The command hypothesis versus the information hypothesis: How do domestic dogs (*Canis familiaris*) comprehend the human pointing gesture?

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1. General Introduction

1.1 Social Living

Living creatures have to deal both with their social and their physical environment in order to survive. The extent to which they are exposed to these two factors can differ to a high degree. For simple organisms, such as free-living amoeba (e.g. genera Amoeba, Acanthamoeba and Neagleria), the physical environment plays a much more important role in their lives than the social environment since most forms of amoeba reproduce asexually (Page 1976). Animals with more complex social lives, like many monkeys and apes, are more exposed to multifaceted situations in which the social environment defines their lives to a high degree. The environment, whether physical or social, underlies changes of various kinds and individuals benefit when they are flexible in their behaviour and adjust appropriately to new environmental conditions. Individuals within social groups, for example, have an advantage when they are able to keep track of the social structure in the group. Conditions such as hierarchical structures might change often and/or drastically and it can be very important for the well-being of an animal to adjust to the new conditions, presupposing that it can detect these changes in the first place.

Dealing with social information cognitively involves creating a *social space*, which is a continually moving and changing system (Csanyi 2005). Not only detecting changes but also handling those changes is another and more advanced step in terms of cognitive flexibility. Social manipulation including, for instance, deception, appeasement and collaboration is a beneficial skill for a social animal. Additionally, it would be advantageous to be able to attribute mental or psychological states to other living beings. Understanding other individuals as agents with intentions, plans, goals, objectives and the ability to make decisions is one prerequisite of having a *theory of mind* (Tomasello et al. 2005). The so-called social intelligence hypothesis (or social theory of intellect or Machiavellian Intelligence hypothesis) is based on the assumption that the social world differs from the physical world in that it is generally more demanding and therefore the intellectual capacities adapted to social life may have special and even particularly sophisticated attributes (Byrne and Whiten 1988). It proposes that the environment in primate social systems leads to the high level of general intelligence that monkeys and apes seem to reveal in several experimental studies. But a group consisting of many animals does not necessarily lead to a high complexity. A large anonymous aggregation may be socially simple. It is more the behavioural repertoire and its refinement of the group members that defines complexity (Byrne 1996). Therefore group size itself is only an indirect estimate of the potential social complexity an individual will encounter. One crucial way to obtain information about social systems in the group is through communication. Communication is a complex field in biology and many definitions have emerged in the past decades of research in the field of animal communication (Shettleworth 1998). Following Shettleworth, in the animal's world communication is defined as being in place when one *sender* influences a *recipient*'s behaviour through the transmission of a *signal.* In the special case of humans, of course, this signal can include the use of language, a communicative ability that makes human communication seemingly unique.

1.2 Human uniqueness

For humans there are many ways to communicate, including, but not limited to, the use of verbal communication through language. There are, for example, several ways of pointing. Humans often use index-finger pointing to communicate with one another. Pointing is a conventional deictic gesture which humans use in order to gain the attention of another person so that a particular entity in the environment becomes the focus of shared attention (Butterworth 2003; Couillard and Woodward 1999). Index-finger pointing as Butterworth (2003) describes it is performed with an extended arm and index finger in the direction of a target (object or direction). The remaining fingers are curled under the hand and the thumb is held down and to the side. The pointing gesture is an intentional, referential and *informative* act, and it is understood in this way from very early on in children's ontogeny (Behne et al. 2005; Butterworth and Grover 1990). It has been shown that human children also differentiate the contextual background of a communicative situation when adults point for them from very early in development. In other words, depending on previous context, a single point can mean different things. Liebal et al. (2009) have shown that 18-month old children do differentiate between two adults pointing to a certain object for them depending on the context established with them in a situation beforehand. In their study, Liebal et al. investigated whether 14-month-olds and 18-month-olds would use shared experience with an adult to determine the meaning of a pointing gesture. In one experiment an adult was playing a puzzle game with the infant. The puzzle consisted of five pieces which had to be placed into a wooden board. Another adult played a clean-up game together with the infant in which they put various items that were laying around on the ground into a close-by box. Depending on which adult pointed at one missing piece later in the experimental trial, the 18-month-olds finished either the clean-up game or the puzzle game together with the adult, based on their shared experience and therefore the context of the previous situation. This shows that context of a certain communicative situation is taken into account when interpreting an adult's given pointing gesture.

Humans deliberately and cooperatively use the pointing gesture from around 14 months of age on to inform others about entities in their environment (Leung and Rheingold 1981) and they do so even in situation that are not beneficial for themselves (Bullinger et al. 2011; Liszkowski et al. 2008). By looking at our closest living relatives, the great ape species, we see a different picture. Comparative studies with great apes have shown that chimpanzees for instance do not show this extraordinary motivation to communicate and share intentions in "cooperative communicative interactions" (Hare 2007; Herrmann et al. 2007; Moll and Tomasello 2007a; Tomasello et al. 2005).

Hermann et al. (2007) tested human children and apes in a large battery of tests including tasks in physical and social cognition. The physical cognitive part consisted of tests of spatial memory (e.g. searching for a hidden reward on a table), numerical competence (e.g. choosing between a smaller and a larger quantity) and tool use (e.g. using a stick to fish for a reward). The social cognitive part included following communicative cues to hidden rewards (using gaze cues, pointing gestures) or imitating simple tasks (e.g. shaking a reward out of a tube). Results showed that the 2.5 year-olds and the apes performed similarly on average in the physical cognitive tasks, but that children outperformed the apes in the social cognitive domain.

In the social cognitive domain, the motivation to share information with each other is seen as essential to the uniqueness of human social cognition (Tomasello et al. 2005). In this respect, it is of high importance to investigate different animal species to gain some knowledge about their social cognitive capacities to compare those to the seemingly unique skills of humans. If other animals also communicate *informatively* and helpfully, this challenges the hypothesis that these forms of communication are uniquely human.

1.4 Dogs' domestication

For some decades now, cognitive research on dogs (*Canis familiaris*) has focused on the mechanisms underlying dog-human communication. Dogs were the first animals to be domesticated by humans (Hemmer 1990) and have been confirmed as the species most closely related to the grey wolf by several studies (Leonard et al. 2002; Savolainen et al. 2002; Tsuda et al. 1997; Vilà et al. 1999; Vilà et al. 1997). Domestic dogs and humans are considered to have shared their lives for a long time. Studies of morphological relics from archaeological excavations date the first instances of the domestication of dogs to at least around 10,000 years B.P. (e.g.Vilà et al. 1997). Over this relative long time span, a number of selective processes have taken place. There are a several (non-exclusive) hypotheses of how the domestication process could have been initiated (Miklosi 2007). The transition from wolf to "prototypic" wolf-dog to domestic dog was long and probably dependent on different selective pressures and other related factors (see below).

One hypothesis is that humans regularly picked wolf pups from their dens, adopted them, fed them, trained and tamed them. Individuals showing the 'right' temperament and/or affiliative tendencies were furthermore selected for over many generations (e.g.Clutton-Brock 1984; Lorenz 1950). However, it is known that it is not at all easy to tame and train wolves. This is supported by many studies (e.g.Frank and Frank 1983; Klinghammer and Goodmann 1987). Therefore it seems unlikely that ancient humans could have repeatedly felt inclined to take wild living wolf pups from the den and tame them at home. It is more likely that such an individual-based selection occurred at the end of the domestication process when wolves had already been tamed and different breeds were selected for (Miklosi 2007).

A second theory involving a population-based selection includes two possible processes casting modern dogs as the descendants of a scavenging canid population. When early humans started organizing their lives in continuous settlements, they provided a novel food source to scavenger canids in the form of their garbage, which they left close to their 'villages'. This food source and, eventually, left-overs from humans hunting events may have been explored by (some) wolf population(s) that, in parallel, underwent morphological, physiological and behaviourally changes (Crockford 2006), and, finally, isolated themselves from the rest of the 'wild' population and "domesticated themselves" (Coppinger and Coppinger 2001). The other scavenger scenario states that an already existing population of wolf-like canids led a scavenger lifestyle and first associated itself with human communities, then explored food provided by human activities. As the production of food waste by human groups grew, the animals became ever more dependent and an exclusive relationship evolved (Koler-Matznick 2002). Both these hypotheses are problematic. The first version of the scavenger hypothesis fails to explain why domestication started only at one location (e.g. Pang et al. 2009) and there is in general little factual evidence for the second version (Miklosi 2007).

A third theory is based on the assumption that dogs and humans passed through a co-evolutionary process. Co-evolution is defined as a reciprocal selection process in which one species is partially dependent of the evolution of another species (Schleidt and Shalter 2003). According to this hypothesis, both dogs and humans have changed in functional (adaptive) ways because of their evolutionary relationship. Schleidt (1999) argues for a pronounced mutual biological and cultural transformative influence which humans and dogs had on one another in ancient times. His assumption is that it was the pastoralist herding pattern and the highly developed packing behaviour of wolves which was exploited and adopted by humans. He argues that this take-over would have advanced human survival strategies in those early times. Human groups building their culture on their relationship with dogs could also have experienced some advantage if dogs contributed to increased fitness of humans. Observing wolves might have aided in the development of hunting or establishing settlements (Schleidt and Shalter 2003; Sharp 1978) and human groups could also have shown variability in tolerating wolves or dogs around them. Again, little factual support is available for this theory (Miklosi 2007). Paxton (2000) suggests that dogs may have helped humans orientation in the environment (because of their superior smelling ability) and this would have allowed for selective changes in human facial (nasal and oral) structures for more skilled production of speech sounds (for critique see Bekoff 2000).

A fourth theory is based on cultural-technological evolution. The assumption here is that the diversification of dogs ran in parallel with cultural-technological evolution and that at the beginning of the domestication process dogs had a restricted role as work aids and even served as food source in some regions (Morey 2006; Morey 2010). Later on, humans could have developed a ritual relationship with dogs over time – a suggestion supported by findings of dog burials worldwide (Morey 2010). More precise diversification then occurred when humans found ways to use dogs for different tasks including herding, guarding, pulling sledges (Morey and Aaris-Sorensen 2002) or, more recently, guiding blind people and as rescue dogs (Fox 1978; Miklosi 2007). In other words, within this theory, the evolution of human culture set the demands and requirements for selective processes of the domestic dog.

Clearly, the domestication of dogs has invited much speculation, as can be seen by the lack of factual evidence for most of the above theories. As a consequence, we currently do not know which of the above theories (if any) resembles what actually happened in the past. What is certain is that dogs and humans spent a long time span together. Living closely with humans for such an amount of time means that dogs share their history with humans. This makes it likely that some special adaptations have occurred in dogs as a result, adapting to the human environment due to intentional or unintentional selection by humans. In addition to morphological and behavioural changes it can be relatively safely assumed that dogs' cognitive abilities have also changed during this timeframe, with the human environment has placing different demands on dogs during the domestication process (Hare and Tomasello 2005). In other words, the new human environment placed new selection pressures on dogs over extended time periods and this should be detectable in them today.

Thus, wolves and dogs should be different. Indeed, in addition to clear morphological changes, dogs have undergone a tremendous transformation in the direction of enhanced docility and affectionate dependency as well as many other behavioural changes (Fox 1978). It is argued that domestication has mostly influenced the quantitative responses to stimuli rather than the qualitative behaviour in dogs. Yet, it seems not to be the case that dog behaviour in general changed in contrast to wolves, but that response thresholds to stimuli were either heightened or lowered (Price et al. 1998). Frank and Frank (1982) also argued, however, that in the transformation from *lupus* to *familiaris*, wolves lost many of the well-defined agonistic rituals that ordinarily promote close and cooperative social interaction. They note that some complex behaviour in wolves has been fragmented over time in dogs (Frank and Frank 1982). Domestication has changed traits in behaviour, morphology, phylogeny and cognition in wolves (Clutton-Brock 1995; Mech and Boitani 2003). These changes happened in favour of tameness, trainability and building interspecific cooperative alliances with other species, especially humans.

1.3 Dogs and humans

In daily interactions with dogs, humans often communicate with them (Miklosi 2007). Assuming that the ability to work with humans was an important factor at some point in dog evolution, it must have always been advantageous for dogs to be able to read human cues. Indeed, studies show that dogs are very skilful in using various forms of human communication (e.g. Hare et al. 1998; Miklósi et al. 1998; Soproni et al. 2001).

There are many ways for a human to communicate with a dog since some communicative channels are similar in both species and so communication can be established via the auditory or the visual modes. The most widely investigated human-given communicative act, in the so-called object choice paradigm, is the pointing gesture (for a review see Miklósi and Soproni 2006). Anderson et al. (1995) introduced this (generally very simple) method to investigate the utilization of human-given communicative cues in animals. In the basic experimental setup of the object choice paradigm, a human experimenter hides a reward (e.g., some food or a toy) in one of several identical cups that are beyond the dog's view. After the reward is hidden, the experimenter provides the dog with a cue e.g., by pointing (and/or gazing) towards one – usually the correct - cup. The dog is then free to choose between the cups. In the event that the dog chooses the correct cup it receives the reward. In cases where the dog chooses the empty cup, it is shown the correct cup without receiving a reward. Statistics across trials and/or dogs will then be able to determine whether dogs were able to utilise the human given cues.

As stated above, dogs show great flexibility when interpreting and using human-given communicative signals (Agnetta et al. 2000; Hare et al. 1998; Miklósi et al. 1998). Hare and Tomasello (2005) have introduced a hypothesis based on the assumption that domestication was the driving factor in the emergence of dog's social cognitive skills. This so-called "domestication hypothesis" is supported by several findings. First, dogs have been shown to be more skilful in reading human communicative cues than their closest wild relatives and progenitors, the wolves (Hare et al. 2002; Kubinyi et al. 2007; Miklósi et al. 2003). This is also true where both species are raised under identical conditions (in a human household) and then tested at the same age (Miklósi et al. 2003; Virányi et al. 2008). Additionally, dogs do not seem to learn this ability during their individual ontogeny. By six weeks of age, dog puppies are already able to follow a human's pointing gesture, even if that means them moving away from the human's hand and this ability shows little variation over a dog's first year of life (Gácsi et al. 2009b; Hare et al. 2002; Riedel et al. 2008; Virányi et al. 2008). In a series of studies, Riedel et al. (2008) tested young dog puppies' ability to use social cues (two different types of pointing) and a physical (marker) cue in an object choice task. The sixty-four participating dogs were divided into different age groups (6-, 8-, 16- and 24-week old pups). All puppies had been raised by their mothers until 8 and 9 weeks of age. Results showed that even 6-week old puppies were able to follow all social cues significantly above chance level in each condition (except the control condition) and there was no improvement up to the 24-months old puppies. In a second experiment, Riedel et al. ruled out the possibility that the dogs' performance might have been guided by local enhancement cues. The authors conclude from their results that dogs' ability to follow human communication is present before humans have a major ontogenetically influence on their behaviour. Furthermore, in the object-choice task, dogs follow the human given cues even from trial one onwards (Hare and Tomasello 1999; Riedel et al. 2006; Soproni et al. 2001).

Dogs have been shown to use a variety of human communicative cues other than common index-finger pointing. For example, they are able to follow a human's gaze, body posture, touching or marking of the correct cup, as well as various forms of pointing cues (cross-pointing, proximal pointing, distal pointing etc.[1]; for a review see Miklósi and Soproni 2006). Yet, there are also studies that have shown that dogs find it difficult to follow highly sophisticated, unfamiliar cues when trying to find the location of hidden food (e.g. Lakatos et al. 2007; Lakatos et al. 2009). In general, however, dogs show high flexibility in using a vast range of cues and are able to solve these tasks regardless of breed (e.g. Dorey et al. 2009; Gácsi et al. 2009a; Hare et al. 2002). Gácsi et al (2009a) found that neither the conditions in which the dogs are kept, nor the time spent interacting with the owner, nor even special (agility) training at using human visual cues, had significant effects on the performance of the dogs. Crucially, it seems that the social component of the gesture is a relevant part of the cue since dogs do not follow pointing gestures communicated, for example, through the use of a stick (Soproni et al. 2002), by a baby doll pointing its arm or a by a mechanical arm (Udell et al. 2008b). Importantly, dogs are able to remember the location of hidden objects for up to four minutes (Fiset et al. 2003). Therefore poor performance in these tasks is most likely not

[1] cross pointing = contralateral hand executes pointing gesture; proximal pointing = the experimenter is standing at equal distance from both targets but the tip of pointing finger is within 10 cm of the target; distal pointing = the experimenter is standing at equal distance from both targets but the tip of pointing finger is at least 50 cm from the target (see Miklósi and Soproni 2006).

due to lack of memory. Crucially, several studies have ruled out lower-level explanations (e.g. using only familiar cues, simple response to movement, reflex-like co-orienting) for dogs' behaviour in these settings (e.g.Agnetta et al. 2000; Hare et al. 1998; Soproni et al. 2001).

Finally, dogs also outcompete humans' closest living relatives - the chimpanzees (Bräuer et al. 2006; Hare and Tomasello 2005) - when it comes to utilising human communicative gestures. Yet dogs are not the only species capable of following human pointing. Studies investigating the communicative skills of domesticated animals other than dogs have shown that a variety of species, including goats (Kaminski et al. 2005), horses (Maros et al. 2008; McKinley and Sambrook 2000) and cats (Miklósi et al. 2005) are also capable of following a human's pointing gesture. Apart from humans themselves, however, no other species has been shown to use human pointing in the same flexible way as dogs do.

There are also some studies showing that extensive training and exposure to humans from an early age can enhance the ability to follow a human's pointing gesture, even in non-domesticated animals like wolves (Virányi et al. 2008) chimpanzees (Povinelli et al. 1997) seals (Scheumann and Call 2004; Shapiro et al. 2003) and dolphins (Pack and Herman 2004). While at first seemingly problematic for the domestication hypothesis, these results do not directly contradict it.

Another possibility that might explain the observed patterns and supports the domestication hypothesis, was put forward by Miklósi et al. (2003). Miklosi et al. assume that domestication merely led to a relatively small initial difference between wolves and dogs with cascading effects further on. The proposed difference may lie in dogs' increased motivation to look at humans. The authors found that the high tendency to look at humans in a communicative situation seems to be a genetic predisposition in dogs, as it is difficult to induce this behaviour at all in young wolves - even after intense socialization. Consequently, these differences alone could lead to different performances in socio-cognitive tasks (Gácsi et al. 2009c). Support for this hypothesis comes from experiments which have shown that dogs are very sensitive to humans' attentional states. Call et al. (2003) conducted a study in which an experimenter forbade dogs to take a piece of food that she laid on the ground after showing it to the dog. The experimenter then engaged in four different conditions: (1) she sat quietly on a chair in one corner of the room facing the dog, (2) she sat down with the same posture as before but was distracted by playing a computer game, (3) she sat down and closed her eyes, or (4) she sat down with her back to the dog. The results showed that dogs took the food significantly more often when the experimenter's eyes were closed, when she was distracted or when she had her back to the dog compared to the condition in which she was facing the dog with her eyes open. Another experiment has shown that dogs would always take the food when the experimenter left the room (Call et al. 2003).

Viranyi et al. (2004) showed that the same sensitivity to the eyes of a human applies for dogs in a non-competitive situation. The researchers tested the dogs' responsiveness to their owner's tape-recorded verbal commands ("Down!") while the owner's attention varied. The owner was either facing the dog or a human partner or none of them, or was visually separated from the dog. Dogs were more ready to follow the command if the owner attended them during instruction compared to situations when the owner faced the human partner or was out of sight of the dog. In addition, Viranyi et al. (2004) showed that dogs would preferentially beg for food from a person who was oriented towards them compared to a person who was oriented away. These studies investigating dogs' attention to the human face support the hypothesis that dogs are, in general, very skillful in and well prepared for reading human communicative cues.

However, others disagree with the hypothesis that domestication is the main factor resulting in dogs special skills and suggest that dogs' behaviour might yet be explained by lower-level mechanisms like associative learning (Bentosela et al. 2008; Dorey et al. 2010; Elgier et al. 2009b; for a recent debate on that topic see: Hare et al. 2010; Udell and Wynne 2008; Udell et al. 2008a; Wynne et al. 2008). This account will be discussed partly in each study of this thesis.

Further studies will need to be conducted in order to investigate the differences in dogs' and wolves' abilities and to test whether domestication is responsible for the emergence of these differences. It might also be useful to study other domesticated animals in comparison with their wild progenitors (pigs and wild boars for example) to provide a comparative reference.

1.5 Hypotheses

This thesis aims to investigate the question of *how* dogs comprehend the human-given pointing gesture. In particular, it is currently still unclear whether dogs' understanding in this respect is comparable to how humans understand such gestures. Given the evidence mentioned above, dogs show some sophisticated abilities which are not simply explained by lower-level mechanisms. Instead, results indicate that higher-level mechanisms are at work.

In the following, I will present two main hypotheses that could explain how dogs do understand the human given pointing gesture. The first hypothesis is the "information hypothesis". This hypothesis claims that dogs comprehend the pointing gesture as a human's means to share information about entities in the environment with them. The second hypothesis is the "command hypothesis", which assumes that dogs understand the pointing gesture as command ordering them where to go. In the following, I will argue for each hypothesis what evidence exists favoring its assumptions and what contradicts them, respectively.

