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The Role of Human Ostensive-Communicative and Referential Cues on the Social Learning of Human Infants and Dogs

Doctoral Thesis

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2013

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Main introduction

1. Social learning: basic concepts and definitions

Systematic studies of social learning in non-human species date back to the 1970s. These early views described social learning as a mechanism for the social transmission of information through a population (Galef 1977) that would result in homogeneity of a certain behaviour that maintains existence long after the interaction (see also Galef 1976). Based on this idea social learning can be considered as a social process that might utilise learning, although this definition is very general. Later, Heyes (1994) also used a relatively broad definition for social learning suggesting that this is a type of "learning that is influenced by observation of, or interaction with, a conspecific, or its products" (Heyes 1994, p. 1). This definition was further modified because although social learning usually occurs between conspecifics, there are increasing examples of cross-species learning, most frequently in human-animal relationships (e.g. Hayes and Hayes, 1952; Moore 1992; Custance et al. 1995; Pongrácz et al. 2003). Therefore more recent approaches propose that the term ''conspecific'' should be substituted for ''another individual'' (Hoppitt & Laland 2008). Hoppitt and Laland (2008) modified Heyes (1994) definition of social learning in a way to include both direct and indirect learning: "social learning… [is] …any process through which one individual ('the demonstrator') influences the behaviour of another individual ('the observer') in a manner that increases the probability that the observer learns" (Hoppitt & Laland 2008, p.108). Thus they do not exclude cases in which the naïve individual is exposed merely to the collective presence of a knowledgeable individual and the new and learnable information, however, the learning process can happen at the absence of the demonstrator (e.g. following the knowledgeable other to the source of food creates a new association between the location and the food source - Hoppitt & Laland 2008).

The direction of information spreading between demonstrator and learner can be a further important characteristic of social learning events in sense of changing the frequency of a certain trait within a population. Cavalli-Sforza and Feldman (1981 in Laland, Richerson & Boyd 1996) developed models of the spread of cultural variants under three types of transmission: vertical (from parent to offspring), oblique (from parental generation to offspring generation), and horizontal (within-generation transmission) (reviewed in Laland, Richerson & Boyd 1996). With this classification they specify the potential transmitters and

receivers of the process. They concluded that while change in the frequency of a trait can be driven by oblique or horizontal transmission vertical transmission has no effect on the frequency. This is because the probability to pick up a trait by naïve individuals is proportional to the probability of the trait's frequency in the population (Laland, Richerson & Boyd 1996). Examining the mechanisms of oblique transmission is one of the central goals of this thesis as it discusses a human specific way of knowledge transmission between parental generation and infants.

2. Classification of social learning mechanisms

Identifying the mechanism of social learning that an animal uses can be important in order to give us a deeper understanding of the animals' cognitive abilities (Galef 1996). However, there are several classifications of the possible social learning processes. Heyes (1994) argues that classifications based on underlying mechanisms are very problematic, since we have no direct access to mental events. She suggests that it is more appropriate to use a classification based on directly observable and measureable traits (Heyes 1994).

In my thesis I will follow the classification of social learning suggested by Want & Harris (2002). Authors of the field most commonly use the categories they use and their work is frequently cited by other authors as a source of classification of social learning (Whiten et al. 2004; Csibra & Gergely 2006; Brugger et al. 2007; Király 2009; Huang 2012). Want and Harris (2002) differentiate five types of social learning mechanisms taking into account three elements of the demonstration:

- the <u>action</u> which leads to the required goal,
- the <u>goal</u> which is the required outcome of the action,
- the <u>causal relationship</u> (or affordance) between the action and the outcome, i.e. how the given action leads to the desired goal.

The type of social learning is identified according to the element that is in the focus of the observer. Throughout the thesis, I will use the terms according to the definition by Want & Harris (2002):

I. <u>Local enhancement:</u> "refers to an increase in interest in the particular location at which one individual has seen another performing some action" (Want & Harris 2002, p. 2).

II. Stimulus enhancement: "refers to a similar process, but one which takes an object, rather than a location, as the focus of increased interest" (Want & Harris 2002, p. 2).

In these cases the observer learns to reach the desired goal through individual learning but what they acquire socially by observing another individual is that there is something interesting (a place or an object) in the certain environment. Importantly, however, learning (knowledge-acquisition) would not occur without a social context, thus we consider these as social processes.

III. Emulation: Want & Harris (2002) provide two definitions of emulation.

a. The original interpretation of Tomasello (1990 in Want & Harris 2002): "learning about the properties of, or causal relations between, objects (rather than just about their presence in the environment)" (Want & Harris 2002, p. 3).
b. Goal emulation (alternative interpretation of Whiten and Ham (1992 in Want & Harris 2002)): "an observer learns simply that a particular goal can be achieved, and sets about achieving that goal by its own means. Again, the specific actions performed by the model are not learnt" (Want & Harris 2002, p. 3). This learning mechanism is often referred to as a separate form of social learning.

IV. Mimicry: "the replication of a model's actions in the absence of any insight into why those actions are effective, or even what goal they served" (Want & Harris 2002, p. 3).

V. Imitation: "involves the recognition and reproduction of the goal of the observed behaviour, as well as the specific actions that brought about that goal" (Want & Harris 2002, p. 3).

a. Blind imitation: when "an imitator might replicate both the form and the goal of an observed behaviour but fails to understand the affordances of the objects involved in that behaviour or the link between the actions and the goal they subserve" (Want & Harris 2002, p. 3).

b. Insightful imitation ('true imitation'): when imitators „learn imitatively and also learn about affordances (in effect, learning what to do, why they are doing it, and how it works)" (Want & Harris 2002, p. 3).

However, Want and Harris (2002) note that this kind of classification is rather theoretical. In practice, identification and classification of different social learning forms are very difficult, especially under natural conditions in the field. Different types are not always mutually exclusive. Although there is low number of possible outcomes these can be caused by a large number of possible mechanisms; not only social but also individual learning.
Furthermore, Heyes (2012) argues that this classification of social learning is based on the behavioural outcome of the learning process but does not tell us anything about the cognitive or neurological mechanism behind. Thus, the types suggested by Want and Harris (2002) are rather the effects of certain social learning processes, not mechanisms. She refers to a growing body of evidence that social and asocial learning share most mental mechanisms.

3. Imitation - an accentuated case of social learning

In this part I provide a deeper analysis of the definition and the mechanism of imitation since this has a central importance in my experimental studies.

Despite Want and Harris' (2002) clear definition of imitation the concept is highly debated, mainly because controversies in ape research. Whereas some researches emphasize the similarities between humans and apes and prefer a definition that can be extended to non-human animals (Byrne & Russon 1998; Whiten et al. 2009; Byrne 2002), others focus on the different aspects and prefer to give a narrower definition excluding animals (Tomasello 1996; Tomasello & Call 1997; Tomasello 1999; Tennie et al. 2009). According to Whiten and colleagues (2009), however, „it is important to recognize a distinction between debates about species differences that hinge on: (i) variations in the way a concept such as imitation is defined versus (ii) for any given definition, the adequacy of relevant empirical evidence in the species of interest. Only such evidence can provide objective, scientific conclusions. Matters of definition, by contrast, cannot be resolved by research." (Whiten et al. 2009, Chapter 2, p. 2418).

