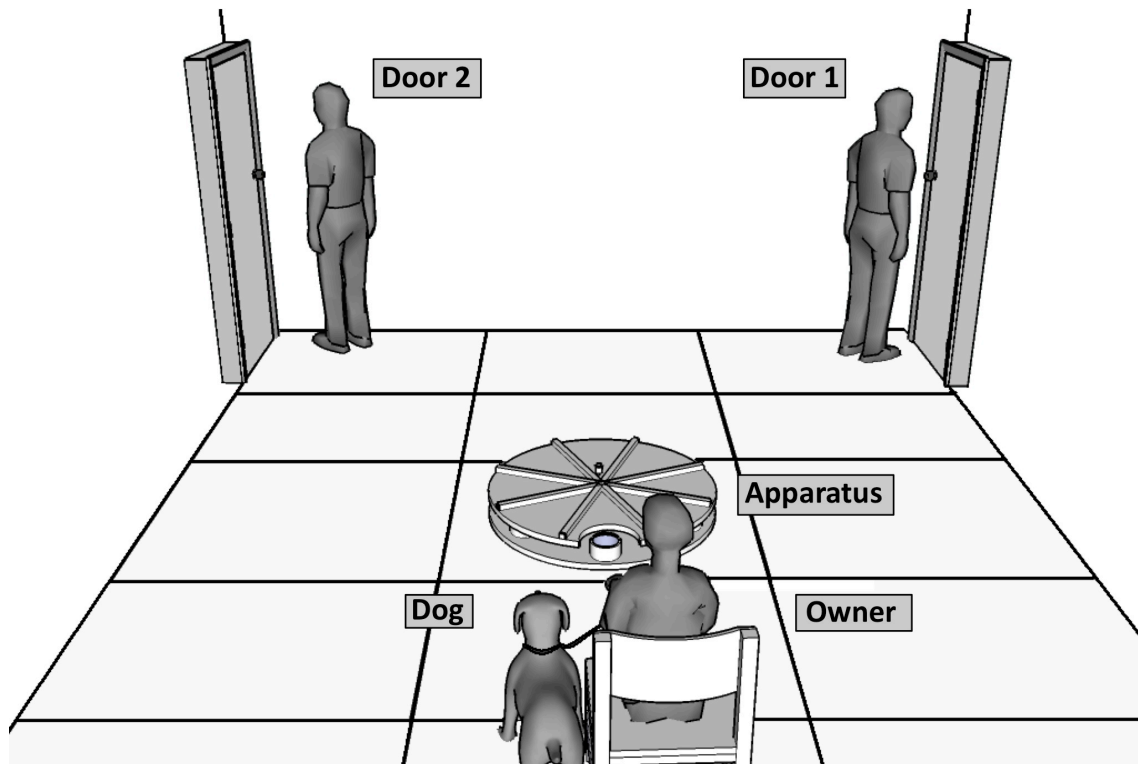


Fig. 5 Schematic drawing of the experimental setup at the beginning of a test trial. The drawing shows the starting position of the dog next to the chair of the owner and the position of the apparatus. The door that the owner used together with the dog is behind the owner's chair and not visible in this drawing. The two experimenters are positioned in front of the doors (Door 1, Door 2) that they use during the training and the learning trials. A grid on the floor marks sections of 1m² each

Procedures

Dogs had to pass the same pretest as in Experiment 1. Subsequently, the successful dogs were familiarized with the experimental room and the two experimenters. The familiarization phase was immediately followed by the training phase, which was similar to Experiment 1 with the exception that only the experimenters and not the owners interacted with the dogs in Experiment 2. After reaching the criterion, the dogs started the learning phase, which consisted of two sessions on two different days and during which they could learn about the

specific abilities of the two experimenters. When the dogs had had the opportunity to observe the actions of the two experimenters in both learning sessions, they received two consecutive test trials (i.e., “Apparatus empty”, “Apparatus blocked”) that were analogous to Experiment 1 (see Fig. 6 for the testing schedule).

For seven of the dogs, the first learning session was carried out immediately after the training phase, and for 13 dogs, this session had to be conducted on a different day – depending on how fast they reached the criterion during the training phase. The interval between the days on which dogs could be tested was between 1 and 15 days (Mean $\pm$ SD = 5.21 ± 3.50 days).

Pretest and familiarization

The procedure of the pretest was the same as in Experiment 1. For the familiarization, the owner entered the experimental room with the dog on the leash and let the dog explore the room and the apparatus for approximately 1 min. Then, both experimenters opened their respective doors and greeted the dog shortly (e.g., petting, talking to the dog) – one after the other. The sequence of greeting was counterbalanced between dogs. Subsequently, the owner left the experimental room together with the dog.

Training phase

Each training trial started with the dog being allowed to observe the Filler hiding six pieces of food in the apparatus from a position next to the owner. After the Filler hid the last piece of food, she only touched but did not engage the blocking mechanism and then left the room. Thereafter, the dog was released by the owner and allowed to manipulate the apparatus with one command known to the dog. After 1 min, the Helper entered the experimental room, and for another minute, she encouraged the dog to manipulate the apparatus or showed it how to do so if the dog did not approach the apparatus by itself. After that, the Helper left the room and the owner called the dog back to their side. The training ended when the dog reached the criterion of obtaining all six food pieces within 1 min.

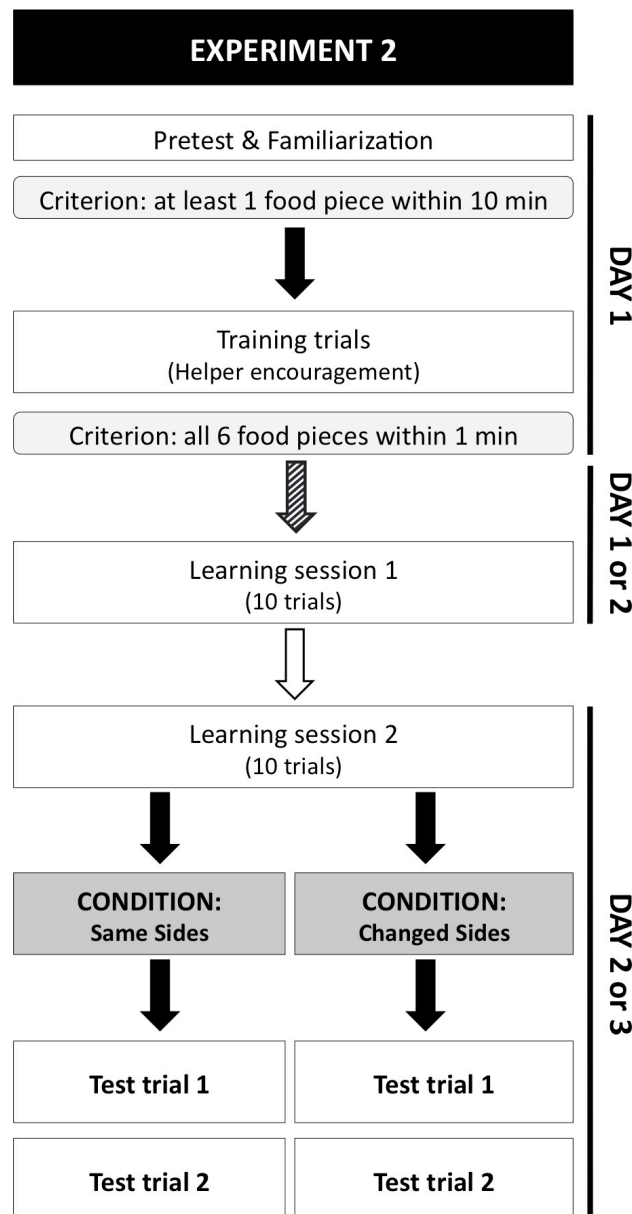


Fig. 6 Testing schedule of Experiment 2

Learning phase

During the learning phase, the dogs had the opportunity to further learn about the specific abilities of the Filler (i.e., providing the food and baiting the apparatus) and the Helper (i.e., unblocking the apparatus when it is blocked).

In the first trial of each session, the dog was allowed to observe the Filler calling the dogs name and then hiding food pieces in the apparatus as in the training trials. After the hiding, the Filler either only touched or engaged the blocking mechanism. In those trials in which the Filler only touched the blocking mechanism, she pretended to hide six pieces of food while she actually only put three pieces into the apparatus. However, in a trial in which the blocking mechanism was engaged, she hid six pieces, of which only three pieces were accessible to the dog before the apparatus stopped rotating. Therefore, in both of these cases, the dog could retrieve three pieces of food during 1 min and after that the owner called it back. In the non-blocked situation, the same procedure was repeated such that the Filler entered the room and once again baited the apparatus. In the blocked situation, the next trial also followed after 1 min, but now the Helper entered the room. She called the dog's name, disengaged the blocking mechanism so that the apparatus could be freely rotated again and positioned the upper disk so that the dog had immediate access to the reward in the next food container. Then, the Helper left the room and the dogs were again allowed to manipulate the apparatus for 1 min, which gave them the chance to retrieve the remaining three pieces of food. Due to this procedure, the dogs received an equal amount of food after observing each of the experimenters' actions.

The sequence of ten trials in each session was semi-randomized with the preconditions that a trial where the dog observed the actions of the Helper could only occur after a trial with the Filler and that trials with the Filler could not take place more than twice in a row. Under these preconditions, dogs underwent six trials in which they could observe the actions of the Filler and four trials in which they saw the actions of the Helper.

Test phase

Directly after the second session of learning trials, two test trials were carried out consecutively, in an order counterbalanced across dogs. Differently from Experiment 1, we had to administer both test trials after the dogs had completed both learning session to ensure that they had an equal amount of experience with the experimenters before being tested in the two different situations.

In the two test trials, the dogs were randomly assigned to one of two groups to differentiate whether they had learned something about the identity of the experimenter or

about the sides from which the Filler and the Helper had entered during learning trials. For half of the dogs, the experimenters stood in front of the same door, through which they had entered throughout the previous phases (Group “Same side”, $N = 10$), for the other dogs, the positions of the experimenters were swapped (Group “Changed side”, $N = 10$).

