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Zusammenfassung

„Theory of mind“ (native Theorie), die Fähigkeit, Annahmen über Bewusstseinszustände anderer Individuen vornehmen zu können, ist ein zentrales Thema diverser Forschungsgebiete. Ob neben Menschen auch Tiere diese Fähigkeit besitzen, ist immer noch umstritten. Wir haben mittels eines „False-Belief (FBU)“-tests, entwickelt von Wimmer und Perner (1983), und unter Anwendung eines „Violation of Expectancy (VoE)“-paradigmas (Onishi und Baillargeon, 2005) untersucht, ob Hunde eine native Theorie innehaben. Unsere Ergebnisse zeigen, dass Hunde ihre Aufmerksamkeitsspanne verlängern, wenn die Handlung des Experimentators nicht in Einklang mit dessen Wissensstand ist. Folglich deuten unsere Ergebnisse darauf hin, dass Hunde tatsächlich Unstimmigkeiten zwischen Handlungen und Bewusstseinszuständen bei Menschen wahrnehmen können.

Abstract

Theory of mind, the capacity to attribute mental states to others, has become a hot topic in various scientific research areas. Whether other animals than humans have this capability is still highly controversial. We conducted a false belief understanding (FBU) task, which was established by Wimmer and Perner (1983), and applied a violation of expectancy paradigm (VoE), first described by Onishi and Baillargeon (2005), to investigate whether dogs have a theory of mind. Our results show that dogs paid more attention when the experimenter's performance was not consistent with his state of knowledge. Hence, our results suggest that dogs can indeed perceive discrepancies between human´s action and their state of knowledge.

Introduction

1.1 Theory of mind

Theory of mind (ToM) has become a relevant and challenging field of research. Scientists from different fields - like biology, ethology, psychology or philosophy, to name a few - are tackling this concept from different sides. Despite of various experiments conducted in this field it remains highly controversial. Piaget and Inhelder's studies about perspective taking and intention attribution (Piaget and Inhelder, 1956) were the first studies related to ToM, which was then specified by Premack and Woodruff in 1978. They interpreted ToM as a system, that allows the holder to attribute oneself and others mental states, such as "believe", "know," "want," and "see" (Premack and Woodruff, 1978). Having a ToM, human beings can be interpreted as subjects responsible for intentional actions based on their underlying beliefs and desires (Gopnik et al., 2001; Wellman, 2005). In humans, ToM occurs in almost every social interaction (Gallagher and Hutto, 2008), mostly unconsciously without volitional actions required. It enables us to reason intuitively and quickly about someone else's good or bad intentions and act consequently (Baron-Cohen, 1995). In brief, ToM can be explained as "a tendency to translate behaviour into mental states, to represent what people do in terms of what they want and what they know or do not know" (Gómez, 2004).

1.2 Cognitive and neurological mechanisms underlying Theory of Mind

1.2.1 Cognitive mechanisms

The mechanisms underlying ToM are still under debate. Two types of approaches have dominated the debate about how mind reading works: theory of theory (TT) and simulation theory (ST). Theory of theory states that mental state attribution is based on a folk psychological theory, which has nothing to do with observations and experiences but derives from theoretical reasoning. This

theoretical reasoning consists of a framework of concepts that relate external stimuli (perceptions) to certain inner states (beliefs and desires) that are translated into behavioural reactions (decisions) (Churchland, 1991; Gallese and Goldman, 1998; Michlmayr, 2002). In contrast, ST suggests that we do not understand others through the use of a folk psychological theory. Rather, subjects apply own experiences to calculate and predict the mental processes of others. They put themselves in the shoes of another person and simulate them. There are many variants of ST. In "off-line" simulation, the own decision-making system is supplied with pretended inputs of beliefs and desires of the person one wishes to simulate in order to predict his or her behaviour. One then lets one's decision-making system "do the work" and comes to a prediction (Davies and Stone, 1995, p.4).

Another open question is whether the cognitive mechanisms involving one´s own mental attributions are also involved in the process of attributing mental states to others. Leslie (1987) and Frith and Happé (1999) agreed that the process which helps individuals to distinguish between a physical reality (first representation) and the belief of a physical reality (second representation) is the same for self and others attributions. However, sufficient experimental evidence is missing which confirms that mental states are first attributed to oneself before attributed to others, even though a study by Gopnik and Meltzoff (1994) concluded that children are able to report others mental states as soon as they are able to attribute their own mental states. Respectively, if they are not able to report their own mental states, they are neither able to attribute others mental states.

1.2.2 Neurological mechanisms

Which areas of the brain are responsible for ToM is also still an open question. In the 90's, first functional imaging studies attempted to shield light on this thematic. They revealed that frontal regions were more active during mental tasks involving ToM than during tasks, which did not require ToM (Goel et al., 1995; Fletcher et al., 1995; Frith and Frith, 2003). In 1996, Gallese et al. discovered at the Institute of Physiology, Parma, that certain sensorimotor neurons in the area F5 of the premotor cortex play a role in ToM in rhesus monkeys. Single-electrode recordings revealed

that these neurons fired when the monkey performs an action. In fact, these neurons started to fire before the beginning of the movement. Certain cells fired in relation with specific actions (Rizzolatti et al., 1996). For instance, one population of cells would fire when the monkey would grasp a nut from a flat surface, even in the dark, without visual input. Still, the most interesting discovery was that the same neurons fired as well when the monkey observed another agent carrying out the same task, in this case grasping a nut. Accordingly, these neurons were termed "mirror neurons". Later on, by means of fMRI studies in humans, mirror neurons could be located in the pars opercularis in the inferior frontal gyrus, a homolog area of the F5 area in rhesus monkeys (Rizzolatti and Craighero, 2004; Dapretto et al., 2006). This brain area is active both when we perform an intentional action, as well as when we observe an intentional action executed by others (Gallagher and Hutto, 2008). Hence, neurons in this area appear to be involved in planning and executing goal directed actions. Over the years many interesting further findings accumulated. For instance, it was found that mirror neurons fire likewise when a subject listens to someone talking about a respective action, indicating that informational input reaches the same mirror neurons via different senses (reviewed in Bauer, 2005).

The relationship between mirror neurons and behaviour, particularly ToM, appears evident. It seems likely that mirror neurons enable a subject to imitate others and thereby to simulate actions mentally, for some authors a basic process for ToM (Rizzolatti et al., 2002; Wellman, 2005). Humans, and likely other social animals, might thereby have evolved a system that is used for understanding, predicting and manipulating the behaviour of others and thereby facilitated social interactions. Humphrey (1976) coined the metaphor of social chess. He claimed that: "Like chess, social interaction is typically a transaction between social partners. One individual may, for instance, wish to manipulate another; but social interactions are compounds of at least two intelligent individuals with different goals and the interaction becomes a two-way game where our strategy must be changed with each movement of the other opponent to react with a successful answer". Mirror neurons help us to understand other's behaviour and to be an optimal player in the

chess game of live. They code spatial movement of individuals in bioelectrical signals in our brain that will proceed and build an answer according to the specific necessities.

Nevertheless, the question whether people understand others states and actions only by simulating them, is still being discussed. Reports postulating a relationship between mirror neurons and ToM are still questioned. For instance, mirror neurons were discovered in rhesus monkeys, but whether this species actually possesses ToM is still being discussed (Heyes, 1998; Marticorena et al. 2011; Martin and Santos, 2014). Additionally, fMRI studies of theory of mind detected activation in parts of the brain that are not part of the mirror neuron system (Frith and Frith, 2003). While these issues do not disprove the link between mirror neurons and theory of mind, some authors have suggested that mirror neurons might be important for imitation, but just a precursor for mindreading (Gallagher and Hutto, 2008).