The question of imitation in certain animals is an important stage of an even more vivid dispute about the existence of animal traditions and culture (Mundinger 1980; Tomasello 1996; Whiten et al. 1999; Whiten et al. 2001; Boesch 2003; Whiten 2005; Laland & Janik 2006) because according to some authors imitation is the basic mechanism of cultural transmission (Whiten et al. 2009). The question of imitation in apes is especially interesting from the evolutionary point of view. Great apes are the closest relatives of humans, thus if they lack imitative ability it would mean that this behaviour evolved *de novo* in humans. As a consequence the possible existence of imitation in any other, non-primate species would then be the result of convergent evolution (see more in Whiten et al. 2009; Whiten et al. 2011).

However, it is generally accepted that imitation has a significant role in humans as a main drive of cognitive and social development of infants and children, a basic mechanism of cooperation and empathy between individuals (Heyes 2009). Furthermore, it is an important mechanism of human cultural inheritance (Heyes 2009) and cumulative culture (Tomasello 1999) although its exclusiveness has been questioned recently (Shea 2009).

4. Social learning in human infants

The unique and high capacity of social learning and information transmission in humans is considered as the main reason of the success of *Homo sapiens* (Rendell et al. 2010). One of the most important aspects of these knowledge transferring and accumulating processes is the increased learning capacity of infants that includes a substantial proportion of learning from a social partner.

4.1. Imitation vs. emulation in infants

The processes of social learning in human infants have been investigated for a long time (Piaget 1951, 1967; Bandura 1962). Different mechanisms of social learning have been implicated using a range of experimental methods (Tomasello 1990; Want & Harris 2002).

Despite this longstanding interest the emergence and development of different learning mechanisms in infants, their functional role in knowledge acquisition and their cognitive background is still debated (Want & Harris 2001; Heyes & Ray 2002; Jones 2009, Heyes

2012). In the following I will focus on imitation and emulation, two complex social learning mechanisms that I have studied in more detail.

Examples of imitation of facial gestures (e.g. tongue protruding, mouth opening) have been reported already from newborns and it has been argued may provide strong evidence for the innate nature of motor imitation as a reflexive response (Meltzoff & Moore 1983, 1989). However, a recent re-analysis of this phenomenon has questioned the relevance of this behaviour. New studies suggest that newborn tongue protruding behaviour is a general sign of increased arousal level, thus this seemingly imitative behaviour may be explained as simple coincidence (reviewed in Jones 2009). Furthermore, Jones (2009) argues that imitative behaviour appears only in the second year of life and there is no evidence that it would have an inherited module, but rather develops in parallel to the infant's motor, cognitive and social skills. Different behavioural imitations appear at different ages.

Emulation, as compared to imitation, appears later in ontogeny. It is often regarded as higher cognitive process because it includes generalization of knowledge over a wide range of similar objects and tasks. During emulation the necessary action steps to reach the desired end state or the affordances that make an object appropriate for a certain purpose are already well understood (Want & Harris 2001, 2002; Horner & Whiten 2005; McGuigan et al. 2007). Emulation does not require the acquisition of a new set of knowledge in every similar situation; it is enough to suit already existing information to the new task. For example, learning that the hollow of the glass makes it appropriate to contain liquids can help to choose a similar object with a hollow for liquid containing in a new situation. In contrast, blind imitation refers to a learning mechanism when the observer learns a certain action which results the desired goal but does not learn about the affordances of the necessary actions. Blind imitation is successful in certain situations, especially, when the causal relationship between the action and the goal is cognitively opaque. In these cases, infants cannot simply infer the role of an action that achieves the desired goal. For example, we all know how to operate cars or remote controls; however, only few of us know how exactly they work. Therefore, we need to observe a knowledgeable individual in order to learn to operate these objects.

Imitation and emulation often result in the same action performance in order to reach the same goal, however, the cognitive processes behind both behaviours are probably different. Therefore, it is important to maintain conceptual distance between them and to carry out systematic tests to reveal which learning mechanism is responsible for a certain copying action (Want & Harris 2002). In spite of the difficulties in disentangling the two mechanisms,

it has been suggested that by the age of fourteen months infants have the capacity for both emulative and imitative learning and can adopt those to a situation depending on the context (Whiten et al. 2009).

In order to choose an imitative or emulative action infants have to be able to make inferences about the functional role of actions leading to a certain end state. For this they can use a number of clues: a) their own a priori existing knowledge about the situation, such as their prior knowledge about the final goal of the action (Carpenter et al. 2002; Williamson & Markman 2006; Király 2009), b) their prior estimation about the difficulty of the task (Harnick 1978; Bauer 1992), c) their prior experiences with the object (Williamson et al. 2008) or, d) their ability of teleological reasoning (Gergely et al. 2002). Furthermore, they can e) adjudge the rationality of the observed action (Gergely et al. 2002, Schwier et al. 2006) or f) understand the causal connection between action and outcome (Brugger et al. 2007).

The performance of infants is also affected by their own executive abilities, such as inhibition of prepotent answer and manipulation skills (Russell et al. 2003). Simple actions are copied with higher fidelity than complex demonstrations (Gattis 2002), and irrelevant actions are imitated when the task is moderately difficult (Harnick 1978).

Beside their pre-existing knowledge infants also consider social or non-social cues from the environment in the decision process. These can be a) the presence or absence of ostensive-communicative cues (Csibra & Gergely 2006; Gergely & Csibra 2006; Nielsen 2006; Brugger et al. 2007), b) the intentionality of action (Meltzoff 1995; Carpenter et al. 1998a), c) social context during re-enactment (Learmonth et al. 2005; Király 2009), d) knowledge about contingent relations (Carpenter et al. 1998b) e) and/or the overall purpose of the demonstration (Meltzoff 1995). The given information about causal relationship between means action and the outcome of the action also influences whether the responses of infants are imitative or emulative (Want & Harris 2001): enabling steps are copied more accurately than arbitrarily ordered sequences (Bauer et al, 2000).

However, it is important to note that in recent years many methods, which were used to examine infants' imitative abilities, have been criticised. For example, it has been claimed that most previous studies did not control for emulation and most of the revealed imitative behaviours can be explained by emulative learning (Jones 2009).

4.2. Social-communicative aspect of human social learning and the ostensive-communicative and referential cues

One important characteristic of the human social learning mechanisms is that learning often occurs in a directional situation where the demonstrator actively transfers information and facilitates learning in the observer (Csibra & Gergely 2011; Csibra 2007). These dyadic situations often involve verbal or non-verbal communication and can result in imitative learning by the learner (Csibra & Gergely 2009; Csibra 2007).

The facilitating effect of non-verbal social communicative cues provided by the demonstrator during the demonstration on the imitative behaviour of infants has been shown in several studies (Gergely & Csibra 2006; Nielsen 2006; Brugger et al. 2007; Király 2009). Nielsen (2006) reported that 18-month-olds are more likely to copy the demonstrator's action in a communicative context as compared to the non-communicative context. Deprived of communication, infants reproduce the goal of the demonstrator using their own method (emulation). Infants' responses are more influenced by the presence or absence of the demonstrator's communicative signals than the information given about the rationality of the action. Király and colleagues (2004) found selective imitation of a new means action in 14-month-olds only in the socially cued condition. More recently, Brugger and colleagues (2007) showed that 14- to 16-month-old infants had the highest imitation rates when an action was demonstrated in a social context and, the action was causally and physically necessary to reach the goal. The authors concluded that infants rely more on the demonstrator's cues when they are uncertain about the relevance of the observed action, and more on their own judgment when they are confident about reaching the goal (Brugger et al. 2007).