In both test trials, the owner entered the experimental room with the dog on leash. Inside the room, the apparatus was already set up for the trial. In the test trial “Apparatus empty”, there was no food hidden in the apparatus. In the test trial “Apparatus blocked”, there were six pieces of food hidden in the apparatus, but the blocking mechanism had been engaged so that the apparatus would stop rotating after half a turn. The two experimenters were standing inside the room in front of the two doors (Door1, Door2). Both experimenters had their backs turned to the dog to avoid potential unconscious cueing. Depending on the assigned group, the experimenters were either positioned in front of their own doors or in front of the opposing door. The owner sat down and released the dog as in the previous trials. A test trial ended after a dog gave up manipulating the apparatus for more than 1 min or after a maximum of 5 min. After the test trial, the owner and the dog left the experimental room, and after a short break, the second test trial followed.

Data analysis

Behavioral coding and statistical analyses were carried out as in Experiment 1. The dogs’ learning rate was also analyzed as in Experiment 1.

The following behavioral variables were coded during the test trials at 0.1 s time resolution:

- Manipulating the apparatus (duration): The dog interacts with the apparatus using its muzzle or paws.
- Looking at the owner (duration): The dog directs its head and eyes (if visible) to the owner.
- Looking at the experimenters (duration): The dog directs its head and eyes (if visible) to one of the experimenters. Analyzed separately for each experimenter.
- Staying close to the experimenters (duration): The dog stays in the area in which one of the experimenters is standing (1 m^2 , indicated by red tape on the floor). Analyzed separately for each experimenter.

- Touching the experimenters (first occurrence): The dog approaches one experimenter and touches her with any part of its body.
- Staying close to the exit (duration): The dog stays in the area behind the owner, right in front of the door through which they had entered (1 m², indicated by red tape on the floor).

Since coding the behavior of looking at the door, through which the dogs had entered and exited the room, could not easily be achieved in Experiment 2 because the owners were seated in front of the door, the behavior of staying close to the exit (i.e., behind the owner) was coded instead. As also in this experiment, the duration of the test trials varied, raw data of the behavioral variables were converted into relative durations. As in Experiment 1, a second coder coded 20% of the videos of the test trials, and Cronbach's alpha was greater than $\alpha = 0.83$ for all behavioral variables. For the discrete variable "Touching the experimenters," the agreement was 100%.

As in Experiment 1, linear mixed models (LMM) were used to examine the effect of experimental group (Same side, Changed side), type of test (Apparatus empty, Apparatus blocked), and test session (First session, Second session) on duration of manipulating the apparatus, the duration of looking at the owner and the duration of staying close to the exit. Separate LMMs were applied to examine the behavior of gazing at and staying in the proximity of the two experimenters in the room during test trials. Analyses of the residuals of the LMMs confirmed normal distribution for all variables but "staying close to the exit" and "staying close to the "Helper". Therefore, these variables were square root transformed and new LMMs were calculated.

Finally, the first choice to touch one of the two experimenters was analyzed with binomial tests separately for the first and the second test trial.

Results

No correlation between age of the dog and learning rate was found (Spearman's rank correlation: $N = 20$, $\rho = -0.145$, $P = 0.543$) in accordance with Experiment 1.

In the test trials, the dogs manipulated the apparatus considerably longer when it was blocked than when it was empty (LMM_{Group_x_Test_x_Session}: $N = 20$, $df = 32$, $F_{Test} = 28.255$, $P = 0.001$). Additionally – while in Experiment 1 we found no effect of the sequence – here dogs manipulated the apparatus longer in the second test trial (LMM_{Group_x_Test_x_Session}: $N = 20$, $df = 32$, $F_{Session} = 4.349$, $P = 0.045$), especially in those test trials where the apparatus was blocked (LMM_{Group_x_Test_x_Session}: $N = 20$, $df = 32$, $F_{Test*Session} = 7.737$, $P = 0.009$).

In this experiment, there was no effect of type of test, sequence, or position of the experimenters on the duration of looking at the owner. However, the dogs spent more time close to the exit behind the owner in the test trials when the apparatus was empty (LMM_{Group_x_Test_x_Session}: $N = 20$, $df = 32$, $F_{Test} = 6.007$, $P = 0.020$; Fig. 7).

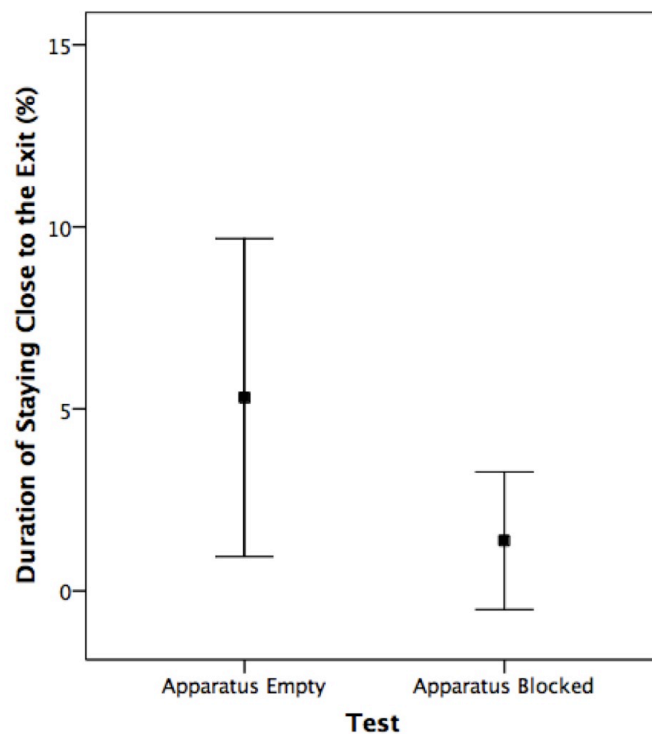


Fig. 7 Means of the relative duration spent close to the exit (with 95% CI), grouped by type of test

In contrast to our expectations, no effect of the type of test on gazing at either the Filler (LMM_{Group_x_Test_x_Session}: $N = 20$, $df = 32$, $F_{Test} = 1.667$, $P = 0.206$) or the Helper (LMM_{Group_x_Test_x_Session}: $N = 20$, $df = 32$, $F_{Test} = 0.526$, $P = 0.474$) during the two test trials was

found. We only found that dogs looked at the Filler less in the second trial than in the first trial ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 20, df = 32, F_{\text{Session}} = 6.915, P = 0.013$), suggesting a decrease in gazing behavior due to a carryover effect from the first to the second test trial. In regard to the behavior of gazing at the Helper, however, we found that when the experimenters stayed in the same position as during previous trials, the dogs looked at the Helper more in the second test trial. Only when the positions were swapped, the gazing pattern was the same as for the Filler with a decrease in the second trial ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 20, df = 32, F_{\text{Group}*\text{Session}} = 5.470, P = 0.026$). Primarily, these results indicate that the dogs did not look preferentially at those experimenters, who previously helped them in the respective problem situations. However, since both experimenters had their backs turned to the dogs, it might be that the dogs did not regard looking at the person as the most effective form of behavior to direct toward them.

Therefore, we also analyzed whom of the experimenters the dogs initially approached and touched and in which trials they spent more time in the proximity of either the Filler or the Helper. Since in this experiment, both test trials were administered consecutively and we expected a possible carryover effect from the first to the second test trial, we analyzed the two test trials separately (see Table 1). Ten dogs first received the test where the apparatus was blocked, in which they were expected to direct their behavior toward the Helper. Those dogs clearly preferred to initially approach and touch the Helper (Binomial test: Helper = 9, Filler = 1, $P = 0.021$, Holm–Bonferroni corrected: $P \leq 0.05$). However, the other ten dogs, which were confronted with the empty apparatus first, showed no clear preference for the Filler (Binomial test: Helper = 7, Filler = 3, $P = 0.344$, Holm–Bonferroni corrected: $P > 0.05$). Moreover – when looking at the first test trials of all dogs together – they preferred to initially touch the Helper (Binomial test: Helper = 16, Filler = 4, $P = 0.012$, Holm–Bonferroni corrected: $P \leq 0.05$). In the second test trial, six dogs touched the Helper and three dogs touched the Filler, but most of the dogs ($N = 11$) did not approach any of the experimenters closely anymore, irrespective of the type of test. This indicates that most dogs stopped approaching the experimenters closely after experiencing that they did not react to their approach in the first test trial.

Table 1 Number of dogs that touched either the Filler or the Helper first, separately for the first and the second test trial

	Person touched in 1st test trial			Person touched in 2nd test trial		
	Filler	Helper	None	Filler	Helper	None
Apparatus blocked	1	9	–	1	3	6
Apparatus empty	3	7	–	2	3	5
Total	4	16	–	3	6	11

Analysis of the duration that the dogs spent in the proximity of the Filler revealed that all dogs spent more time close to her when the apparatus was empty, but the group of dogs for which the experimenters had swapped sides spent generally less time close to the Filler ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 20, df = 32, F_{\text{Test}} = 5.735, P = 0.023; F_{\text{Group}} = 6.390, P = 0.017$, Fig. 8). Staying in the proximity of the Helper, however, was independent of the type of test trial for the dogs. We only found that they spent less time with the Helper in the second test trial ($LMM_{\text{Group}_x\text{Test}_x\text{Session}}: N = 20, df = 32, F_{\text{Session}} = 4.139, P = 0.050$; Fig. 8).

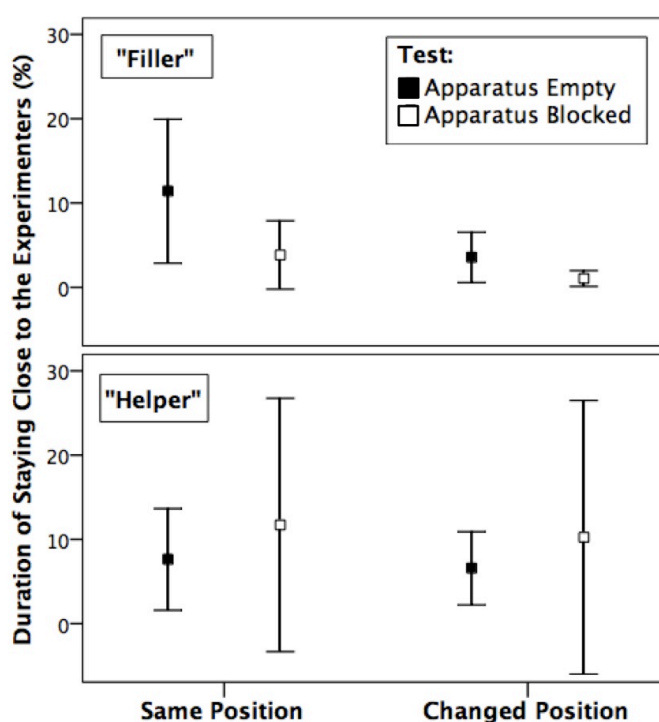


Fig. 8 Means of the relative duration spent close to one of the experimenters (with 95% CI), grouped by the test condition. The upper panel shows the duration spent close to the Filler, the lower panel shows the duration spent close to the Helper

Discussion

In this experiment – similarly to Experiment 1 – we found that the dogs manipulated the apparatus longer when it was blocked than when it was empty, while they spent more time close to the exit when the apparatus was empty. The dogs did not preferentially look at any of the two experimenters depending on the type of test, but they preferred to first approach and touch the Helper. Finally, we found that the dogs spent more time in the proximity of the Filler when the apparatus was empty.