1.3 Significance of Theory of mind in humans - Mindblindness

ToM enables us to be socially competent, feel empathy for our equals, reduce conflicts and enhance interactions successfully. Much more friction, stress and misunderstanding would occur in group-life if the group members would lack ToM (reviewed in Bauer, 2005). On the other hand, individuals that master ToM have the possibility to play with the assumptions of others and to manipulate them, by giving false impressions (e.g. actors, spy agents; Lockl et al., 2004).

How would our lives be different without a theory of mind? Autism is widely accepted as a genetic developmental disorder of the brain, which lasts the whole life (Bailey et al., 1996). Its diagnosis is based on behavioural criteria. Empirical impairments are found in reciprocal social interactions and in verbal and nonverbal communication. Furthermore, it was observed that the repertoire of activities and interests is restricted (Happé, 1999). For autistic children the immediate social environment is unpredictable and incomprehensible due to a neuro-cognitive mechanistic deficit (Frith and Happè, 1999; Baron-Cohen, 1995; Wellman el Liu, 2004). These assumptions derive

from extensive false-belief-experiments that are simple to solve for healthy children while children with autism fail (Frith and Happè, 1999). Exceptions to this categorization are individuals with Asperger syndrome. This minority within the autism spectrum presents higher social and communication abilities in comparison to autistic children. It builds an exception to the hypothesis that autism is a consequence of a failure of the ToM mechanism. While children with Asperger syndrome show impairments in ToM tasks in comparison to healthy children, when growing up they develop a better social understanding and are finally able to pass ToM tasks (Bowler, 1992). Carruthers (1996) suggested that if the mechanism that allows normal individuals to infer states of knowledge to others is impaired in autistic children, also the self-knowledge mechanism should be impaired. Another group of individuals that have been shown to suffer from ToM deficits are deaf preschool children raised by non-deaf parents. This group shows impairments and delays in their ToM capacities in escalation tests in comparison to non-impaired children (Peterson et al., 2005; Wellman and Liu, 2004).

1.4 Development of ToM in humans

ToM has been extensively studied in humans with deficits in understanding others' mental states, and also in children. Scientists try to identify the factors that influence the acquisition of ToM. Up to a certain age, children cannot understand that others regard the same object, idea etc. from a different point of view and that many things turn out to be different than they look like by first sight. To shield light on the questions when and how this "metamorphosis" takes place, developmental psychologist started studying children populations with verbal aptitude using false belief understanding (FBU) tasks (Wimmer and Perner, 1983; Baron-Cohen et al., 1985; Perner et al., 1987). Wimmer and Perner (1983) demonstrated that only 15% of 3 year old children, but 78% of 4-5 year old children could solve a false FBU task. Wellman, Cross and Watson (2001) supported this finding. They demonstrated in an extensive Meta analyses from 143 studies and over

500 FBU tasks that remarkable changes happen in relation to FBU, and hence ToM, between the age of 3 and 5 years. Wellman (2004) described some aspects that accelerated the development of a ToM in preschool children, for instance conversations with parents about mental states and emotions (Dunn and Brown, 1993; Ruffman et al., 2002), language abilities (Astington and Baird, 2005), living in enriched social environments or sharing experiences with others (e.g. Perner et al., 1994). Hence, how we infer behaviours depends on our previous experiences, knowledge about others, behavioural rules, etc. However, there are different perspectives about how ToM is achieved and developed. While for some scholars, it is the product of learning processes, others claim that ToM is a capacity evolved in the "theory of mind module": such a module appears to be based on an innate potential ability that appears early in life and requires previous social and other experiences to mature (Wellman, 2005). Several mental states are postulated to be necessary for ToM (Förstl, 2007; Wimmer und Perner, 1983), for instance a naive theory that helps us translating other's behaviour into mental states (Astington, 1991; Gomez J., 2004).

1.5 Benchmarks for ToM

To make predictions about the mental states of others, it is important to understand that others can hold false beliefs. Therefore one needs the ability to comprehend that the opinions and ideas of oneself are not always identical with those of others (Bischof-Köhler, 1998). That means that one must take the perspective of others and not attribute its own knowledge to them but to have the capacity to catch and understand someone else's point of view (Petermann et al., 2004). According to many scientists, FBU is a reliable indicator for ToM: "Predicting the behaviour of someone with a mistaken belief is only possible if one can grasp the representations that others have of the world, and this is why FBU is an excellent indicator of having a theory of mind" (Gómez J., 2004). FBU is based on the ability to comprehend that others hold thoughts about reality that might not be true. It is suggested that in order to understand false beliefs, one must understand that its own knowledge is

formed through input from the environment and previous experiences, and consequently one´s own beliefs and mental states can differ from reality. Moreover, the behaviour and behavioural strategy of each individual might change with different beliefs and mental states.

Cognitive scientists developed three different tests to study FBU. First experiments were conducted with children and later adapted to study ToM in animals (see below). The following methods have been used.

Location-change task:

This task has been developed by Wimmer and Perner (1983). Plenty of other studies followed, for instance by Clements and Perner (1994), Baron-Cohen et al. (1985) and Perner et al. (1987). FBU has hitherto been assessed using a verbal false-belief task in which the experimenter tells stories. An example of such story is as follows: "Sam leaves his toy in a box, he goes for a nap, Joe enters the room, takes the toy and plays with it, once he finishes he leaves the toy in the other box. Sam comes back looking for his toy. Is he going to look in the place where he last left it or is he going to search where the object really is?" When asked by the experimenter, most 3-year-olds wrongly claim that Sam would look for the object in the second location, where they know the toy is hidden. As the experiment demands highly verbal and executive capabilities solely children older than 3 years can participate. That does not necessarily imply that younger children do not have a ToM. Instead there is plenty of evidence that infants younger than three years are capable of tracking others attention (eg. Gergely et al., 1995; Frith and Happè, 1999), attribute apparently simpler mental states, such as desires (Wellman, 1990 and 1991) and understand pretended play (Leslie, 1987 and 1988). Onishi and Baillargeon (2005) adapted this method to study false belief understanding using a violation of expectation (VoE) paradigm. VoE is defined in a simplistic way as the mental process that appears after an unusual event is observed and the predictions that the individual has had about the event differ from what happened. This theory assumes that subjects predict the outcome of actions of other subjects and react with a spontaneous response. It was found that children make these

predictions and react by enhancing their attention time to the event when violation of expectation appears (Baillargeon, 1987). Onishi and Baillargeon (2005) measured the time children spent looking at an action. The children looked longer at an action when it was unexpected because they did not predict the action to happen and thereby Onishi and Baillargeon could deduce that the children understood the others mental states in the task.

Content-change task:

In the content-change task the children do not have to attribute false beliefs to others but instead they have to understand what it means to have a false belief. One example is the "Smarty task" (Gopnik and Astlington, 1988): the experimenter shows a smarty box to the children and asks them what they think is inside. Usually the children answer that smarties are inside of the box. They are then asked to open the box and see what is inside. When they do so, they discover a bunch of pencils instead of smarties. Finally, the experimenter asks the children what they thought was inside before they opened the box. The majority of 3-year-old children reply "pencils", while 4-year-old children would usually say "smarties" (Gopnik and Astington, 1988; Petermann et al., 2004). Also other questions can be applied in the test, for instance "What do you think your friend would answer if we ask him what is inside?", to apply the test for FBU in others.