Recent findings support the view that infants have higher tendency to copy actions where the demonstrator's performance is accompanied by the so called ostensive-communicative cues and referential cues. These cues are categorized as a non-verbal communicative complex whose joint presence in a demonstration creates a communicative situation (Gergely & Csibra 2006; Csibra & Gergely 2009).

Ostensive-communicative cues are a group of communicative signals that are often used in knowledge transferring situations. They include e.g., calling infant's name, smiling at and making eye-contact with infants. The other group of cues, the referential cues, include pointing and/or looking at the object, making referential expressions, gaze altering between the infant and the reference (see also in Topál et al. 2008; Király 2009; Brugger et al. 2007; Király et al. 2004; Nielsen 2006; Southgate et al. 2009). Gergely and Csibra (2009) suggest

that the role of ostensive-communicative cues is to address the learner and increase the attention state in the learner who interprets these cues as a sign of communicative intention. While referential cues help to identify the target of the demonstration by directing the learner's attention toward the new and relevant part of the environment.

The ability of infants to recognise and follow ostensive-communicative and referential cues as an intentional communicative gesture has been shown in several independent studies. Here, I will present some of the studies reviewed in Csibra and Gergely (2009), as examples of our current understanding and development of these cues in the early ages.

Ostensive-communicative cues:

Eye contact. Already newborns have a preference for eye contact (Farroni et al. 2002). Moreover, they prefer schematic faces with an eye-contact-like stimulus over others (including those identical but presented upside down, Farroni et al. 2006). Four-month old infants can interpret eye contact as an ostensive-communicative cue according to neuroimaging studies (Kampe et al. 2003). In infants similar neuronal activation can be detected as in adults in response to both direct gaze and eye brow raise, which are interpreted as ostensive communicative signals by adults (Grossmann et al. 2008). Several studies have suggested that the human eye is biologically adapted to follow the direction of the gaze precisely because of the contrast polarity between the dark iris and the white sclera (Kobayashi & Kohshima 1997; Ricciardelli et al. 2000; Tomasello et al. 2007; Tomalski et al. 2009). This unique built-up of the human eye makes it easier to detect and follow the gaze direction of others. Preference for schematic faces with contrast polarity of the eyes is present already in newborns (Farroni et al. 2005).

Motherese or infant directed speech. Vocal cues also have an important role in ostensive communication. Four-month old infants have a preference for infant directed speech over adult directed speech (Fernald 1985; Fernald & Kuhl 1987). Infant directed speech is defined as "the special way of speaking that is used when caretakers address infants" by de Boer (2005, p.1). Infant directed speech tends to be slower, simpler; more clearly articulated and has higher and wider intonation contours than adult directed speech (Fernald & Kuhl 1987; Fernald et al. 1989). Already newborns show a preference to a visual stimulus that is accompanied with infant directed speech (or also called as 'motherese') over adult directed speech (Cooper & Aslin 1990) even when the speaker was an unfamiliar person (Cooper et al.

1997). Infant directed speech, furthermore, has a crucial role in language acquisition of children (de Boer 2005).

Referential cues:

Gazing and gaze alternation. The ability of infants for gaze following and joint attention with another human is considered as one of the basic elements of their communicative functioning (D'Entremont 2000). However, Emery and colleagues emphasize that while gaze following and joint attention are strongly connecting notions they are different cognitive abilities with different developmental and phylogenetic background (Emery et al. 1997). They define gaze following as "the ability of one individual (X) to follow the direction of gaze of a second individual (Y) to a position in space (not an object)" (Emery et al. 1997, p. 1), while joint attention when „X follows the direction of Y's gaze to the object that is the focus of Y's attention. Joint attention thus requires extra computation to process the object of attention, not just the direction of gaze." (Emery et al. 1997, p. 1). D'Entremont (2000) added that in a joint attention situation, gazing and gaze following are happening simultaneously.

The appearance of gaze following and joint attention in human infants is, however, controversial (Emery et al. 1997). Whereas studies conditioning infants to follow the gaze or use highly visible target objects reveal gaze following already at 3-6-month-old infants most studies suggest that spontaneous gaze following appears only at 12-month-old infants (reviewed by D'Entremont 2000). Importantly, gaze following behaviour proved to be strongly connected to the visibility of the eyes of the demonstrator. Already 12-month-old infants followed the gaze of a person when his eyes were visible during the gaze shift in contrast when his eyes were closed (Brooks & Meltzoff 2002). The authors interpreted this as a development of the concept of "seeing" or "visual attention" (Brooks & Meltzoff 2002). However, some studies suggest that although 12-month-old infants can follow another person's gaze direction it is not clear whether this indicates recognition of attention focus or these only develop at an older age (reviewed by Aureli et al. 2009).

Gaze alternation from the demonstrator's side in a joint attention situation can be considered as a referential cue as it aims to direct the subject's attention to a certain place or object in order to communicate about it. In this triadic situation gaze alternation works as a visual pointing for infants that creates a common focus (Tomasello et al. 2007). When for instance infants lose sight of the object indicated by the gaze of a demonstrator they tend to

look back at their communicative partner in order to get new information about the object (Butterworth & Jarrett 1991 in Moore & Dunham 1995).

Infants tend to follow the gaze of another person when they can engage eye contact and there is a target object as a referent. This suggests that they have some expectations toward the direction of the gaze shift. This was proven in an experimental situation where 9-month-olds prefer to look at a face when the gaze shift happens toward an object rather than toward an empty space (Senju et al. 2008). However, importantly this preference was present only when the demonstrator made eye contact with the infant at the beginning (Senju et al. 2008).

Pointing. The understanding (i.e. following the direction) and performance of pointing in humans start rather at the second half of the first year of age (Woodward 2002). Recently it has been revealed that comprehension of different types of pointing gestures develops significantly between the twelfth an eighteenth months of life (Pfandler et al. 2013). In a longitudinal testing experiment 12-month-old infants did not perform above chance level in following any of the pointing gestures, whilst for the age of 18 months they turned out to be successful with all of them (Pfandler et al. 2013).

However, there are at least two different interpretations of the pointing gesture which interpretations probably appear in different ages; i) a referential interpretation, where infants interpret the pointing as a referential gesture which attracts their attention to a certain location or object and, ii) an intentional interpretation, where infants assign a communicative intention to the gesture; requiring an object (imperative intention) or sharing an interest in an object (declarative intention) (for more details see Aureli et al. 2009). While intentional pointing is always referential at the same time, referential pointing is not necessarily intentional. A so-called pre-referential interpretation of pointing appears between 9- and 12-month of age (Woodward & Guajardo 2002) when infants are able to locate an object with the help of a close pointing. Referential understanding of distant pointing develops by the age of 14-month. At 15-month, infants are able to follow pointing and find even a hidden object (reviewed by Aureli et al. 2009). Understanding pointing as an object-directed gesture at the end of the first year is parallel to the development of usage of object-directed pointing (Woodward & Guajardo 2002). Aureli and colleagues (2009) suggest that understanding pointing gesture as a communicative intention of the pointer starts only at the second year of life (Pfandler et al. 2013). Thus, the infants' understanding of the components of the pointing gesture undergoes stepwise developmental changes during this age.