I will begin with the information hypothesis. As one precondition to understand the pointing gesture informatively, dogs need to be able to recognize another's attentional state. Studies have shown that dogs are indeed able to do so (Call et al. 2003; Schwab and Huber 2006; Virányi et al. 2004). In humans, there is evidence that from 12 months on, children are able to follow an adult's gaze when the latter's eyes are open compared to situations in which the adult's eyes are closed or when she is wearing a blindfold (Brooks and Meltzoff 2002). Additionally, infants point significantly more for an adult when she is attentive to them in contrast to situations when the adult is looking away. Taken together, these studies show that both dogs and human children are able to recognize the attentional state of a cue-giver.

Studies also show that dogs are sensitive to a human's perspective, which builds upon the capacity to follow another's gaze cue (Bräuer et al. 2004; Kaminski et al. 2009). Kaminski et al. (2009) tested dogs in a setting in which they were required to fetch a toy and additionally keep track of the of the experimenter's visual perspective. In this task, a human sat on a chair in one end of a testing room. The dog was held by another human on the opposite side of the room facing the experimenter. In the middle of the room and between the dog and the human there were two barriers; one opaque, the other transparent. Two toys were placed behind the barriers from the experimenter's perspective. Due to the characteristic of the barriers, the human could only see one of the two toys, namely the one lying behind the transparent barrier. In contrast to the human's perspective, dogs had visual access to both toys. When the experimenter asked the dog to fetch one of these toys with the instruction "Bring!" (German equivalent for "Fetch!") dogs more often brought the toy behind the transparent barrier compared to the toy lying behind the opaque barrier. This suggests that they understood something about the experimenter's perspective. Children by 12 months of age in a similar setting were able to distinguish between situations where an adult had visual access to only one of two toys compared to a situation in which she could see both toys. They considered an adult's reaching gesture as being goal-directed in a situation when both toys were visible compared to the situation when only one object was in the adult's perspective (Luo and Baillargeon 2007). However, perspective taking abilities per se are not sufficient to succeed in point following task since it was also found that other species show perspective taking abilities without being able to succeed in cooperative communicative paradigms (macaques: Flombaum and Santos 2005; chimpanzees: Hare et al. 2000). Of more importance than simply following the gaze cue of another individual is to do so precisely. Soproni et al. (2001) found that dogs did not follow a human's gaze direction to an empty location above a target object. Dogs used only gaze cues which were precisely given to a referent in place. Their performance was comparable to children tested in a similar study that compared young human children and chimpanzees in the same set-up (Povinelli et al. 1999). Chimpanzees, in contrast to dogs and children, did not distinguish between gaze cues above and precisely at the target which suggests that they do not consider the referent as being important for this communcative situation. This indicates that children and dogs, but not chimpanzees are sensitive to a human's gaze cue directed to a specific target.

Together these results suggest that dogs are sensitive to a human's attentional state as well as perspective and are able to distinguish relevent from irrelevant gaze cues. However, dogs fail to succeed in other tasks that are important to comprehend a human pointing gesture as being informative and helpful. Another more sophisticated prerequisite to understand communicative cues as informative is to understand something about the signaller's knowledge state. Studies suggest that dogs are not able to distinguish between a knowledgeable and an ignorant human. Viranyi et al. (2006) tested dogs in a so called "ignorant helper" paradigm. In this task, for dogs to play with a certain object they needed to inform the human about the location of a tool and to provide these cues depending on the knowledge state of the human. Dogs failed to succeed in this task while 2.5 year-old infants successfully signalled to the experimenter depending on her knowledge state. However, another study had contradictive findings and showed that in a so-called "guesser-knower" paradigm, dogs were able to follow cues from a "knower" dog that had seen the food reward being hidden more than cues from a "guesser" dog which had not witnessed the hiding process. This is in contrast to Viranyi et al. (2006) suggesting that dogs might be able to differentiate between knowledgeable and ignorant individuals (see also Cooper et al. 2003). Another condition in Kaminski et al's (2009) barrier study tested dogs in the same setting as described previously except that here two opaque barriers were used resulting in the human having no visual access to any of the toys. In contrast, dogs again had visual access to both of the toys. In the experimental trials, the experimenter watched the placement of one of the toys while having not witnessed the other toy's placement. Therefore when being asked to bring one toy they could only mean the one which they were knowledgeable of. Dogs in this setting brought both toys equally often, thus were not able to take into account the experimenter's past visual access. It has been shown that, before reaching their second year of life, human infants are able to consider the knowledge state of an adult (Liebal and Tomasello 2009; Moll and Tomasello 2007b; Onishi and Baillargeon 2005). Other studies with human infants have shown that, from 12 months on, they are able to helpfully signal when adults search for relevant information (e.g. Liszkowski et al. 2006). In Liszkowski et al.'s (2006) task children had to discriminate between two objects; one because the adult needed it for a certain activity and the other that served as a distracter object that the adult only handled and looked at. When the experimenter left the room, another adult entered and hid both objects in two different locations. The experimenter re-entered and searched for the object she needed to continue her previous activity. Results showed that the children indicated the location of the target object significantly more often than the location of the distracter object. This suggests that infants are able to understand the relevant information intended by a signal (see also Liszkowski et al. 2008). A comparable study conducted with dogs has shown that, in a similar situation, dogs were not able to indicate helpfully the location of a relevant object (Kaminski et al. in press). These results indicate that infants, but not dogs are able to helpfully provide information to others. Whether dogs' failure to do so is due to a lack of cognitive capacity or a lack of motivation would be a useful aim for further investigations.

Another important factor essential to understanding communicative cues as being informative is to perceive the signaller's intentions. This ability allows a receiver to comprehend that a signal is given with the intention to inform cooperatively. In a study by (Kaminski et al. submitted), dogs have been shown to be able to differentiate between intentional and unintentional cues of a human experimenter. Here, a human in an object-choice task was providing cues either by intentionally pointing to a baited cup in contrast to trials in which she performed a similar arm movement but while looking at a watch on her wrist. Dogs only followed the intentional cues and not the unintentional ones. In the same paradigm, 14-month old children showed the same performance (Behne et al. 2005), which suggests that both dogs and children are able to discriminate intentional from unintentional communicative acts. When an experimenter instead used a physical marker to either intentionally or accidentally mark the baited container, dogs followed in both conditions suggesting a physical marker is a salient cue regardless of the intention of the human to provide the cue (Riedel et al. 2006). Another question is whether dogs are able to discriminate between rational and irrational actions of a human. Kaminski et al. (2011) have shown that dogs were not able to differentiate the following situations: a human acted rationally and was indicating the location of a hidden reward by using her leg because her hands were occupied by holding a pile of books; the human did the same pointing action with her hands unoccupied, but held in the same position as if she was holding the pile of books. In contrast to dogs, children show the ability to imitate (and therefore differentiate) rational but not irrational actions of an adult (e.g. Gergely et al. 2002). The evidence as to whether dogs view a signaller as an intentional agent is contradictive and requires further investigation.

Another prerequisite for an informative understanding of the pointing gesture is to use any cue that is meant as helpful, even in situations when a recipient other than oneself is the intended one. If this cue is understood as command, however, an individual should be more inclined to use only signals directed at him. Kaminski et al. (submitted) tested dogs in a task in which an experimenter provided cues for another human experimenter, a so called 3rd party individual. Dogs did not use that information, which was in contrast to 14-month-old children who “eavesdropped” these cues that were not directed at them (Gräfenhain et al. 2009). For dogs, it seems that the informational value of the cue is not as useful as it is for children. This favours the idea that dogs understand the pointing gesture as instructive cue ordering them where to go rather than an informative one.

There is other evidence, however, that dogs do comprehend the pointing gesture as an instruction telling them where to go, which leads to the second hypothesis, the command hypothesis. As mentioned above, this hypothesis states that dogs do understand the pointing gesture of a human as an imperative command – i.e. one which they *have* to follow. With use of the term “command” I do not refer to a discriminative stimulus which dogs have learned during their individual ontogeny. I rather refer to a combination of stimuli (pointing + gaze + attention + addressing the dog) of the human, which might contain an instructive or directive message for the dogs.

One study, which has given some indication that dogs understand the pointing gesture as a command, is that of Szetei et al. (2003). Here the investigations were largely focused on addressing an altogether different issue to do with dogs’ comprehension of the pointing gesture. The authors wanted to find out what influence the competing role of human gesture cues (i.e. pointing) versus object-related cues (visual and/or olfactory) would have on dogs’ behaviour in an object-choice task. The results showed that when there was no experimenter providing them with cues, the dogs could efficiently use both visual and olfactory cues to locate the hidden reward. The food treats which have been used in this study was made of strong smelling food. However, when this food-related information (i.e. smelling the hidden food or witnessing the food being hidden) was contradicted by an experimenter pointing to the empty cup, the dogs’ performance in the task worsened, as they tended to follow the experimenter’s erroneous pointing gesture. This could be due to dogs understanding the gesture as an instruction of the human that tells them where to go and which cup to choose.

Another study also found results favoring the command hypothesis. Elgier et al. (2009a) tested dogs in an object choice task using two different experiments. The first experiment investigated the effect of extinction of point-following behaviour. Results showed that dogs ceased their point following behaviour when that response no longer allowed them to obtain the reinforcer. Importantly, the authors addressed the question of whether dogs would differentiate between their owners and an unfamiliar experimenter in these tasks. Results showed that dogs receiving the cue from their owner required significantly more trials to extinguish the response compared to receiving the cue from the unfamiliar experimenter. This result speaks for an imperative understanding of the pointing gesture since dogs were more inclined to follow the gesture of their owner who is presumably more relevant when it comes to obedient behaviour. However, there are also contradictory findings. Miklosi et al. (1998) tested dogs in an object choice task with their owner and a familiar experimenter. Dogs did not differentiate in their point following behaviour in this set-up. They followed the gesture of both owner and experimenter to the same extent.

In humans, children have been shown to follow cues from an experimenter even when those cues conflict with the dog’s own perceptual knowledge (Ma and Ganea 2010). Thus, it is likely that children are also influenced to some degree by the authoritative nature of an adult cue-giver.

Overall, in the case of dogs there is evidence for and against both the command hypothesis and the information hypothesis. The objective of this thesis is to investigate in more detail how dogs comprehend human forms of communication, specifically the pointing gesture.

1.6. Aim of the thesis

My first study addressed the question of whether dogs would note the context of a communicative situation with a human or whether they would follow the pointing gesture 'blindly' in any situation. Here, a human always pointed to an empty spot on the ground. Dogs were divided into two groups. One group found food on the floor prior to each experimental trial. This was the context group. The other group found no food prior to the experimental trials and was therefore the no-context group. The hypothesis was that if dogs could pay attention to the context of a communicative situation, their behaviour would differ between groups. This would support the idea that dogs' ability to use human forms of communication is explained rather by higher-level mechanisms than by lower level mechanisms such as pure association (e.g. between the human's hand and a reward).

My second study tests both the command hypothesis and the information hypothesis. It includes two (related) experiments. In the first experiment of study 2 dogs were tested in a standard object choice paradigm in which food was hidden in one of two possible locations. Two factors were systematically varied. The first was the dogs' knowledge of where the food was hidden and the second one was the presence of the authority (the human) during their choice. The human always pointed to the incorrect location; that is, to the empty cup. In some conditions the dogs had previous knowledge that the pointed-to cup was empty and in some conditions they did not. If dogs interpret the pointing gesture as a command ordering them where to go, they should follow the gesture irrespective of their own (and sometimes conflicting) knowledge. Even if dogs perceive pointing as an informative gesture, they may still rely on their own knowledge and, based on this, may sometimes ignore the point of the human. I also varied whether the human (and therefore the authority) was present while the dog made its choice. In the case where the authority was present, the dogs' motivation to follow the command should be enhanced, as has been shown in other studies (Call et al. 2003). This would support the command hypothesis. In the second experiment of study 1 it was investigated whether dogs would behave differently in the same setting as in experiment 1 when they did not have direct visual access to the baiting process of the experimenter.

The second study tested the command and the information hypotheses. It investigated dogs in an object choice task where a human pointed to a hidden toy. Before the experimental trials started dogs were divided into four groups and each group was introduced to a human who had a different attitudes. Either the human was very strict and authoritative towards the dogs or she was the opposite (i.e. loose with her commands and not authoritative); or she was a reliable person who provided the dogs with honest information or she was the opposite (i.e. unreliable with providing dishonest and unreliable information for the dogs). The question here was whether dogs would behave differently in the object choice task that followed. I hypothesized that, if dogs perceive the pointing gesture as imperative (i.e., the command hypothesis), they should differ in their behaviour more between the authoritative and non-authoritative group of dogs. If dogs consider the pointing gesture more as information (the information hypothesis) dogs would differ more between both the reliable and unreliable groups. If dogs followed both authoritative and reliable pointers, then both the command and the information hypothesis would be supported.

The fourth study again focuses on both the command and the information hypothesis. It also includes two related experiments. In both experiments, the authority of the person pointing was varied. Sometimes this person was an adult human and sometimes a child, whom dogs consider less of an authority (e.g. Brogan et al. 1995). If dogs interpret pointing as a command we would expect dogs to differentiate between those situations in which an adult and those in which a child pointed since the latter is less of an authority figure for them. If they perceive pointing as an informative gesture they should follow both, adult and child to the same degree since level of authority would not play a role in this situation.

Taken together, the studies outlined above investigate how dogs perceive the human-given pointing gesture. Is dogs' understanding explained by a low-level mechanism or might they have similar higher-level cognitive capacities to humans? The following studies approach this question.

2. Study 1

2.1 Introduction

Dogs are very skilled at understanding some forms of human communication, in particular, the pointing gesture (e.g. Miklósi and Soproni 2006). Experimental studies have mainly investigated dogs' comprehension of pointing gestures in the so-called object choice paradigm. In this paradigm a reward (e.g., food) is hidden in one of usually two identical cups and the experimenter provides the dog with a communicative cue, e.g., by pointing (and/or gazing) at the correct cup. The dogs are then free to make a choice between the potential locations of the hidden food. A growing body of research demonstrates that, compared to other non-human species, dogs are highly skilled in these forms of communicative signals from humans (e.g. Bräuer et al. 2006).

All previous studies investigating dogs' comprehension of the pointing gesture have used some type of reward (e.g., food) as a motivational device to encourage the dogs to participate. Frequently, the reward serves as the object-referent of the human's communicative gesture. As a consequence, in these studies, dogs have always been exposed to reward-related situations. Thus we only have knowledge about dogs' comprehension of the pointing gesture in situations where dogs are highly motivated to find something, such as food. In this context, even a gaze cue without pointing is sufficient to enable dogs to locate the hidden food (Soproni et al. 2001).

One exception is Agnetta et al. who tested dogs in a gaze-following task where a human experimenter attempted to direct the dog's gaze to one of three predetermined locations (straight up, directly to the left, or directly to the right of the dog) by turning her head and looking at that location for approximately 5 seconds. No reward was provided for any particular response. A response was measured as looking at the three possible target locations or elsewhere (e.g. at the experimenter). The results showed that dogs do not reliably follow a human gaze in such non-foraging situations. In a similar study investigating level of comprehension of a human's directional gaze and head nodding cues, Soproni et al. (2001) found that dogs did not follow a human's gaze direction to an empty location above a target object, as opposed to indicating the object directly. Their study was conducted using a two-way food choice task. Food was present as a motivational device and dogs had to choose between two containers. But with no referential component (target object) in the gesture dogs were not able or motivated to follow it.

Taken together, these results suggest that dogs need the accompanying referential component (object referent) to fully comprehend the communicative intention behind a human's gaze cue. Thus, for dogs, it seems that communication needs to be about a referent and the mere presence of food in the communicative situation does not seem to change this finding. This suggests that gazing is not a cue that is used by dogs simply because it is based on an association with the presence of food. Both of the afforementioned studies, however, investigated dogs' understanding of a human's attentional state directed to different target directions. They did not specifically investigate dogs' comprehension of intentionaly communicative human cues.

To my knowledge, no study has investigated how dogs would respond to a pointing gesture with no referent, but which is clearly meant as a communicative act. Dogs' behaviour in this kind of situation would provide valuable information about the mechanisms that underly their comprehension of a human's pointing gesture. If dogs follow this gesture regardless of contextual or referential information in a communicative situation, one would be inclined to regard this more as associative behaviour. In other words, the human's hand is associated with food and therefore dogs follow that hand direction regardless of contextual and /or referential information. In addition, dogs may interpret pointing as a command ordering them to move to a certain location or in a particular direction, irrespective of the context established (Szetei et al. 2003).

In the current study, therefore, I addressed the question of how dogs would respond to a pointing gesture with accompanying gaze-alternation to an empty location. I used a 2 x 2 x 2 design. As a between-subject factor, the experimenter pointed to an empty spot on the ground versus no gesture being used whatsoever (control).

As a second between-subject factor, I established a food searching context for half the dogs (context group), while for the other half no such context was established (no context group). From the previous studies on gaze-following, I expected dogs to regard a context in which food had previously been discovered to be more relevant than one in which no food had ever been present. The other question of the study was whether dogs would differentiate between the experimenter's tone of voice. This was varied within-dogs to be either informative or imperative to investigate whether the human's vocally expressed motive would have an effect on the dog's behaviour.

2.2 Methods

Subjects

Forty-eight dogs (25 females, 23 males) of various breeds and ages (*M* = 4.7 years; age range: 1-12.5 years) participated in this study and were included in the analysis (see tab.1). All dogs lived as pets with their owners and were tested at the Max-Planck Institute for Evolutionary Anthropology (MPI EVA) in Leipzig, Germany.

All dogs had received the training typical of pet dogs. The owners were registered on a database at the MPI EVA and had agreed for their dogs to participate in the study.

The pre-conditions for participation were that the dogs had to be food motivated and comfortable remaining in a testing room without their owners. Three dogs were excluded from the study prior to testing because of anxiety in the testing room. The study was conducted in quiet rooms at the MPI EVA (3.6m x 2.9m). Recordings were made with one camera (Panasonic NV-GS180) fixed to the ceiling and the room was filmed from above using a special wide-angle lens ("fish eye", Sony Sakar, 37mm; 0.45x).

Experimental Design

Presence versus absence of a food searching context and the absence and presence of a gesture was varied between dogs. Dogs were grouped such that one group (N=24) received the experimental condition (with pointing gesture), while the other group (N=24) received the control condition (no pointing). In each of those groups dogs were again grouped such that one group (N=12) received the context trials (food present), while the other group (N=12) received the no-context trials (food absent).

The experimenter's motive (imperative vs. informative) was presented as a within dogs factor. This resulted in a 2x2x2 design with the following 4 experimental conditions: *experimental-context-informative, experimental-context-imperative*, *experimental-no context-informative*, *experimental-no context-imperative* and the following 4 control conditions: *control-context-informative, control-context-imperative, control-no context-informative, experimental-no context-imperative*.

Each dog received 8 trials in total. In half of those trials, the experimenter's communicative motive was informative while in the other half it was imperative. The informative and imperative trials were blocked such that half of the dogs in each group started with the informative trials followed by the imperative trials, and vice versa for the remaining dogs in that group. The experimenter's position and the location she pointed to was counterbalanced across trials and semi-randomized, with the stipulation that she should never be in the same position and should never point to the same location in more than two consecutive trials (see fig. 1). When she pointed to a location on her right, she gestured with her right arm and respectively for the left. Dogs were allowed to move freely throughout the duration of the trial.

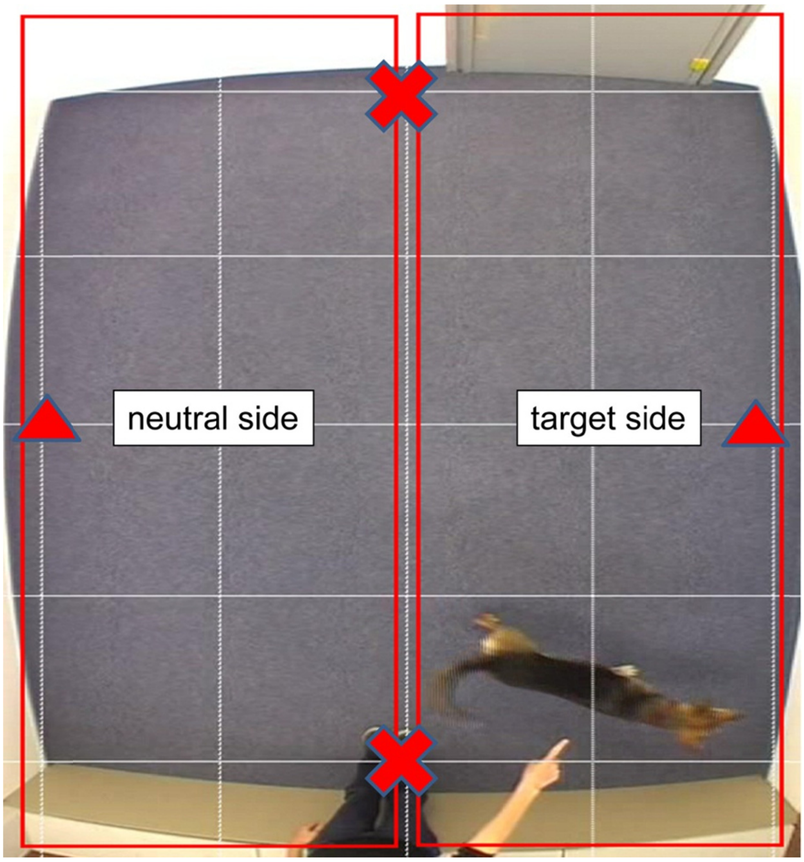

Figure 1: Experimental set-up for study 1. Cross = possible positions of the experimenter; triangle = possible (always empty) spots on which the experimenter pointed; target side = side on which the experimenter pointed to; neutral side = side on which the experimenter not pointed to.