As in Experiment 1, the manipulative behavior of the dogs confirmed that they differentiated between the two problems with the apparatus but again they did not preferentially look at their owners when the apparatus was blocked or when it was empty. This was less surprising in the present experiment because the dogs were provided with two actively helping experimenters, while their owner remained passive. Moreover, we found that the dogs spent more time close to the exit when the apparatus was empty than when it was blocked. However, they also spent more time in proximity of the Filler when the apparatus was empty. Accordingly, it is likely that both factors – expecting to leave and expecting the experimenter to enter – accounted for the increased amount of looking at the door when the apparatus was empty in Experiment 1.

Interestingly, although in this experiment – in contrast to Experiment 1, in which facing the blocked apparatus was a novel problem – the dogs repeatedly had the experience that they could not successfully manipulate the apparatus anymore once it was blocked, they nevertheless did not give up manipulating the apparatus in the test trial. If during the learning phase dogs did not understand the unblocking effect of the Helper's action on the blocking mechanism but focused purely on her encouragement (i.e., calling the dog's name and allowing the dog to continue with manipulating the apparatus), they might have learnt that the solution was to further manipulate the apparatus when finding it blocked. The more interactive behavior of the Helper – mainly occurring in the trials of the training phase – may also explain why the dogs preferred to approach and touch her first, independently of the problem they were facing.

The only result we found in support of the dogs' understanding of the specific ability of at least one of the experimenters was that they spent more time in proximity of the Filler when the apparatus was empty. This preference for the Filler was less pronounced when the

experimenters swapped sides so that she was no more in the same position as during previous trials. However, the dogs did not preferentially stay close to the Filler's door when the Helper had taken her position, suggesting that dogs relied not simply on the position but also on the person. Being confused by the Filler and the Helper changing position might have been enhanced, given the fact that the experimenters had their backs turned to the dog, which likely made the recognition of the persons more difficult.

General discussion

In both experiments, we found that previous interactive behavior of a human partner influenced how intensively dogs initiated interactions with that person when facing a problem. Thus, the dogs differentiated between two unfamiliar persons they got to know in the given situation, but they also context-specifically tuned their gazing behavior toward their owner, with whom they had lifelong experiences. Our findings are in accordance with earlier results demonstrating that looking at humans in problem situations is either based on genetic predispositions and/or more easily learnt in dogs than in non-domesticated canids (Gácsi et al. 2009; Virányi et al. 2008), but that its form (Gaunet 2008) and amount (Bentosela et al. 2008) are readily adjusted to the context as well as the interaction style of the humans (Marshall-Pescini et al. 2009). While dogs' sensitivity seems to exceed the unselective social referencing pattern of 7-month-old infants (Striano and Rochat 2000), determining whether such an adjustment to human behavior relies on conditioned responses, learning about the human's behavioral cues or reaches into reasoning about others' intentional and perceptual characteristics requires further research.

We found no evidence that the dogs would adjust their gazing behavior to the potential helping abilities of the owner in Experiment 1 or the active helping role of the Helper in Experiment 2. This is probably due to the fact that they did not recognize the Helper's specific ability to unblock the device, even when they had the opportunity to repeatedly observe her manipulating the blocking mechanism and unblocking the apparatus with this action. Few experimental studies have so far investigated action understanding in dogs. One study demonstrated that dogs interpreted the action of conspecifics in relation to its effect on the environment (Range et al. 2007), but no such study exists about the causal understanding of

human actions. Several studies have shown, however, that humans' ostensive communication easily overshadows the causal evaluation of an action demonstrated by a human and leads dogs into erroneous performance (Kupán et al. 2011; Prato-Previde et al. 2008; Szeteci et al. 2003; Topál et al. 2009). Also in our study, the human's dog-directed communication seems to have a stronger effect on the behavior of the dogs than understanding the role of the humans in unblocking the apparatus. In case of refilling the apparatus, however, the dogs seem to demonstrate some understanding and adjust their behavior accordingly. After finding the apparatus empty, they look at the door more often when the Filler is outside (in Experiment 1) and spend more time close to her when she is inside the room (Experiment 2). One possible explanation for this discrepancy might be that – due to our need to randomize the trials in which dogs experienced the actions of the Filler and the Helper – the dogs saw the Filler more often than the Helper and therefore had more opportunity to learn about the specific ability of the Filler. Another possible explanation is that the behavior of putting food into the apparatus can be seen as a transparent action that dogs had become familiar with during their lives in the human environment. The unblocking of the apparatus by the Helper, who used a mechanism that was visually inaccessible for the dogs, however, can be regarded as an opaque action that the dogs did not understand. From a study that directly compared dogs to human children (Virányi et al. 2006), there is evidence that dogs fail to recognize the function of intermediate steps in a more complex sequence of actions that are only indirectly linked to getting access to a reward. Participants had to indicate the position of either a toy or a stick that was needed to retrieve the toy— depending on the knowledge state of the experimenter. While the children indicated the position of either the toy or the stick according to which of them was not known to the experimenter, the dogs preferentially indicated the position of the toy in all of the conditions. The authors concluded that the dogs might not have recognized that the stick was needed to retrieve the toy and therefore only indicated the position of the toy.

It is a question, of course, whether the behaviors directed specifically at the Filler when the apparatus was empty reflected the communicative intention of the dogs or simply their expectations that the Filler would enter or move to refill the apparatus soon. The procedure of both experiments made it predictable for the dogs that after the apparatus was emptied, the Filler would enter and refill it. Learning this sequence can be the basis for adjusting the Filler-directed behaviors of the dogs to the test conditions, without requiring a real understanding of the Filler's role in refilling the apparatus (Povinelli et al. 1992). Looking at the door through

which the experimenter was expected to enter in Experiment 1 seems to confirm that the behavior reflects expectations rather than being a form of communication. However, in Experiment 2, where both experimenters had their backs turned toward the dogs, we found that they adjusted their preference of whom to approach and touch, but not their gazing behavior to the previous actions of the experimenters. This may indicate that they tried to communicate with the experimenters and did not consider gazing to be the right way of initiating communication. Previous studies have already shown that dogs are sensitive to the attentional state of a person (Call et al. 2003; Schwab and Huber 2006) and that they choose to beg from a seeing person rather than from a blindfolded person or a person that had their body turned away from the dog (e.g., Gácsi et al. 2004). Again, whether this reflects taking other behavioral cues or attentional mental states into account cannot be decided based on these data.

In a problem situation, Miklósi et al. (2000) carefully analyzed the temporal pattern of object- and owner-directed looks of dogs and their other attention-calling behaviors. They argued that human-directed looks function as attention-getting communicative signals. Based on our results, we do not claim that the human-directed looks of the dogs reflect communicative intentions. It is also unlikely, however, that looking at a human partner in this problem situation occurs only because dogs divide their attention between two interesting things (i.e., the apparatus and the owner) or because they want to check the owner's reactions to the ongoing events. It is possible, though, that their gazing behavior is to a great extent driven by their expectations about the next actions of their human partners (Topál et al. 2005). These predictions can be formed based on what the dogs learnt during the course of the experiments as well as during their lifelong experiences, but this knowledge certainly contains specific information about the individual humans in relation to the given context and allows dogs to flexibly adjust their behavior.

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CHAPTER 4

Dogs' attention towards humans depends on their relationship, not on social familiarity

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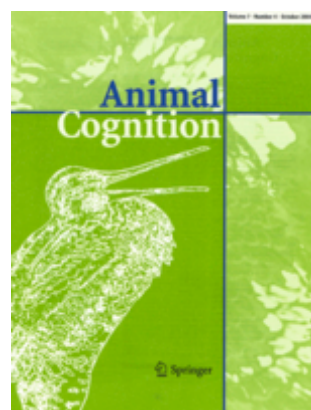
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Dogs' attention towards humans depends on their relationship, not on social familiarity

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Abstract

Both in humans and non-human animals it has been shown that individuals attend more to those individuals that they previously interacted with and/or that they are more closely associated with than to unfamiliar individuals. Whether this preference is mediated by mere social familiarity based on exposure or by the specific relationship between the two individuals, however, remains unclear. The domestic dog is an interesting subject in this line of research as it lives in the human environment and regularly interacts with numerous humans, yet it has a particularly close relationship with its owner. Therefore, we investigated how long dogs (*Canis familiaris*) would attend to the actions of two familiar humans and one unfamiliar experimenter, while varying whether dogs had a close relationship with only one or both familiar humans. Our data provide evidence that social familiarity by itself cannot account for dogs' increased attention towards their owners since they only attended more to those familiar humans, with whom they also had a close relationship.

Keywords

Domestic dogs • Social attention • Social familiarity • Dog-human relationship

Introduction

In recent years, evidence has accumulated both in humans and non-human animals that information does not flow uniformly within social groups (Rendell et al. 2011). In a row of comparative experiments that used the same experimental set up for various species it has been shown that ravens (Scheid et al. 2007), marmosets (Range & Huber 2007) and human children (Range et al. 2009) attend more to the actions of individuals with whom they are more familiar and have a closer affiliation. Further, guppies (Swaney et al. 2001) as well as ravens (Schwab et al. 2008) have been found to copy the behaviour of closely associated individuals more frequently than the behaviour of less familiar individuals. Additionally, human children have been found to rely more strongly on and to endorse the information provided by a person that they had previously interacted with than the information provided by an unfamiliar individual (Corriveau & Harris 2009). The mechanism mediating this preference to attend to, copy and rely on some individuals from one's social group rather than others, however, remains unclear.