Appearance reality distinction task:

This test was generated to measure whether children understand that knowledge can be modified, what seems to be true by first sight can turn out to be wrong. The experimenter shows the children an object, looking like a stone, and asks them what they think it is. Normally they answer "a stone". But as they touch it, they realize that it is actually a sponge. Finally they are being asked "What is this in reality?" and "When you see it, does it look like a stone or like a sponge?". This test helps to investigate whether children understand the differences between appearance and reality.

Except for Onishi and Baillargeon´s (2005) study, to stand the tests, all three types of false belief tasks demand high verbal capacities, which might reduce the accuracy of the tests.

Following Tinbergen´s "four questions" (1963), comparative psychologist, cognition biologist and primatologist have rediscovered the interest in studying behavioural mechanisms in non-verbal populations, namely animals or infants, in a functional and evolutionary framework. The range of species being studied has increased since (Miklósi et al., 2004), and interesting diversifications of different types of experiments evolved. So far, most of these experiments were first conducted in monkeys. The first, pioneering experiment in ToM was conducted by Premack and Woodruff in 1978. They questioned whether chimpanzees have ToM. They showed a chimpanzee, Sarah, videotapes of people trying to solve problems, like reaching a bunch of bananas hanging from the ceiling. Sarah was able to select photographs that depicted solutions to the problems. For the authors, ToM is a system, which allows individuals to predict the behaviour of others (Premack and Woodruff, 1978; Sodian and Thoermer, 2007). The repercussion of this publication was notable by the number of publications that followed in developmental and comparative psychology. But for some authors, the experiment by Premack and Woodruff was inconclusive. They argued that Sarah could have responded on the basis of functional similarity (Savage-Rumbaugh et al., 1978), formerly learned associations (Heyes, 1998) or intentional relationship (Gómez J., 2004).

Povinelli et al. (1990) investigated whether chimpanzees could distinguish between knowledgeable and ignorant experimenters: a piece of food was hidden in one of four containers and the subject was aware that one experimenter was looking at the baiting process while the other was ignorant and unable to see the baiting process himself. The containers were placed in front of the subject and the subject was allowed to choose one. Surprisingly, in many experiments like these, most monkeys and apes fail to use the attentional cue from the experimenter to choose the baited container, even if they looked at the correct container initially (Povinelli et al., 1997).

Heyes (1998) proposed a way to test mental state attribution via triangulation using a modified version of the Povinelli et al. (1990) setup. The two experimenters should wear two different types of glasses in different colours: one opaque and the other pellucid. The apes were allowed to explore

the glasses beforehand. Then they watched the same procedure as in Povinelli et al. (1990) and decided which one of the experimenters could be trusted. Triangulation is a compounding test that consists of a set of tests (discrimination test) that, once combined, provides a higher order test (transfer test). By means of the transfer test, higher states of mind can be tested.

Another study of Povinelli and Eddy, published in 1996, was based on cooperation with the experimenters. The chimpanzees were trained to ask an experimenter, on the other side of a transparent Plexiglas wall, for food. The wall had two holes, with the experimenter positioned in front of one. During training trials the animal received the reward only for reaching through the hole closer to the experimenter. During the experiments, two experimenters held out food, but one could clearly see the chimpanzee as before, whereas the other could not. The surprising result of these experiments was that chimpanzees gestured as often to the experimenter who could not see them as to the experimenter who could. The authors interpreted the results as evidence that chimpanzees do not have the capacity to put themselves in someone else's position.

Hare (2001) argued that unlike humans, chimpanzees do not cooperate with others sharing food; instead they simply monopolize food. He thought that an experiment based on food competition would be more realistic than the one designed by Povinelli in 1990. In his study, he brought two chimpanzees (a dominant and a subordinate) in two rooms connected by a third room where two pieces of food were placed in equal distance from each chimpanzee. The subordinate could see both pieces of food but in case of the dominant, an obstacle was hiding one piece of food. When the subordinate chimpanzee was released he went to the piece, which was visible solely for him. These results contradict the findings of Povinelli. Hence the question whether monkeys and great apes are able to appeal to mental states (goal, perceptions and beliefs) to explain the behaviour of others is still a controversial issue.

It was often suggested “that unlike macaques, chimpanzees have a capacity to attribute knowledge, feelings and intentions to others and can picture themselves in someone else´s position” (Premack

and Woodruff, 1978; De Waal, 1996). However, Flombaum and Santos (2005) reported evidence for ToM in macaques. They confronted rhesus macaques with a human competitor. Two pieces of food were presented in front of the monkey and the human. In one condition, the human's body and face was oriented towards one piece of food. In the second condition, the body was oriented towards one piece of food and the face oriented towards the other piece. They found that Rhesus macaques stole food from humans, whose head was not oriented in the direction of the food. This result emphasizes that Rhesus macaques can infer others motivations and states of knowledge and react to them in the most profitable way for themselves, again contradicting Povinelli´s findings in apes.

Bugnyar et al. (2004) showed similar results in ravens (*Corvus corax*). The ravens relocated themselves in order to track a human's line of sight. This capability is believed to be a basic step for the development of a mature ToM (Byrne and Whiten, 1991). Furthermore it has been found that ravens can precisely change their behaviour depending on the state of knowledge of conspecifics (Bugnyar and Heinrich, 2005). In this paradigm, it was shown that a raven, knowing about the location of a reward, behaves differently when confronted with two different competitors. One, who had seen the conspecific catcher hiding the reward and thus could potentially pilfer the caches ("knower"), and one, who had not seen the catcher hiding the reward (the cage was enclosed by curtains) and hence was an ignorant "guesser". After the caching trial, the caching raven was returned to the aviary either alone or together with the "knower" or "guesser". The caching raven remembered which bird observed the caching and treated it as a potential pilfer: subjects retrieved more often their caches in an observer´s "knower" presence than when alone or with the "guesser".

1.6 Theory of mind in dogs

Even though the dog (*Canis familiaris*) is one of the most successful mammalian species that has dispersed around the earth, dogs have often been regarded as an ethologically "uninteresting"

species. But within the last decade the behavioural research in dogs has increased dramatically (Miklósi et al., 2004). We think that the dog is a unique model among domesticated species due to different factors: the domestication process as well as the developmental socialization in the human environment (Topál et al., 2009). By raising individuals of evolutionarily distant species in the human social environment, the development of human‐like behaviours could be facilitated analogously to the changes that took place during hominization (Topál et al., 2009). Dogs have been selected according to different characteristics (physical and cognitive) for different ecological demands, like hunting or herding, challenges were different but cooperation with humans was always a crucial criterion for selection (McConnell and Bayliss, 1985; Slabbert and Rasa, 1997) where empathic and communicative dogs would be probably selected over others (Virányi and Range, in press).

The change of environment, from their natural niche to a human niche, let dogs evolved to a completely new niche and human social environment seems to be dogs natural niche nowadays (Miklósi, 2007). They also formed heterospecific social groups (dog-human) until such a point where dogs seem to be predisposed to develop close contact with humans (Gácsi et al., 2005). An application of tests about human attachment (Bowlby, 1969; Scott, 1992) between mothers and their infants, that was applied to adult dogs and their owners, showed analogous results to the attachment that mothers present to their children (Topál et al., 1998). However, still little is known about how early stimulation affects the development of the dog–human relationship (Topál et al., 2009).