Procedure

Pre-Phase

To establish the context of the respective group of dogs, each dog participated in a pre-phase. The procedure was as follows. First the dog was led into a waiting room adjacent to the testing room. The experimenter entered the testing room with a piece of food held in tongs to prevent her hands from smelling of food. She placed the food on the ground in a predetermined location and left it there in the *context trials*, but removed it after a few seconds in the *no context trials*. The rationale behind this was to control for odour. Then the experimenter guided the dog from the waiting room into the testing room. The dog was allowed to move freely while the experimenter walked once around the testing room without paying the dog any attention. This was to introduce dogs to the food-related situation.

In the *context trials*, every dog found the piece of food without the experimenter needing to indicate it in any way and the dogs were free to take it without m the experimenter attending to their behaviour.

The *no context trials* were identical to the *context trials* with the exception that there was no food for the dog to find. The rationale behind this was to keep the procedures of both groups comparable.

After a short inspection of the room by the experimenter and the dog, they both left the testing room and waited outside in the hallway for one minute. After the waiting time had elapsed, the dog and the experimenter proceeded to the experimental phase of the trial. This procedure was the same in both the experimental and the control condition.

Experimental trial

After the pre-phase, the dog and the experimenter re-entered the testing room. The experimenter stood on the location where the food had been placed beforehand. This was done to prevent dogs coming to that spot. They could potentially have smelled where the food had previously been placed, they may have been drawn to it, and this could have caused a side bias. The experimenter stood against the wall facing the room. After two seconds she called the dog's name and then pointed at a predetermined location. During pointing, she altered her gaze between the dog and the target location three times and simultaneously said "Da!" (German equivalent for "There!") either in a high-pitched, friendly voice (*informative trials*), or with a strong command-like voice (*imperative trials*). When it was time for her to stop gaze alternating, she maintained her gesture and gaze in the direction of the target location for ten seconds. After the 10 seconds had elapsed the experimenter switched her body posture, looking up at the ceiling with her arms hanging beside her body. This lasted 30 seconds and then the trial ended. The next experimental trial started with the pre-phase of that trial.

Control trial

The procedure in the control trials was exactly the same as in the experimental trials except that the experimenter did not point for the dogs at any time. Instead of pointing, the experimenter changed her body posture after addressing the dog and alternating her gaze in the very same way as described in the experimental trials. The experimenter looked up at the ceiling with her arms hanging besides her body. This lasted 40 seconds and then the trial ended. The rationale for the control condition (in addition to my randomized positions and target locations) was to investigate whether the pointing gesture is the main reason for dogs to decide on one side of the room over the other.

Scoring

Before analyzing the videos of the experiments, a grid was superimposed over the footage using the program Adobe Premiere (version 2.0). The grid divided the testing room into two halves to measure the dog's location in the room. For behavioural measurements I observed two main actions. 'Search' was defined as the dog directing its nose to the ground and the lowering its head. 'Obedience', included 'sit' and 'lay'. 'Sit' was defined as every position where the dog's hind legs rested on the ground keeping its forelegs straight and 'lay' was defined as every position where all four of the dog's legs and belly rested on the ground. In the experimental condition, the experimenter always pointed to a predetermined spot in the room. The side to which the experimenter pointed was termed the "target side" and the other half of the room was termed the "neutral side".

In the control condition, positions were the same except that the experimenter did not use a pointing gesture. For statistical analyses the dependent measures were 1) the frequency and duration of the dogs' searching and 2) the frequency and duration of the dogs' obedience during the first 10 seconds after the experimenter started addressed the dog. The videos were then analyzed using the program Interact (Mangold, version 9.1.0).

A second coder coded 20 percent of the original video material with Interact for reliability purposes. Reliability was good for the behavioural measurement 'obedience' (duration: Pearson r = 0.915; frequency: Pearson r = 0.899) and good for the measurement 'search' (duration: Pearson r = 0.855; frequency: Pearson r = 0.865).

2.3 Results

Search behaviour

A visual inspection of a plot of residuals against predicted values showed no pattern; I therefore concluded that an ANOVA could be conducted. I began looking at the duration and frequency of the dog's searching behaviour in the experimental and the control condition (between dog factor: condition) as well as the context, the no context conditions (between dog factor variant) and in the informative and imperative trials (within dog factor intonation) regardless of the two halves of the room. Therefore two 2 (condition) x 2 (variant) x 2 (intonation) repeated measure ANOVAs were conducted. Neither the duration nor the frequency measurements showed a significant interaction between the three factors condition, variant and intonation (duration: $F_{(1,44)}$=2.042, p=0.160; frequency: $F_{(1,44)}$=0.340, p=0.563). Additionally, there was no interaction between the factors intonation and variant (duration: $F_{(1,44)}$=1.776, p=0.189; frequency: $F_{(1,44)}$=0.340, p=0.563), but there was a significant interaction for the frequency measurement ($F_{(1,44)}$=6.753, p=0.013) and a trend for a significant interaction between the factors intonation and condition for the duration measurement ($F_{(1,44)}$=3.812, p=0.057) indicating that dogs searched longer and more often in the informative trials over the imperative trials, but only in the experimental condition, not in the control condition. Furthermore, there was a significant interaction between the factors condition and variant showing a longer searching behaviour in the context trials over the no context trials, but only in the experimental condition ($F_{(1,44)}$=5.087, p=0.029) and only for the duration not for the frequency measurement.

There was no main effect of the factor intonation (duration: $F_{(1,44)}$=0.179, p=0.675; frequency: $F_{(1,44)}$=2.365, p=0.131) but there was a main effect of the factor variant for the frequency measurement showing that dogs searched more often in the context trials over the no context trials ($F_{(1,44)}$=30.465, p<0.001) across conditions.

For the frequency measurement, there was a main effect of condition ($F_{(1,44)}$=7.794, p=0.008), but not for the duration measurement ($F_{(1,44)}$=3.297, p=0.076) indicating that dogs searched more often but not longer in the experimental over the control condition.

I then looked at the same measurements with respect to the room divisions (target side vs. neutral side). Two 2 (condition: experimental vs. control) x 2 (variant: context vs. no context) x 2 (intonation: informative vs. imperative) x 2 (halves: target vs. neutral) repeated measures ANOVAs indicated that for both duration and frequency measurement there were neither four-way nor three-way interactions between any factors.

However, the following two-way interactions were indicated. For the duration measurement there was a trend for a significant interaction and for the frequency measurement there was a significant interaction between the factors intonation and condition showing again that dogs searched more often and longer in the informative trials over the imperative trials, but only in the experimental condition (duration: $F_{(1,44)}$=3.812, p=0.057; frequency: $F_{(1,44)}$=7.958, p=0.007). Additionally, an interaction between the factors halves and variant only for the duration measurement revealed that dogs searched longer in the 'target side' over the 'neutral side', but only in the context trials (duration: $F_{(1,44)}$=4.588, p=0.038; frequency: $F_{(1,44)}$=3.174, p=0.082). An interaction in each ANOVA between both the factors halves and condition revealed that dogs searched longer and more often in the 'target side' over the 'neutral side' but only in the experimental condition (duration: $F_{(1,44)}$=5.224, p=0.027; frequency: $F_{(1,44)}$=11.450, p=0.002). Another interaction between the factors condition and variant revealed again that dogs were searching longer and more often in the context trials over the no context trials, but only in the experimental condition (duration: $F_{(1,44)}$=5.087, p=0.029; frequency: $F_{(1,44)}$=4.725, p=0.035).

Furthermore, it was revealed that there were main effects of halves for search behaviour in duration ($F_{(1,44)}$=13,396, p=0.001) (see fig. 2) and frequency ($F_{(1,44)}$=12,994, p=0.001) (see fig. 3) as well as for the factor variant (duration: $F_{(1,44)}$=23.141, p<0.001; frequency: $F_{(1,44)}$=31.730, p<0.001). For the frequency measurement there was a main effect of condition ($F_{(1,44)}$=9.091, p=0.004), but not for the duration measurement.

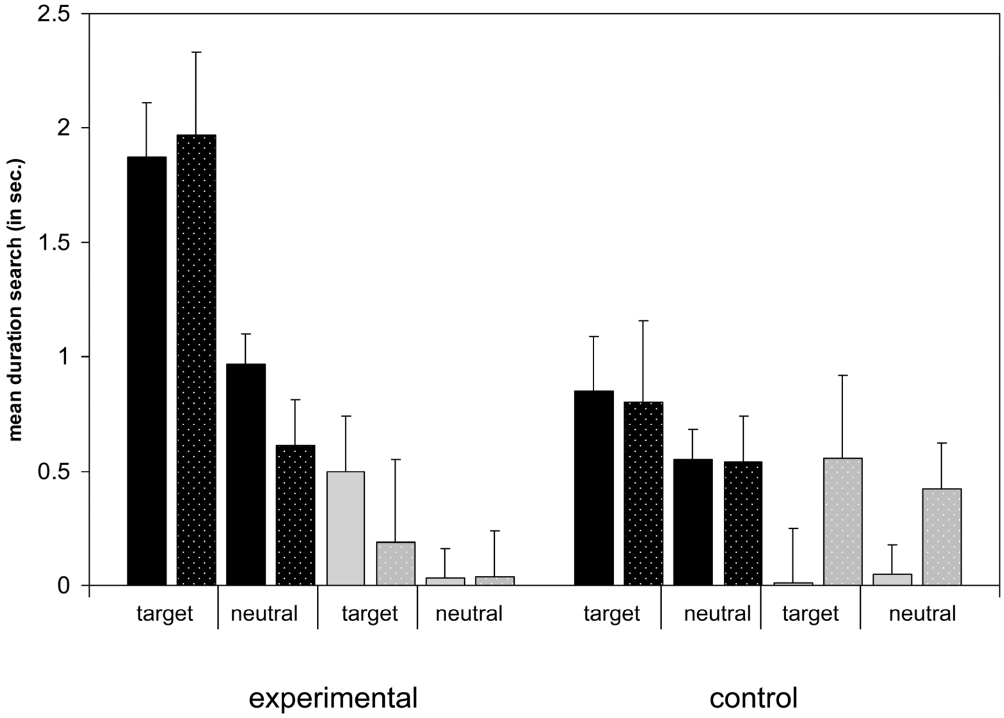

Figure 2: Mean duration (in sec.) of dog's search behavior (SE) in study 1. Black bars = context trials, grey bars = no context trials; filled bars = informative trials, dotted bars = imperative trials. N= 48.

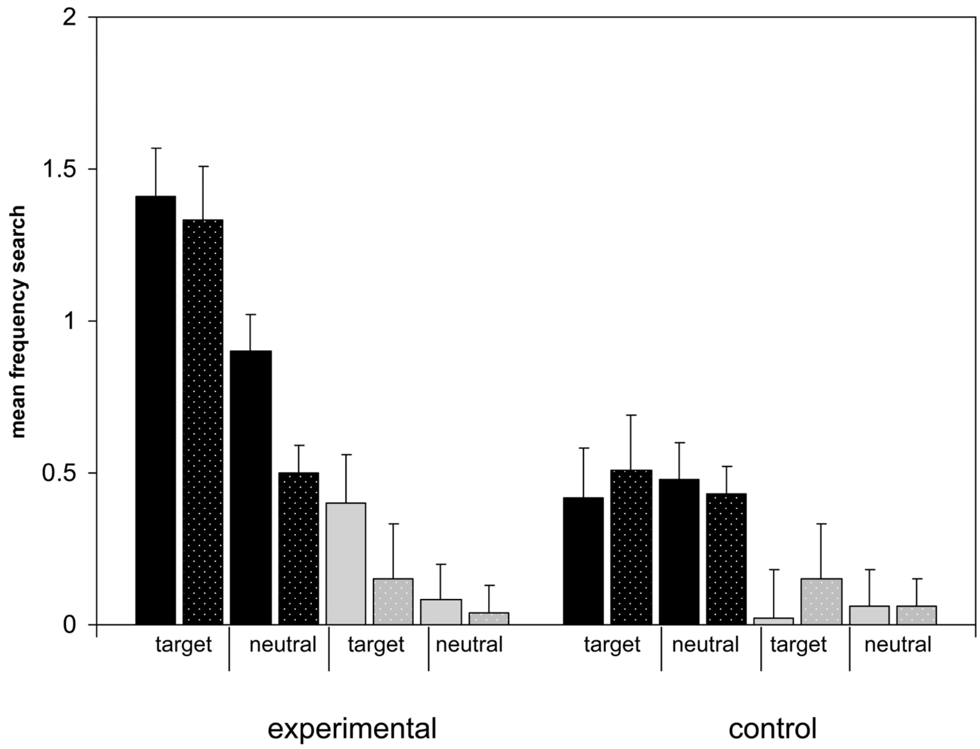

Figure 3: Mean frequency of dog's search behavior (SE) in study 1. Black bars = context trials, grey bars = no context trials; filled bars = informative trials, dotted bars = imperative trials. N= 48.

Obedience behaviour

Finally, I examined the frequency and duration of the dogs' obedient behaviours like sitting and lying down. Again, I conducted two 2 (condition) x 2 (variant) x 2 (intonation) repeated measures ANOVAs, which revealed that there was no significant interaction between all three factors (duration: $F_{(1,44)}$=0.343, p=0.0.561; frequency: $F_{(1,44)}$=1.086, p=0.303). There were also no significant interactions between the factors intonation and variant (duration: $F_{(1,44)}$=0.446, p=0.508; frequency: $F_{(1,44)}$=0.272, p=0.605). However, for the frequency, but not for the duration measurement, there was a significant interaction between the factors intonation and condition illustrating that dogs showed obedience behaviour more often in the imperative trials over the informative trials, but only in the experimental condition (duration: $F_{(1,44)}$=0.032, p<0.858; frequency: $F_{(1,44)}$=0.000, p<0.001) (see fig. 4). Furthermore, there was a main effect of intonation for the duration measurement, revealing that dogs showed longer obedience behaviour in the imperative trials over the informative trials regardless of any other factor (duration: $F_{(1,44)}$=4.487, p=0.040).

Again, I also conducted two 2 (condition) x 2 (variant) x 2 (intonation) x 2 (halves) repeated measures ANOVAs to examine at the dogs' location in the room while performing those behaviours and compared whether dogs performed the actions within the 'target side' or the 'neutral side'. Again, there were no significant four-way interactions between all factors nor were there any significant three-way interactions between any factors. There was, however, a significant two-way interaction between the factors halves and condition for the frequency, but not for the duration measurement (duration: $F_{(1,44)}$=2.701, p=0.107; frequency: $F_{(1,44)}$=4.616, p=0.037) revealing that dogs showed more obedience behaviour in the target side over the neutral side, but only in the experimental condition, regardless of context or no context trials. Additionally, there was a significant interaction between the factors halves and intonation for the frequency, but not for the duration measurement (duration: $F_{(1,44)}$=1.436, p=0.237; frequency: $F_{(1,44)}$=7.061, p=0.011) revealing that dogs showed obedience behaviour more often within the 'target side' than within the 'neutral side', but only when the experimenter used an imperative tone of voice and irrespective of condition. No other factors or their interactions were significant.

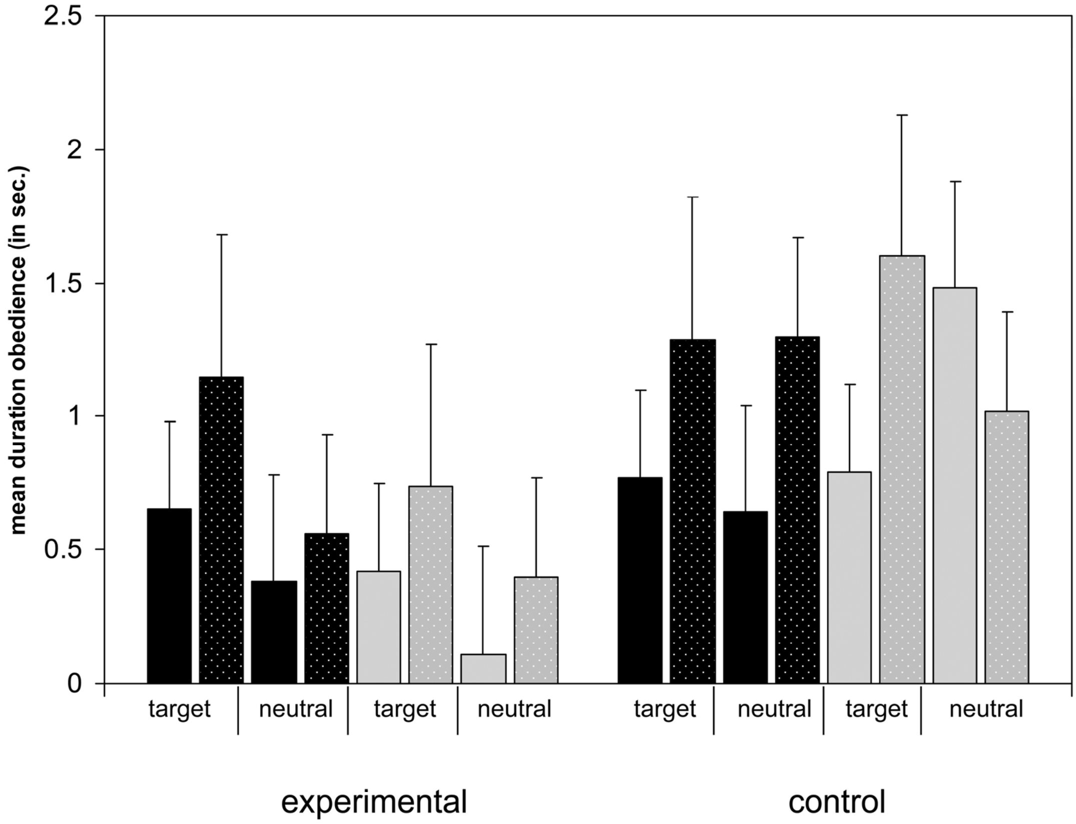

Figure 4: Mean duration (in sec.) of dog's obedience behavior in study 1. Black bars = context trials, grey bars = no context trials; filled bars = informative trials, dotted bars = imperative trials. N= 48.

2.4 Discussion

The context study demonstrates that dogs respond differently to human pointing with gaze alternation depending on contextual information in a communicative situation. Crucially, this speaks against a behaviour which is based purely on associative mechanisms.

Specifically, dogs that had experienced a food-related foraging situation beforehand searched for longer when they saw a human pointing to an empty location on the ground compared to those dogs that had not experienced such a context. Importantly, the dogs' behaviour in the control condition (where they had the same experience, but the experimenter did not point) demonstrates that the pointing gesture was the initiator for the dogs to search in the experimental condition as they searched significantly less when there was no communication at all. This suggests that dogs expect to find a referent when they see the human point somewhere.

Interestingly, the frequency measure of dogs' searching indicates that the dogs searched more often in the context trials than in the no context trials, regardless of condition. I suggest that the frequency measure indicates that dogs checked briefly whether there was food around or not. The duration measurement, however, might be indicative of enduring and intentional search behaviour. That is, when the experimenter used the pointing gesture the dogs searched for a longer time span than when the experimenter only vocalized.

Importantly, the dogs did not search randomly after seeing a pointing gesture. If they had experienced the human pointing for them, dogs searched for longer and more often in the area that the human was pointing to. More importantly, they searched longer in the direction the human was pointing to, but only in those trials where they had experienced a food context prior to the communicative situation.

Interestingly, when dogs had *not* experienced finding food beforehand, they ignored the pointing gesture during their search and did not prefer to search in the direction indicated. This shows that dogs do not follow a pointing gesture irrespective of the context in which they receive it. Importantly, in the control condition, the dogs also searched to the same extent in both halves of the room.

These findings contradict a purely associative account of point-following as has been suggested by some researchers (e.g. Udell and Wynne 2008; Udell et al. 2008a; Wynne et al. 2008). If dogs had simply learned to associate the hand gesture with food, I would expect them to search in the direction of the gesture no matter what context has been established previously. Instead, the dogs only seemed to expect to find something upon following the gesture when they had reason to do so.

Another finding of the context study is that the human's intonation had an effect on the behaviour of the dogs. Dogs showed more frequent search behaviour when they were addressed with a high-pitched, friendly tone of voice than an imperative, command-like tone of voice. This was only found when they had seen the human pointing for them compared to the control condition, but regardless of whether there was a food context prior to this communicative situation or not. It could be that a high-pitched voice in combination with a pointing gesture rouses the dogs, which then triggers more activity, resulting in more search behaviour in general. In contrast to the increased search activity in the informative trials, dogs sat or laid down in the direction of the pointing gesture more often when they were being addressed with an imperative command-like tone of voice.