Behne et al. (2005) found that 14-month old children are able to choose an object in an object-choice task when the cues are given in a communicative way but they show very poor performance if the same cues are given in a non-communicative way.
By the age of 18-month infants understand pointing as a communicative gesture even if it was addressed to another person and they are only observers of the otherwise communicative situation (Gräfenhain et al. 2009).
Between the age of 2 and 3 their understanding of this gesture will be more developed. At this period of life infants start to use the direction of the pointing index finger and not generally the direction of the hand or the arm (Lakatos et al. 2009). This is an important step as the first obvious evidence that children understand the communicative intention behind this gesture. Together with the development of other communicative abilities, there is an increased development in their cooperative abilities between the age 2 and 3 years.

5. The natural pedagogy theory

By the end of their third years young children can speak fluently and they are surprisingly skilful in using complex objects, like remote controls, mobile phones or computers. Importantly, they know the function of most objects around them, and they know what the objects are made for. However, infants usually do not fully understand the precise mechanism how the action leads to the desired result, i.e. they cannot make a causal connection between the actions and the goals. This much information would be impossible to acquire relying only on learning by observation, especially if for the learning of use they need to have complete understanding of the causal connection between the actions and the goals. This is not different from adults since adults of most societies grew up in an environment surrounded by complex objects and use them without any deeper understanding of their exact functioning (see 'cultural opacity' in Gergely & Csibra 2006).

According to Csibra and Gergely there is a 'special human context' of social learning, which helps to acquire and transmit this amount of information with high fidelity in a fast and efficient way. They call it *natural pedagogy* (Csibra & Gergely 2009, 2011). The natural pedagogy theory suggests that there is a unique "teaching-learning" context in humans which can facilitate knowledge transmission in a fast and efficient way. The knowledge is transmitted by the complex of non-verbal ostensive-communicative and referential cues between the knowledgeable 'teacher' and the naïve 'learner'. There is a mutual capacity of both sides for the usage/understanding of these cues. Previously (Main introduction, 4.1) I

emphasized that a demonstration of an action accompanied with communicative cues can increase the probability of imitative learning. Csibra and Gergely suggest that, furthermore, ostensive-communicative and referential cues can increase the tendency to *copy cognitively opaque* actions (Gergely and Csibra 2006) that can *facilitate selective understanding* of a situation (Király et al. 2004) and importantly *transmit generic information* (Csibra & Gergely 2009).

Infants – who are the most common learners considered under the natural pedagogy theory – have an early sensitivity to pay increased attention to ostensive-communicative cues expressed by a demonstrator toward them (see Main introduction 4.2). Furthermore, they pay increased attention to a situation when it is demonstrated using referential cues. By contrast, adults – who are the most common teachers – intuitively use such cues toward infants when they intend to teach something (Gergely & Csibra 2006). The knowledgeable 'teacher' with the ostensive-communicative cues unequivocally addresses the 'learner' who will pay increased attention to the following action. This 'ritual' can be important to make sure that the recipient is prepared well enough to get the message. The referential cues are appropriate to identify the referent of the demonstrated action. These inform the 'learner' what is new and relevant in the demonstration, thus what is worth to learn.

The authors suggest "natural pedagogy is a basic cognitive adaptation, which is indicated by the fact that young infants display receptivity to adults' ostensive communications well before they show evidence of learning from such interactions." (Csibra & Gergely 2009, p. 149).

5.1. The characteristics of the natural pedagogy

In this chapter I will introduce some of the characteristics of natural pedagogy through examples from recent studies.

5.1.1. Increased responsiveness.

Early evidence of the initiative intention in communicative acts of the ostensive-communicative cues is the increased responsiveness of gaze following for 6.5-month-olds after they were addressed by verbal communication experimentally (Senju & Csibra 2008). Two factors, eye contact and motherese, were examined in this experiment. A higher

proportion of 6.5-month-old infants followed the direction of the gaze shift by a human demonstrator after she made eye contact or addressed the infant with motherese before the gaze shift. This shows that infants have a preference for cues that address them by someone. Furthermore, they require these ostensive cues for gaze following. The connection of gaze following behaviour to ostensive cues indicates that these cues have an early communicative role in the human development. Furthermore, infants' selective response suggests that ostensive cues might have significance in the referential understanding of the head turn (Senju & Csibra 2008).

5.1.2. Selective imitation and "efficiency blindness".

One important characteristic of natural pedagogy is the increased imitative tendency even if the situation is causally or teleologically opaque (Csibra & Gergely 2011). In an earlier study Gergely and colleagues (2002) showed that infants' imitation is not a blind and automatic copy but rather a selective and insightful imitation of an observed action. They extended Meltzoff's original study where he used a peculiar head movement to switch on a lamp that was lying in front of him on the table by his forehead (Meltzoff 1988). In the original study 14-month-old infants imitated this strange movement one week later. In the new version of the study Gergely and colleagues (2002) used the same head action but in two different conditions: in one of them the demonstrator's hands were occupied by a blanket she was covered with ('hands-occupied' condition) and in the other condition though she was covered with the blanket, her hands were free and were lying on the table next to the lamp ('hands-free' condition). They noticed that infants chose a seemingly "efficiency blind" solution, namely they imitated the more complicated head action in the 'hands free' condition which replicated the results of Meltzoff's study. The copying behaviour, however, disappeared after the 'hands occupied' demonstration where infants used a more convenient solution; they used their hands to operate the lamp. They concluded that infants in the 'hands occupied condition' understood that the demonstrator intended to turn the light on but she could not use her hands and therefore used her forehead. But there was no explanation like this in the 'hands free' condition the demonstrator had no physical obstacle to use her hands. Therefore, infants could presume that for some unknown reason that must have been the more rational reason and they imitated the observed head action (Gergely et al. 2002). This result was interpreted as a case of selective imitation and suggests that infants have insight of the rationality of an action (Gergely et al. 2002). On the other hand, this is a good example of a copying behaviour in a

cognitively opaque situation. In a follow-up study Király and colleagues (2004) repeated the experiment adding a further variable to the situation; the presence / absence of communicative cues during the demonstration. Interestingly, the selective nature of imitation was found only after the communicative demonstration; infants imitated the head action in the 'hands free' condition but used their hand to switch the lamp on in the 'hands occupied' condition. This difference disappeared in the non-communicative situation, i.e. the difference between proportions of head versus hand users was not significant. This can be interpreted as ostensive-communicative cues generate a special attention state in infants during which they show an increased interest toward the action of the demonstrator and not only the attained goal state (Gergely & Csibra 2006). These results also show that the likelihood of imitating behaviour increases in case of cognitively opaque or less efficient actions after a communicative demonstration as the highest proportion of infants copied the strange head-action in the 'hands free' condition after the communicative demonstration (Király et al. 2004).

Selective imitation and relevancy expectation in infants after a communicative demonstration were also shown by Southgate et al. (2009) in an imitation task. 18-month-old infants had to imitate style (a toy dog was hopping) and outcome (a dog went into a house) of a demonstrated action after three different types of demonstration. In the first group infants saw an ostensive demonstration and got verbal information about the outcome before the demonstration (ostensive prior information). The second group of infants observed the same ostensive demonstration without the prior verbal information of the goal (no prior information). The third group participated in a non-communicative situation but all the infants got the prior verbal information (non-ostensive prior information). Higher proportion of infants copied the action style in the ostensive priori information group than in the no prior information or the non-ostensive priori information group. Furthermore, infants in the ostensive prior information group copied less the outcome of the action than in the other two groups. These results suggest that infants at this age a looking for relevance in an action after observing it in a communicative way. If an aspect of the action is verbally emphasized it will loose its relevance and they will tend to copy another aspect that may be relevant, for example the style of the demonstration. This experiment furthermore provides another example of selective imitation based on the presence/absence of communicative cues as infants are more likely to imitate the action style after a communicative situation whereas they will rather imitate the outcome after a non-communicative situation.