A cognitive convergent evolution could occur in dogs and humans (Miklósi, 2004). This includes a similar socialization and learning process (Virányi and Range, in press). This convergent evolution may have promoted the development of complex cooperative social interaction, what became the basis, for example, for training dogs to assist blind or mobility-disabled people (Naderi et al., 2001). Miklósi et al. (2004) questioned whether and how genetic diversity influences social cognition in dogs, and whether there are social abilities shared by all dog breeds independent of their genetic

makeup. It would be a mistake to rely only on genetic changes that happened since the dog separated from the wolf, *Canis lupus*, also behavioural adaptation should play a major role. Comparison with the ancestor is important for convergent modelling. If the environment of wolves and dogs is equalized then the remaining behavioural differences could be explained in terms of inherited factors, and/or maternal prenatal influences (Topál, 2009).

Wolves, dogs' closest living relatives (Scott and Fuller, 1974), live in social groups and show co-operative behaviours (Mech, 1970; Frank, 1980). For hunting, wolves need to understand others´ states of knowledge and exploit it (Mech, 1970; Frank, 1980; Bräuer et al., 2004) not only from conspecifics but also from the prey itself (Frank and Frank, 1982; Gagnon and Dore, 1994). In line with this assumption, Range and Virányi (2011) showed that wolves are excellent at using conspecific as well as human gaze cues even to track gaze behind barriers. Udell and colleagues (2008) showed that human-raised wolves could even outperform shelter dogs that have limited experiences with humans in their use of human-given cues. On the other hand, dogs can learn "momentary distal pointing" earlier than wolves, showing that they are genetically predisposed to develop this skill faster. It seems that wolves need a longer learning period than dogs to reach the same gesture understanding (Virányi and Range, in press).

Since pet dogs can revert to feral life within a few generations (Daniels and Bekoff, 1989), the reverse is possibly also true for feral animals. Belyaev and colleagues (1969) started a 50 year long experiment, replicating what the domestication could have looked like by selecting a group of foxes against fear and aggression toward human: only those animals were fed that approached the hands of humans standing in front of their cages. Foxes showed already in the 6^{th} generation domestication characteristics like tail-wagging and licking the experimenters hand, additionally, were more skilled at using humans gestures. On the basis of these results and others conducted by them, Hare and Tomasello (2005), constructed their emotional-reactivity hypothesis, where they argued that the success of these selected individuals in using human cues was a by product of being selected for reduced fear and aggression. Interestingly, when socialized by humans, wolf puppies,

unlike dogs, still prefer the conspecific partner to the human when offered the choice (Frank and Frank, 1982; Gácsi et al., 2005). The results were in line with another study, which showed that in contrast to 4-month-old dog pups, grey wolf cubs of the same age did not fulfil the criteria for attachment with humans (Topál et al., 2005a).

Range and Virányi (2011) reported that wolves reliably follow the gaze of conspecifics from a very early age on and that just some months later they can also follow the gaze of humans around a barrier. Several studies have revealed that dogs can rely on various human body gestures like communicative signals, such as pointing or gazing (Hare & Tomasselo, 1998; Miklósi et al., 1998, Topál et al., 2009), and even, they are able to generalize to novel forms of the pointing gesture, suggesting some level of understanding about the referential character of the signal (Soproni et al. 2002). Following previous studies in Apes (Povinelli and Eddy, 1996), dogs were offered the opportunity to beg food from two persons, one who faced the subject and one that looked in the opposite direction (the orientation of the torso was the same for both). Dogs selectively begged from the person facing them (Gácsi et al., 2004). Soproni et al (2001) showed that dogs understand how looking into a baited container signalled the presence of food, but looking above the container did not.

Gagnon and Dore (1992) suggested that dogs could search accurately on standard invisible displacements. However, recent research has questioned these results by showing that dogs did not fulfil the object task paradigm. Topál et al (2005) hid an object in full view of the dogs at a new location. Results showed that many subjects were more inclined to seek out the hidden object at various locations rather than to go directly to the location of the object, which they knew. (Topál el al., 2009).

In different experiments it was demonstrated that dogs rely on visual cues of human attention and modify their behaviour in accordance. Bräuer et al. (2004), studied perspective taking in dogs. They observed that dogs could infer the visual perception of humans. When the experimenter prohibited food consumption, dogs ate significantly more often in the hidden condition (experimenter not

watching) than in the visible condition (experimenter watching). Similar results were found by Schwab and Huber (2006): dogs obeyed the owners command rather when the owner was paying attention, and disobeyed when the owner was not attentive.

Another experiment demonstrated that dogs could anticipate the actions of their owners, Kubinyi et al. (2003) asked dog owners to change their route after arriving back from walking the dog. Instead of taking the shortest route to their flat, they had to make a short detour. This action was repeated and half of the subjects gradually not only escorted the owner but also overtook them and finished the detour earlier. At a behavioural level, social anticipation can also be interpreted as a mechanism for reducing conflict in the course of interaction between two parties (Topál, 2009).

But whether dogs understand human´s intentions remains highly debated. Kaminski et al. (2009) presented contradictory results using a different approach. They used two objects, one visible for both the dog and the experimenter, while the other was visible only for the dog. The experimenter asked the dog to bring the object. Dogs did not bring the object that was visible for the experimenter more often than the hidden one. They argued that dogs are not sensitive to humans' visual perspective and that dogs cannot put themselves in the position of the human. Cooper et al. (2003) tested dogs in a cooperative task. Following Povinelli´s experiment in 1990, three possible target locations, and two human indicators were presented to the dogs. The dogs watched how the baiting process was observed by an experimenter (knower), while a second experimenter was not present (guesser). Then, both experimenters pointed at different cages. Astonishingly, only in the first out of six trials did the dogs choose more often the location indicated by the knower.

The studies presented above show that dogs are an excellent subject for studying animal behaviour, and that, due to its convergent evolution with humans dogs are possibly theory of mind holders.

1.7 Project outline

The aim of this project was to investigate whether dogs are able to attribute false believes about the location of an object to the experimenter. The project was based on Onishi and Baillargeon (2005) study in children.

In our study, the subject observed experimenter 1 hiding a bunch of keys in one location and leaving the room. Then experimenter 2 entered and reversed the location of the keys. Where would the subject expect the experimenter 1 to look for the keys? If the subject understood the action and the state of knowledge of the experimenter 1, it would assume that he would look for the keys in the place where he left them. However, if Experimenter 1 would choose the actual location of the keys, then the subject's expectations should be violated and it should react with a prolonged gazing time. In other words, the subject should understand that the Experimenter 1 was holding a false belief. For this, the subject must have understood the experimenter´s intentions and state of knowledge. These processes are involved in ToM and whether dogs have these abilities is an important question in the field of animal cognition.

2 Methods

2.1 Study location and period.

The experiments were conducted at the Clever Dog Lab (CDL) Vienna from June to October 2011. All subjects were volunteered by their owners to participate in cognitive and behavioural research.

2.2 Experimental subjects

In our study we tested 162 dogs. Seventy-nine dogs were excluded for different reasons: they failed the object permanence test (n=53), they were out of view of the camera (n=4), they did not pay attention during the baiting process (n=4), they did not meet the age-criteria (n=14), or due to errors by the experimenter (n=4). The remaining 83 dogs were on average 48 months old, ranging from 12 to 96 months. Thirty-six female and 47 male dogs took part in this study. The dogs were of different breeds. Age was balanced between conditions (see table 1).

Table 1. Detailed table of the participating experimental subjects in our experiment between conditions.