Several studies in non-human animals found that a relatively short exposure to another animal is sufficient to create social familiarity (e.g., guppies: 12 days, Griffiths & Magurran 1997; sheep: 72 hours, Keller et al. 2011), which then elicits a preference for this specific individual compared to unfamiliar individuals. This social preference has been argued to lead to more proximity to the familiar individuals and consequently to a stronger propensity to acquire information from this individual (Swaney et al. 2001). Others, however, suggest that the relationship between two individuals goes beyond mere social familiarity and is specified by the nature of their past interactions. Further social interactions are thus dependent on the specific characteristics of the relationship. Strong evidence for the latter claim comes from studies with children showing that insecurely attached children do not rely on information provided by their mother more than that provided by an unfamiliar experimenter (Corriveau et al. 2009). This cannot be due to a lack of social familiarity – since those children interact with their mothers daily – but must result from their specific relationship. Nonetheless, in most studies to date it is hard to disentangle the effects of mere social familiarity based on exposure and of the specific relationship between two individuals, since those two effects are usually strongly confounded.

The domestic dog is an interesting subject in this line of research as it lives in the human environment and regularly interacts with numerous humans, yet it has a particularly close

relationship with its owner (Topál et al. 1998). Range and colleagues (2009) found that dogs paid significantly more attention to food-related actions of humans than to those of a conspecific. Beyond that, dogs have also been found to pay more attention to their owners than to an unfamiliar experimenter when observing them walking through a room (Mongillo et al. 2010). However – due to the reasons elaborated above – also in dogs the mechanism for this preference is not well understood.

Therefore, the aim of this study was to investigate whether dogs' attention towards humans was affected by social familiarity or the specific relationship. Accordingly, we investigated how long dogs would attend to the actions of three different models: two familiar humans living together in one household with the dog and one unfamiliar experimenter. Additionally, we varied whether dogs had a close relationship with only one or both of the familiar humans. To investigate whether the behaviour of the model had an influence on dogs' attention, each model performed three different actions differing in the intensity of interaction with the target object. In a second phase we also investigated whether dogs would preferentially approach a location where a specific action had been performed.

Materials and methods

Participants

Twenty-four dogs from various pure or mixed breeds participated in this experiment with two humans living together with them in one household. Both familiar humans provided information about who was responsible for the dog (i.e., pet care, vet visits) and three factors likely to influence their relationship with the dog (i.e., duration in the same household, joint activities, frequency of feeding). For half of the dogs (N=12; 7M/5F; mean age $\pm$ SD=3.9 $\pm$ 2.64 years) the two humans shared the responsibility and both had a comparably close relationship with the dog. For the other half of the dogs (N=12; 6M/6F; mean age $\pm$ SD=5.1 $\pm$ 3.12 years) only one of the humans was the main caregiver. The other person interacted with the dog on a daily basis but was not responsible for the dog. All participating humans (14M/34F) were at least 14 years old (Mean age $\pm$ SD=35.9 $\pm$ 15.30 years) and had been living together with the dog for a minimum of 10 months (see Table 1 for detailed information about the participants).

Table 1 List of dog and human participants, indicating the sex and breed of the dogs, and the gender, time spent together in the same household with the dog (“Exposure”, months), joint activities (i.e., walking, playing, training, and working; “Activity”, hours per week), and frequency of feeding (“Feeding”, average occasions per week) for the two familiar humans. Familiar human 1 was the person registered as the owner of the dog.

	Dog:			Familiar Humans:				
	Name	Sex	Breed	Identity	Gender	Exposure (mths)	Activity (hs/wk)	Feeding (occ/wk)
Responsibility shared	Akina	F	Akita Inu	Fam1:	female	10	21	4
				Fam2:	male	10	10	3
	Bobby ^a	M	French Bulldog	Fam1:	female	60	5	6.5
				Fam2:	female	48	2	3
	Cleo	F	Border Collie	Fam1:	female	13	18	7
				Fam2:	female	13	22	7
	Dewey	M	mixed breed	Fam1:	female	76	25	3.5
				Fam2:	female	76	17	3.5
	Flori	F	Pomeranian	Fam1:	female	21	14	7
				Fam2:	male	21	8	5
	Kim	F	Poodle	Fam1:	female	44	9	1
				Fam2:	female	44	10	13
	Lucy	F	mixed breed	Fam1:	female	75	43	13
				Fam2:	male	75	6	0.5
	Luis	M	Shetland Sheepdog	Fam1:	female	12	n/a	n/a
				Fam2:	female	12	10	4
	Nash	M	Siberian Husky	Fam1:	male	108	3.5	7
				Fam2:	female	108	1.3	7
	Robin	M	mixed breed	Fam1:	male	17	16.3	7
				Fam2:	female	17	38	0
Responsibility not shared	Sanji	M	Continental Toy Spaniel	Fam1:	female	54	12.5	4.5
				Fam2:	female	54	9	3.5
	Viktor	M	Havanese	Fam1:	female	19	8	4
				Fam2:	female	19	18	3
	Amy ^a	F	Siberian Husky	Fam1:	female	53	10	6
				Fam2:	male	35	6	1
	Benji	M	White Swiss Shepherd Dog	Fam1:	female	110	3.5	14
				Fam2:	male	110	0	0
	Bonnie ^a	F	White Swiss Shepherd Dog	Fam1:	female	42	22	4.5
				Fam2:	female	40	16	2.5
	Cash ^a	M	Australian Shepherd	Fam1:	female	40	15.5	13
				Fam2:	male	18	3.5	1
	Cheyenne	F	Australian Shepherd	Fam1:	female	46	13	14
				Fam2:	male	46	4	0
	Filon	M	Australian Shepherd	Fam1:	female	15	28	7
				Fam2:	female	15	1.5	0
	Gina	F	Poodle	Fam1:	male	129	12	0
				Fam2:	female	129	6	1
	Mika	F	Poodle	Fam1:	female	114	12	1
				Fam2:	male	114	5	0
Responsibility not shared	Monti	M	mixed breed	Fam1:	male	24	8	13
				Fam2:	female	24	7	0.5
	Napoleon ^a	M	mixed breed	Fam1:	female	48	7	11
				Fam2:	male	20	1	3
	Palmira	F	Belgian Sheepdog	Fam1:	female	46	9.5	9
				Fam2:	male	46	2.5	5
	Ted	M	mixed breed	Fam1:	female	12	14	9.5
				Fam2:	female	12	2.3	4.5

^a Dogs with which not both familiar humans had been living together equally long.

In the group “Responsibility shared” (N=12) one pair of familiar humans had not been living together with the dog equally long (difference Fam1-Fam2: 12 months). In the group “Responsibility not shared” (N=12) this was the case for four pairs of familiar humans (difference Fam1-Fam2: 2 months, 18 months, 22 months, 28 months). In the group “Responsibility shared” there was no significant difference in the hours spent with joint activities (Wilcoxon test, N=11, $Z=-0.800$, $P=0.424$) or the frequency of feeding (Wilcoxon test, N=11, $Z=-1.407$, $P=0.159$) between the two familiar humans. In contrast, in the group “Responsibility not shared” the main caregiver (Familiar human 1) spent significantly more time with joint activities (Wilcoxon test, N=12, $Z=-3.065$, $P=0.002$) and with feeding the dog (Wilcoxon test, N=12, $Z=-2.945$, $P=0.003$).

Experimental set up

Testing took place in a quiet experimental room (6m x 5m) at the Clever Dog Lab (Nussgasse 4, 1090 Vienna). Three sets of three boxes were used as targets for the actions of the human models in this experiment. The sets differed in colour and material but all boxes were filled with shredded newspaper. In each session, three boxes were positioned in a semi circle at equal distances from the observation position of the dog (Fig. 1a). At the observation position the dog was gently restrained by one of the familiar human participants with a short lead while the other human was standing next to the dog passively (Fig. 1b). The experimental room was equipped with one camera showing a close-up of the dog and three additional wide-angle cameras. All cameras were connected to monitoring and recording equipment in the adjacent room.

Procedure

The experiment started with a habituation phase. In this phase the experimenter, the two familiar humans and the dog entered the experimental room and the dog could explore the room and the three sets of boxes freely for one minute. After this phase each dog received three experimental sessions with the three human models: a) first familiar human, b) second familiar human, and c) unfamiliar female experimenter. All three sessions were carried out on one day with short breaks in-between the sessions. The sequence of the experimental sessions

was counterbalanced across dogs. All three humans were present in the room throughout the experiment.

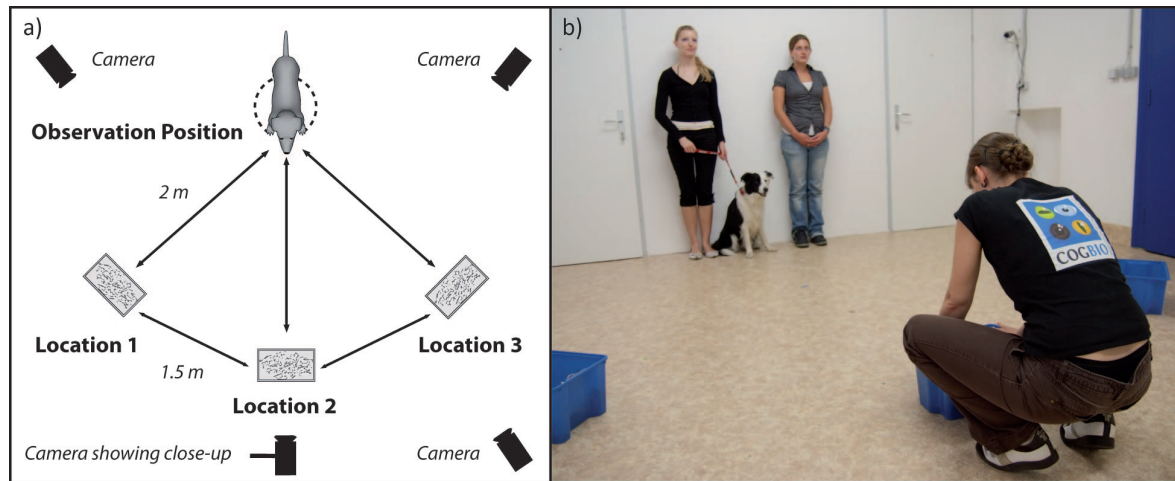


Fig. 1 a Schematic birds eye view of the experimental set up and the positions of the four cameras. b Photo showing the positions of the dog and the humans during the demonstration phase (Photo by A. Gaigg).