5.1.3. Generic information transmission.

An important aspect of pedagogical learning is that ostensive-communicative and referential cues not only enhance imitative learning of the new and relevant information but convey generic information. A typical characteristic of objects in human environment is that the location of an object is rather 'here-and-now' information which refers only to the present since objects' location is not persistent in time and space, whereas the visual feature of an object is a permanent property in space and time (Csibra & Gergely 2009). Learning about the visual features has an important role in learning to categorize objects in early infancy. Csibra and Gergely (2009) stated that whereas "location could be regarded as a transient episodic feature that represents no generalizable information… …the visual features of an object normally belong to its permanent properties (objects do not tend to change their appearance), and therefore are informative when recognizing the same object again or when identifying other objects of the same kind" (Csibra & Gergely 2009, p. 151). Visual features accordingly are enduring generic properties of objects that carry generalizable information and these properties can be the base of the object categorization learning. According to the authors: "children expect to learn something generalizable in ostensive-referential contexts rather than just become informed about particular episodic facts that obtain only in the 'here-and-now' (Csibra and Gergely 2009, p 151). A growing body of evidence supports this claim (Yoon et al. 2008; Futó et al. 2010; Marno et al. submitted).

Infants may show 'person-centred' interpretation of attitudes shown by another person toward an object in non-communicative situation, whereas they interpret attitudes as 'object-centred' after observing them in an ostensive-communicative context (Egyed et al. 2007). The object-centred interpretation of attitudes then presumes a generic property of the object (e.g. good or bad object) whereas the person-centred interpretation is rather 'here-and-now' information (e.g. this person likes or hates this object).

Egyed and colleagues (2007) showed that 18-month-olds showed an object-centred interpretation of facial expressions after observing two opposite emotional expressions toward two novel objects in an ostensive-communicative demonstration. In the demonstration a model expressed positive emotions (smile) toward one unfamiliar object on a table and negative emotion (disgust) toward another different looking unfamiliar object. In the test phase either the demonstrator or a new person came in and asked for one of the objects to be handed over by the infant. After ostensive-communicative demonstration the infants were more likely to hand over the positively cued objects for both the familiar demonstrator and the unfamiliar person. After a non-communicative demonstration they gave the positively cued

object when the demonstrator asked for it but there was no object preference when an unfamiliar person asked for the object.

Another example of the generic interpretation of communicative demonstration is the experiment of Yoon and colleagues (2008). After non-communicative presentations (reaching for a toy) nine-month-olds watched an event longer when the location of an object was changed than when the feature of the object changed. In contrast, after communicative presentation (pointing to a toy) they watched longer towards objects whose feature had changed than to objects whose location was changed (Yoon et al. 2008). Interestingly the same phenomenon was observed in adults. In a touch screen experiment adults were more likely to recall a change of the location than the feature of an object on the screen after a non-communicative presentation, whereas they tended to notice the change in the feature of the object rather than the location after a communicative presentation (Marno et al. submitted).

Further interesting demonstration of the modulating effect of communication on information processing comes from a study applying the 'A-not-B task' (Topál et al. 2008). In the original version of this task the experimenter hides a toy at a location, after which infants have the opportunity to retrieve it from there. After a few trials, the experimenter hides the toy – in full view of the infant – at another location. The general finding is that infants younger than one year of age search for the toy at the first location ('A-not-B error', originally described by Piaget 1954) and this failure to retrieve the toy is usually interpreted as a problem of motoric inhibition. However, in the experiment of Topál and colleagues (2008) when the hiding event was demonstrated in a non-communicative context the ratio of committing this error significantly declined. According to the authors communication during the hiding – which is generally part of the standard procedure – biases them to extract generic knowledge from the demonstration (i.e. this container is the one with the toy or this toy belongs in this container) and this leads to the ignorance of location information (Topal et al. 2008).

5.1.4. Uniqueness and universality.

Natural pedagogy is a human adaptation universal and unique in human cultures. Unique in the way that so far there is no evidence that any other non-human species shows similar teaching-learning mechanism, and universal because all human cultures bear the potential of pedagogical learning even if they have huge variety in forms and intensity (Csibra & Gergely 2009, 2011).

Although there is evidence that some forms of teaching exist in animals (e.g. pied babblers (*Turdoides bicolour*), meerkats (*Suricata suricatta*), tandem-running ants (*Temnothorax albipennis*) or chimpanzees (*Pan troglodytes*) (reviewed in Csibra & Gergely 2011), the authors argue that those transmit 'here-and-now' and not generic information and/or do not involve communication into the interaction which is the most important characteristic of natural pedagogy. Csibra and Gergely (2011) emphasize that there is no evidence for natural pedagogy in our closest relatives the apes and therefore this skill must have evolved in the hominine lineage.

5.2. Natural pedagogy in the human cultural evolution

Csibra and Gergely (2011) suggest that natural pedagogy has a special role in the human cultural evolution; it is a product and at the same time a possible driving force of it. It is an imitation based mechanism that makes arbitrary, conventional and cognitively opaque information transmission possible. Consequently, infants already can acquire loads of information without basic causal understanding at a young age. Thus natural pedagogy can facilitate cumulativeness in the cultural evolution (Csibra and Gergely 2011).

5.2.1. Cognitive opacity of the cultural transmission.

Despite the fact, that cultural transmission happens with high fidelity the mediated information may not always be cognitively transparent for the recipient. Human culture is full of achievements that are - partly or fully – cognitively opaque. The ability to mediate information without deeper understanding makes it possible to share the cost of invention between individuals whilst all individuals can benefit from it. Thus the knowledge of the population can accumulate much faster than in a population where the individuals must have a cognitive understanding of the information in order to be able to acquire it (Gergely & Csibra 2006, Csibra & Gergely 2009). Natural pedagogy based on blind imitation that makes it possible to transfer cognitively opaque information (see "Head-lamp experiment" by Király et al. 2004 in Main introduction 5.1.2). This also supports the idea that natural pedagogy has an important role in the cultural transmission.

5.2.2. Arbitrariness and conventionality.

An important and unique feature of our culture is that several elements are arbitrary and conventional, thus cannot be individually invented (Gergely & Csibra 2006). Probably the most remarkable element is the human language, but habits, traditions, rituals or beliefs are also important parts of our life that can be inherited only socially. Therefore natural pedagogy - which enables the transmission of cognitively opaque information with high fidelity - may be suitable for transmitting arbitrary and conventional information. In this way it can provide an important mechanism of cultural transmission (Gergely & Csibra 2006).

5.3. Critiques of the natural pedagogy hypothesis

Natural pedagogy theory provides a possible mechanism for several characteristics of the human social learning system and culture. However, the supporting experimental evidence, although growing, is still in its infancy. There are several criticisms of the (or certain parts of the) theory that come from both experimental and theoretical fields. These criticisms may warn us that the field of social learning in infants and human cultures require much more experimental research and field observations in order to evaluate the theory adequately.

Here, I will list two of these criticisms.