Condition	Number	Sex (m/f)	Mean Age (months)
1	24	9/15	48.10
2	21	14/7	44.28
3	19	12/7	46.86
4	19	12/7	52.95
Total	83	47/36	47.96

2.3 Materials

Fig.1.: Apparatus. Four cameras were filming the dog (A), dog with owner (B), dog with owner, boxes and keys (C) and the subjects perspective towards the doors and experimenters (D). *k: keys, br: right box, bl: left box, d1: door 1, d2: door 2.*

All experiments were conducted in a 7 x 4 m^2 large room (fig. 1). Two out of three doors in the room were used during the experiment. These two doors (d1,d2) were at adjacent walls, approximately 1.5 m apart and led to different rooms. Two grey plastic boxes (br,bl), measuring 15x20x20 cm^3, were placed in the middle of the room, approximately 1.40 m apart, with their open sides facing the ceiling at the beginning of the experiments to illustrate that they were empty.

For the FBU test, a bunch of keys was used. At the beginning, the keys were placed on the floor between the boxes (the location was marked by a cross made of adhesive tape). Opposite to the doors was a chair for the dog owners to sit on. The dogs were positioned in front of their owners,

hence facing the boxes and the doors, but not their owners. Moreover, the owners were wearing a blindfold. Four cameras were set up, one in each corner of the room. They were switched on at the beginning of each test session and recorded until the end of the session. The cameras were set up so that the whole scene was clearly visible in the recordings: one camera (Sony HVR Z1) focused on the dog's body and face, the second (JVC GZ HM30) on the dog and his owner, the third camera (JVC GZ HM30) focused on the two doors, and the fourth camera (JVC GZ HM30) on the dog and the boxes. All cameras were connected to a video capture receptor (pinnacle) connected to a computer outside of the experimental room.

2.4 Experimental Design

The procedure was similar to the one described by Onishi and Baillargeon (2005). In the first scene, the "pre-trial action", the experimenter 1 picked up the keys and hid them in one of two boxes. In the second phase, the experimenter 2 changed the location of the keys. In the final phase, the experimenter 1 reached for one of the two boxes, which did or did not contain the keys, depending on the condition. Each dog participated in only one out of four conditions (see table 2 for a summary) In two expected conditions (1 and 3) dogs observed an expected action, meaning experimenter 1 reached for the box in which, according to his knowledge, the keys should be hidden. In contrast, in the two unexpected conditions (2 and 4) dogs observed an unexpected action: the experimenter 1 reached to the box in which, according to his knowledge, the keys should not be hidden. In condition 1 and 2, the experimenter 1 was not present during the relocation of the keys. Hence he was unaware that the keys were not in the box in which he left them. In the first condition, experimenter 1 then chose the box in which he left the keys before leaving, hence performing an expected action. In the second condition he performed an unexpected action by grabbing the box containing the keys. In condition 3 and 4, experimenter 1 was present while the keys were relocated by experimenter 2. Consequently, experimenter 1 knew about the ultimate place of the keys.

Choosing, nevertheless, the wrong box reflected an unexpected action (condition 4) and choosing the right box reflected an expected action (condition 3).

Table 2. Detailed table of the conditions in relation with Action, Experiment 1 present/absent, relocation and box reached.

Condition	Action	During relocation, experimenter 1 was:	Relocation	During phase 3 experimenter 1 reached for the:
1	Expected	Absent	YES	Correct box
2	Unexpected	Absent	YES	Incorrect box
3	Expected	Present	YES	Correct box
4	Unexpected	Present	YES	Incorrect box

2.5 Procedure

2.5.1 Procedure False belief Understanding

Experimenter 1 entered the room together with the owner, whereas experimenter 2 was already present. While the experimenter 1 explained the experiment to the owner, the dog was allowed to move freely and explore the location. During this time, experimenter 2 stayed present in the room in proximity to door 2 but did not talk or move. After the dog had noticed that the boxes were empty, the experimenter 1 turned them upside-down and left a bunch of keys at the marking (fig. 1c (k)) between the boxes. Experimenter 1 asked the owner to sit down, hold the dog between her/ his legs and, once he, experimenter 1, left the room, to blindfold her/himself in order to not influence the dog's behaviour. As soon as the dog paid attention, the experiment started. Experimenter 1 left the room through door one (fig. 1d (d1)), experimenter 2 left the room through door two (fig. 1d (d2)). After 30 s, experimenter 1 entered the room through door one, headed towards the keys and exclaimed "Ah, here are my keys!". He picked them up from the floor in the middle of the two

boxes and hid them under one of the two boxes (counterbalanced across dogs), announcing “I will leave them in the right/left box”. In conditions 1 and 2 the experimenter 1 then left the room through door one, while he stayed in the room during the whole process in conditions 3 and 4. Experimenter 2 entered the room through door two. He searched for the keys first in the wrong location, to demonstrate that the box was empty, and then in the right box. After having found them, he relocated the keys in the other box clearly visible for the dog, and left the room through door 2. The relocation was either observed by experimenter 1 (condition 3 and 4) or not visible for experimenter 1 (condition 1 and 2). In the latter case, experimenter 1 re-entered the room again through door one, 30 s after the experimenter 2 had left. He headed towards the marking (Figure 1d (x)), in order to retard the reaction of the dog, and then redirected his direction towards the box of choice, knelt down and grasped for it. A period of 30 s was allowed to elapse during which the experimenter did not remove his hands from the box and the looking time of the dog was measured.

2.5.2 Procedure Object Permanence Task.

Because dogs have been reported to have problems with solving object permanence tasks (Collier-Baker et al., 2004), we conducted an object permanence task (OPT) at the end of each session to ensure that each dog was able to infer the position of the keys after they were moved from one box to the other. Only the data from those dogs that successfully completed this task were used for analysis.

The setup of the room was the same as in the FBU task before the start of the experiment, but the boxes were lying on the side with their bottom sides facing the dog, hence masking their contents. The experimenter presented a toy, brought along by the owner, to the dog. The experimenter hid it in one box, showed his empty hands, and then changed the position of the toy to the other box, while being observed by the dog. He went back to the mark in the middle between the two boxes, and asked the owner to release the dog. If the dog then headed towards the box containing the object, it passed the trial. Six trials were given for each dog. If it passed at least 5 trials it passed the

test and the data of the FBU task (previous experiment) were processed for analysis. Based on this criterion, 54 dogs were excluded from further analyses.

2.6 Analysis

The videos were analysed with Solomon coder, developed by András Péter, using frame-by-frame analysis. The looking time of the dog, defined as: the total time (s) that the subject expended looking at the box or experimenter measured for a maximum period of 30 seconds, started when experimenter 1 was taking hold of one of the boxes. The experimenter 1 did not remove his hands from the box during this time. Raw data were analysed with SPSS 20. Data were tested for normality of distribution with the non-parametric one-sample Kolmogorov-Smirnov test. The Kolmogorov Smirnov test revealed that the data were normally distributed (condition 1: $p=0.231$, $n=24$; condition 2: $p=0.891$, $n=21$; condition 3: $p=0.432$, $n=19$; condition 4: $p=0.447$, $n=19$). Therefore a parametric test, student t-test, was applied to find significant differences in looking time between conditions (1 to 4). Furthermore, dogs were divided in groups, according to sex or age, respectively, and significant differences in looking time were reanalysed. To test whether these variables were equally distributed between conditions 1 and 3 (observation of expected actions) and 2 and 4 (observation of unexpected actions), we made a crosstab and applied the Pearson Chi-square test. No bias was found (age: $\chi^2 = 1$, sex: $\chi^2 = 0.184$). Neither was the presence of the actor ($\chi^2 = 0.827$), the side of the hidden object ($\chi^2 = 0.658$), or the performance in the object permanence task ($\chi^2 = 0.241$) biased.