The most likely explanation for this is that the imperative tone of voice triggers obedient behaviours. This finding is also supported by Lindsay in the field of applied dog behaviour and training, who states that "the tonal variations in which vocal signals are given help to communicate a human's emotional state and immediate intentions to a dog. The dog may not appreciate the symbolic or conceptual significance of a word, but it does appear to be extremely sensitive and responsive to the feeling content of vocal signals reflecting the will of the speaker" (Lindsay 2005). Thus, the results of the context study support the view that dogs do not follow the human pointing gesture 'blindly', but instead take contextual information into account.

Several studies have demonstrated that dogs follow pointing to objects like cups or containers containing a reward in a communicative situation (e.g. Soproni et al. 2001). Studies investigating gaze-following have found that dogs will not follow a human's gaze to an empty space (Agnetta et al. 2000) but these studies investigated whether dogs would recognize the human gaze as a mental state of attention and not what the dogs understand about a human's intentional communicative act towards a referent.

To gain information about the processes which underlie dogs' comprehension of human communicative acts, one has to investigate dogs' responses to the communicative acts of humans, as was examined in this study. To my knowledge, this is the first study looking at dogs' comprehension of the pointing gesture while pointing to an empty space with no obvious referent being present. Dogs showed a highly flexible use of the pointing gesture and their response depended on the context as well on the human's underlying communicative motive. Purely associative explanations do not account for their behaviour. Future studies will need to be conducted in order to ascertain if my findings about dogs' differential response to pointing in conditions with and without contextual information is evidence that dogs truly understand pointing as a referential communicative act.

3. Study 2

3.1 Introduction

This study investigated the command as well as the information hypothesis. For this purpose, I tested whether dogs differentiate between attributes of the experimenter in an object choice task. Studies have shown that dogs are able to differentiate between different characteristics of humans in experimental settings (Kundey et al. 2010). In the current study, before taking part in the experimental object choice trials, the experimenter aimed to establish a certain relationship with the dog. For some dogs she was a reliable person, for some dogs unreliable. Another unrelated pair of attributes was authoritative versus non authoritative. If dogs could differentiate between those conditions, one could draw some conclusion about dogs' understanding of the pointing gesture.

If the information hypothesis is true and dogs interpret the pointing gesture as being informative, I should find different responses between the reliable and unreliable conditions and no such differences between the authority and no authority conditions. Here, the prediction would be that dogs will follow the human pointing gesture more often to the correct location in the reliable condition over the unreliable one. The ability to utilise information is only advantageous when coupled with the ability to discriminate a reliable source from an unreliable one.

If the command hypothesis is true and dogs would therefore interpret the pointing gesture more as a command (imperative) that they have to follow in any case, they should differentiate between the experimenter in the conditions with authoritative and non-authoritative attribution. The prediction would be that dogs would follow the gesture more often to the correct location in the authoritative over the non-authoritative condition. In a pre-phase, dogs had experienced that there were no consequences when disobeying a command in the non-authoritative condition, but that they got corrected when disobeying the authoritative experimenter. Consequently, dogs should regard the pointing gesture when understood as a command as more relevant in the authority condition.

3.2 Methods

Subjects

142 dogs of various breeds and ages participated in this study. 86 dogs had to be excluded for different reasons (e.g.: no motivation to play with the experimenter, anxiousness in the testing room, criterion not fulfilled – see below). Therefore 56 dogs (25 males, 31 females; mean age: 4.4 years; age range: 2-13 years) were included in the analysis (see tab. 2). All dogs lived as pets with their owners and were tested at the Max-Planck Institute for Evolutionary Anthropology (MPI EVA) in Leipzig, Germany. All dogs had received the training typical of pet dogs. The owners were registered in a database of the MPI EVA and had agreed for their dogs to participate in the study. The pre-conditions for participation were that dogs had to be toy motivated and would be comfortable remaining in the testing room without their owner. The study was conducted in a quiet room (5.80m x 3.60m) at the MPI EVA. Recordings were made with two cameras (Panasonic NV-GS180).

Experimental design

Dogs participated in a warm up phase first. By reaching a certain criterion they were invited to come for a second session on a second day (min. 1 day and max. 14 days after the first session) in which they received part of the warm up phase again as a reminder. Afterwards the experimental trials started.

Procedure Warm-up

The dog and the experimenter entered the testing room and played with a toy for 2 minutes (step1). The experimenter then put the toy on a board (150cm x 24cm) which was attached to a wall in the room at a height of 160 cm. Both dog and experimenter left the testing room afterwards. The establishment of the relationship between human and dog proceeded depending on the following 4 conditions (step 2).

Authority condition: Both dog and experimenter entered the testing room. The experimenter put the toy in the middle of the room while saying “Aus” (=”No”) and gave a command to the dog like “Sitz” (=”Sit”) or “Platz” (=“Lie down”) in one corner of the room. The dog was not allowed to take the toy. The experimenter always insisted on the given command until the dogs followed it. The experimenter sat down on a chair and was distracted by reading a journal. If the dog moved and took the toy, the experimenter would get the toy back by saying “Aus” (=”No”), guide the dog to the corner and repeat the command “Lie down”. This procedure continued for about 5 minutes. Then the experimenter and the dog left the testing room.

***No authority condition*:** Both dog and experimenter entered the testing room. Here the procedure was similar to the *authority condition*. The experimenter gave the same commands, but when the dog did not follow the commands she did not insist on them and the dog could take the toy and move freely in the room. To repeat the procedure and to be able to have more situations in which the dog might disobey the commands of the experimenter, the toy had to be taken away gently by the experimenter after it was fetched by the dog.

Reliable condition: First the experimenter hid the toy in one of three hiding places (in a bucket, behind a barrier, in a cardboard box) while the dog was held by a second experimenter outside the testing room. After the toy had been hidden, the dog was led into the testing room and was allowed to search for it. The helper stayed outside the room. The experimenter stood next to the hiding place looking at the toy and calling excitedly with high pitched voice “Schau mal, hier ist es!“ (=”look over here, here it is!”) repeatedly until the dog found the toy. When the dog found the toy, the experimenter and the dog played with it for 10 seconds and then both left the testing room. The next round started with the experimenter hiding the toy in another of the three hiding locations and the procedure followed that described for the first location. Another round for the third location followed.

Unreliable condition: Here the procedure was the same as in the reliable condition with the exception that the experimenter only pretended to hide the toy in the hiding places before the dog entered. In reality, there was no toy present in the room. The dog was therefore not able to find a toy in the hiding places.

After finishing step 1 and 2 both steps were repeated in the same order for four consecutive times with short breaks of 2 minutes in between. For passing the first testing day and to continue with the second testing day dogs had to fulfil the following criterions (step 3) in a separate task:

***Criterion authority condition*:** Dogs had to follow 3 out of 4 commands (2x "Sit" and 2x "Lie down"): The experimenter and the dog entered the testing room. There was no toy present. The experimenter started to give one command (either "Sit" or "Lie down") to the dog and waited 5 seconds. Regardless of how the dog reacted, the experimenter would then encourage them to follow her to another corner of the room and then give the second command. The procedure was continued until the experimenter had given all four commands to the dog. It was recorded how often the dog followed the command.

***Criterion no authority condition*:** Dogs should not follow 3 out of 4 commands (2x "Sit" and 2x "Lie down"). The procedure was the same as in the *Criterion authority condition.*

***Criterion reliable condition*:** Dogs should search for the toy 4 times out of 6 (2 times in each hiding place). The procedure here was the same as in the establishing phase of the *reliable condition* except that the toy was hidden 6 times (2 times in each hiding place). It was recorded how often the dog fetched the toy from the hiding places.

***Criterion unreliable condition*:** Dogs should search for the toy no more than 2 times out of 6 (2 times in each hiding place). The procedure here was the same as in the *criterion reliable condition*.

After passing these criteria, dogs were invited for the second testing day on which step 1 and step 2 were repeated twice in the same order as on the first testing day (step 4). This repetition served as a reminder and refreshment of the establishment from the first testing day. After this step dogs were introduced to the experimental trials (step 5).

Experimental trials

The experimental design was an object choice task with the dog's favourite toys. We used two containers (28 cm x 10 cm x 20cm) to hide the toy and a barrier (50 cm x 60 cm) to prevent the dog from seeing the toy being hidden in between trials. The experimenter was standing behind and in the middle of the two containers, which were placed 120 cm from each other. The dog was held by a helper facing the first experimenter and containers. The dog was positioned 90 cm away from. Before the experimental trials started, dogs were exposed to situations in which the experimenter established a certain relationship with the dog (see warm up procedure above). The final object choice trials consisted of 12 experimental trials and 6 control trials. The control trials were given in a block after the experimental trials. In all 18 trials the toy was never hidden on the same side in more than two consecutive trials.

Scoring (object choice)

Touching one container with the muzzle or paw or approaching it to a 10cm distance was scored as choice. Dogs were recorded as choosing correctly (container with the toy), incorrectly (empty container) or making no choice (did not choose either container). A second coder coded 20 percent of the original video material reliability purposes. Reliability was excellent (kappa = 0.97).

3.3 Results

Because the data was not normally distributed (based on Kolmogorov Smirnov test) I used non-parametric tests for independent samples. To see whether the four conditions differed I conducted a Kruskal-Wallis-H-test. There were no significant differences between the four conditions in the experimental trials (Kruskal-Wallis-H-test: H=1.837, p=0.607) (see fig. 5).

In addition, experimental trials of each condition were compared to the control trials of the respective condition. The comparison between the experimental trials and the control trials in the authority condition revealed a significant difference (Wilcoxon signed-ranks Test: T=97.5, N=14 (0 ties), p=0.005) showing that dogs chose the correct container more in the experimental trials compared the control trials. The comparison between the experimental trials and the control trials in the no authority condition revealed again a significant difference (Wilcoxon signed-ranks Test: T=90.5, N=14 (0 ties), p=0.017). Again dogs chose the correct container more in the experimental trials compared to the control trials. The comparison between the experimental trials and the control trials of the reliable condition revealed no significant difference (Wilcoxon signed-ranks Test: T=72, N=14 (1 tie), p=0.063) showing that dogs did not choose the correct container more in the experimental trials compared to the control trials. The last comparison between the experimental trials and the control trials of the unreliable condition revealed a significant difference (Wilcoxon signed-ranks Test: T=76.5, N=14 (2 ties), p=0.003) showing that dogs chose the correct container in the experimental trials more compared to the control trials.

Furthermore it was tested whether the experimental trials of each condition differed from chance level (50%). A comparison of the experimental trials of the authority condition against chance level revealed a significant difference (Wilcoxon signed-ranks Test: T=78, N=14 (2), p=0.002) showing that dogs chose the correct container above chance level. The comparison of the experimental trials of the no authority condition revealed again a significant difference (Wilcoxon signed-ranks Test: T=93.5, N=14 (0 ties), p=0.010) which showing again that dogs chose the correct container above chance level in this condition. The experimental trials of the reliable condition differed significantly from chance level (Wilcoxon signed-ranks Test: T=73, N=14 (2), p=0.017) which showed that dogs chose the correct container above chance level. A last comparison between the experimental trials of the unreliable condition and chance level revealed a significant difference (Wilcoxon signed-ranks Test: *T*=66, *N*=14 (3 ties), *p*=0.003) showing again that dogs chose the correct container above chance level.

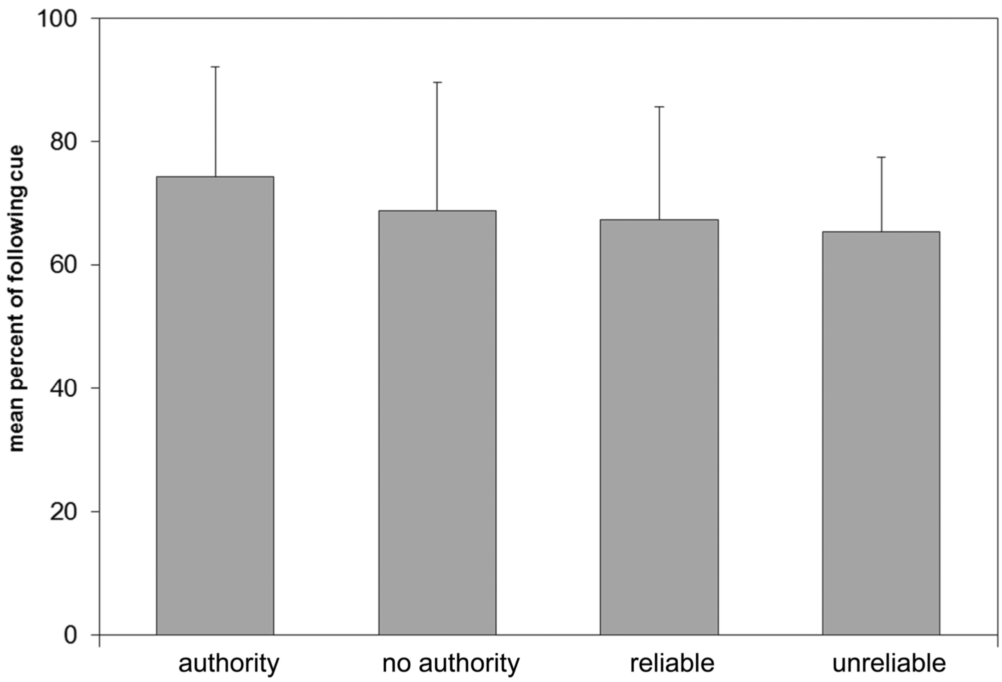

Figure 5: Mean percentage of dogs following the cue (SD) in study 2. N=56.

3.4 Discussion

This study addressed the question of whether dogs would behave differently in an object choice task depending of the attitude of the human pointing to a hidden toy for them. By systematically varying the reliability and authority of the human experimenter, I aimed to test between several hypotheses regarding how dogs understand the human pointing gesture. There were four groups of dogs, each of which experienced a human showing one of the four different types of attitudes in an establishing phase. In a following experimental phase dogs were exposed to an object choice task in which the human always pointed to the correct container. Except in one condition, the performance of the dogs in the experimental trials differed from their performance in the control trials in which the experimenter did not provide any cues for the dogs. In addition, each dog group used the human cues, and thus picked the correct cup and found the hidden toy above chance level in the experimental trials.

However, the dogs did not differentiate between any of the human attitudes, as there was no difference found between these four groups' performances.

One interpretation of this result could be that dogs simply ignored the experimenter's attitude. In other words, the attitude of the human was not of relevance for the dogs in their decision to follow the pointing gesture in the object choice task. Another explanation for the dogs' behaviour in this study is that dogs may only connect the attitude of a human to only one specific event or situation and therefore might have considered each situation (establishment and object choice task) as two distinct events which were not connected to each other, even if they were both experienced with the same experimenter.

Alternatively, since the human in the warm-up trials of the experimental trials always showed the dogs in a cooperative and reliable way that one of the boxes might contain a toy, they might have connected this cooperative attitude to the following testing situation.

However, before the main experiment started, the pilot phase gave the impression at least that dogs changed their behaviour according to the attitude of the human. Assuming this effect to be factual, then it's possible that the criteria and procedure of the main experiment were not appropriate or sufficient for dogs to understand the experimenter's attitude. Studies have shown, however, that dogs are able to differentiate between different attitudes of an experimenter (Kundey et al. 2011; Kundey et al. 2010; Petter et al. 2009). Petter et al. (2009) tested dogs in an object choice task where one container was baited with food and the other one was empty. The question was whether dogs would distinguish between a cooperative and a deceptive experimenter. In half of the trials the cooperative experimenter pointed to the baited cup and in the other half the deceitful experimenter pointed to the empty cup. The experimenters not only pointed to the cup, they were also standing behind it (i.e. they positioned their body behind the pointed-to cup). Results showed that dogs learned to approach the cooperative experimenter more often than the deceiver. After just 2 sessions (each containing 40 trials), dogs were able to differentiate between the two experimenters. This shows that dogs do not require much exposure to different humans to be able to discriminate between them. Dogs have also been shown to act on information about unfamiliar individuals through reputation-like inferences by observing third-party interactions (Kundey et al. 2011). It seems unlikely, therefore, that dogs in the current study had problems distinguishing between different experimenter types. However, in contrast to other studies, the dogs tested here did not have to choose between two experimenters. Each group was exposed to one particular experimenter and her attitude. It might be easier for dogs to perceive the attitude of humans when they are required to choose between different experimenters.

It cannot be ruled out that the set-up used in this study was insufficient to investigate the questions asked, for the reasons given above. Thus, the results presented here are preliminary and further studies are required.

One possible approach to continue this line of research would be to include trials in the object choice task where dogs were in a conflicting situation. This could be achieved by the experimenter pointing to the empty box with dogs being informed about this fact. Dogs would then have knowledge about the true location of the food and would be in a conflict situation when the human pointed to the other (empty) cup. For the authority and no authority conditions it would mean that, assuming dogs do see the pointing gesture as a command, one would expect them to follow the gesture more in the authority condition than the non-authority condition. This is the same prediction as in the current study. But, by putting dogs into this conflicting situation, one might be better able to reveal a difference. The same holds for the other attribute pair; namely the reliable and the unreliable condition. Creating a conflicting situation might reveal a difference in the dog's behaviour that would support the information hypothesis. Thus, future studies need to be conducted. The next study manipulates the experimenter's attitude indirectly rather than directly. Rather than displaying different attitudes towards the dog through their actions, the experimenter's presence or absence results in them having authority or no authority in the room respectively.

4. Study 3

4.1 Introduction

Domestic dogs are flexible in comprehending human forms of communication. One example is dogs' comprehension of the human pointing gesture in the so-called object choice paradigm. However, as of yet it is not clear how dogs actually interpret the pointing gesture in these settings. One possible interpretation is that dogs, like humans, interpret a pointing gesture as an informative communicative act, telling them where to find the hidden food. This hypothesis is called the "information hypothesis". Children reliably follow an adult's pointing gesture to distal targets from an early age (Carpenter et al. 1998) and they seem to understand the communicative intentions behind that gesture. One prerequisite for understanding pointing as an informative gesture is the ability to attribute certain psychological states to other individuals, such as knowledge, desires, intentions etc. This would require higher-level cognitive mechanisms.

The opposite extreme to this hypothesis would be that dogs learn to use pointing exclusively by lower-level mechanisms; namely associating the hand of the human with the provision of food. In this case, dogs would only be expected to follow the hand when they expect to find food (e.g. Dorey et al. 2010; Wynne et al. 2008). The fact that young puppies even from the age of 6 weeks follow a human given pointing gesture, however, argues against a major influence of learning on this behaviour (Riedel et al. 2008). Study 1 of this thesis has also ruled out the explanation of dog's reactions to a human pointing gesture as resulting from associative learning.

A third and more intermediate hypothesis would be that instead of interpreting pointing as information about where to find food, dogs interpret pointing as a command, ordering them where to go. This is called the "command hypothesis". Evidence for this was found in a study by Szetei et al (2003), in which a human experimenter pointed to one of two locations - one of which contained strong-smelling food that was potent enough for dogs to be able to detect it from a distance, the other of which was empty and odour-free. In one condition of this study the human pointed to the empty location. In 79% of cases the dogs ignored their own, more reliable sensory information in order to follow the pointing gesture. This finding is difficult to reconcile with the assumption that dogs interpret pointing as information telling them where to find the reward. Instead, this evidence suggests that dogs interpret pointing as some kind of command ordering them where to go; even if it is against their own better knowledge. In a series of studies, I aimed to test the hypothesis that dogs interpret pointing exclusively as a command, ordering them to move to a particular location.

4.1.1 Experiment 1

In the first study, I tested dogs in a standard object choice paradigm in which food was hidden in one of two possible locations. I systematically varied two factors: the dogs' knowledge of where the food was hidden and the presence of the authority (the human) during their choice. The experimenter always pointed to the incorrect location; that is, to the empty cup.

Sometimes the dogs were aware that this cup was empty and sometimes they were not. If dogs interpret the pointing gesture as a command ordering them where to go they should follow the gesture irrespective of their own (and sometimes better) knowledge. If dogs perceive pointing as an informative gesture they should rely on their own knowledge and sometimes ignore the point of the human. It was also varied whether the experimenter (and therefore the authority) was present while the dog made its choice. In the case where the authority was present, the dogs' motivation to follow the command should be enhanced, as this has been shown in other studies (Call et al. 2003).

4.1.2. Methods

Subjects

Forty-eight dogs (25 females and 23 males) of various breeds and ages (M = 5 years; range 1-11 years) participated in this study and were included in the analysis (see tab.3).

Twelve additional dogs had to be excluded after pre-testing for various reasons (e.g., they were uncomfortable in the testing room or with the apparatus). Their data was not included in the analysis. All dogs lived as pets with their owners and were tested at the Max-Planck Institute for Evolutionary Anthropology (MPI EVA) in Leipzig, Germany. All dogs had received the training typical of pet dogs. The owners were registered in a database of the MPI EVA and had agreed for their dogs to participate in the study. The pre-conditions for participation were that dogs had to be food motivated and would be comfortable remaining in the testing room without their owner.