5.3.1. The importance of teaching.

While natural pedagogy is built on a teaching-based information transmission system there are several authors who suggest that teaching is not as important in the human societies. According to some field observations by anthropologists teaching is a little known mechanism in a number of archaic tribes and some of the non-Western societies (especially in Africa) are pedagogy-free (reviewed in Csibra & Gergely 2011). Furthermore, there are some reservations that even in Western societies teaching has a less prominent role in information transmission how natural pedagogy would make us believe (reviewed in Csibra & Gergely 2011). However, studies supporting these claims typically use more strict definitions of teaching that exclude pedagogical demonstrative teaching. In several societies pedagogical teaching was determined to be rare and had lesser significance in the learning process but some form of pedagogical teaching does exist. Until now there is no example of any pedagogy-free human culture (Csibra and Gergely 2011).

5.3.2. Over-imitation vs. selective imitation.

Two phenomena of infant social learning, selective and over-imitation seem to be contradictory (Whiten et al. 2009, 2011). Context-dependent selective-imitation emphasized by the natural pedagogy hypothesis, and lack of imitation at incidental actions (Carpenter et al. 1998a) appear to be in contrast to the well-known phenomenon of over-imitation (or over-copying) of children, which was shown even at the age of 5. Imitative tendencies of infants have been proven very strong in several situations with relative blindness to the circumstances suggesting that over-imitation is a strongly determinative feature of infancy and early childhood (Whiten et al. 2009, 2011).

6. Dog, as a model species of comparative analyses on human social cognition

The assembly of species-specific traits that determine the unique and specific cognitive skills of humans is called as the "Human Behaviour Complex" (Csányi 2000; Topál et al. 2009a). Natural pedagogy is one of these species-specific features, which is unique but universal in humans (Csibra & Gergely 2009, 2011).

For studying the origin, mechanism or function of a single behavioural trait or a behaviour complex comparative analysis is one of the most important methods in ethology. Comparing behavioural traits in homologue species (like apes and humans) can give answers about the origin of a certain behaviour, whereas comparing analogue behaviours in distant related species may refer to functional similarities (Topál et al. 2009a). Identifying convergent evolution and finding analogue behavioural traits between distant related species can help us making inferences about the factors contributed to the appearance of a behavioural trait or a behaviour complex.

Studying human species-specific behavioural systems - such as natural pedagogy - using an ethological approach is crucial for our deeper understanding but underutilised (Topál et al. 2009a, examples of human non-human comparative experiments: Nagell et al. 1993; Horner & Whiten 2005; Haun et al. 2006; Lakatos et al. 2009). Comparative analyses of a species-specific behaviour is challenging because of the difficulty to find species with homologue or analogue behavioural traits (Topál et al. 2009a). Apes – the closest relatives of humans – for example seemed to show no or low sensitivity of the human ostensive-communicative and referential cues; they perform poorly in object-choice tasks when they have to rely on human communicative gestures (reviewed by Call & Tomasello 2005; Bräuer et al. 2006; Call et al. 1998; Itakura & Tanaka 1998). Chimpanzees (*Pan troglodytes*), for

example, showed low level of comprehension of the human pointing without training in an object-choice task (Povinelli et al. 1997; Itakura et al. 1999).

Recent studies on apes' and monkeys' understanding of the human communicative cues, however, warn to be critical of the conclusions of these studies (Mulcahy & Hedge 2012). This review suggests that the experimental set ups which have been widely used for testing apes and monkeys in object-choice tasks in order to measure their comprehension on the different communicative cues might be responsible for their poor choice behaviour (Mulcahy & Call 2009; Mulcahy & Suddendorf 2011). Set ups used for testing apes vs. dogs and infants – whom are excellent cue followers – turned out to be slightly different (the distances between the containers, thus their positions from the viewpoint of the subjects are different; the containers are much closer to the demonstrator in case of apes than in dogs or infants) yet this difference might be determining in their choice behaviour (see for review in Mulcahy & Hedge 2012). Therefore, whether apes are suitable subject of such a comparative work is still a question.

There is, however, one species living close to humans which has been regarded as a promising subject of comparative analyses for the Human Behaviour Complex: the domesticated dog (*Canis familiaris*) (Topál et al. 2009a). The domestication theory of dogs (Miklósi et al. 2003) states that dogs evolved traits which increased their chance for survival in the anthropogenic environment. This led to behavioural changes; dogs accumulated new socio-cognitive skills that are similar to human socio-cognitive behaviours (Miklósi & Topál 2012).

The domesticated dog is a suitable subject for a convergent behavioural modelling for at least three reasons (Topal et al. 2009a): 1) dogs and humans share the same social environment with the same socio-cognitive challenges, 2) dogs and humans show convergent evolutionary processes; they are phylogenetically distant species that developed similar behavioural traits due to adaptation to the same socio-cognitive environment, 3) they not only share similar behavioural traits but they show a complex level of behavioural similarities ("Dog Behavioural Complex").

Experimental studies have started to focus on these unique abilities only during the last 20 years (Miklósi et al 2004). Studies proved that dogs show high sociality (Gácsi et al. 2005; Topál et al. 2005; Bräuer et al. 2006), cooperation (Miklósi et al. 2003) and communication ability (Hare et al. 2002; Virányi et al. 2008; Gácsi et al. 2009a) with humans. This offers a new approach of studying dog socio-cognitive behaviour in comparison to humans; the system theoretical approach. It means comparative analyses can involve complex

behavioural systems (like attachment) or on the whole dimension of sociality (Topál et al. 2009a). Dog-human comparative work has the additional advantage that one can conduct comparative analyses of the two species in the same conditions without taking one of them out of its natural environment.

6.1. Similarities between the social skills of dogs and human infants

Living in the human social environment resulted in the evolution of new skills in dogs, such as following human attention, sensitivity for the human communicative cues, engaging in social learning and cooperative interactions (e.g. blind leading) or showing a reduced level of aggression toward humans (Miklósi & Topál 2012). Their ability to learn about the human communicative cues makes dogs suitable for comparing their performance to that of human infant in experimental situations in order to look at similarities or dissimilarities in the underlying cognitive mechanisms.

Here I will introduce those behavioural similarities that are mostly important from the point of the natural pedagogy theory.

6.1.1. Social learning from humans.

Similarly to human infants, dogs rely on information from humans in problem solving situations (Topál et al. 2009a). Dogs showed improved performance to get access to a food placed to the corner of a V-shaped fence after observing a human demonstrator detour the fence (Pongrácz et al. 2001). When there was an opening at the corner of the V-shaped fence dogs were able to find a food alone. However, after the opening was closed they could not solve the problem anymore alone. Dogs were not able to choose alternative solutions, such as detouring the fence, probably because the alternative solution was more costly (i.e. they had to take a longer route, and in addition they have to start by moving away from the food). However, a human demonstration of the detour helped dogs to find the successful way to the food. Most importantly from the point of the natural pedagogy was the observation that dogs learning ability from the human demonstrator was strongly relying on the verbal cues the human demonstrator used during the demonstrator; namely she/he was talking to the dog (Pongrácz et al. 2003).

6.1.2. Reliance on the human ostensive-communicative and referential cues.

The most widespread method to test dogs' understanding and reliance on communicative cues are two-way choice tasks (see Reid 2009). These tests revealed that choice behaviour of dogs can be controlled by the communicative cues given by the experimenter (e.g. Miklósi et al. 2004; Miklósi & Soproni 2005; Topál et al. 2009a, b) even if they have unambiguous knowledge about that the reward object (or the larger quantity of food) is in a different location than the communicatively reinforced one (Szetei et al. 2003; Erdőhegyi et al. 2007; Prato-Previde et al. 2008). However, a systematic analysis of these cues is necessary to understand how they affect the behaviour of dogs.