Each experimental session consisted of a sequence of two phases: an attention phase followed directly by a choice phase. During the attention phase, the dog could observe a human model performing actions at the three boxes for 30 seconds, timed by a ticking clock on the wall. To see whether the type of action influenced the attention of the dog, we used three different actions: a) crouching down and looking inside the box without touching it, b) crouching down while looking into and touching the box, and c) crouching down and searching the box noisily (Fig. 2). The model always started with the box positioned in location 1, continued to the box in the middle and then ended with the box in location 3, performing a different action at each box. The sequence of the three actions was semi-randomized between models with the restriction that an action never occurred at the same location across the three models. During the attention phase, the model never called the dog's attention and refrained from establishing eye contact. The two humans next to the dog at the observation position did not look at the dog or at the actions of the human model. Instead they looked at the small screen of a camera mounted on the opposite side, which allowed them to indirectly observe the behaviour of the dog.



Fig. 2 Photograph of the experimenter displaying the three actions carried out during the attention phase: a) crouching, b) touching, and c) searching (Photo by A. Gaigg).

After the model returned to the observation position, the choice phase followed immediately. The dog was released by the human holding the lead with one command to run free and/or search (e.g., “Run!”, “It’s yours!”). During this phase the humans remained in their position and did not look at the actions of the dog. After one minute, the dog was called back by one of the familiar humans and everybody left the room together with the dog. The next session started after 5 minutes during which the experimenter prepared a new set of boxes.

Data analysis

Experimental sessions were videotaped for later behavioural coding with Solomon Coder beta (©2006-2009 András Péter). Statistical analyses were carried out with SPSS Statistics 17.0.0 (©2008 SPSS Inc.).

In the attention phase, we coded the “duration of looking at each action (s)” from the video showing the close-up of the dog, defined as the dog directing its eyes at the model from the instance when the model started performing the action for a duration of 30 seconds. Those

three durations were summed up as the “total duration of looking at the three performed actions (s)” of each human model. A second coder blind to aim and conditions of the experiment coded 20% of the videos and Cronbach’s alpha was greater than $\alpha=0.95$ for both behavioural variables. In the choice phase we coded, whether the dog approached any of the boxes (yes/no) and which of the boxes where the different actions had been performed was approached first (actions approached: crouch, touch, search).

We calculated a linear mixed model (LMM) with the response variable “total duration of looking at the three performed actions (s)”, the fixed factors “sequence of sessions” (first session, second session, third session), “responsibility” (shared, not shared), and “identity of the model” (1st familiar human, 2nd familiar human, unfamiliar experimenter), and the random factor “dog”. We additionally calculated a separate LMM with the response variable “duration of looking at each action (s)”, the fixed factors “responsibility” (shared, not shared), “type of action” (crouching, touching, searching), “sequence of actions” (first action, second action, third action), and “identity of the model” (1st familiar human, 2nd familiar human, unfamiliar experimenter) and the random factor “dog”. In both cases the models comprising the main effects and all possible interactions yielded the lowest AIC and were therefore selected. Analyses of the residuals of the LMMs with Shapiro-Wilk test confirmed normal distribution for all variables. For post-hoc analyses, we used paired samples t-tests.

We used Pearson’s chi-squared test to analyze dogs’ approaches to the boxes (yes/no) after the actions of the three different models (1st familiar human, 2nd familiar human, unfamiliar experimenter) and a binomial test to analyze dogs’ approach behaviour. Both tests were calculated separately for the two groups (Responsibility not shared, responsibility shared).

Results

When investigating the overall duration of looking at the actions during the attention phase we found that dogs did not attend equally long to the different human models (LMM_{Sequ*Resp*Mod}, N=24, df=54, F_{Mod}=6.959, P=0.002, Fig. 3), while responsibility and sequence had no main effect on how long dogs observed the model (LMM_{Sequ*Resp*Mod}, N=24, df=54, F_{Sequ}=2.013, P=0.143; F_{Resp}=1.003, P=0.321). However, separate post-hoc tests for the two groups of dogs revealed that when the two familiar humans shared the responsibility for

the dog, there was a significant difference between both familiar humans and the unfamiliar experimenter (paired-samples *t*-test, $N=12$, $df=11$: $t_{\text{Fam1,Unfam}}=2.625$, $P=0.024$; $t_{\text{Fam2,Unfam}}=2.539$, $P=0.028$), while dogs looked equally long at the two familiar humans ($t_{\text{Fam1,Fam2}}=0.303$, $P=0.768$). In contrast, the dogs with only one main caregiver looked at this person significantly longer than at both the other familiar human ($t_{\text{Fam1,Fam2}}=3.356$, $P=0.006$) and the unfamiliar experimenter ($t_{\text{Fam1,Unfam}}=3.699$, $P=0.004$). Importantly, there was no difference in attention paid to the unfamiliar experimenter and the familiar but not responsible human ($t_{\text{Fam2,Unfam}}=0.543$, $P=0.598$).

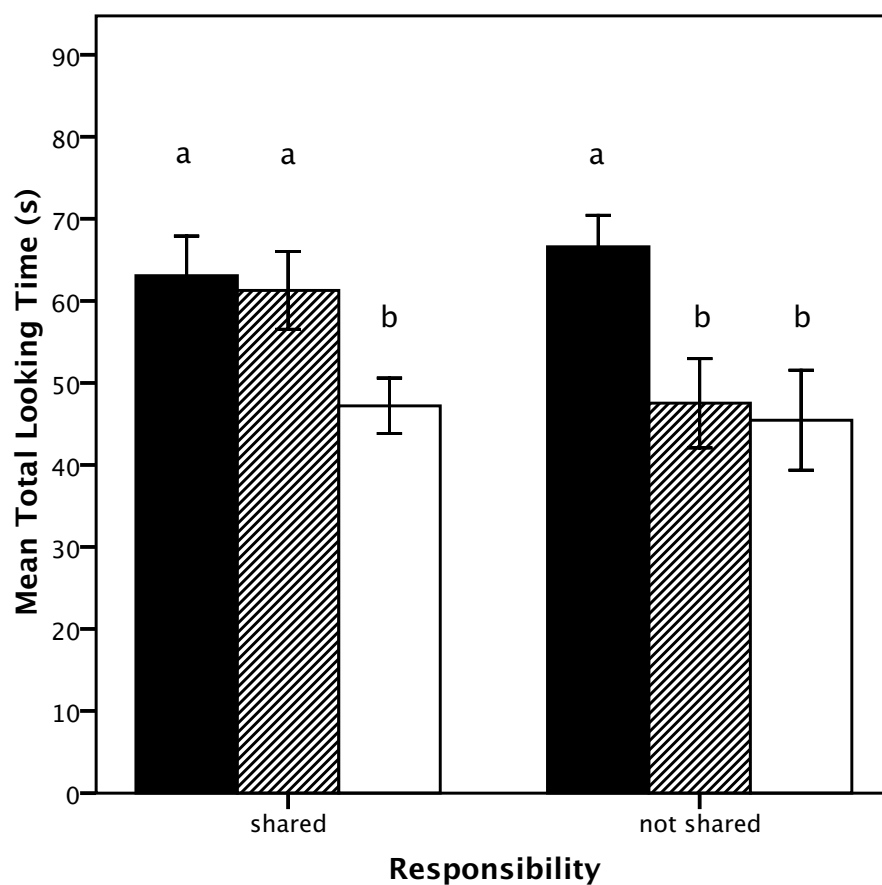


Fig. 3 Mean total duration ($\pm$ SEM) of looking at the actions of each model, grouped by responsibility of the familiar humans. Black bars, 1st familiar human; striped bars 2nd familiar human; white bars, unfamiliar experimenter.

When comparing the duration that dogs looked at each of the performed actions, we again found an effect of the identity of the model as in the overall looking duration

($LMM_{Resp*ActType*ActSequ*Mod}$, $N=24$, $df=162$, $F_{Mod}=12.385$, $P\leq 0.001$). We also found that dogs paid less attention to the last action performed by the models ($F_{ActSequ}=8.671$, $P\leq 0.001$; paired-samples t-test, $N=24$, $df=71$, $t_{Act1,Act3}=4.512$, $P\leq 0.001$, $t_{Act2,Act3}=3.295$, $P=0.002$). In contrast, we found only a non-significant trend that the dogs were looking differently long at the three actions ($F_{ActType}=2.854$, $P=0.061$). Responsibility had no main effect on dogs' attention ($F_{Resp}=0.123$, $P=0.726$) and none of the interactions reached significance.

In the choice phase, dogs did not base their choice of which box to approach first on where a specific action had been performed in the preceding attention phase (actions approached: crouch, $N=17$; touch, $N=17$; search, $N=15$). Moreover, in 32% of the trials dogs did not approach any of the boxes during the choice phase. When analysing the effect of the identity of the model on whether dogs would approach the boxes, we found that there was a difference between the two groups. Dogs that had only one main caregiver approached the boxes more than expected by chance when this person acted as the model and less than expected by chance when the unfamiliar experimenter acted as the model (Pearson's chi-square, $N=36$, $df=2$, $X^2=10.971$, $P=0.004$). In contrast, dogs for which both familiar humans shared the responsibility showed the same approach pattern for all three models ($X^2=0.321$, $P=0.852$). Taking all three human models together, dogs from the group "responsibility shared" mostly approached the boxes in the choice phase (yes: 28 trials, no: 8 trials; Binomial test, $P=0.001$, Table 2).

Table 2 Total number of trials in which dogs either approached or did not approach the boxes, grouped by model identity and responsibility.

	Responsibility not shared				Responsibility shared			
	Fam 1	Fam 2	Exp	Total	Fam 1	Fam 2	Exp	Total
Approach	Number of trials							
yes	11	7	3	21	9	10	9	28
no	1	5	9	15	3	2	3	8

Discussion

In contrast to previous studies investigating dogs' attention towards humans (Mongillo et al. 2010; Range et al. 2009) our data allowed us to discern between social familiarity – resulting from exposure to a person – and the quality of the relationship with a person as the basis for dogs' attention. We found that the dogs attended significantly more to the familiar

humans from their household than to an unfamiliar experimenter only when the person was responsible for the dog and had a close relationship characterized by many joint activities and frequent feeding. When the human was familiar to the dog from an equally long exposure period but spent less active time with the dog than the main caregiver, dogs only paid as much attention to them as to the completely unfamiliar experimenter. Therefore, social familiarity by itself cannot account for dogs' increased attention towards their owners found in previous experiments (Mongillo et al. 2010; Range et al. 2009). If this effect would have been due merely to a lower degree of familiarity with the second human from the household – because dogs spent more time per day with their main owner – then the amount of attention paid to this person would have been in-between the attention towards the primary caregiver and the completely unfamiliar experimenter. However, there was no difference between the attention towards the second familiar, but not responsible person and the unfamiliar experimenter.