Materials

The study was conducted in quiet rooms at the MPI EVA (3.96m x 3m; 5.9m x 3.6m). Recordings were made with two cameras (both a Panasonic NV-GS180) connected by a splitter (VC – VC-CQ4ZSA). To ensure that dogs could only make a single choice, even when they was alone in the room, the cups (height 9cm, bottom diameter 8cm, top diameter 5cm) were placed in a special Plexiglas box (140cm x 16cm x 20cm). At each end of the box were compartments (opening: 23cm x 20cm) in which the cups were placed with a distance of 1.20m between them (experimental set-up see fig. 6). The whole box had a sliding cover, which had to be moved to one side in order to reach the contents of a compartment (see fig. 7). The cover ensured that opening one compartment closed the other one simultaneously with a magnet. Dogs could therefore only choose one side of the box in each trial. To control for odour, additional food was hidden in the box below a cover such that the dog could not see it but could smell it. In addition, a curtain was placed in between the dog and the experimenter. A second person (helper) handling the dog also had to manipulate the curtain depending on the condition.

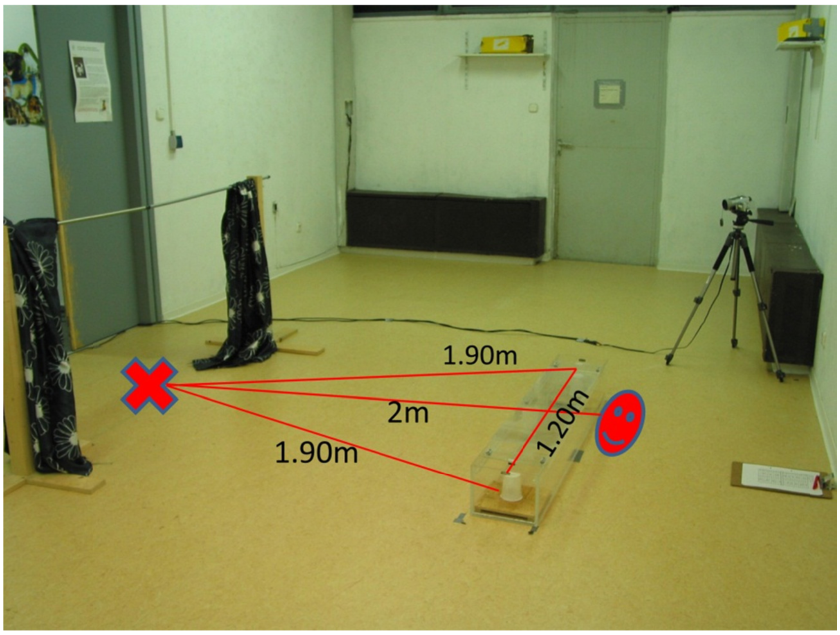

Figure 6: Experimental set-up of study 3. Cross = position of dog and helper; face: position of experimenter.

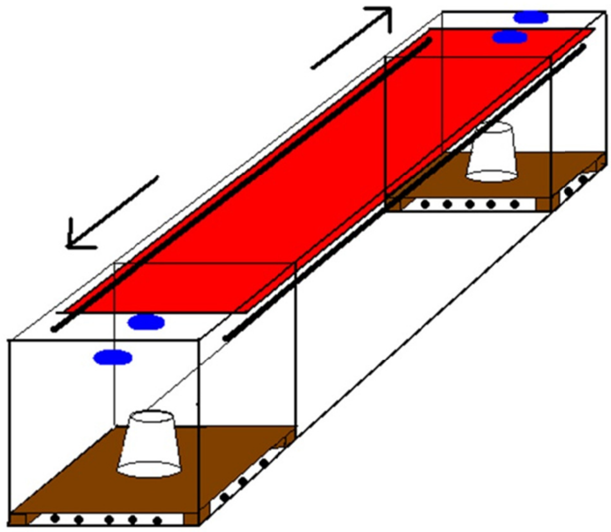

Figure 7: Box used in study 3.

Warm-up

Before the experimental trials began, dogs participated in a short warm-up phase. This phase was conducted to ensure that the dog was food motivated and to familiarize the dog with the Plexiglas box. In this phase the dog, the experimenter and the helper stood in predetermined positions and the experimenter caught the attention of the dog by tongue-clicking. The experimenter then baited one of the cups, which were placed in the Plexiglas Box in full view of the dog. The experimenter’s visual orientation was directed to the box while the she baited it. The helper then released the dog so that a choice could be made by touching the cup with either the muzzle or a paw. When the dog chose the correct cup they were allowed to eat the food. If they chose the empty cup, they got no reward though the food in the other cup was shown to them. The location of the reward was counterbalanced such that it appeared alternately on the right and left side equally often. This was repeated until the dog could recover the food from the box without any manual and/or verbal help from the experimenter once on each side.

General Procedure

At the beginning of each trial the helper guided the dog to the predetermined position. Before a trial started, the experimenter always ensured that the dog was attentive to her. The experimenter faced the dog and if it was not attentive, she made noises (e.g. clicking the tongue) to get the dog's attention. Then the experimenter pointed three times to the empty location using a distal dynamic pointing gesture accompanied by gaze alternation. Dogs were divided into two subgroups. For one group of dogs the experimenter used additional ostensive cues (high-pitched voice, saying the German equivalent of: "dog's name, look; look, dog's name!"). For the other group, the experimenter remained quiet while giving her gesture. The rationale for this was to see whether dogs would differ in both conditions from each other.

They could possibly be either distracted by the ostensive cues of the experimenter or be more attentive to the procedure. The following procedure depended on the condition:

***Authority leaves - Dog knowledgeable*:** The experimenter showed the dog a piece of food then baited one of the cups in full view of the dog and lifted the other (empty) cup to demonstrate that it was empty. After the baiting process, she produced the cue (towards the empty cup) and left the room. Immediately afterwards, the helper released the dog and left the room as well. The dog then had one minute to make a choice.

***Authority leaves - Dog ignorant condition*:** The experimenter showed the dog a piece of food and directly afterwards the helper closed the curtain such that the dog could not see the baiting process. The experimenter then baited one of the cups and sham baited the other to make sure that the dog could not receive uncontrolled audible information. The helper opened the curtain and the experimenter produced the cue. Then both the experimenter and the helper left the room, as described above.

***Authority stays - Dog knowledgeable*:** The procedure was identical to the *Authority leaves - Dog knowledgeable* condition but with the experimenter remaining in the room after producing the pointing gesture, standing motionless with arms hanging down, head bowed and eyes open. The helper left the room 5 seconds after the experimenter gave the cue and came back into the room after one minute had elapsed if the dog had not already made a choice.

***Authority stays - Dog ignorant*:** The procedure was identical to the *Authority leaves - Dog ignorant* condition except that the experimenter stayed after giving the cue as described in the above condition.

The experimenter would not look at the door or pay any attention to the helper leaving and entering the room in any of the above conditions. The location of the food was counterbalanced and semi-randomized with the stipulation that the food could never be in the same location for more than two consecutive trials. Each dog received six trials in each condition resulting in 24 experimental trials altogether per dog. Trials were presented in two sessions, which were conducted on two different days with a maximum break of 14 days between them and a minimum break of one day. The four conditions were counterbalanced and semi-randomized with the stipulation that neither the authority state (human absence or presence) nor the dog's knowledge state (knowledgeable or ignorant) could ever occur in more than two consecutive trials.

Scoring

After the data collection, I looked at two different measures. The first was the dogs' choice. It was scored as a "cue" response if a dog chose the cup that the experimenter was pointing at. If the dog chose the other cup, it was scored as a "food" response. A choice was made when the dog touched a cup directly with her muzzle or paw. If a dog did not choose at all it was scored as a "no choice". Those trials were excluded from the analysis, and therefore we had to calculate in percentages. I first looked at the mean percentage of trials in which the dogs followed the pointing gesture to the empty cup. A visual inspection of a plot of residuals against predicted values showed no pattern and I therefore concluded that an ANOVA should be conducted. A second coder coded 20 percent of the original video material for reliability purposes. Reliability for the measurement of dog's choice was excellent (kappa = 0.94).

The second measure taken was the latency until the dog made a choice. Time was measured from the moment the helper released the dog to the moment the dog made a choice. A second coder coded 20 percent of the original video material for reliability purposes. Reliability for the measurement latency was excellent (Pearson $r = 0.994$).

4.1.3 Results

I conducted a repeated measures ANOVA with the two main within factors being "presence of the authority" (present vs. absent) and the dogs' "knowledge of the food location" (knowledgeable vs. ignorant). An initial inspection of the between dogs "use of additional ostensive cues" showed that the use of ostensive cues had no effect on any of the factors, which is why we excluded this factor in the final analysis and collapsed the data for the 48 dogs. Whether or not the dogs knew the location of the food had a significant effect on their choices, as dogs followed the pointing gesture to the empty cup significantly more if they had no information about the real location of the food ($F_{(1, 47)} = 112.47$, $p < 0.001$) (see fig. 8). Whether or not the authority was present during the dogs' choice had no effect ($F_{(1, 47)} = 0.638$, $p = 0.428$) and there was no interaction between these two factors ($F_{(1, 47)} = 2.63$, $p = 0.112$).

To see if there were any learning effects during the study, I conducted a 2 x 2 x 2 ANOVA with within factors "presence of the authority" (present vs. absent), the dogs' "knowledge of the food location" (knowledgeable vs. ignorant) and 'half of trials' (first half vs. second half). 'Half of trials' had no effect on any of the other factors as none of these comparisons reached significance. There is therefore no evidence of improvement over time.

In addition, I looked at the latency until dogs made their choice. Again I conducted a repeated measures ANOVA with the two main within factors "presence of the authority" (present vs. absent) and the dogs' "knowledge of the food location" (knowledgeable vs. ignorant). A main effect of "knowledge" showed that dogs were faster to choose the cup in those trials in which they had witnessed the food being hidden (ANOVA, $F_{(1,47)} = 4.447$, $p = 0.040$), but only in those trials in which the human stayed in the room as there was a significant interaction between the dogs' knowledge and the human's presence (ANOVA, $F_{(1,47)} = 5.050$, $p = 0.038$).

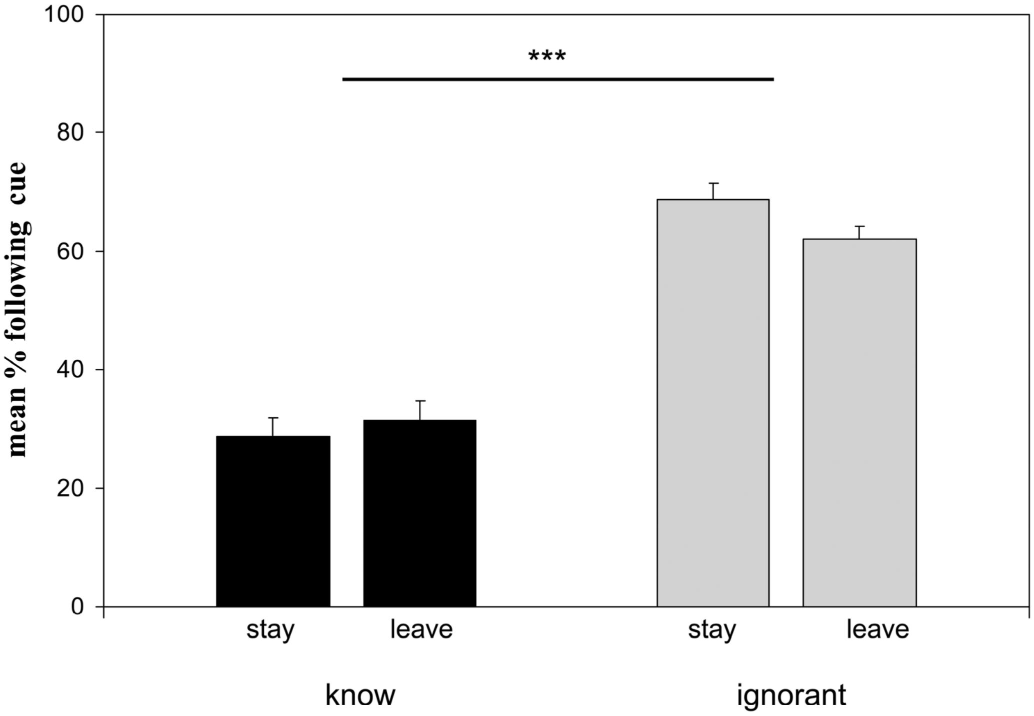

Figure 8: Mean percentage of dogs following the cue (SE) in experiment 1 of study 3. N=48. ***P<0.001.

4.1.4 Discussion

In this study, dogs' clearly differentiated conditions in which they had seen the baiting process from conditions in which they had not. Dogs followed the pointing gesture in trials in which they had no additional information about the location of the hidden food other than the pointing gesture. When the dogs had seen the cup being baited they relied on their prior visual experience and chose the baited cup, ignoring the pointing gesture. The experimenter's (the authority's) absence or presence had no influence on the dogs' choice suggesting that the pointing gesture was not interpreted as a strong command, which had to be obeyed even against dog's own knowledge. If that were the case, the expectation would be that dogs would follow the pointing gesture more often in those cases in which the human, and therefore the authority, was still present after the command had been given. The behaviour of the dogs also speaks against a purely associative behaviour, e.g. the hand of the human is associated with food. Otherwise they would have always followed the pointing gesture, even to the empty cup.

There is evidence that in situations in which dogs received the command to not take a certain piece of food, they would obey that command if the authority remained in the room but nearly always disobey if the authority left them alone (Call et al. 2003). This shows that the presence or absence of the authority clearly influences dogs' obedience. The fact that dogs do not distinguish between these situations here, supports the idea that in this study dogs did not interpret the pointing gesture as a command.

However, it could be the case that seeing the food being hidden in some conditions but not others was such a strong stimulus that the dogs could not inhibit going to where the food was hidden, even in the presence of the authority. This is why I conducted a follow up study in which the general setting was identical but the dogs never actually saw the food. Instead they learned, prior to the study, that food was hidden under a black cup and not under a white one.

4.2.1 Experiment 2

This study was conducted to rule out the possibility that seeing the food was such a strong stimulus that it could not be inhibited by dogs, resulting in them choosing the baited cup. This might have interfered with the dog's obedience. To control for this, dogs had to be prevented from seeing the baiting process directly. Therefore dogs had to learn that food is always in a certain cup, namely a black one, instead of a white one. They learned this contingency in an associative learning task.

4.2.2 Methods

Subjects

Twenty dogs (15 females and 5 males) of various breeds and ages (*M* = 5 years; range: 1-11 years) participated in this study and were included in the analysis (see tab. 4). Fifty-two additional dogs had to be excluded after pre-testing for various reasons (mainly because they did not pass the pre-test or they were uncomfortable in the testing room or with the apparatus). Their data was not included in the analysis. The description of acquisition and background of the dogs were identical to experiment 1. In addition to the preconditions of experiment 1, dog had to pass a pre-test (see below). None of the twenty dogs had participated in experiment 1.

Materials

Materials were the same as for experiment 1 with the exception that instead of two identical cups, we used two different pairs of cups, which were identical in shape and size (height 9cm, bottom diameter 8cm, top diameter 5cm) but differed in color. One pair consisted of a black and a white cup, while the other pair consisted of two grey cups. All cups were wrapped with adhesive tape in the appropriate color.

Warm-up (Association task)

Dogs had to participate in a warm-up phase (object choice task) in which they were expected to grasp the association between the black cup always containing food and the white one remaining empty. In total the dogs received 60 trials. The warm-up phase was conducted on the first day. If the dogs passed the task, they were invited for another test, which occurred no more than 2 weeks later (minimum 1 day later). If a dog did not meet the acceptable threshold (85% of a block of 20 trials performed correctly) it was excluded from the study. Four dogs were excluded from this rule. One was very close to reaching the threshold (80%) and when tested on another day, it reached 85% immediately. Three other dogs reached the threshold on the first day, but because too much time elapsed before beginning the second session, they were tested a third time from the beginning on another day and they succeeded.

The procedure was as follows: In the first phase (first 10 trials), the experimenter manipulated the cups and food such that the dog could see that the food was placed on top of the black cup and the white cup was never touched. When the dogs chose the correct cup, they were allowed to eat the food. If they chose the wrong cup, they were shown the food, but were not allowed to have it. The location of the black cup (and therefore the food) was counterbalanced and semi randomized, with the stipulation that it could never be on the same side in more than two consecutive trials. In the next 10 trials (11-20), the dogs observed the experimenter hiding the piece of food under the black cup. The white cup was lifted simultaneously to demonstrate that it remained empty. From trial 21 onwards, the dogs did not witness the manipulation of the two cups and therefore had no direct information about the location of the food. If the dog made the correct choice it was allowed to eat the food. If the choice was incorrect the dog was shown that the cup was empty and where the food was actually located. Twenty dogs passed this pre-test. Twelve dogs met the criterion within the block of trials 21-40 (mean: 37.5) and the other 8 dogs met the criterion in the last block, consisting of trials 41-60 (mean: 50 trials). All 20 dogs were invited to participate on the second day in the next week from the first testing day onwards (min.1 day from warm up; max. 7 days from warm up).

Warm-up with box

Before the first session on the second day of testing started, dogs were required to familiarize themselves with the box, which was identical to that used in experiment 1. The pre-test in this study differed to the pre-test in experiment 1 in that the dogs' memories had to be refreshed to remind them that the black cup contained food as they had learned on the first testing day. The dogs therefore received 20 warm-up trials during which time they could also familiarize themselves with the box. In the first ten trials they could again observe the experimenter hiding the food before making a choice. From the 11^{th} trial onwards dogs did not witness the hiding. In order to finally qualify for the study, dogs had to successfully find food in 8 out of the last 10 trials. All dogs reached this criterion.

General Procedure

The general procedure of the study and the type of gesture used was identical to experiment 1 with the exception that now knowledge/ignorance about the food location was established through the types of cups used. In the knowledgeable conditions I used the black and white cups while during the ignorant conditions I used two grey cups. This resulted in the same four conditions as in experiment 1. The experimenter used a high-pitched voice, saying the German equivalent of: "dog's name, look; look dog's name!" before pointing just as was done with half of the dogs in experiment 1.

The four conditions *Authority leaves - Dog knowledgeable*, *Authority leaves - Dog ignorant, Authority stays - Dog knowledgeable and Authority stays - Dog ignorant* were conducted in the same manner as in experiment 1 with the exception that here, dogs did not witness the hiding process of the food. Counterbalancing, number of trials and timing were all administered in the same way as in experiment 1.

Scoring

As in experiment 1, I scored choice and latency to choose, using the same definitions. I first looked at the mean percentage of trials in which the dogs followed the pointing gesture to the empty cup. An inspection of residuals plotted against predicted values showed no pattern, and I therefore concluded that an ANOVA should be conducted. Again, a second coder coded 20 percent of the original video material for reliability purposes. Reliability for choice was excellent (kappa = 1), as was reliability for latency (Pearson $r = 0.989$).

4.2.3 Results

I conducted a repeated measures ANOVA with the two main within factors "presence of the authority" (present vs. absent) and the dogs' "knowledge of the food location" (knowledgeable vs. ignorant). Again, dogs' knowledge about the location of the food had a major effect on the dogs' behaviour. Dogs followed the pointing more frequently when they had no information about the location of the food than when they did ($F_{(1,19)} = 31.357$, $p < 0.001$) (see fig.9). The factor authority alone had no effect on dogs' performance ($F_{(1,19)} = 0.967$, $p = 0.338$). There was no significant interaction between any of these factors.

To see if there were any learning effects, I conducted a 2 x 2 x 2 ANOVA with the within factors 'authority present' (yes vs. no), 'knowledge of food location' (yes vs. no) and 'half of trials' (first half vs. second half). 'Half of trials' had no effect on any of the other factor as none of these comparisons reached significance. There is therefore no evidence of improvement over time.

In a second step, I examined the latency of choice. An ANOVA with the two main within factors "presence of the authority" (present vs. absent) and the dogs' "knowledge of the food location" (knowledgeable vs. ignorant) revealed no significant effect (authority: $F_{(1,19)} = 3.870$, $p = 0.064$; knowledge: $F_{(1,19)} = 0.125$, $p = 0.728$).

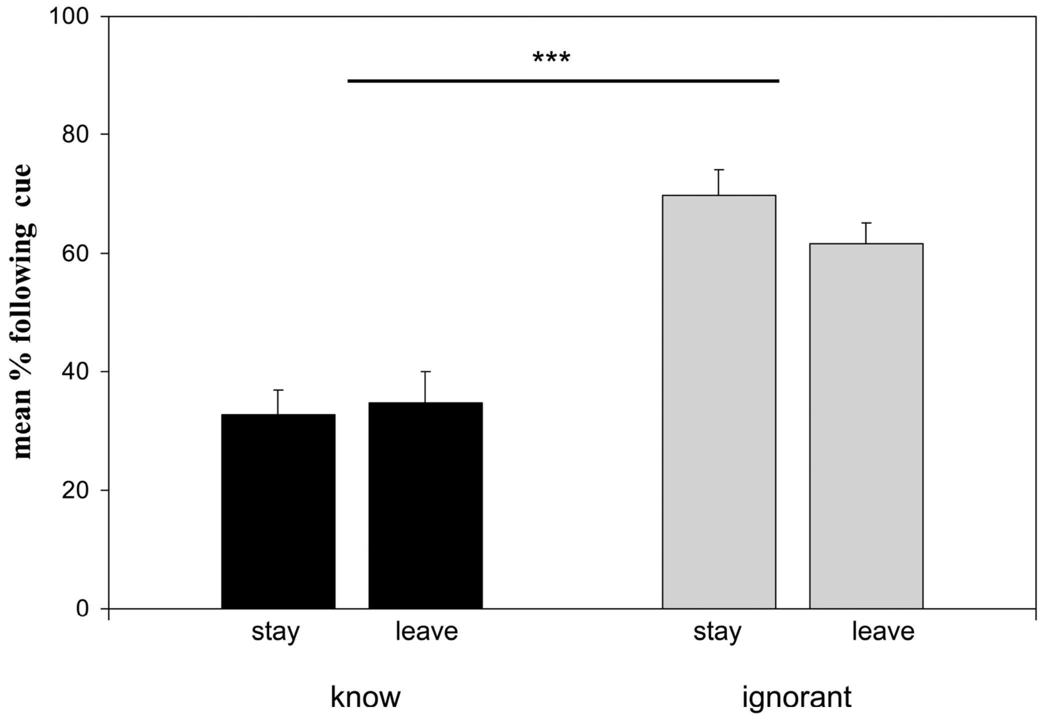

Figure 9: Mean percentage of dogs following the cue (SE) in experiment 2 of study 3. N=48. ***P<0.001.