3 Results

3.1 Experimenter is absent.

In condition 2, in which the experimenter 1 performed an action, which was inconsistent with his state of knowledge, the looking time was significantly longer (21.9±4.9 s) than in condition 1 (13.6±10.3 s), in which the action was consistent with the state of knowledge of experimenter 1 (t-test: p=0.001, n=45; fig.2 a).

3.2 Experimenter is present.

The same was true for conditions 3 (action was consistent with the experimenter´s state of knowledge) and 4 (action was inconsistent with the experimenter´s state of knowledge): the dogs paid attention for longer time (17.8±8.0 s) when the actor performed an unexpected action in condition 4, than in condition 3 (11.4± 8.4 s), when the actor picked the wrong box although he had been present when the second actor hid the object in the other box (t-test n=38, p=0.021, fig. 2 b).

3.3 Sex

3.3.1 Experimenter is absent.

In condition 1, females looked on average for a shorter time period (10.4±7.5 s) than males (18.8±12.6 s) in response to the expected action. The result was, however, not significant (t-test, p=0.095, n=24). Moreover, in condition 2, the looking time in females was slightly increased (22.3±4.8 s) in comparison to males (21.7±5.2 s). The result was not significant (t-test, p=0.787, n=21, fig. 3).

3.3.2 Experimenter is present.

The same was true for conditions 3 and 4, which were performed in the presence of the experimenter 1. In condition 3, when observing an expected action, females paid less attention (8±8 s) than males (13.4±8.3 s). The result was not significant (t-test, p=0.191, n=19). In condition 4,

when observing an unexpected action, females looked slightly, but insignificantly (t-test, p=0.366, n=19, fig. 3 longer (20.1±6.8 s) than males (16.5±8.6 s).

3.4 Age

To test whether age influences the dogs' performance in the experiments, data were separated according to age (younger or older than 42 months) and compared.

3.4.1 Experimenter is absent.

In condition 1, the mean looking time in young dogs was slightly, but insignificantly (t-test, p=0.098, n=24), lower (9.7±10.3 s) than in older dogs (16.8±9.6 s, fig. 5). In response to an unexpected action (condition 2) there was no significant difference in looking time between young dogs (22.5±4.7 s) and older dogs (21±5.6 s; t-test, p=0.532, n=21, fig. 5).

3.4.2 Experimenter is present.

Young dogs paid slightly, but insignificantly (t-test, p=0.73, n=19), less attention in condition 3 (8.12±7.4 s) than older dogs (15.0±8.4 s). In condition 4, there was no significant difference between younger (16.1±10.5 s) and older dogs (18.9± 6.5 s; t-test, p=0.541, n=19, fig. 5).

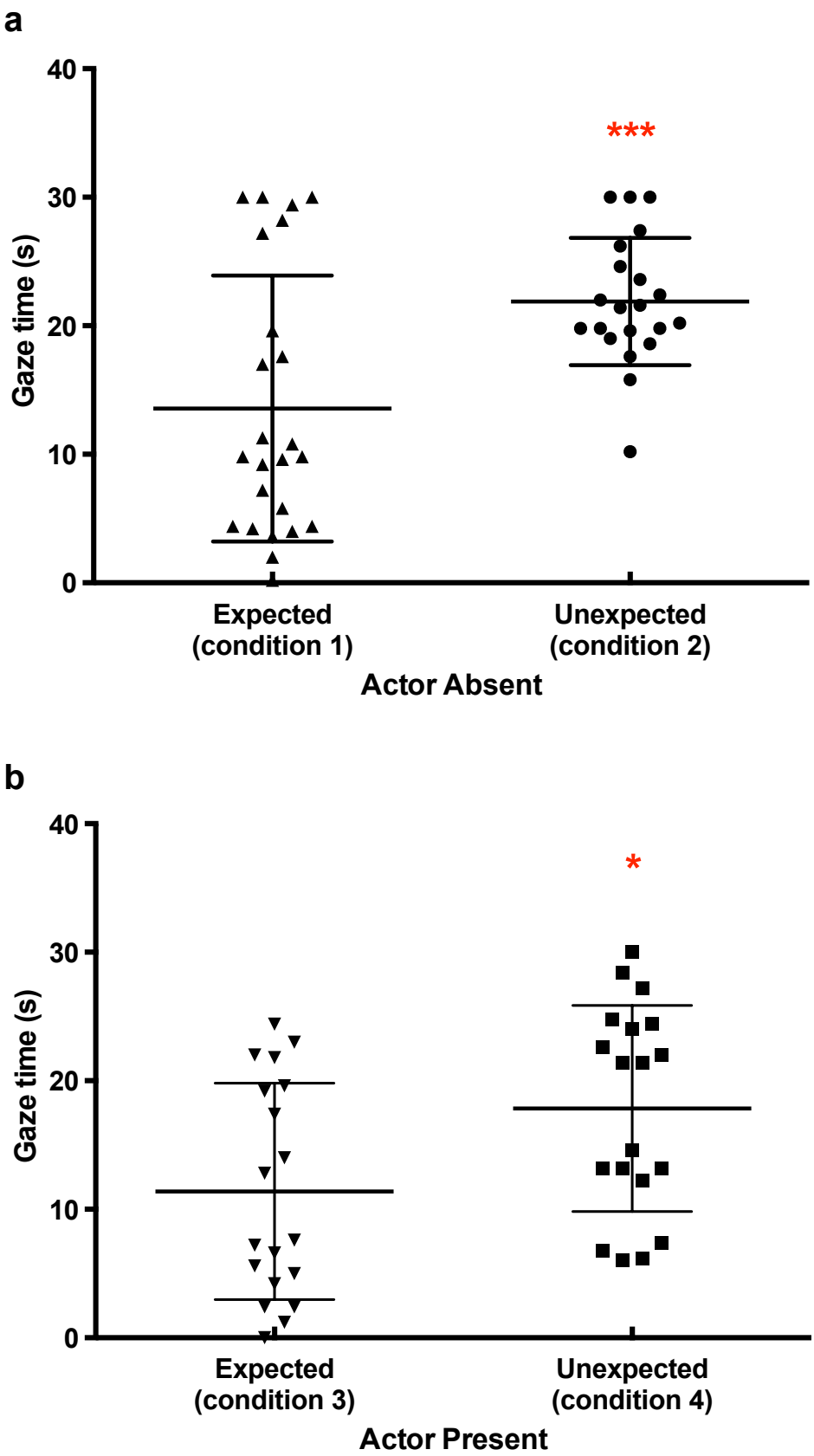

Fig. 2. Dogs looked on average longer at the unexpected than at the expected action. That was the case when the actor was absent **(a)** or present **(b)** while the object was replaced. *** $p<0.001$; * $p<0.05$