Corollary support for our findings comes from an earlier study investigating dogs' behaviour in a problem-solving task (Topál et al. 1997). The authors found that dogs that were classified as having a close companion relationship with their owner (i.e., living in the house as a family member) looked at their owners significantly more than dogs having a less close working relationship (i.e., being kept outside for guarding or other purposes) during the task. In our study all dogs were kept in the household as pets. Although the familiar humans that were not responsible for the dog interacted with the dog significantly less than the main caregiver, they nevertheless participated in joint activities with the dog for some hours per week. Most of them also occasionally fed the dog. Therefore, it seems likely that a small amount of joint interactions with a human is not sufficient to influence dogs' attention but that a threshold of positive interactions with a specific human has to be reached to raise their attention towards this person above that towards an unfamiliar human.

When looking separately at dogs' attention towards the different performed actions we found that for none of the human models, dogs differentiated in their attention to the different performed actions. Also in the choice phase the dogs did not preferentially approach any of the boxes where a specific action had been performed. This is surprising, given that fact that dogs have been shown to be able learn from a human demonstrator through observation (e.g., Kubinyi et al. 2003; Pongrácz et al. 2001) and can even be trained to observe and copy minute body movements of a human model (i.e., "Do-as-I-do" task: Huber et al. 2009; Topál et al. 2006). However, it is possible that in our experiment – since dogs did not see the

outcome of the model's actions – they did not perceive any of the actions as more salient or relevant than the others.

In summary, this study indicates that in dogs past interactions with a human specify their relationship beyond the effect of mere social familiarity, and that this relationship in turn influences their future social interactions. Similar effects of individual relationships have been described in several other species. In primates (Fraser et al. 2010) and ravens (Fraser & Bugnyar 2010) for example the “quality of the relationship” between two individuals influences the likeliness of reconciliation after agonistic interactions – a mechanism that has also been proposed for dog-dog interactions (Cools et al. 2008).

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CHAPTER 5

Conclusion

The aim of this dissertation was to investigate the link between the dog-human relationship and dogs' performance in three socio-cognitive tasks involving human partners. In the first study (Chapter 2) I found that in a problem-solving task the presence or absence of the owner, but not the owner's behaviour influenced the dogs' duration of manipulating an apparatus for retrieving food. The dogs manipulated the apparatus for shorter periods in the absence of the owner, irrespective of their general degree of separation distress. These results provide evidence for the similarity between the secure base effect in dogs and human children and show that this effect can influence dogs' performance in a problem-solving task. Further, I found that while the experimenter did not provide a secure base for interacting with the environment for the dogs, they nevertheless spent most time in her proximity in the absence of the owner. This suggests that an unfamiliar person can provide some social support for a dog in a stressful situation. In the second study (Chapter 3) I showed that the behaviour and interaction style of a human partner in a preceding training phase influenced how intensively dogs initiated interactions with that person when being faced with a problem in the test phase. In the first experiment, dogs that had previously been encouraged by their owners whenever they looked back at them later gazed at them for longer periods when they were faced with each of two problems (i.e., empty apparatus, blocked apparatus). In the second experiment, the dogs could learn that two experimenters could each solve one of the two problems during an initial phase. In the test situation the dogs did not preferentially look at any of the two experimenters and they always approached the experimenter that had previously unblocked the apparatus first. However, we found that when the apparatus was empty the dogs stayed longer next to the experimenter that had always filled the apparatus with food reward. These results indicate that dogs' human-directed behaviour (i.e., gazing at the human, approaching a human) can be influenced by the interaction style of a person within the experimental setting and that dogs can – to some extent – adjust their behaviour to the previous actions of a person. In the third study of this dissertation (Chapter 4) I found that the dogs attended significantly more to familiar humans from their household than to an unfamiliar experimenter – but only when the person was responsible for the dog and had a close

relationship. When the human was familiar to the dog but did not have a close relationship, dogs only paid as much attention to them as to the completely unfamiliar experimenter. This indicates that the specific relationship that a dog has with a person influences its attention towards that person.

In sum, the results of the studies included in this dissertation indicate that dogs form close and highly individualized relationships with humans and that these relationships influence their behaviour towards these humans. They further confirm earlier findings that the dog-human relationship is in many aspects similar to the relationship between human infants and their caregivers (Palmer and Custance 2008; Prato-Previde et al. 2003; Topál et al. 1998). From attachment research in human children it is known that the interaction style of the caregiver strongly influences the relationship that the child forms with this specific person (Ainsworth et al. 1978). While the behaviours that are part of the attachment system (i.e., proximity maintenance, separation distress, secure base effect, safe haven effect; Cassidy 1999) can be found in all children, the caregivers' reactions to these behaviours influence how strong and in which way children express each particular component. If the caregiver is inconsistent or unpredictable in satisfying the child's needs for proximity and security, the child develops attachment behaviour patterns that have been classified as insecure (i.e., avoidant or resistant; Ainsworth & Wittig 1969) or disorganised (Main & Solomon 1990). It is an interesting question whether the interaction style of the owner has a similarly strong influence on the dog's relationship. Preliminary data suggests that dogs' attachment can be different towards different humans living together with the dog in the same household (Mariti et al. 2011). However, it remains to be investigated which factors really determine the relationship. It is equally likely that not only the human partner's interaction style but also the dog's personality contribute to the form of the dog-relationship.

In the second study included in this dissertation (Chapter 3) I found an effect of the owner's interactions style on how much the dog initialized human-directed gazing behaviour when being faced with a problem. Although I only investigated a short-term effect within the experimental setting, these results are in line with a previous study showing that dogs that lived together with their owners as pets – and probably had a more interactive relationship with their owners – looked back at the owners longer when they were faced with a difficult task than dogs kept outside of the house (Topál et al. 1997). Further, Marshall-Pescini and colleagues (2009) found that dogs with a different training background also differed in this

form of human-directed behaviour. This result could also be attributed to the different way in which owners interacted with their dogs within these different forms of training. However, it can also be argued that the dogs simply formed an expectancy of the actions of their human partner from previous interactions and that this expectancy triggered the gazing at the human (Bentosela et al 2008). In the first experiment of my study dogs looked at the door through which the experimenter was expected to enter to bait the apparatus, which seems to indicate an expectancy on the dog's part rather than a communicative act. However, in the second experiment the dogs switched to approaching the experimenters closely rather than looking at them when this form of communication was not useful anymore (i.e., because both experimenters had their backs turned to the dogs). This suggests that dogs were in fact trying to initiate communication with the experimenters. Also in human children it has been argued that relatively simple associative processes are important in the early development of the attachment relationship (Ainsworth et al. 1978) and of communicative behaviour (Striano and Rochat 2000), which are only later replaced by cognitive representations.

Furthermore, the results of this dissertation show that the relationship that dogs form with humans is specific for each human partner. In the third study included in this dissertation (Chapter 4) I found that dogs even differentiated in their attention towards equally familiar humans, who lived with them in the same household and interacted with them daily. This effect might be caused by either the amount or the type of interactions between the person and the dog (i.e., attending dog school, playing, walking, feeding). Dogs might attend the more to a person the more positive interactions occurred between them and this attention might reflect a greater expectancy of an event that is positive or in another way relevant for the dog. This could lead to a virtually automatic preference to orient to the owner compared to a stranger (Mongillo et al. 2010). However, I found that the dogs paid equally little attention to a person from their household with whom they interacted occasionally as to an experimenter with whom they had never interacted before. Therefore, it is likely that either a threshold of interactions has to be reached or that a certain type of interaction is needed to influence dogs' attention. In my study, the owners provided only basic information on daily interactions with the dog (i.e., walking, playing, training, working, and feeding). It is possible that with more detailed questions on the specific interactions and/or more objective measurements the factors influencing dogs' attention could be pinpointed more precisely in future research.

Further, although I found a clear connection between the relationship with a human and the dog's attention towards that person, it is not clear whether this also affects dogs' ability to learn from this human via observation. In my study, dogs' did not show more interest in a location where the human had performed a specific action and also did not differentiate between the different humans in this regard – apart for an increased motivation to inspect any box after watching the actions of the main caregiver. These results seem to be in line with previous findings, where dogs learned to detour a V-shaped fence equally well from the owner as from an unfamiliar experimenter (Pongrácz et al. 2004). However, there was an important difference between the two studies. In the study of Pongrácz and colleagues (2004) the demonstrators were calling the dog's attention while detouring the fence, whereas in my study the humans remained silent and refrained from establishing eye contact. Since it is known that dogs respond with increased attention to ostensive-communicative cues from a human partner (i.e., calling the dog's name, establishing eye contact with the dog; Téglás et al. 2012), these cues could have overshadowed the difference between the two demonstrators in the previous study (Pongrácz et al. 2004). Furthermore, detouring a fence is a relatively simple task where the animal has to watch for only a few seconds to learn the solution. Prolonged attention is probably more important for tasks where the dog has to learn a more complex behaviour and there the differences between attention to the owner and to an unfamiliar experimenter might be more relevant.

The results of the three studies included in this dissertation also provide interesting insight about the relevance of unfamiliar humans for a dog. In the first study (Chapter 2) I found that while the experimenter did not provide a secure base for interacting with the environment, she nevertheless seemed to provide some social support for the dog in the absence of the owner. In the second study (Chapter 3) dogs could also learn to differentiate between two previously unfamiliar experimenters and approach them when being faced with a problem. This is another indication that dogs have developed a predisposition to attend to and cooperate with humans in general and that this predisposition is also evident outside their close relationships with their owners (Gácsi et al. 2009).

Although the samples of the studies included in this dissertation do not allow an analysis of breed differences because not enough individual dogs per breed group were tested, it will be an interesting topic for future research whether there are any differences between the strength or the types of relationships that different breeds form with their human partners. Scott and

Fuller (1965) found differences between the emotional and motivational characteristics of different breeds in a controlled laboratory setting and such differences are likely to influence the dog-human relationship. However, when investigating such breed differences in the pet dog population, one would have to control for differences due to owner characteristics or interaction styles. It is conceivable that owners with certain attitudes towards dogs or who plan to use the dog for a specific purpose would select specific breeds and consequently bias the findings.