4.2.4 Discussion

The general results of this experiment are in line with those of experiment 1. Again dogs followed the pointing gesture more frequently when they had no information about the location of the food than when they did. Again, authority had no major effect on the dogs' choices.

This shows that seeing the food and not being able to inhibit a response cannot explain dogs' ignorance of the pointing gesture in situations in which dogs are knowledgeable. More likely therefore is that pointing may not be seen as a strong command.

However, an alternative explanation could be that pointing is interpreted as an associative stimulus and in the situation with conflicting stimuli (pointing gesture and cup colour) dogs simply follow the associative stimulus, which is stronger for them. During the pre-test dogs had to learn that the black cup contained food and the white cup was empty. The only possible mechanism by which they could learn this was by association. This task was obviously challenging, which became apparent from the large number of dogs that could not complete it. Therefore the dogs that had passed this pre-test most likely passed it because they formed a strong association between the food and the colour of the cup.

One could argue, therefore, that the colour of the cup and the pointing gesture are just two stimuli associated with food, of which, if presented in conflict, one (the pointing gesture) is weaker than the other. However, recent evidence clearly shows that the pointing hand is not just seen as an associative stimulus. It is known from studies conducted with six week old puppies that no major learning is required for dogs to follow the human pointing gesture (see Riedel et al. 2008). The puppies in this study were successful in utilising the gesture even though they had to actively move *away* from the hand in order to find the food. The set-up was built up in a way that the puppy was sitting in the middle of two cups. The experimenter therefore had to point in direction of the puppy but either a small distance to the right or to the left of it. To choose a cup, puppies could not simply go into the direction of the human's hand; they needed to turn either to their left or their right side and walk to one of the cups.

As a result, the current findings are interpreted in line with those from the first experiment. I can exclude that dogs in this task understand the pointing gesture as a strong command which they have to follow. They chose to ignore the gesture when they knew about the actual location of the food.

4.3 General Discussion

The current study tested both the command and the information hypotheses. The dogs' strategies suggest that they do not see a human's pointing gesture as a command ordering them to walk in a certain direction. If dogs are presented with cues signalling the location of food, they ignore the pointing gesture directing them to the wrong location, irrespective of the presence of the authority figure.

This suggests that pointing is a gesture that dogs choose to ignore in situations in which they have better knowledge. These results speak against the command hypothesis and therefore are in contrast to the findings of Szetei et al. (2003) in which it was found that dogs would follow the pointing gesture irrespective of their own better knowledge. One reason for this difference could be that the Szetei et al. (2003) study and my study address different modalities. While Szetei et al. (2003) addressed the olfactory and the visual system my study exclusively addressed the visual modality. Seeing food and then following another visual stimulus (the gesture) to an alternative location may be more difficult than smelling the food and then following a cue based in another modality i.e. visual.

Experiment 2 shows that seeing the food being hidden does not have an influence on the dogs' choice. Previous studies showed that the presence or absence of an authority has a strong effect on dogs' obedience. Call et al. (2003) showed that dogs ignore a human's command forbidding them to eat a piece of food as soon as the human leaves the room. However, if the human remains in the room after giving the command, dogs obey and steal significantly less food, especially if the human is fully attentive and looking at the dog - just as in the current study (Call et al 2003, see also Schwab and Huber 2006).The fact that dogs in the current study did not differentiate between situations in which the authority was present or absent may suggest that, for them, following the pointing gesture was different from following a command, where the presence of the authority matters. Therefore, if pointing is perceived as a command, dogs should obey, even if there is a conflict between their own knowledge and the human's pointing gesture. That dogs follow commands (and do so more often when the human stays in the room) even if they have to suppress their motivation to take food is corroborated by several studies (Call et al. 2003, Schwab and Huber 2006). Therefore the most plausible conclusion is that dogs do not perceive pointing as a command.

This conclusion does not necessarily support the information hypothesis. It does not necessarily follow that dogs interpret pointing as an informative gesture, informing them about the location of the reward. Dogs' understanding of others' psychological processes seems to be limited. Dogs are sensitive to a human's attention (Call et al. 2003; Gácsi et al. 2004; Schwab and Huber 2006) and there is evidence that dogs may be sensitive to a human's perspective in a fetching situation (Kaminski et al. 2009). However, dogs do not seem to interpret past events as affecting a human's knowledge (Kaminski et al. 2009) which suggests that dogs are limited to only interpreting present events (see also Topal et al. 2009).

Therefore, instead of interpreting pointing as a means to share information, dogs may interpret pointing as an imperative, telling them where to go. However, the current studies show that they do not do so in a command-like structure, but imperatives can have different levels of authority. An imperative can also be meant as a suggestion, which, in some situations, can be ignored e.g., when one's own knowledge is in conflict with this suggestion.

Further studies have to be conducted to explain how dogs understand the human pointing gesture. The next study aims to gather more information about how dogs do interpret the pointing gesture. Here, instead of manipulating the authority of the experimenter by their presence or absence, I manipulated the experimenter's authority level by the experimenter's age. Adults and children (who are meant to be lower authoritative humans for dogs) participated in the following study.

5. Study 4

5.1 Introduction

The fourth study tested again both the command hypothesis and the information hypothesis. Previous studies testing dogs in object-choice tasks were performed via an experimenter pointing for dogs to a hidden food location. Sometimes the experimenter was their owner (e.g. McKinley and Sambrook 2000) and sometimes the experimenter was not their owner (e.g. Hare and Tomasello 2005). Miklósi et al. (1998), for example, tested dogs both in conditions with their owner and in conditions with a familiar experimenter and found that dogs did generalize from one person (owner) to another (familiar experimenter) in following the given cues. However, other studies have revealed owner-stranger effects in object choice task (Elgier et al. 2009a). In all studies, the experimenter, whether the owner or a stranger, was an adult. One could assume that in the case that dogs do understand the pointing gesture as command, they would make no difference in their point-following behaviour between different adult experimenters. There is evidence that dogs do generalize clear verbal commands from one trainer to another (Scharrer et al. April 2010; October 2010).

In the current study, the authority of the person pointing was varied. Sometimes this person was an adult human and sometimes a child, whom dogs consider less of an authority (e.g. Brogan et al. 1995; Sacks et al. 1996; Schalamon et al. 2006). If dogs interpret pointing as a command, I expected dogs to differentiate between those situations in which an adult and those in which a child pointed because following a command from a human with higher authority should be more relevant for dogs. If they perceive pointing as an informative gesture they should follow both adult and child to the same degree since level of authority would not play a role in this situation.

The assumption that dogs consider dogs to be lower in authority status than adult humans is only inferred from studies about dog bites (e.g. Sacks et al. 1996) since there is no study, to my knowledge, which addressed this hypothesis directly. Sacks et al. report from an evaluation of a survey that children had 3.2 times higher medically attended bite rates than adults in their sample. This leads to the conclusion that dogs see children as lower authoritative humans to whom they are not as obedient in comparison to adults. In the second experiment of study 2 I addressed the question about dog’s perception of children as lower authorities more directly.

5.2.1 Experiment 1

There is little factual evidence for the assumption that children are considered to be lower authorities for dogs. Only studies of dog bite incidents speak for this idea since children are at higher risk of being bitten by dogs. This could be due to reasons other than dogs seeing children as lower authorities, such as children's unsafe handling of the dogs or incautious touching of body parts with which dogs are not comfortable and which is not in young children's knowledge. However, many authors of applied dog behaviour and training write about being careful in situations where dogs and children meet because dogs would not regard children as high ranking figures (e.g. Ohl and Endenburg 2007; Schmidt-Röger 2008). Their warning is not based on specific experimental studies in this field which originally test this hypothesis, but rather from personal experience working as dog trainers (Ohl, personal communication). The little knowledge we have seems to support the idea that dogs do not consider children as high authorities.

To ensure that the dogs did distinguish between commands coming from an adult or a child, I first ran an experiment in which I tested the dogs' reaction to a command ("Sit") coming from a 4.5 - 5-year old child or an adult. Dogs and experimenters were invited to participate in this study.

5.2.2 Methods

Subjects and Experimenters

Twelve dogs (6 males, 6 females) of various breeds and ages (*M* = 6.25 years, range: 1.5-13 years) participated in this study (see tab. 5). All dogs lived as pets with their owners and were tested at the Max-Planck Institute for Evolutionary Anthropology (MPI EVA). All dogs had received the training typical for pet dogs. The owners were registered in a database of the MPI EVA and had agreed for their dogs to participate in the study. The pre-conditions for participation were that the dogs had to be food motivated and comfortable remaining in the testing room without their owner. Dogs could only take part in the study if they had never lived with children aged 0-10 years. Six naive pairs of experimenters (mother-child dyads) were recruited to participate in this study (children: 4 boys, 2 girls). A precondition was that neither mothers nor infants had had major contact with dogs before, e.g., as a pet etc.

Procedure

The study was conducted in a quiet room (4m x 3.8m) at the MPI EVA. For safety reasons, children and adults were separated from the dogs by a Plexiglas wall (length 4m, height 1.80m). The dogs were led into one compartment of the room through a door coming from the backyard of the building. The experimenter entered the other compartment though a door leading from the inner hallway of the building.

Six adult-child pairs acted as experimenters. Each pair of experimenters tested 2 dogs. Each dog received 8 trials; 4 with the child as the experimenter and 4 with the adult. Half of the dogs started with the adult as the experimenter and the other half started with the child as the experimenter. To ensure that dogs could hear the vocal command through the Plexiglas partition separating the experimenter from the dog, we cut 8 holes (diameter 5 cm) into the middle of the partition in a vertical line.

The procedure was as follows: the dogs were allowed to move freely, with no other person present. Then the experimenter (child or adult) entered her side of the room, went to her designated location and remained there with her hands close to her body. She/he looked at the dog, caught the dog's attention by calling its name and then commanded the dog to sit ("Sitz"/"Sit"). The command was given once after which the experimenter waited for a helper to enter the room and to guide the dog out. This occurred 7 seconds after giving the command. The dogs were not been rewarded for any behaviour.

Scoring

I coded the dogs' behaviour after the experimenter gave the command with regard to whether the dog obeyed the command or not. The response was counted as "sit" when the dog's hind quarters rested on the ground while it kept its forelegs straight. A second coder coded 20 percent of the original video material for reliability purposes. Reliability was excellent (kappa = 1).

5.2.3 Results

I looked at the mean percentage of trials in which dogs followed the command to sit. Dogs followed the command significantly more often in the adult-condition (M = 58.3, SD = 37.4) than in the child-condition (M = 20.8, SD = 20.9) as demonstrated by a paired sample t-Test ($t(11) = 5.7$, $P < 0.001$) (see fig. 10).

In some trials, children had difficulty following the instructions for the procedure and therefore it is doubtful whether these trials can be considered valid. For example, on some occasions, children could not inhibit saying the command twice when the dog failed to obey it the first time. Even ignoring these trials and instead conducting a more conservative analysis, a paired-samples t-test still shows the same pattern. Dogs do follow the adult-given command significantly more often (M = 62, SD = 40.8) than the child-given command (M = 21.3, SD = 24.3), $t(8) = 5$, $P = 0.001$, $d = 1.7$).

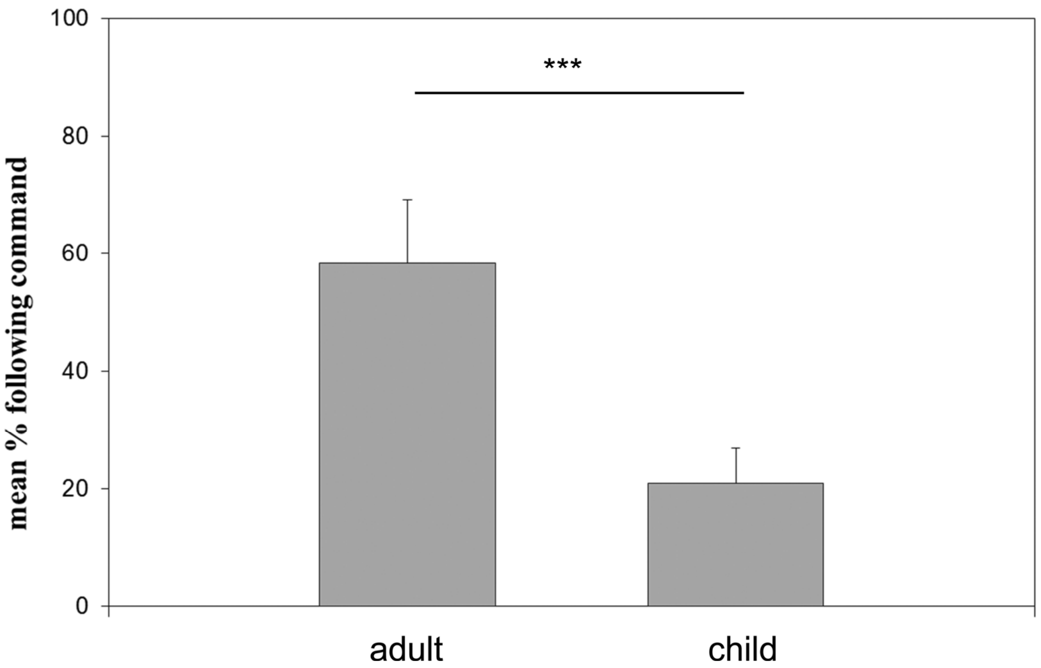

Figure 10: Mean percentage of dogs following the experimenter's "Sit" (SE) command in experiment 1 of study 4. N=12. ***P<0.001.

5.2.4 Discussion

In this experiment dogs clearly differentiated between a "sit" command coming from an adult compared to the same command coming from a 4,5-5-year-old child. This result confirms the general assumption that dogs do see human children as lower authorities than adult humans (e.g. Brogan et al. 1995; Sacks et al. 1996; Schalamon et al. 2006). Consequently, they follow commands more reliably when they are given by adults. Why dogs exhibit this difference needs to be discussed. First of all, one can argue that dogs are usually taught or trained by adults. Therefore dogs are used to following commands from adult humans. While there is evidence that dogs are able to generalize commands from one adult trainer to another adult trainer (Scharrer et al. April 2010; October 2010) to my knowledge there is no study testing dogs in situations where *children* give commands to dogs. To test for this "adult trained" hypothesis in more detail, one would have test dogs that had also been trained by children (or at least younger adults) to compare their obedience behaviour with that in situations with adults.

Another explanation for dogs' behaviour in the current study is that the different voices of both experimenter types lead dogs to differentiate between adults and children. To test for this possibility one would need to conduct this study with recorded voices. If dogs would differentiate between their response behaviour then one could argue that the different voices were the crucial factor for dogs to follow adult commands over children given commands. For now, the current findings support the assumption that dogs do see children as lower authorities than adults. The reason why dogs see children as individuals being lower in rank needs to be the object of further studies. This study should really be seen as starting point for future studies to investigate in more detail whether dogs see children as lower in authority status than adult humans. However, it does show that in a clear command-like situation, dogs do not show as much obedience behaviour towards children as they do towards adults in the same situation. This result provided the basis for the second experiment of this study, which tested dogs in an object choice paradigm in situations where an adult human points for the dogs to a hidden food reward in contrast to children pointing for the dogs. Here, the prediction is that if the command hypothesis is true, dogs should follow the pointing gesture more often if it is coming from a person with a normal level of authority, compared to a person with a lower level of authority. If, however, the information hypothesis is correct, then there should be no (or only little) difference between how often dogs follow the pointing gesture of adults and children.

5.1.1 Experiment 2

In this study I varied the level of authority of the human giving the pointing gesture. Sometimes the person pointing was an adult human (always female) and therefore an individual with a normal level of authority for the dogs. Sometimes the person pointing was a four-and-a-half to five year-old child (female or male), with a lower level of authority for the dogs (as demonstrated by the previous experiment).

5.1.2 Methods

Subjects

Twenty two dogs (12 females, 10 males) of various breeds and ages (M = 3.5 years, range: 1.5-9 years) participated in this study and their data was analysed. Two additional dogs had to be excluded subsequently from the analysis because, after coding the data, I recognized that there were some experimenter faults throughout all conditions for these dogs. Seven additional dogs had to be excluded before the study started for various reasons (e.g. because they could not remain in a room without their owner). Their data were not included in the analysis either. All dogs lived as pets with their owners and were tested at the Max-Planck Institute for Evolutionary Anthropology (MPI EVA). All dogs had received the training typical for pet dogs. The owners were registered in a database of the MPI EVA and had agreed for their dogs to participate in the study. The pre-conditions for participation were that the dogs had to be food motivated and comfortable remaining in the testing room without their owner. Dogs could only take part in the study if they had never lived with children aged 0-10 years. I recruited twelve mother-child pairs as experimenters. A precondition was that neither mother nor infants had had major contact with dogs before, e.g. as a pet etc. The children (8 girls, 4 boys) had a mean age of 4.9 years (age range: 4.6 – 4.9 years).

Materials

The study was conducted in a quiet room (4m x 3.8m) at the MPI EVA. For safety reasons, children and adults were separated from the dogs by a Plexiglas wall (length 4m, height 1.80m). Two opaque (white) plastic cups were used (height 9cm; bottom-diameter 8cm; top-diameter 5cm) to hide the food. The two cups were placed on a wooden board (1.80m x 0.30m) lying on the floor with a distance of 1.30m between them. Cups were placed on the dogs' side of the barrier. The distance between dog and each cup was 2.10m. The experimenter stood on a marked spot 2.40m away from the dog and 50cm away from the middle of the Plexiglas-partition and therefore 1.0m away from each cup (see fig. 11 and fig. 12). Recordings were made with two cameras (both a Panasonic NV-GS180).

Figure 11: Experimental set-up of study 4. Condition: adult-no gaze.

Figure 12: Experimental set-up of study 4. Condition: child-no gaze.

Warm-up (dogs)

Each dog participated in a warm up to make sure they were familiar with the general procedure. The experimenter stood between the cups (without the Plexiglas-wall) facing the dog, held by a second person (helper). Then the experimenter placed one piece of food on top of one of the two cups. The helper released the dog and it was free to make a choice by either touching one of the cups with the muzzle/paw or approaching it within a distance of 10 cm. If the dog made the correct choice they got the reward. In the case of a wrong choice, the dog was shown the reward, but was not allowed to eat it. The same procedure was repeated for the other side. This was continued until the dogs made correct choices over 4 consecutive trials. I considered the criterion to be sufficient for ensuring that dogs made the connection between food and the cup. I did not want dogs to complete more trials than necessary for motivational reasons.

Warm-up (experimenters)

The children and their mothers also had to participate in a warm-up to familiarize them with the general procedure. The whole process was presented to the children as a searching game in which the children had to help the dogs find the food. Children were told that they were only allowed to help the dogs with their eyes and by pointing and without any form of vocalization whatsoever.

General Procedure

At the beginning of each trial the experimenter (either child or adult) entered the testing room and positioned themselves at the predetermined spot. Then the helper baited one of the cups with a piece of food, while being watched by the experimenter. Sometimes the children were asked again, before the dog entered the room, how they would help the dog find the food (to remind them of the condition). Then the helper left the room to fetch and guide the dog to its position. After positioning the dog on the predetermined spot the experimenter (child or adult) began pointing at the baited cup. The dogs then received one of four possible conditions:

***Adult pointing + Gazing*:** The adult human alternated pointing and gazing. After establishing eye contact with the dog, the adult pointed (distal pointing) to the baited cup with the outstretched ipsilateral-arm and index finger. Then the adult pointed three times and left the arm and finger outstretched in a motionless position directed at the baited cup until the dog made its choice. The gaze of the experimenter always accompanied the pointing direction of the finger, which alternated between the dog and the baited cup. The adults were asked to touch their nose between pointing sequences. This was to ensure their gestures conformed to the children's gestures (see below).

Adult pointing: Here the procedure was the same as that in the "Adult pointing + gaze alternation" condition except that the experimenters retained eye contact with the dog throughout the trial until the dog made its choice rather than looking at the baited cup and then back at the dog.

Child pointing + Gazing: This procedure was identical to the adults' procedure. To help the children with the pointing procedure, children were asked to touch their nose with their finger between pointing sequences.

Child pointing: Again the procedure was identical to the "Child pointing + gaze alternation" procedure except that now the experimenters kept eye contact with the dog throughout the trial until the dog made its choice.