Ostensive-communicative cues:

Eye contact. Eye-contact in wild living animal species generally functions as a threatening cue (e.g. Topál & Csányi 1994). By contrast, in certain situations dogs show sensitivity and preference for this ostensive cue of humans (Topál et al. 2009a; Kaminski et al. 2012). Even only few weeks old dog puppies seek eye contact to a human, therefore this preference exists already at very early ages (Gácsi et al. 2005). Dogs, furthermore, prefer begging for food from a person who faced the dog and not from someone who was turning away (Virányi et al. 2004). This demonstrates that dogs are able to use eye contact of a person as a discriminative sign of attention. Dogs performed better after an intentional (communicative) than a non-intentional (non-communicative) demonstration (Kaminski et al. 2012). The key element influencing the dogs' behaviour was the eye contact during the intentional demonstration. Importantly, they also provide evidence that puppies show similar reliance on eye contact as adult dogs suggesting a genetic background of this feature (Kaminski et al. 2012).

Getting verbal attention. Attention getting from the human demonstrator proved to be an important factor for dogs (Virányi et al. 2004). Earlier I mentioned that in a social learning task dogs significantly improved their problem solving ability (go around a V-shaped fence) after observing the demonstration accompanied by getting verbal attention (Pongrácz et al. 2004). However, when the demonstrator was another dog and observers got the attentive cues from an outsider human person their performance level decreased (Range et al. 2009). These results show that dogs are sensitive for the attention getting cues only if those come directly from the demonstrator, which is probably the consequence of their short focus and the inability to share their attention between more actions (Range et al. 2009).

When eye contact was used during the test, the performance of dogs was not influenced by verbal cues before the demonstration. However, when there was no eye contact (the demonstrator was turning her back to the dog) the dogs performed better when their name was called before the test. Interestingly, dogs seemed not to be sensitive to their own name specifically; in a pointing task they behaved in the same way if a random name was used. However, when another person was named and addressed by eye contact they ignored the demonstration. The conclusion of these results was that dogs have the ability to decide if a person addresses them or someone else (Kaminski et al. 2012).

Referential cues:

Gazing and gaze alternation. Gaze following behaviour is an important feature in several non-human species in order to infer to their socio-cognitive capacities (Emery 2000). Dogs turned out to be sensitive to the direction of human gaze (Kaminski et al. 2009), moreover they rely on the direction of the human attention in object choice tasks (Soproni et al. 2001; Kaminski 2009). Dogs perform better than expected by chance when they have to find a hidden object using human gazing cues as the source of information. However, their performance is usually poorer than when pointing gestures are offered (Kaminski et al. 2012, Bräuer et al. 2006). Dogs are able to discriminate gazing at an object from gazing above an object or into an empty space although they perform better if the object is gazed at directly. This suggests that they have some understanding about the referential content of gazing (Soproni et al. 2001; Agnetta et al. 2000).

Pointing. Dogs are experts in finding hidden objects based on the pointing cue according to several studies (e.g. Bräuer et al. 2006, Soproni et al. 2001, Lakatos et al. 2009, Miklósi & Soproni 2005). They perform consistently during their development (from age of 2 months to 14 months) and they do not improve in consecutive tests (Virányi at al. 2008, Gácsi et al. 2009b). Dogs tend to interpret pointing more successfully than gazing (Kaminski et al. 2012; Bräuer et al. 2006). In contrast to gazing, pointing may be visually more perceivable because of the changed body contour of the demonstrator. Furthermore, extended arm and finger (or leg) function as an arrow and reduce the distance between demonstrator and object (Soproni et al. 2001, Lakatos et al. 2009). According to a recent study the usage of the pointing gestures by dogs is at the same level as a 2 year-old humans (Lakatos et al. 2009). Dogs rely on the pointing cue successfully even if an odour cue of food comes from another not

communicated container (Szetei et al. 2003) or the demonstrator stands behind a non-communicated container (Soproni et al. 2002). They are able to rely on a pointing gesture correctly even when the demonstrator is moving away from the cued container (McKinley & Sambrook 2000). Importantly, they perform significantly better after a communicative demonstration than during non-communicative tasks (Kaminski et al. 2012).

Human-directed cues. Dogs are not only skilful in understanding ostensive-communicative and referential cues, but uniquely among animals they are able to use them toward humans. Dogs were reported in several studies to use gazing behaviour toward a human when they encounter an unsolvable task, in order to request help or solicit information (Miklósi et al. 2003, Lakatos 2011). Dogs tend to gaze often at the demonstrator when they meet a challenging task as early as 2-month-old (Passalaqua et al. 2011). Furthermore, dogs show social referencing (alternate gazing between a human and an object and behaviour regulation according to the emotional information) in a situation where they meet a new and "scary" object (Merola et al. 2012). Dogs tended to approach the object if the owner showed positive emotions and showed more gazing between the owner and the object. They also rather stayed in their original position when the owner showed negative emotions toward the object.
Cooperative behaviour between guide dogs and owners may rely on mutual cue using and understanding between the cooperative partners (Naderi et al. 2001).

Importantly, comprehension of the human communicative gestures does not necessarily mean innate adaptation for understanding these cues without any individual experience (Miklósi & Topál 2012). Because of the evolutionary co-existence of dogs with the highly social and communicative humans, social competences of dogs expanded in a way that they became able to acquire inter-specific communication. This expanded communicative ability also supports the evolutionary changes in dogs' socio-cognitive abilities (Miklósi & Topál 2012).

6.1.3. Selective imitation and "efficiency blindness"

There is evidence that similarly to human infants, dogs are sensitive for the rationality of an observed action and show selective imitation. In an experiment dogs copied an unusual paw action after observing a demonstrator dog solving a task by its paw. However, when the demonstrator dog's mouth was occupied by a tennis ball the dog subjects did not copy the paw action but used the more common solution; their mouth to solve the problem (Range et

al. 2007). In the experiment a human person used ostensive-communicative cues to evoke the dogs' attention before the demonstration. This suggests that dogs had some level of understanding about the inability of the demonstrator dog to use its mouth when it was occupied by the tennis ball. Therefore it used its paw to solve the task. This is similar to infants' selective behaviour (Gergely et al. 2002, see Main introduction 5.1.2.); communicative demonstration may have triggered infant-like selective imitation in dogs (Range et al. 2007).

Dogs also show "efficiency blindness" driven by human ostensive-communicative cue. It was proven in certain experimental conditions that they preferred the less or non-efficient solution over an efficient one. Dogs systematically chose the communicatively signed but empty container in a two-way choice task even when they had unambiguous information about that the reward is in the other container (Erdőhegyi et al. 2007).

Dogs just like human infants commit the so called A-not-B error (see Main introduction 5.1.3.) after a communicative - but not after a non-communicative - demonstration of the hiding event (Topál et al. 2009b). The authors suggest that the "search mistake" in the communicative situation cannot be assigned only to the attention diverting effect of the cues that were performed only toward the empty container because dogs showed strong preference toward the empty container and not searching by chance (Topál et al. 2009b).

In both cases there is behavioural analogy between dogs and human infants in their reliance on the human ostensive-communicative cues. Furthermore, these cues may dispose a certain behaviour that may be different from their own behaviour without the communicative context (Topál et al. 2009b). However the cognitive mechanism between dogs and infants might be different. Whereas natural pedagogy generates long term learning in infants (Csibra & Gergely 2009), in case of dogs following the communicatively assigned behaviour might be primarily driven by behavioural synchronisation to avoid conflict and prepare to cooperate (Miklósi & Topál 2013). However, it cannot be excluded that even in case of dogs learning is also involved when they follow a demonstration of a (less efficient) action (*see General discussion*).