Finally, the results of this dissertation are also vital for future research with dogs in the socio-cognitive domain – especially when integrating humans into the experiments. The secure base effect found in the first study (Chapter 2) could reduce dogs' motivation and persistency in any experiment when tested in the absence of the owner and therefore also reduce their performance. Additionally, dogs tested with their owners as the demonstrator in a social learning experiment might be more attentive than dogs tested with an unfamiliar experimenter – although these differences could probably be overcome with using ostensive-communicative cues. Taken as a whole, the results of this dissertation provide evidence that there is a link between the dog-human relationship and dogs' performance in socio-cognitive tasks.

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SUMMARY

The relationship between humans and domestic dogs (*Canis familiaris*) started when humans tamed the dogs' ancestors about 15.000 years ago. One trait that enabled dogs' subsequent spread through every human culture and strengthened its position as one of the most successful domesticated species was their ability to form close and highly individualized relationships with their human owners. While nowadays it is known that those relationships have a strong beneficial effect on the owners, questions regarding the influence of the dog-human relationship on dogs' behaviour and cognitive abilities have largely been neglected. Here, I set out to specifically investigate the connection between the dog-human relationship and dogs' performance in socio-cognitive tasks.

In the first study I tested if the presence/absence or the behaviour of the owner had an influence on dogs' performance in a problem-solving task. I showed that while the presence of the owner provided a secure base for the dogs during the experiment, the behaviour of the owner had very little effect. In the second study I conducted two experiments, in which I confronted dogs with two problem-solving situations. In the first experiment I could show that dogs' looking behaviour directed at their owners was influenced by owners' previous interaction style. In the second experiment dogs were also able to flexibly adjust their behaviour to the situation-specific characteristics of two previously unknown humans. Finally, the third study was centred on the question whether the attention of dogs toward the actions of humans depended on the type of relationship between the dog and the human or merely on social familiarity. Results showed that familiarity alone could not account for dogs' increased attention towards their owners since they did not differentiate between familiar and unfamiliar people, unless familiarity was linked to having a high-quality relationship.

The results of these studies point to a substantial interconnection between the dog-human relationship and dogs' performances in socio-cognitive tasks, which has wide implications for cognitive testing in domestic dogs.

ZUSAMMENFASSUNG

Die Beziehung zwischen Menschen und Hunden (*Canis familiaris*) begann vor mehr als 15.000 Jahren, als die Menschen erstmals die Vorfahren der heutigen Hunde domestizierten. Ein Merkmal, das die folgende Ausbreitung des Hundes in alle menschlichen Kulturen ermöglichte und seine Position als eine der erfolgreichsten domestizierten Tierarten stärkte, war seine Fähigkeit, enge und sehr individuelle Beziehungen mit seinen menschlichen Besitzern einzugehen. Während heutzutage bekannt ist, dass diese Beziehungen einen starken positiven Effekt auf die Besitzer haben, wurden Fragen bezüglich des Einflusses der Hund-Mensch-Beziehung auf das Verhalten und die kognitiven Fähigkeiten des Hundes bisher größtenteils vernachlässigt. In dieser Dissertation untersuche ich die Verbindung zwischen der Hund-Mensch-Beziehung und den Leistungen von Hunden in sozial-kognitiven Aufgaben.

In der ersten Studie testete ich, ob die An- oder Abwesenheit des Besitzers oder sein Verhalten die Leistungen des Hundes in einer Problemlöseaufgabe beeinflussten. Ich zeigte, dass das Verhalten des Besitzers nur wenig Einfluss auf den Hund hatte, die Anwesenheit des Besitzers hingegen dem Hund eine sichere Basis für die Exploration während des Versuchs bot. In der zweiten Studie führte ich zwei Experimente durch, in denen ich Hunde mit zwei verschiedenen Problemlöseaufgaben konfrontierte. Im ersten Experiment konnte ich zeigen, dass die Blicke der Hunde zu ihrem Besitzer durch die vorangegangene Interaktion beeinflusst wurden. Im zweiten Experiment konnten die Hunde ihr Verhalten auch flexibel an die situations-spezifischen Charakteristika von zwei vorher unbekannten Personen anpassen. Die dritte Studie konzentrierte sich schlussendlich auf die Frage, ob die Aufmerksamkeit von Hunden gegenüber den Handlungen eines bestimmten Menschen von der Beziehung zu diesem Menschen oder nur von Vertrautheit beeinflusst wurde. Die Ergebnisse zeigten, dass die Vertrautheit allein nicht ausschlaggebend für die große Aufmerksamkeit von Hunden gegenüber ihren Besitzern sein konnte, weil sie nicht zwischen bekannten und unbekannten Menschen unterschieden, solange die Vertrautheit nicht auch mit einer engen Beziehung gekoppelt war.

Die Ergebnisse dieser Studien weisen auf beträchtliche wechselseitige Verbindung zwischen der Hund-Mensch-Beziehung und den Leistungen von Hunden in sozial-kognitiven Aufgaben hin, welche umfangreiche Implikationen für kognitive Tests mit Hunden haben.

APPENDIX I

List of participating dogs

Dogs that participated in the three studies included in this dissertation are listed here with their sex, spay/neuter status, age, breed, breed classification, and training level (Tables A-I.2 – A-I.5). Breed classifications are according to the grouping of the Fédération Cynologique Internationale (FCI; see Table A-I.1).

Table A-I.1. Classification of breeds according to the FCI

FCI breed groups	
1	Sheepdogs and Cattle Dogs (except Swiss Cattle Dogs)
2	Pinscher and Schnauzer, Molossoid Breeds, Swiss Mountain and Cattle Dogs
3	Terriers
4	Dachshunds
5	Spitz and Primitive types
6	Scenthounds and Related Breeds
7	Pointing Dogs
8	Retrievers, Flushing Dogs, Water Dogs
9	Companion and Toy Dogs
10	Sighthounds

In all tables, puppy training denotes basic socialization with humans and other dogs and the practice of simple commands (e.g., “come”) at a dog school. Basic training level signifies the dog’s knowledge of basic commands (e.g., “come”, “stay”, “sit”, “lie down”) acquired at a dog school, from a private instructor or at home. Obedience training encompasses more advanced training at a dog school. Agility, dog-dancing, flyball, frisbee, and herding are dog sports in which the dog stays in visual contact with the owner and is guided by verbal commands and/or gestures. IPO (i.e., Internationale Prüfungsordnung) is a dog sport that incorporates aspects of police dog work (i.e., tracking, advanced obedience, protecting). Search & rescue, hunting, and mantrailing are dog sports in which the dog has to cooperate with the owner while at the same time being able to work independently at greater distances. Canicross signifies cross-country running together with the dog. Assistance & service and therapy dogs are trained to assist disabled people or provide comfort to people (e.g., in hospitals, in nursing homes, in schools).

Table A-I.2. Participants of the study “The Importance of the Secure Base Effect for Domestic Dogs – Evidence from a Manipulative Problem-Solving Task” (Chapter 2)

Dog	Sex	Intact	Age (y)	Breed	FCI	Training
Yazkin	female	no	1.4	Australian Shepherd	1	herding, frisbee
Cerber	female	yes	0.9	Belgian Shepherd Dog (Malinois)	1	obedience
Borsi	female	yes	1.1	Border Collie	1	obedience
Jessy	female	yes	9.5	German Shepherd	1	obedience, agility, dog-dancing
Merszi	female	yes	3.1	Siberian Husky	5	basic
Csumpi	female	yes	2.2	Bolognese	9	basic
Jolán	female	no	2.1	mixed breed	-	obedience
Lola	female	no	2.0	mixed breed	-	basic
Becks	male	yes	2.7	Border Collie	1	flyball, herding
Chili	male	yes	1.1	Border Collie	1	agility
Grog	male	yes	2.6	Border Collie	1	obedience, herding
Pavlov	male	yes	2.1	Border Collie	1	agility, herding
Stick	male	yes	1.0	Border Collie	1	obedience, herding
Tivo	male	yes	1.1	Siberian Husky	5	canicross
Jona	male	yes	5.8	Bolognese	9	basic
Ramirez	male	yes	1.0	Pug	9	basic
Bull	male	yes	1.1	mixed breed	-	basic
Füles	male	no	1.7	mixed breed	-	obedience
Wilson	male	no	1.3	mixed breed	-	obedience
Vándor	male	no	7.6	mixed breed	-	obedience, agility

Table A-I.3. Participants of the study “Domestic dogs (*Canis familiaris*) flexibly adjust their human-directed behavior to the actions of their human partners in a problem situation” - Experiment 1 (Chapter 3)

Dog	Sex	Intact	Age (y)	Breed	FCI	Training
Rozi	female	yes	2.3	Border Collie	1	obedience, herding
Lexa	female	no	3.4	German Boxer	2	obedience
Waresa	female	yes	2.9	Rhodesian Ridgeback	6	basic
Cipó	female	no	3.9	Labrador Retriever	8	hunting
Borka	female	no	1.4	mixed breed	-	assistance & service
Kira	female	no	4.2	mixed breed	-	obedience, agility, therapy
Lidi	female	no	9.0	mixed breed	-	obedience
Gizi	female	no	3.8	mixed breed	-	basic
Vito	male	yes	1.1	Australian Shepherd	1	obedience, frisbee, herding
Azúr	male	yes	5.5	Border Collie	1	obedience, agility
Móric	male	no	3.8	Border Collie	1	obedience, herding
Tódor	male	yes	3.4	Border Collie	1	obedience, agility, herding
Oszkár1	male	no	4.8	German Shepherd	1	obedience, search & rescue
Chester	male	yes	6.8	Belgian Shepherd Dog (Groenendael)	1	basic
Cherry	male	yes	10.4	Airedale Terrier	3	obedience, IPO, mantrailing
Zsivány	male	yes	4.3	Hungarian Pointing Dog	7	obedience, agility
Madzag	male	no	2.3	Hungarian Pointing Dog	7	obedience, agility, frisbee, flyball
Spock	male	no	3.4	Labrador Retriever	8	basic
Benji1	male	no	8.1	mixed breed	-	obedience, agility, flyball
Füli	male	no	4.7	mixed breed	-	obedience, agility
Lucky	male	no	2.8	mixed breed	-	obedience, agility
Matyi	male	no	2.4	mixed breed	-	obedience
Oszkár2	male	no	4.8	mixed breed	-	obedience, IPO agility, therapy
Dömper	male	no	8.2	mixed breed	-	obedience, therapy
Bodor	male	no	4.7	mixed breed	-	obedience, agility, IPO