After each trial, the helper and the dog left the room and the next trial was prepared. Each "mother-child pair" tested two dogs and, following a within dog design, each dog received each condition. Each dog received six trials in each condition, resulting in a total of 24 trials altogether. Some trials had to be repeated (12.7% of total trials) because of experimenter errors. This was especially true when the experimenter was the child. 19.3% of all child trials had to be repeated (for adult trials it was 6.1 %). The experimenter type was blocked; that is, half of the dogs started with the adult experimenter while the other half started with the child experimenter. Trials with and without gaze alternation were given in blocks with the stipulation that half of the children and half of the adults started with gaze alternation and the other two halves started without gaze alternation.

Scoring

I coded the dogs' choice behaviour. It was scored as a "correct" response if a dog chose the cup to which the experimenter was pointing. If the dog chose the other cup, it was scored as an "incorrect" response. A choice was considered to have been made if the dog approached one of the cups to within a distance of at least 15cm. If the dog chose correctly, it was allowed to eat the food. If the dog chose incorrectly the helper showed the dog that the cup was empty and it was not allowed to eat the food from the other cup. The dog was prevented from investigating the other cup by holding its collar and guiding it out of the room. If a dog did not choose at all it was scored as a "no choice". These trials were excluded from the analysis and therefore we had to calculate in percentages. A second coder coded 20 percent of the original video material for reliability purposes. Reliability was good (kappa = 0.872).

5.1.3 Results

I examined the mean percentage of the dogs' correct choices in the four different conditions. I conducted a repeated measurement ANOVA with the two within factors authority (mother vs. child) and gaze alternation (yes vs. no) and the between dogs factor mother-child dyads. The between factor mother-child dyads had no effect on any of the within factors and there was no main effect of dyad ($F_{(1,10)}$= 0.653, p = 0.745).

I therefore collapsed all data and re-ran the ANOVA. Authority had no effect on the behaviour of the dogs ($F_{(1,21)}$= 0.403, p = 0.532), neither did the use of gaze alternation ($F_{(1,21)}$= 0.387, p = 0.541) and there was no interaction between the two factors authority and gaze alternation ($F_{(1, 21)}$= 0.977, p = 0.334).

To see if order of blocks had an effect on the dogs' behaviour I conducted another ANOVA with the two within factors authority (mother vs. child) and gaze alternation (yes vs. no) and the between dogs factor first experimenter (mother vs. child). This showed that dogs differed in their behaviour with the child and the adult and that this difference depended on the order in which they received the trials as there was an interaction between the within factor authority and the between factor first experimenter ($F_{(1,20)}$= 0.008, p = 0.050). A post-hoc pair-wise comparison showed that dogs only behaved differently with the child or the adult in the group of dogs that received the adult trials first (t(10)= -2.736, p = 0.021). Dogs improved over trials in these cases and were better in the second half compared to the first.

To test whether dogs were improving over trials in general, I compared the first half of trials with the second half irrespective of authority. I found that dogs were better at finding the hidden food in the second half of trials compared to the first half (paired sample t-test; $t(21) = -2.069$, $p = 0.051$). The dogs chose the correct cup above chance level in all of the four conditions (one sample t-test: *Child, no-gaze*: $t(21) = 19.250$, $p < 0.001$; *Child, gaze*: $t(21) = 15.937$, $p < 0.001$; *Adult, no-gaze*: $t(21) = 11.981$, $p < 0.001$; *Adult, gaze*: $t(21) = 14.183$, $p < 0.001$) (see fig 13).

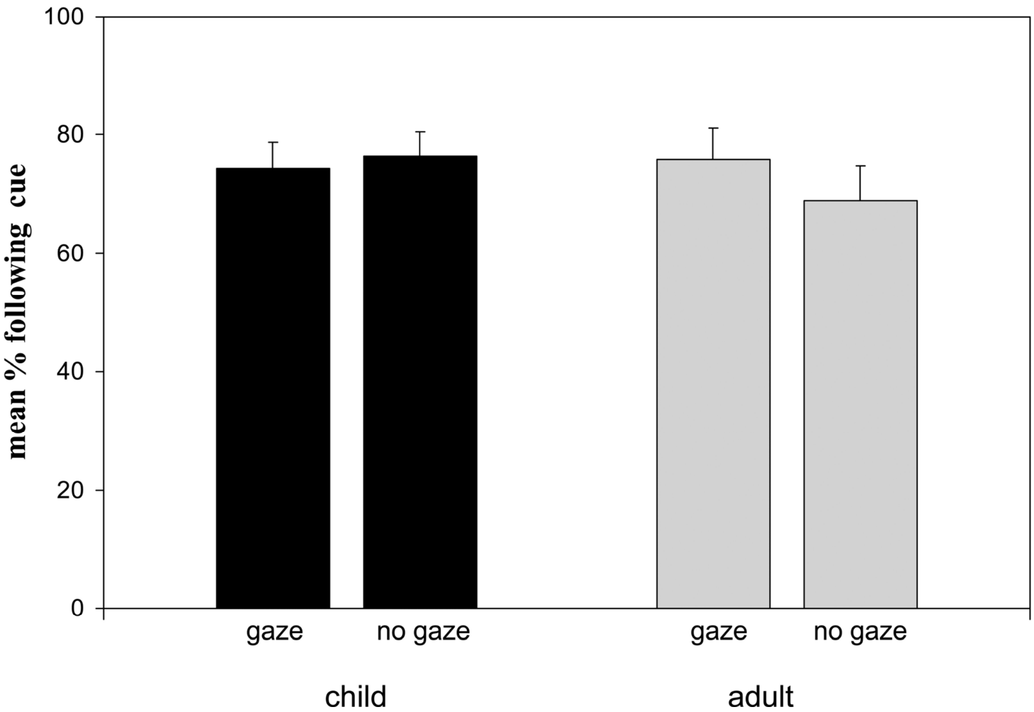

Figure 13: Mean percentage of dogs following the cue (SE) in experiment 2 of study 4. N=24.

5.1.4 Discussion

In this experiment, dogs responded to human pointing irrespective of whether the person pointing was an adult or a child with less authority. Thus, these results speak against the command hypothesis. If the command hypothesis is true and dogs were interpreting the pointing gesture as command, I would have expected dogs to differentiate between adult and child trials. It would be more relevant to follow a command given by a human with higher authority status than commands given by a human with lower authority status, namely a child.

5.3 General Discussion

This study has two findings. First, I found clear experimental evidence that dogs react differently to commands from adults than to commands from children. In the first experiment, the dogs largely ignored the command when it was given by a 4,5-5-year-old child. Second, the dogs did not differentiate between children's and adults' pointing gestures. The dogs followed the pointing gesture in the second experiment and found the food irrespective of the authority level of the person pointing. This suggests again that dogs do not seem to interpret pointing as a strong command comparable to a command like "sit". Therefore results speak against the command hypothesis as an explanation for dogs' response to the pointing gesture.

Dogs in the second experiment chose above chance level in all four conditions. They could solve the task from the beginning, but they improved at finding the hidden food in the second half of the trials. Therefore, dogs improved over time and authority had no effect except in those trials in which the first experimenter was the adult. However, in that group, dogs even performed against the hypothesis: they were significantly more successful at using the pointing gesture when it came from the child rather than the adult. One explanation for this could be that because the children occasionally found it difficult to perform the pointing gesture, more trials had to be repeated. However, it clearly shows that the level of authority of the person performing the pointing gesture does not affect dogs' performance. An important future study would be to see how dogs react in conflicted situations, e.g. children and adults point to the empty cup and dogs are aware of the true location of the food, namely the not pointed-to cup. If the command hypothesis is true, dogs would follow the gesture of the adults more persistently than the gesture given by a child. They would ignore their own knowledge (i.e. the true location of the food) in order to follow the command of the experimenter. When the experimenter is a human with higher authority (i.e. and adult rather than a child), the dogs should follow the command more often, in spite of their own better knowledge. However, the results of study 1 in this thesis showed that dogs in an object choice task with an adult person pointing to an empty cup dogs will ignore this gesture and choose the full cup according to their knowledge of the true location. However, this has not been tested with children as experimenters so far.

In contrast to the findings of experiment 2 of study 4 in this thesis, dogs clearly differentiated between a "sit" command coming from an adult compared to a command given by a child. Dogs showed significantly more obedience behaviour towards the adult human and did not follow children's commands to the same extent. This finding supports the general assumption that, for dogs, children are not seem to be humans with high authority status who's commands need to be followed. Further studies need to be conducted to investigate what exactly lead dogs to behave differently in both situations. For example, a dog's individual training experiences could play an important role. The difference in dogs' behaviour could also be due to bodily differences in children and adults (e.g. different voices) behaviour.

6. General Discussion

The studies presented here investigated social cognitive abilities of domestic dogs (*Canis familiaris*) in pointing and command studies. Dogs are known to be very skilful in using human given communicative cues (e.g. Agnetta et al. 2000; Hare et al. 1998; Miklósi et al. 1998). The present studies were conducted to gain insight about *how* dogs do understand human communicative cues, in particular the pointing gesture.

Two hypotheses were tested: the command hypothesis and the information hypothesis. The command hypothesis is based on the assumption that dogs understand the human given pointing gesture (or at least parts of it) as an instruction (command) which they have to follow. The information hypothesis assumes that dogs understand the pointing gesture as pure information, which is given by a human to inform them about a third entity in the environment. This would require higher-level mechanisms than the command hypothesis as one prerequisite for understanding communicative cues as informative is to be able interpret others' intentions in communicative interactions. This would be similar to how humans interpret those cues.

The experimental paradigm to test these hypotheses used the most in the studies within this thesis was the object choice paradigm, where a human hides food (or objects) in one of two cups and later marks one of the cups communicatively. Most often the experimenter uses a point to mark one of the cups and the dog is then free to make a choice.

Study 1 investigated dogs' behaviour when a human pointed to an empty spot on the ground. The question here was whether dogs would follow this gesture 'blindly' or whether (previously established) different contexts would influence their behaviour. Another question was whether dogs would behave differently in trials in which the human uses an informative (high-pitched, friendly) voice when addressing the dog in contrast to using an imperative (deep, command-like) voice. Results showed that dogs clearly differed in their behaviour between the two contextual backgrounds. One group of dogs found a piece of food on the ground prior to the experimental trials (context); the other group did not find anything (no context). Dogs searched more often in the direction of the pointing gesture when they had experienced a food context prior to testing. Another finding was that dogs would search more often in trials in which the experimenter addressed dogs in an informative way. They were more inclined to sit or lay down when the experimenter spoke in a deep voice. Results favour the idea that, in dogs generally, higher level mechanisms are at work when utilizing the human given pointing gesture and speak against a purely associative account. This gives reason to test for the possibility of higher-level mechanisms in the point following behaviour of dogs. Therefore the command hypothesis and the information hypothesis were tested in the following studies.

Study 2 investigated dogs in an object choice task that contained their favourite toy. Dogs were divided into four groups. These four groups differed in that they were each introduced to an experimenter who exhibited different characters. For one group of dogs, the experimenter was an authoritative human, for the other she was non authoritative, for the third group she was reliable and for the last group she was unreliable. In the object choice task that followed these presentations, dogs did not differ in their behaviour in the four groups. They followed the pointing gesture above chance level and to the same degree with no difference between conditions. Thus, dogs did not seem to consider a human's attitude as important for their behaviour in an object choice task. Results could not find support for either of the hypotheses (the command hypothesis or the information hypothesis). Possible follow-up studies are discussed, which attempted to reveal differences in dogs' behaviour.

Study 3 showed that dogs rely on their own (sometimes better) knowledge in an object choice task when they are in a conflicting situation in which a human communicates the wrong (i.e. the empty) hiding place of hidden food. When dogs did not have information on where the food had been hidden, they relied on the human's gesture. The second experiment in this study showed that this pattern did not change, even when dogs were prevented from seeing the food being hidden in general. Thus, parts of study 3 established that dogs did not process the human pointing gesture as a strong command that they do have to follow in every instance. Dogs are able to ignore the gesture when it would lead to a disadvantageous outcome for them. These results contradict the command hypothesis but do not necessarily favour the information hypothesis. Some prerequisites for understanding the human pointing gesture as information that is helpfully and intentionally provided by the human have not been revealed in dogs so far and studies provide contradictive evidence.

Study 4 addressed the question of how dogs distinguish between experimenters with different authority states (child vs. adult), again using an object choice task, but also incorporating a command task as a validation of the underlying assumptions of the study. The first experiment of Study 4 tested whether dogs would follow a verbal command from a human child to the same degree as if the command came from a human adult. During the study, dogs were not rewarded for their response behaviour to a “sit” command from the human. Results showed that dogs behaved differently with following the adult-given command significantly more often than the command coming from the child. This result supports the general assumption that dogs do not see children as high authorities compared to adults. This fact was then used to establish the second experiment of study 4. The second experiment revealed that dogs did not distinguish between a child and an adult pointing out the correct location of a hidden food treat for them. This was despite the established relationship from the first experiment that children are less authoritative for dogs than adults are. The hypothesis that the understanding of the gesture is an imperative one - not supported here - maintains that dogs would not follow the child gesture to the same extent as they would in cases of the adult. Thus, under the command hypothesis, dogs should follow human adult pointing more than the pointing of children. Since, in this study, dogs followed both types of experimenters (adults and children) to the same degree, it suggests that authority did not play a crucial role in the dogs’ choice to follow the gesture. Thus, Study 4 did not support the command hypothesis for pointing, but again this does not necessarily favour the information hypothesis due to the reasons mentioned above. In the following each of the four studies will be discussed in more detail.

The results of the first study contradict a pure associative account in dogs’ point following behaviour. Dogs responded flexibly depending on a contextual background to a human-given pointing gesture to an empty spot. If the hand of the human was associatively connected to a reward, then dogs were expected to follow the gesture in any case and respond with the same behaviour. This was not the finding of this study. Additionally, the tone of voice of the experimenter did have an influence on dogs’ behaviour. Dogs behaved differently depending on the voice of the experimenter, which suggests some additional flexibility in their response behaviour. Only a few studies to date have tested how dogs would behave if an experimenter gave cues to an empty spot. For example Agnetta et al. (2000) tested dogs in a gaze-following task where a human experimenter attempted to direct the dog’s gaze to one of three predetermined locations (straight up, directly to the left or directly to the right of the dog) by turning her head and looking at that location for approximately 5 seconds. A response was measured as looking at the three possible target locations or elsewhere (e.g. at the experimenter). Dogs were not rewarded for any behaviour. The results showed that dogs do not reliably follow human gaze in such non-food related situations. This is in line with the observed behaviour in the no context trials in the current study. Indeed, dogs followed the direction of the gesture in these trials but did not search for the food to that extent that they did in the context trials. The assumption therefore is that dogs did not expect a referent to be found in the no context trials. In another study, Soproni et al. (2001) found that dogs did not follow a human’s gaze direction to an empty location above a target object. The experimenter used directional gaze and head nodding cues either indicating the object directly or an emtpy spot above the object. Their study was conducted using a two-way food choice task. Results showed that dogs were not able or not motivated to follow the cue with no referential component (target object). It seems that dogs need the accompanying referential component (object referent) to fully understand the communicative intention behind a human’s cue. Thus, for dogs it seems that communication in this setting needs to be about a referent. The mere presence of food in the commuinicative situation does not seem to change this finding.

This suggests that gazing and poinitng are not cues used by dogs simply because they are based on an association with the presence of food. Both of the afforementioned studies investigating dogs’ response to gaze cues were conducted to find out how dogs understand a human’s attentional state that is directed to different targets. They did not specifically investigate dogs’ comprehension of intentiaonally communicative human cues . There is evidence that dogs are able to differentiate between unintentional and intentional gestures (Kaminski et al. submitted). It could also be that dogs did not react so much to the gaze cues because there was no signs of intentionality in the human’s gesture. However, it is clear from these studies that dogs react to human cues when there is reason to do so and this shows again how flexible this behaviour is. behaviourIt cannot be explained by pure association.

Study 2 supports the idea that the authoritative status of the experimenter is not an important factor for dogs’ point-following behaviour. In this study, dogs experienced two different phases. In the first one, the establishment phase, each group of dogs was exposed to a human with a different character trait (authoritative, no authoritative, reliable and unreliable). In a second phase, the object choice phase, dogs were exposed to an object choice task in which the same human from the establishing phase) was pointing to a hidden toy for them. An explanation for the result that dogs did not differentiate between the four conditions (built up from the establishing phase) might be that dogs perceived the establishing phase as not connected to the object choice phase even though the same experimenter was present in both situations. Support for this idea is given in a study by Bradshaw et al. (2009). Here, the authors emphasize that “dominance” is not a fixed character trait in dogs; it is rather a characteristic which determines relationships both between pairs of dogs and between dogs and their owners. In the current study, "authority level" can be equated with "dominance status". It could be that the past event (establishing phase e .g. experiencing the human being authoritative) is not important for dogs in the following object choice task.

Furthermore, to participate in the object choice task dogs had to pass a warm-up phase. This was conducted in a cooperative way and dogs could simply have "forgotten" about the attitude of the experimenter in the establishing phase because it was not relevant in this clearly cooperative situation. Dogs also did not differentiate between a reliable and an unreliable human, which supports the previously mentioned idea. They clearly stopped searching for the toy in the unreliable condition in the establishing phase but they participated in the object choice task, presumably because this is not connected to the past experience.

A logical follow-up to this study would be to bring dogs into a conflicting situation. The experimenter would not point to the correct box, as was implemented in this study, but instead would point to the incorrect (empty) box with dogs witnessing the hiding procedure. Then dogs would be in a conflicting situation and the need to decide to follow or ignore the gesture would be higher than in the current study. This method might reveal differences in dog's behaviour more easily that the current method used.

The results of Study 3 tested dogs in situations where their knowledge state and the human's authority level were manipulated. Dog's behaviour in this setting contradicts an understanding of the pointing gesture as a strong command in dogs and thus goes against the command hypothesis. If they were interpreting the gesture in a command-like and instructive way, the dogs should have followed the gesture even in those cases where knowledgeable about the correct location of the food. It could be that dogs did not consider the gesture to be a command because the gesture in this study was not retained by the experimenter during the time it took dogs to choose one of the cups. If the gesture was ever acting as a command for the dogs, it was no longer present when the dogs made their choice. Conversely, when commands are given to dogs verbally, they are also no longer "present" when dogs follow them - dogs respond to them *after* the word is spoken. Therefore there may be no reason to believe that the pointing gesture – as a command - alone needs to be present for dogs to follow it. However, there is some evidence in this direction from a study by Kundey et al. (2010) who showed that dogs were more inclined to follow a static pointing gesture to the empty cup even when they had visible access to the food in the container of the baited cup. Thus, when the human used a momentary gesture dogs chose the baited cup more often.

Could it therefore be the case that a static point has more of an imperative character than a momentary one? This may be a premature conclusion, since Szetei et al. (2003) has found that dogs would also follow a brief momentary gesture to an empty cup even if they have knowledge about the correct food location. In summary, the question of whether the command structure of a point depends on its presentation time in relation to choice is currently not fully answered. What is clear, however, is that dogs in Study 3 did not behave as if they understood the pointing gesture as command. Additionally, the result that dogs ignored the pointing gesture in situations in which they witnessed the hiding process (and therefore knew about the correct location) is in line with results from Erdöhegyi et al. (2007). These authors also found that dogs in an object choice task used direct visual information (i.e. they could see where the food is hidden) to choose between two possible locations of food, even when that information was competing with a social cue (e.g., gaze). When there was no direct information about the food location, dogs preferred the cup marked by the human. One possibility is that seeing the food being hidden in the "knowledgeable" trials was too strong a stimulus. The dogs might not be able to inhibit a response to this information (choosing this factually baited cup) regardless of any gesture being given at the same time or before. The second experiment of Study 3 addressed this possibility. Here, dogs learned prior to testing that a black cup (in contrast to a white cup) always contained the food. Therefore it was possible to test dogs in the same setting as in the first experiment except that dogs did not witness the baiting process directly. The indication of the food was therefore indirect, coded by the colour of the cup. In the conditions corresponding to the case in which dogs had knowledge about the food location they were now confronted with a black cup (i.e. baited) and a white cup while the experimenter always pointed to the white (empty) cup. However, results showed the same pattern as in the first experiment. Dogs followed the gesture in cases where they did not know where the food was hidden (two grey cups, an additional control condition). In the main test, they also relied on their own knowledge in cases where they still knew (albeit indirectly via the colour code) the correct food location, since they knew that the black (and not pointed-to) cup contained the food reward.

One could also argue that, having learned the association between the black cup and food, dogs were heavily conditioned to choose the black cup. The pointing gesture as another stimulus may have been too weak to override this pull. But for the gesture to be an associative cue, one would predict dogs to choose the black cup in 100% of those trials in which dogs knew about the food location. This was not the case. Dogs did not choose the black cup more than dogs in the respective condition in the first experiment where no learning was conducted prior to the test trials. Therefore the explanation that the pointing gesture could be an associative cue is rather unlikely. The results showed the same pattern as in the first experiment. Importantly, in the first experiment dogs were not previously exposed to an association task about the location of the food. Therefore the possibility that dog's behaviour was based on associative mechanisms is, again, rather unlikely. It might be that in the first experiment, the gesture was seen as a discriminative stimulus which was followed based purely on associative learning. If true, this would support the association hypothesis and dogs would have only chosen the baited cup (where the human was not pointing at) because seeing the food being hidden was a stronger stimulus than the gesture. While this would seem a credible alternative hypothesis, there is strong evidence against this view, i.e. against the view that dogs perceive the pointing gesture simply as discriminative stimulus (Riedel et al. 2008).