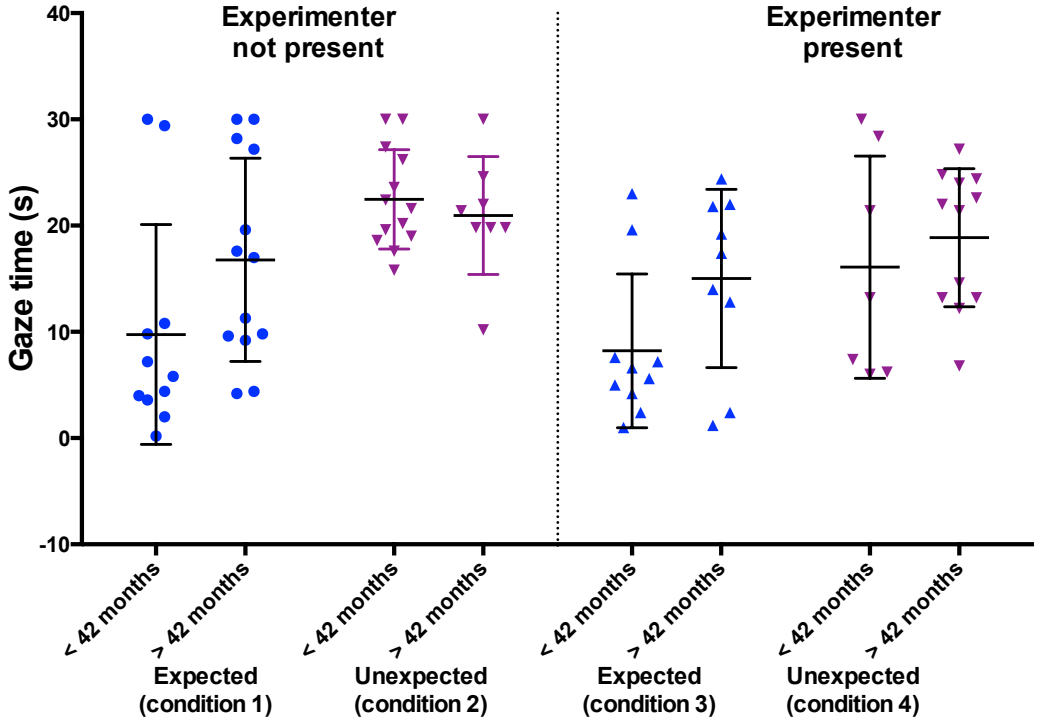

Fig. 5. Dogs younger than 42 months looked on average less time at the expected actions and paid more attention during the unexpected actions than dogs older than 42 months, both during the experimenter-absent condition, as well as during the experimenter-present condition. Differences were not significant.

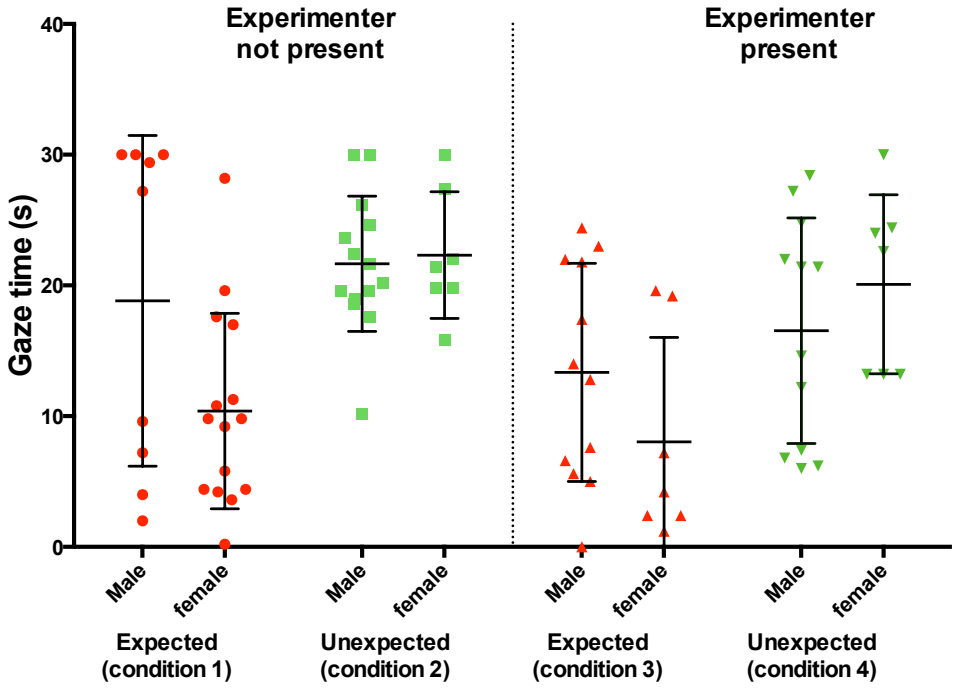

Fig. 3. Females looked on average less time at the expected actions and paid more attention during the unexpected actions than males, both in the experimenter-absent condition, as well as in the experimenter-present condition. The differences were not significant.

4 Discussion

The main goal of this study was to test whether dogs understand human´s false beliefs. To our knowledge, the present study is the first to study FBU in dogs using a violation of expectation task. We found that dogs paid significantly more attention during the unexpected conditions, when the experimenter's behaviour was not consistent with his state of knowledge, than during the expected conditions, when the experimenter´s behaviour was consistent with his state of knowledge. These results indicate that the dog´s expectations were violated.

In condition 1 and 2, where the experimenter was absent during the relocation of the object, dogs paid significantly more attention when the experimenter went to the right location than when he went to the wrong location. This result shows that dogs were having expectations about how the experimenter would act based on the experimenter´s false belief.

In our control experiments, condition 3 and 4, the experimenter stayed in the room, watched the baiting process and went to the box where the object currently was (condition 3) or to the box where he originally had left the object (condition 4). When comparing condition 3 and 4 we found that dogs paid significantly more attention to condition 4 than condition 3. These results suggest that dogs made predictions about the behaviour of the experimenter. They had to understand the goal of this behaviour and have in account the experimenter´s belief about the location of the object.

Taken together, these results suggest that dogs can represent the actions of others, similar to humans. Hence, our results are consistent with the assumption that dogs have elements of a ToM. Although rhesus monkeys (*Macaca mulatta*) are closer related to humans than dogs are, they did not pass a similar FBU task. They appear to represent behaviour only as a function of others information states, such as knowledge and ignorance, but they lack representations of others' beliefs. Marticorena et al. (2011) replicated Onishi and Baillargeon experiment with rhesus monkeys using, as well, human as agents: they divided the 4 conditions presented in our study into two experiments. Rhesus monkeys showed increased attention when an aware experimenter reached

to the incorrect location (Experiment 1), but appeared to make no prediction about where an experimenter, holding a false belief, will search (Experiment 2). This pattern of performance has been replicated by Martin and Santos (2014) in a similar experiment, suggesting that rhesus monkeys reason about other agents' knowledge states, but not their beliefs. Their conclusion was that non-human primates do not share human abilities to automatically represent others' beliefs. Our positive results in a similar task with dogs offers another possibility namely that animals selected in the human environment and highly socialized with human may understand human false believes. Perhaps an interspecific theory of mind (macaque-human) is not present in wild macaques, as they may not have being under the biological pressure to develop it, perhaps process like domestication and socialization may have provided dogs with an interspecific ToM. This does not mean, however, that monkeys may not posses an intraspecific ToM or the potential to present it if correctly socialized. Hence, ToM studies in dogs are crucial to bring light into this debate.