Table A-I.4. Participants of the study “Domestic dogs (*Canis familiaris*) flexibly adjust their human-directed behavior to the actions of their human partners in a problem situation” - Experiment 2 (Chapter 3)

Dog	Sex	Intact	Age (y)	Breed	FCI	Training
Sally	female	yes	4.9	Belgian Shepherd Dog (Groenendael)	1	obedience, IPO
Moss	female	no	3.7	Border Collie	1	obedience, herding, dog-dancing, frisbee
Skye	female	yes	1.1	Border Collie	1	obedience, herding
Csipke	female	no	8.8	Collie	1	basic
Paca	female	no	5.1	Jack Russel Terrier	3	obedience
Bodza	female	no	5.5	Hungarian Pointing Dog	7	obedience, hunting, search & rescue
Szösz	female	no	1.2	Poodle (Medium)	9	assistance & service
Lizinka	female	no	5.8	mixed breed	-	basic
Molly	female	no	4.4	mixed breed	-	basic
Vitamin	female	no	3.3	mixed breed	-	obedience, agility, frisbee, flyball
Boci	female	no	3.3	mixed breed	-	basic
Szuszi	female	yes	15.8	mixed breed	-	basic
Florida	male	yes	1.0	Australian Kelpie	1	obedience, agility, frisbee, herding
Jeff	male	no	9.3	Belgian Shepherd Dog (Groenendael)	1	obedience, IPO, mantrailing
Rony	male	no	3.9	Belgian Shepherd Dog (Tervueren)	1	obedience, agility
Brandy	male	no	10.6	Border Collie	1	obedience, herding, dog-dancing, agility
George	male	yes	1.3	Border Collie	1	obedience, agility
Trisztán	male	yes	1.3	Schipperke	1	obedience, agility, frisbee, flyball
Berci	male	no	3.7	German Pointing Dog	-	obedience, agility, flyball
Metosz	male	no	4.8	mixed breed	-	obedience

Table A-I.5. Participants of the study “Dogs’ attention towards humans depends on their relationship, not on social familiarity” (Chapter 4)

Dog	Sex	Intact	Age (y)	Breed	FCI	Training
Cheyenne	female	yes	4.0	Australian Shepherd	1	basic
Palmira	female	no	4.1	Belgian Shepherd Dog (Tervueren)	1	mantrailing, agility
Cleo	female	yes	1.3	Border Collie	1	puppy, herding, agility
Bonnie	female	no	3.7	White Swiss Shepherd Dog	1	puppy, agility, IPO, mantrailing
Akina	female	no	1.0	Akita Inu	5	puppy
Florie	female	yes	2.1	German Spitz (Pomeranian)	5	basic
Amy	female	no	5.9	Siberian Husky	5	obedience
Gina	female	no	10.9	Poodle (Medium)	9	agility, obedience, flyball, frisbee
Mika	female	no	9.3	Poodle (Medium)	9	agility
Kim	female	yes	3.8	Poodle (Toy)	9	agility
Lucy	female	no	6.6	mixed breed	-	basic

Table A-I.5.cont.

Dog	Sex	Intact	Age (y)	Breed	FCI	Training
Cash	male	yes	3.5	Australian Shepherd	1	agility, obedience, herding
Filon	male	no	1.4	Australian Shepherd	1	basic
Luis	male	no	2.5	Shetland Sheepdog	1	obedience, agility
Benji2	male	yes	9.3	White Swiss Shepherd Dog	1	dummy, mantrailing
Nash	male	yes	9.3	Siberian Husky	5	obedience, mantrailing
Sanji	male	yes	4.8	Continental Toy Spaniel (Papillon)	9	basic
Bobby	male	no	5.8	French Bulldog	9	basic
Viktor	male	no	1.8	Havanese	9	puppy
Monti	male	no	2.4	mixed breed	-	basic
Robin	male	yes	1.8	mixed breed	-	basic
Dewey	male	yes	6.5	mixed breed	-	basic
Napoleon	male	no	4.6	mixed breed	-	basic
Ted	male	no	2.0	mixed breed	-	puppy, agility

APPENDIX II

Supplementary Material for:

“The Importance of the Secure Base Effect for Domestic Dogs – Evidence from a Manipulative Problem-Solving Task” (Chapter 2)

Supplementary methods

Ainsworth’s Strange Situation Test (ASST)

We used a shortened version of the original ASST [6] modified to be applicable for testing dogs. The ASST can be used for measuring the different components of dogs’ attachment to their owners (i.e., proximity maintenance, separation distress, secure base, and safe haven effects). For the purpose of the current study, we were only interested in dogs’ display of separation-related behaviors (SRB; [14]) when left alone, indicating their degree of separation anxiety in the absence of the owner.

Dogs were tested in the ASST 1-18 weeks ($\text{mean} \pm \text{SD} = 6.7 \pm 5.93$) prior to the main experiment. The ASST took place in a different experimental room (3.5m x 4.5m) that was unknown to the dogs. The room contained two chairs (one chair for the owner and one chair for the stranger), two shelves, building blocks placed on one shelf out of the dog’s reach, several toys placed on the floor, and a water bowl with fresh water.

The ASST consisted of seven episodes, each lasting approximately 3 minutes. In three episodes a stranger was present in the room. The stranger was of the same sex as the dog owner and had never been seen by or interacted with the dog prior to the experiment.

- **Episode 1: Dog with owner**

The owner entered the experimental room with the dog on leash, sat down on the designated chair, took the leash off and let the dog run free. The owner put the leash down beside the chair. During the first 2 minutes the owner filled out a questionnaire without interacting with the dog. After hearing a signal from outside, the owner carried building blocks from one shelf to the other for 1 minute without interacting with the dog. After that, the owner sat down and continued filling out the questionnaire without interacting with the dog.

- **Episode 2: Dog with owner and stranger**

The stranger entered the room and sat down on the other chair passively for 1 minute. Then the stranger tried to engage the dog to play for 2 minutes. After the first minute, the stranger asked the owner to leave the room.

- **Episode 3: Dog with stranger**

The stranger sat down the designated chair. During the first 2 minutes the stranger filled out a questionnaire without interacting with the dog. After that, the stranger carried building blocks from one shelf to the other for 1 minute without interacting with the dog. After that, the stranger left the room.

- **Episode 4: Dog alone**

The dog stayed alone in the room for three minutes.

- **Episode 5: Dog with owner**

The owner entered the room. After shortly greeting the dog, the owner sat down on the designated chair and filled out a questionnaire for 3 minutes without interacting with the dog. After hearing a signal from outside, the owner left the room.

- **Episode 6: Dog alone**

The dog stayed alone in the room for three minutes.

- **Episode 7: Dog with stranger**

The stranger entered the room. After shortly greeting the dog, the stranger sat down on the designated chair and filled out a questionnaire for 3 minutes without interacting with the dog. After that, the stranger took the dog on the leash and left the room together with the dog.

During the two episodes, in which the dog was left alone in the room (Episode 4, Episode 6), we scored dogs' SRB according to Mendl et al. [18]. SRB comprised vocalizing (barking, whining, howling), staying close to the door (with or without scratching the door), destructive behavior, and defecation/urination. Since destructive behavior and defecation/urination were never observed during the two episodes, those behaviors were excluded from the analysis. A score of 0 was given for each of the two behaviors (i.e., vocalizing, staying close to the door), if the behavior occurred never or less than 25% of time during the episode, a score of 1 was given, if the behavior occurred between 25% and 50% of the time, and a score of 2 was given, if the behavior occurred more than 50% of the time. The scores from both behaviors were added to give the total SRB score.

Supplementary results

Linear mixed models (LMM)

Effects of the main factors “sequence of conditions” (1st, 2nd, 3rd), “type of apparatus” (aDP, aSB, aSC, aRS), and “condition” (cAO, cSO, cEO) and the two-way interactions on the variable “duration of manipulation” as calculated by an LMM can be seen in Table S1.

Table S1. Effects on the variable “duration of manipulation”.

Dependent variable	N	df	Factor	F	P
Duration of manipulation	20	36	<i>Sequence of conditions</i>	1.522	0.232
			<i>Type of apparatus</i>	0.464	0.709
			<i>Condition</i>	12.478	0.000***
			<i>Sequence*Apparatus</i>	1.161	0.348
			<i>Sequence*Condition</i>	0.565	0.690
			<i>Apparatus*Condition</i>	1.172	0.343

Effects of the main factors “sequence of conditions” (1st, 2nd, 3rd), “type of apparatus” (aDP, aSB, aSC, aRS), and “condition” (cSO, cEO) and the two-way interactions on the variable “duration spent in the proximity of the owner” as calculated by an LMM can be seen in Table S2.

Table S2. Effects on the variable “duration spent in the proximity of the owner”.

Dependent variable	N	df	Factor	F	P
Duration spent in the proximity of the owner	20	22	<i>Sequence of conditions</i>	0.242	0.787
			<i>Type of apparatus</i>	1.092	0.373
			<i>Condition</i>	0.017	0.897
			<i>Sequence*Apparatus</i>	0.756	0.612
			<i>Sequence*Condition</i>	2.198	0.135
			<i>Apparatus*Condition</i>	1.179	0.341

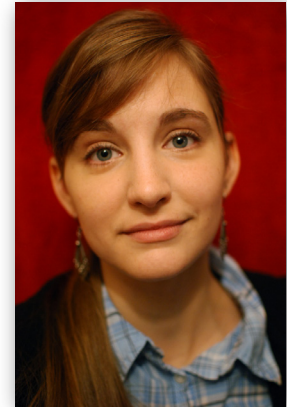
Effects of the main factors “sequence of conditions” (1st, 2nd, 3rd), “type of apparatus” (aDP, aSB, aSC, aRS), and “condition” (cAO, cSO, cEO) and the two-way interactions on the variable “duration spent in the proximity of the experimenter” as calculated by an LMM can be seen in Table S3.

Table S3. Effects on the variable “duration spent in the proximity of the experimenter”.

Dependent variable	N	df	Factor	F	P
Duration spent in the proximity of the experimenter	20	36	<i>Sequence of conditions</i>	4.611	0.016*
			<i>Type of apparatus</i>	0.488	0.720
			<i>Condition</i>	17.221	0.000***
			<i>Sequence*Apparatus</i>	1.489	0.210
			<i>Sequence*Condition</i>	2.923	0.034*
			<i>Apparatus*Condition</i>	1.104	0.379

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