Further, the results of study 1 of this thesis support the idea that low-level mechanisms like associative learning do not play a major role in dog's point following behaviour.

Dogs in the first experiment of study 3 did not distinguish between trials where the experimenter was present in the room or absent from it. If dogs understood the pointing gesture as a command, they would be expected to differentiate between those two conditions. Thus, this finding did not support the command hypothesis. Other studies have shown that when humans give a clear command to dogs and then leave the room (or else stayed and merely close their eyes) dogs take the food more often compared to situations in which the human is present and attentive to them (Call et al. 2003; Schwab and Huber 2006). But since dogs did not regard human's presence or absence as relevant in the set-up of my first experiment of study 3, this is further evidence against the command hypothesis. In summary, there is little support for the command hypothesis in study 3. Again, this does not necessarily lead to the conclusion that the information hypothesis is true as factual support for this in other studies is lacking.

The results of study 4 suggest that dogs do not differentiate between a child and an adult pointing to a hidden food location in an object choice task. This result is in line with that of study 3. Dogs do not seem to understand the pointing gesture as a strong command. If the command hypothesis were correct, dogs should have followed the pointing gesture of the adult more than the pointing gesture from the child, since children are meant to be perceived as lower authorities in dogs. The expectation was that dogs would rather ignore and not choose any cup in the trials involving children compared to the adult trials, based on the discrepant authorities. Alternatively, it is also not wrong - or disadvantageous - for dogs to follow the pointing of the children even if they are not considered to be a high authority. The reason is that it was to their own advantage to follow each point since dogs always found food under the pointed-at cup. Thus, there was no conflicting situation for them. A logical follow up condition would be to introduce a disadvantage to the dogs to follow points. Here, the experimenter (adult or child) would always point to the empty cup, with dogs previously having witnessed the baiting process. If dogs regard the pointing gesture as a command then they should then follow adult points more than child points. A potential problem here is that study 3 has already established that dogs tend to ignore even adult deceptive points. Yet, all that would be needed for this extension to the study is different levels of ignoring points between adult points and child points and, for this, the dog behaviour may still be variable enough. Other studies have successfully shown that dogs differentiate between their owner and an unfamiliar experimenter in this kind of task (Elgier et al. 2009a).

As part of the procedure of study 4 involved the assumption that children are less authoritative than human adults for dogs, this was tested by me in a different paradigm. In the first experiment of my fourth study, it was successfully shown that dogs clearly differentiate between an adult and a child giving a “sit” command. Dogs were more inclined to follow the command coming from the adult than the same command coming from a 4,5-5-year-old child. This result supports the generally accepted idea that dogs do not see children as high authority humans (e.g. Brogan et al. 1995; Sacks et al. 1996; Schalamon et al. 2006). Yet, why exactly dogs followed the adult’s command more often than the children’s command in this experiment needs to be investigated in future studies. One hypothesis dictates that human children are indeed less authoritative for dogs than are human adults. How they perceive this is currently not altogether clear. They may use correlated cues, for example. It could be, therefore, that dogs acted based on the difference of the voice of a child as compared to the voice of an adult. This could be tested by conducting a similar experiment to experiment 1 of study 4, but using the same recorded voices for both children and adult experimenters. Dogs’ differentiation could also be based on other bodily characteristics such as the body height of both the adult and the child. However, this experiment was not conducted to investigate what exactly it is what makes dogs perceive children as lower authorities than adults. This is a question for future studies. That said, the results of this experiment are in line with others studies in showing that dogs do not see children as high authoritative humans (e.g. Brogan et al. 1995).

In summary, this thesis investigated dogs' understanding of the human pointing gesture. It has been shown that dogs are very flexible in using human forms of communication; a fact that is supported by the results of this thesis. Dogs were shown to take into account contextual information when following the pointing gesture. Furthermore, they relied on their own knowledge in situations where the human gave incorrect information about a hidden piece of food. Additionally, when they had no information about the hidden food, they relied on the human's gesture. Therefore they considered their own knowledge state to be relevant for making a decision to follow or follow not the human's pointing gesture. This supports their flexible behaviour in this sort of task. In contrast, the characteristics of the human pointing for them seemed to be irrelevant for their response behaviour. They did not differentiate between a reliable or an unreliable person or the various manipulations of the experimenter's authority state. Taken together, these results do not support the command hypothesis. This in turn does not necessarily favour the information hypothesis. For dogs to understand the pointing gesture as being informative there need to be some conditions in place. Dogs should be able to see the pointing gesture as a helpful, intentional and rational action which is used to inform others cooperatively. At present, studies do not show sufficient evidence for these conditions to be fulfilled. The observation that dogs do not distinguish between experimenters' different characteristics in the studies of this thesis speaks against dog's capacity to perceive humans as agents with intentions and goals – a capacity that would be required for a higher-level explanation. Further studies needs to be conducted to investigate in more detail whether dogs' ability to read human communicative cues is comparable with human communication.

7. Summary

The present thesis concerns the social cognitive abilities of domestic dogs (*Canis familiaris*). It investigates the mechanism by which dogs comprehend human forms of communication. In particular, this thesis examines evidence for and against two hypotheses as to how dogs use human communication. The first is the command hypothesis. This hypothesis is based on the assumption that dogs do comprehend the human-given pointing gesture as an instruction to go in the direction the human is pointing at. The second is the information hypothesis. It states that dogs perceive the pointing gesture as pure information given to inform them about some entity in the environment.

Study 1 investigates whether dogs would follow a human point to an empty spot without having experienced a context prior to the communicative situation. This was compared to another group of dogs which that had experienced such a context, i.e. finding food on the ground previously. The results showed that dogs do not follow a pointing gesture ‘blindly’. They did consider the contextual background of the situation and also the tone of voice of the experimenter when responding to the gesture. This finding is not explained by dogs simply associating the human’s hand with food.

Study 2 focused on dogs’ comprehension of the pointing gesture in situations when they have experienced previously that the experimenter has a certain attitude. For some dogs the human is a reliable person, for another group she is unreliable. A third group experienced the human being authoritative and for a last group the human was non- authoritative. Results showed that dogs did not differentiate between the different conditions and followed the pointing gesture above chance level in all conditions.

Study 3 of this dissertation investigated dogs’ behaviour when a human gives incorrect information about the location of hidden food. Sometimes dogs had information about the correct food location and sometimes not. Results showed that dogs did rely on their own visual experience when they knew where the food was hidden and ignored the misleading gesture. When they did not have information about the hidden food, they followed the human gesture. A second experiment in the same study suggested that being prevented from the visual access of the food hiding process does not change this behaviour pattern. Results from both experiments 1 and 2 of study 3 argue against an imperative understanding of the human-given pointing gesture in dogs and rather favour an informative understanding.

Study 4 examines the question of whether dogs would behave differently in an object choice task with the experimenter being either a 4,5-5-year-old child or an adult. Children are not considered to be high authoritative humans for dogs. A difference in their choice behaviour would have given support for the idea that dogs could understand the gesture as a command. Results showed that dogs did not differentiate between child and adult experimenters in this set- up. Additionally, dogs did follow a “sit” command from an adult more often compared to the same command given by a child.

Taken together, these studies provide valuable insight into how dogs understand human forms of communication. The general observation that dogs do not follow the human given pointing gesture in every instance contradicts the command hypothesis, but does not necessarily favour the information hypothesis. However, the studies highlight the enormous flexibility in dogs’ point following behaviour and give ideas for future studies.

8. Zusammenfassung

Die vorliegende Arbeit beschäftigt sich mit den sozial-kognitiven Fähigkeiten von Haushunden (*Canis familiaris*). Sie untersucht die Mechanismen, die dem Verständnis von Hunden für menschliche Kommunikation zugrunde liegen. Im Einzelnen soll das Für und Wider folgender zwei Hypothesen untersucht werden. Die erste Hypothese ist die „Kommando-Hypothese“. Diese Hypothese beruht auf der Annahme, dass Hunde die menschliche Zeigegeste als Kommando betrachten, welchem sie zu folgen haben. Die zweite Hypothese ist die „Informations-Hypothese“. Diese geht davon aus, dass Hunde die menschliche Zeigegeste als reine Information ansehen, die sie über Gegebenheiten in der Umwelt informiert.

Studie 1 zeigte, dass die Hunde den Kontext einer Situation berücksichtigten, wenn sie der menschlichen Zeigegeste folgten. Zusätzlich passten die Hunde ihr Verhalten an verschiedenen Stimmlagen des Menschen an. Das Verhalten der Hunde in dieser Studie ist nicht darauf zurückzuführen, dass die Hunde der Zeigegeste nur folgen, weil sie durch vorherige Erfahrungen die menschliche Hand mit einer Belohnung assoziiert haben.

Die zweite Studie untersuchte, ob Hunde zwischen verschiedenen Verhaltensweisen (autoritär, antiautoritär, zuverlässig und unzuverlässig) unterscheiden, die der Mensch ihnen gegenüber in einer Etablierungsphase zeigte. In einem folgenden Objekt-Wahl-Test zeigten die Hunde aus allen vier Gruppen keine Unterschiede in ihrem Verhalten. Sie wählten denjenigen Becher, auf den der Mensch zeigte. Die Ergebnisse lassen vermuten, dass diese Information hier irrelevant für sie ist.

In der dritten Studie hatten die Hunde in einem Objekt-Wahl-Test entweder beobachten können, wo das Futter versteckt wurde oder sie hatten keinen visuellen Zugang zu den Bechern, während des Versteckvorganges. Der Mensch zeigte in dieser Studie immer auf den leeren Becher. Zusätzlich wurde auch variiert, ob der Mensch anwesend oder abwesend ist, während der Hund einen Becher wählt. Es zeigte sich, dass die Hunde der Zeigegeste folgten, wenn sie nicht gesehen hatten, wo das Futterstück versteckt wurde. Haben sie aber vorher beobachten können, wo das Futter versteckt wurde, ignorierten sie die Zeigegeste und wählten den mit Futter bestückten Becher. Ob der Mensch anwesend war oder nicht, hatte keinen Einfluss auf das Verhalten der Hunde. Dieses Ergebnis widerspricht der Kommando-

Hypothese. Gemäß dieser Hypothese hätten die Hunde in jeder Situation der Zeigegeste folgen müssen.

Eine weitere Studie, Studie 4, untersuchte, ob das Verhalten der Hunde in einem Objekt-Wahl-Test abhängig von dem Autoritätsstatus des Versuchsleiters ist. Hier zeigte entweder ein vier- bis viereinhalb-jähriges Kind oder ein Erwachsener auf einen von zwei Bechern, in dem das Futter zuvor versteckt wurde. Die Hunde folgten der Geste beider Versuchsleiter-Gruppen gleichermaßen. Die Hunde unterschieden wiederum zwischen den beiden Versuchsleiter-Typen, wenn ein klares „Sitz"-Kommando ausgesprochen wurde und folgten hier dem Erwachsenen, nicht aber dem Kind.

Zusammenfassend sprechen die Ergebnisse der aufgeführten Studien gegen die Kommando-Hypothese, was aber nicht gleichzeitig Evidenz für die Informations-Hypothese liefert. Sie geben einen Einblick in das Verständnis menschlicher Kommunikation beim Hund und heben seine besondere Flexibilität in diesem Verhalten hervor. Sie liefern Anlass und Ideen für zukünftige Studien.

9. Tables and Figures

Tables

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10. References

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Lebenslauf

Der Lebenslauf ist in der Online-Version aus Gründen des Datenschutzes nicht enthalten

Appendix

Table 1: Subjects who participated in study 1.

Subject	Gender	Age	Breed
Simba	M	5.5	Labrador
Jazzmann	M	6.5	Jack Russel Terrier
Frida	F	2	Mongrel
Filou	M	2.5	Mongrel
Tyson	M	5.5	Tibet Spaniel
Cassy	F	4.5	Mongrel
Pascha	M	4.5	Giant Schnauzer
Raja	F	1.5	Mongrel
Elly	F	7.5	Labrador
Barney	M	6.5	Mongrel
Luna	F	9.5	Australian Shepherd
Brutus	M	2	Bullterrier
Evita	F	7	Labrador
Cue	M	1	Border Collie
Motte	F	1.5	Mongrel
Merlin	M	6.5	Mongrel
Emmi	F	4.5	Weimaraner
Yukon	M	10	German Shepherd
Skippy	F	6	Mongrel
Emily	F	11.5	Mongrel
Sunny	F	4	Jack Russel Terrier
Susi	F	1.5	Mongrel
Moto	M	3.5	Mongrel
Fritzi	F	2	Mongrel
Franzel	M	7.5	Miniature Schnauzer
Django	M	3.5	Mongrel
Fix	M	1.5	Malinois
Lehmi	M	4.5	Mongrel
Boscaille	F	2.5	Malinois
Jasper	M	1	Mongrel
Guiness	M	3.5	Dalmatian
Dana	F	8	Husky
Maxl	M	2	Sheepdog
Tamu	F	1	Rhodesian Ridgeback
Chiron	M	4.5	Magyar Vizsla
Jody	F	4	Magyar Vizsla
Blue	M	1.5	French Bulldog
Aurelie	F	1.5	Mongrel
Judy	F	1.5	French Bulldog
Kiri	F	12	Mongrel
Casy	F	6.5	Labrador

Asta	F	3.5	Magyar Vizsla
Carus	M	4	Parson Jack Russel Terrier
Catie	F	1.5	Australian Shephard
Amy	F	7	Magyar Vizsla
Chappi	M	3.5	Labrador
Kayah	F	9.5	Bardino
Panda	M	12.5	Mongrel

Table 2: Subjects who participated in study 2.

Subject	**Gender**	**Age (years)**	**Breed**
Bruno	M	5	Boxer
Wilma	F	8.5	German Shepherd
Carrie	F	3	Shorthaired Pointer
Kosy	F	10	Mongrel
Yula	F	3.5	Labrador
Pine	F	4.5	Shorthaired Pointer
Dusty	M	5	Border Collie
Wolf	M	3	German Shepherd
Luna	F	7	Mongrel
Balu	M	8	Shorthaired Pointer
Filou	M	7.5	Mongrel
Dori	F	3	Mongrel
Balou	M	6.5	Mongrel
Cherry	F	8	Mongrel
Vento	M	6	Fox Terrier
Thyson	M	2	Jack Russel Terrier
Contessa	F	6	Labrador
Nena	F	5	Labrador
Bruno	M	7	Golden Retriever
Fara	F	6	Mongrel
Kira	F	3.5	Mongrel
Bayca	F	4	Golden Retriever
Jessi	F	4	Mongrel
Cantor	M	3.5	German Shepherd
Naydin	M	5	Golden Retriever
Tomi	M	4.5	Mongrel
Paul	M	3	Labrador
Laila	F	6	Labrador
Colette	F	13	Fox Terrier
Spike	M	5	Border Collie
Fynn	M	5.5	Border Collie
Fridolin	M	2	Mongrel
Paula	F	2	Labrador
Ayk	M	6.5	Magyar Viszla

Elton	M	3.5	Labrador
Trixie	F	2	Mongrel
Phoebe	F	5	Mongrel
Bruno	M	4	Labrador
Trulla	F	4	Border Collie
Sydney	F	7.5	Border Collie
Paula	F	10	Mongrel
Lola	F	5.5	Mongrel
Cheyenne	F	2.5	Malinois
Grambambuli	M	3.5	Mongrel
Caja	F	4	Mongrel
Frieda	F	2.5	Mongrel
Bleibda	M	6	German Shepherd
Max	M	10.5	Airdale Terrier
Pepsi	F	2	Golden Retriever
Momo	F	6	Border Collie
Ronja	F	2	Mongrel
Bacardi	F	7	Mongrel
Laika	F	7	German Shepherd
Balou	M	4	Flat Coated Retriever
Vienchen	F	4.5	Labrador
Caspar	M	3.5	Mongrel

Table 3: Subjects who participated in experiment 1 of study 3.

Subject	**Gender**	**Age (years)**	**Breed**
Strolch	M	3	Mongrel
Lotte	F	5	Labrador
Jack1	M	3	Jack-Russel-Terrier
Schnuffel	M	5.5	Labrador Retriever
Jack2	M	8	Bearded Collie
Anka	F	8	Mongrel
Aura	F	1	Giant Schnauzer
Higgins	M	2	Jack-Russel-Terrier
Marco	M	7	Mongrel
Matilda	F	1.5	Mongrel
Luna	F	1.5	German Shepherd
Quincy	M	6	German Shepherd
Emily	F	3	Labrador
Karah	F	3	Labrador
Pauline	F	6	Portuguese Waterspaniel
Jimmy	M	5	Labrador Retriever
Stoffel	M	2.5	Miniature Schnauzer
Solo	F	6.5	German Shepherd
Baxley	M	4	Golden Retriever

Laila	F	4	Labrador
Ronja	F	3	Labrador
Maya	F	1	Boxer
Tina	F	6.5	Mongrel
Oscar	M	1	Mongrel
Chico	M	11	Mongrel
Bora	F	2	Beagle
Rudi	M	5	Beagle
Wanja	F	11	Sheepdog
Balou	M	6.5	Schapendoes
Capone	M	5	Mongrel
Checki	M	3.5	Cocker Spaniel
Caja	F	3.5	Boxer
Dusty	M	5	Mongrel
Candy	F	3	West Highland White Terrier
Gina	F	4	Mongrel
Biene	F	3	Mongrel
Rex	M	10.5	Mongrel
Maylo	M	7	Mongrel
Baghira	F	3	Mongrel
Alma	F	3	Mongrel
Scatty	F	10	Mongrel
Toby	M	9	Mongrel
Lilly	F	7	Labrador
Marvin	M	6.5	Mongrel
Sally	F	10	Bullterrier
Tommy	M	5	Labrador
Lupo	M	11	Mongrel
Polly	F	8	Mongrel

Table 4: Subjects who participated in experiment 2 of study 3.

Subject	**Gender**	**Age (years)**	**Breed**
Zosi	F	3	Mongrel
Nicky	F	3.5	Malinois
Biene	F	4	Labrador
Kimi	F	9.5	Border Collie
Bayca	F	4.5	Golden Retriever
Becky	F	5.5	Golden Retriever
CJ	F	5	Border Collie
Karlo	M	5	Labrador
Laana	F	6	Labrador
Mira	F	2	Mongrel
Finnwolf	M	4	American Canadian Shepherd
Luck	M	4	Mongrel

Taira	F	2	Mongrel
Trulla	F	5	Border Collie
Sydney	F	8	Border Collie
Lotte	F	1	Labrador
Grace	F	4	Labrador
Ben	M	11	Mongrel
Quincy	M	9	German Shepherd
Wilma	F	2	Mongrel
Wolf	M	4	German Shepherd

Table 5: Subjects who participated in experiment 1 of study 4.

Subject	**Gender**	**Age (years)**	**Breed**
Richard	M	13	Mongrel
Gonzo	M	4.5	Labrador
CJ	F	5.5	Border Collie
Mira	F	2.5	Mongrel
Chico	M	12.5	Mongrel
Rocky	M	3.5	Mongrel
Gismo	M	4.5	Golden Retriever
Kitty	F	10	Mongrel
Krümel	F	6	Yorkshire Terrier
Drops	M	7.5	Parson Jack Russel Terrier
Kira	F	1.5	Mongrel
Onja	F	4	Airdale Terrier

Table 6: Subjects who participated in experiment 2 of study 4.

Subject	**Gender**	**Age (years)**	**Breed**
MayaW	F	2.5	Labrador
Gusti	M	1.5	Tibet Terrier
Balou	M	3	Flat Coated Retriever
Jessi	F	4.5	Mongrel
Tisza	M	1.5	Mongrel
Anka	F	9	Mongrel
Pine	F	4.5	German Shorthaired
Candy	F	2	West Highland White
Oscar	M	1.5	Mongrel
Babingi	F	1.5	Rhodesian Ridgeback
LunaP	F	4.5	Labrador
Debbie	F	3.5	Beagle
Rocky	M	6	Mongrel
Maya	F	1.5	Boxer

LunaS	F	2	Mongrel
Milka	F	4	Labrador
Checki	M	2.5	Cocker Spaniel
Jack	M	4	Jack Russel Terrier
Caja	F	3	Mongrel
Pogo	M	6.5	Mongrel
Jimmi	M	6	Labrador
Nico	M	4	Airdale Terrier
Pitty	F	8	Rottweiler
Lotte	F	6	Labrador

Erklärung

Hiermit erkläre ich, Linda Scheider, geboren am 9.November 1980 in Rheine, dass ich die Dissertation „The command hypothesis versus the information hypothesis: How do domestic dogs (*Canis familiaris*) comprehend the human pointing gesture?" selbstständig angefertigt und keine anderen als die von mir angegebenen Quellen und Hilfsmittel verwendet habe. Sämtliche Entlehnungen sind unter Angabe der Quellen kenntlich gemacht.

Leipzig, den___________________

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Linda Scheider