Our results are in line with previous studies in dogs. It has been reported that dogs are able to imitate in an inferential, selective manner (Range et al., 2007), to discriminate between "attentive" and "inattentive" humans (Gácsi et al., 2004; Virányi et al., 2004) and to recognize what a human can or cannot perceive (Call et al., 2003; Braüer et al., 2004). All these capacities indicate a low level of ToM. Schwab and Huber (2006) showed that dogs obeyed the owners command rather when the owner was paying attention, and disobeyed when the owner was not attentive. Further, Virányi et al. (2008) showed that dogs could differentiate between knowledgeable and ignorant humans, although Kaminski (2011) argued that the increase in indicatory behaviour could be due to the presence or absence of the helper rather than due to the knowledge of the dog about the owner´s knowledge state. However, we did not find differences in attention time of dogs when comparing the "experimenter present condition" with the "experimenter absent condition", both for expected and unexpected actions, respectively. Hence, Kaminski´s critics do not apply to our results.

Still, many methodologies used to study theory of mind in non verbal subjects and the complex interpretations of their results, have faced criticism because it is debatable whether they are capable

of empirically demonstrating awareness of another's knowledge state (Heyes, 1998; Penn & Povinelli, 2007) or whether these complex behaviours could be explained by other pathways (Perner and Ruffman, 2005; Ruffman, 2014; Udell et al., 2011): Wellman (2005) criticised the conclusions by Onishi and Baillargeon reasoning that the subject, in our case the dog, might not have expectations about the experimenter's action at all during the experiment. In other words, the subject may not understand that the experimenter was holding a false belief but solely that the experimenter was unaware of the location of the object: *"If the infant looks longer at event A than event B, we can infer they did not expect A. We cannot infer that, in contrast, he did expect B; the infant might have no expectation about B, but still look longer at A because he did not expect that. We have no evidence as to the infant's expectation about B".* We suggest that if the subject does not have expectations about B, it should not have expectations about A neither. If the subject would think that the experimenter was unaware of the object's location, it should not enhance it´s attention when the experimenter goes to the right location because it is not surprising that he could search in the right box just by chance. Evidences in favor of this argumentation came from Scott and Baillargeon (2009): they conducted an experiment identical to their false-belief experiment except that the agents were ignorant as opposed to mistaken. The infants looked about equally long when the agent reached for either location. These results indicate that the infants in the false-belief experiment did not merely expect the agent to look for the object in the incorrect location and were not surprised when the agent reached in the correct location. In our experiment we did not find differences when comparing the controls (conditions 1 and 3). It has been discussed above that dogs may understand agent´s motivations and form expectations about where the agent will look in condition 1. We didn´t find attention differences between condition 1 and 3, these results could be interpret as dogs not giving different states of knowledge to the agent.

Further alternative explanations to FBU in infants came from Ruffman and Perner (2005). They proposed a "3-way-association" mechanism: they claimed that during the pretrials, an actor-object-

location was created and if an association of elements (e.g. "actor-object-yellow box") would be still sustained while the infants were exposed to the test stimuli, a consistent test combination would require less processing and, consequently, a shorter looking time than a new combination of elements (e.g. "actor-object-green box"). In the latter case, the infants might show longer looking times when they examined the new combination, because they must form a new association. Perner and Ruffmann based this hypothesis on a neurophysiological study by Wann et al. (1999). However, Csibra and Southgate (2006) argued that in this study indeed hippocampal regions in rats were activated differently by novel versus familiar arrangements of pictures, however no conclusions could be drawn about the formation of associations when observing actual actions. They argued that although these associations could be formed in some cases, it was unconvincing to present them in that context. Luo and Baillargeon (2007) and Luo and Johnson (2009) went further and experimentally demonstrated that the "3 way association" was not the cause of the VoE. In their experiments, infants looked longer after observing that an agent had been repeatedly grasping object-A and after that, the agent grasped object-B. This VoE did happen when the object was visible and accessible during the whole experiment. If the object B was only present at the end of the experiment, infants did not enhance their attention when the experimenter grasped object B. This result stands against the hypothesis by Ruffman and Perner and indicates that infants did not merely form associations but considered the motivational states behind the agent´s actions (Baillargeon et al., 2010). The same should be true for our experiment; the "3 way association" cannot explain the differences found between our experiment conditions.

Ruffman and Perner (2005) and Ruffman (2014) further claimed that the attention enhancement could also be based on "behaviour rules". In their minimalism interpretation: *"Infants may have noticed (or are innately predisposed to assume) that people look for an object where they last saw it and not necessarily where the object actually is*" and argued that infants might have reflected on behaviour rather than mental states. They also claimed that it could be possible that infants simply represented the agent's ensuing behaviour having seen the object at a certain location. In response

to these critics, Marticorena et al. (2011) and Martin and Santos (2014) showed that rhesus monkeys only looked longer at events that violated their own beliefs and did not seem to differentiate between events in which another agent's belief was violated or confirmed. These results suggest that the infants' performance in Onishi and Baillargeon study might reflect more sophisticated representational abilities than some questioning researchers had originally proposed. After evidence from previous experiments in monkeys suggested that they have all the alternative representational capacities that these researchers claimed to explain for the positive results in Onishi and Baillargeon´s study.

Their findings hint that infants' successful performance in this task can not only result from the kind of mind-reading abilities observed in primates (Marticorena et al., 2011) but that a more complex mental ability is needed. In our opinion, whether infants and dogs are building this behavioural rule is only relevant to some extent, as if so, they would still need to understand the others motivations (experimenter wants the keys), intentions (experimenter is searching for the keys) and knowledge (experimenter was not present during the relocation of the object), basics capacities for having a theory of mind.

The positive results of our study are also in contradiction with the proposed factors required to develop a ToM by Ruffman (2014). In his review Ruffman presented 5 keystones for children's learning about mental states. Among others, language is reckoned a key component to achieve theory of mind. Our results suggest that dogs possess elements of ToM and therefore strengthens the idea of alternative ways than language to gain ToM.

It should be noted that a number of factors might influence the performance of dogs in a violation of expectation task, for instance stress, wariness, etc.…We could not find looking time differences in male and aged dogs when presented expected versus unexpected stimuli. We assume that this result can be explained by the generally higher attentiveness of these two groups to distractors (attention enhancement in the expected conditions). However, we cannot rule out the possibility that the expectations of male and aged dogs were not violated in response to the unexpected stimuli. Sex

differences were found in a size constancy study (Müller et al., 2011) where it was detected that female dogs responded to a size constancy violation, while male dogs did not. Mongillo et al. (2011) found that aged dogs showed longer orientation time towards a stranger than younger dogs did. They suggested that a decreased capacity in aged dogs to discriminate socially relevant elements might apply. Further, it was discovered in a visual search task with distracters that older dogs showed significant impairment in accuracy and reaction time (Snigdha et al., 2012). Other studies have indeed shown that senior dogs have a reduced capacity to inhibit distracting stimuli (Tapp et al., 2003). Moreover, Wallis et al. 2014 have investigated whether there are differences regarding age in dogs concerning their selectiveness of attention and sensorimotor abilities in a switching task. The latency to establish eye contact with the experimenter was significantly higher in older dogs, compared to adolescent dogs.

5. Conclusion

Our experiments show that dogs are able to recognize that an experimenter can hold a false belief about an object's location when it was hidden in the experimenter's absence, and therefore suggest that dogs hold elements of a ToM. We are confident that our results can clarify to some extent the question whether non-human species can posses a ToM. The dog, due to its convergent evolution and close relationship with humans, is the ideal experimental subject to use in an interspecific FBU test, in contrast to other animals, which have not been previously accustomed to humans. The convergent aspects between dogs and humans offer a theoretical framework that can help us find answers to how the evolution of important human cognitive processes happened. Still, many questions remain to be investigated. For instance, the development of false-belief understanding in dogs and other species.

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