6.2. Differences between the social skills of dogs and wolves

Dogs split from wolves sometimes between 15.000 and 30.000 years ago and most modern breeds were created over the last 150 years (Larson et al. 2012), however, the process of their evolution is opaque. During domestication the human environment selected for an

ability to develop specific social-cognitive skills, including lower levels of aggression and higher levels of affiliation displayed toward humans (Miklósi et al. 2003, Hare et al. 2002). Comparative studies between dogs and wolves can provide us with a deeper understanding of the evolution process of dogs' comprehension of the human communicative gestures.

An important difference in the socio-communicative abilities of dogs and wolves was discovered by Miklósi and colleagues (2003). In an obstructed situation when subjects had difficulties or were unable to solve the problem alone, dogs tended to look back much earlier and more often to the demonstrator for initiating communicative interactions than hand raised and equally socialized wolves.

Further studies revealed that differences in their reliance on certain communicative cues are already present in their early lives. The choosing success of 4-month-old dog and wolf puppies were compared in a two-way choice task based on their comprehension of human pointing gestures (Virányi et al. 2008). Dogs at this age outperformed the intensively socialized (hand-raised) wolves that performed at chance level. Furthermore, dogs did not need to be intensively socialized for this performance since ordinarily socialized pet dogs brought the same performance as highly socialized ones. Similar results were found at the latency of getting and maintaining eye contact at the beginning of the demonstration; hand-raised and pet dogs both initiated eye contact significantly earlier than wolves. Interestingly, the performance of dogs did not increase substantially after intensive training sessions, however, wolves for their age of 11 months performed comparable success rate to same age dogs (Virányi et al. 2008). This suggests that learning of the usage of cues is possible for both species; however, this ability develops much faster in case of dogs. During the testing event dogs and wolves showed other remarkable behavioural differences; whilst dogs showed higher willingness to cooperate and higher attentiveness during the demonstration wolves struggled and bit more frequently (Gácsi et al. 2009a).

The results of comparative studies on the communicative behaviour of similarly socialized dogs and wolves may refer to a) heritable differences between the two species (Virányi et al. 2008) which emerged on evolutionary level together with b) differences in their epigenetic processes due to different social environment on the epigenetic level (see 'synergistic' hypothesis by Gácsi et al. 2009a).

Infant-dog and wolf-dog comparative studies together can give us deeper insight into the socio-cognitive changes the domestic dog went through as a result of the intensive exposure for the human environment. Adaptation to this new social environment resulted

developmentally early emerging ‘infant-like’ communicative skills in dogs, such as the ability to engage eye contact and follow human gazing or pointing gestures without intensive socialization. However, importantly these behavioural similarities between human dogs and human infants do not necessarily refer to the same underlying mechanisms or motives behind their behaviours (see Topál et al. 2009b).

Therefore, direct and indirect comparative studies are necessary on infants’ and dogs’ reliance and interpretation of the human ostensive-communicative and referential cues in order to learn more about the functions and mechanisms of these cues in both human pedagogy and the dog-human interactions.

Objectives

The natural pedagogy theory is well described in the human infant literature (Gergely & Csibra 2006; Csibra & Gergey 2009, 2011), however, until now there is relative little direct empirical evidence to support this theory.

In this thesis I propose to find further evidence on natural pedagogy and deepen our understanding about the mechanism of information transmission with ostensive-communicative and referential cues. The domestic dog has been proven to show 'infant-like' features in its sensitivity and utilization on the human ostensive-communicative and referential cues. Therefore my additional aim is to reveal possible similarities and differences in the function and mechanism of this non-verbal communicative system between the two subject groups.

I use two different approaches. First, I compare different age groups of human infants and dogs in identical experimental conditions related to natural pedagogy theory. Second, I introduce variables (such as the presence/absence of the demonstrator or the complexity of the task) which were previously reported to affect at least one of the subject groups' behaviour related to these human communicative cues, however, they have been never tested systematically in both communicative and non-communicative situations.

Throughout the thesis I compare directly and indirectly the behaviour of dogs and human infants. In the course of the comparative studies I endeavoured to set up demonstrational situations as similar as possible for the different subject groups. This is important since - as recent research revealed (e.g. Mulcahy & Call 2009) – relative small differences between the set ups can result very different behaviours in the comparable species which might lead erroneous conclusions (Mulcahy & Hedge 2012).

I carried out this comparative method through three levels by conducting three studies; 1) the level of sensitivity and responsiveness, 2) the level of interpretation of the cues, 3) the level of interpretation of the transmitted information.

The first level (**Study 1**) is to compare dogs' sensitivity and responsiveness on the communicative cues to human infants. Several previous studies have shown that similarly to human infants, dogs are particularly sensitive to human communicative cues (see Main introduction 6.1.2.). However, it is essential to test whether dogs and infants are similarly receptive and responsive using the same methodology for detecting deeper mental processes. This study examines the sensitivity of dogs to ostensive-communicative and referential cues

with an eye tracker technique. The protocol of this study follows the methodology and set up previously used in human infants (Senju & Csibra 2008). This makes it possible to compare the reactions of dogs and infants in an indirect way.

The second level (**Study 2**) is to compare directly the interpretation of the communicative cues in dogs and infants. Earlier studies already drew our attention to that; dogs and infants may be similarly reactive on the human communicative cues but this behavioural similarity can be driven by different motives (Topál et al. 2009b). The natural pedagogy suggests that communicatively presented information evokes long lasting learning in infants (Gergely & Csibra 2006; Csibra & Gergely 2009). There is evidence that infants show increased imitative tendencies in a communicative situation compared to a non-communicative one (Király et al. 2004; Nielsen 2006; Brugger et al. 2007). Dogs also tend to follow communicatively presented demonstrations; they also copy a seemingly less effective solution when it was demonstrated in a communicative context (Erdőhegyi et al. 2007). However, there is little information whether (similarly to human infants) they interpret these situations as an intention of teaching from the demonstrator's side, and they follow the demonstration in order to learn from it. Alternatively, as it was already suggested communicative cues can be interpreted as a command of the demonstrator that ordains a specific behaviour in that concrete situation (Topál et al. 2009b). In case of learning it is presumable that copying the demonstrator's solution is independent from the demonstrator and the context of the demonstration, while in case of obeying a command the copying behaviour is demonstrator- and context-dependent. However, it is also possible that both learning and obeying intentions play a role, furthermore, other interpretations cannot be excluded either.

The third level (**Study 3**) proposed to examine the generalisation hypothesis in natural pedagogy theory, namely how the different subject groups interpret the information they received in the communicative situation (see Main introduction 5.1.3.). The generalisation hypothesis suggests that communicative cues transfer generic knowledge; they emphasize the general properties of a certain object that can be transmitted for all objects of the same kind (Csibra & Gergely 2009). Therefore, they teach about the featural attributes of the object (as the generalizable property) (Csibra & Gergely 2009). When infants observe a communicative demonstration where an object is involved they attend to learn about the featural attributes (e.g. colour or shape) as a permanent property of the certain object. Therefore, they can use their knowledge later when they meet the object again. In contrast, non-communicative demonstration triggers learning about the location of the object. However, there are only few experimental evidences on the generalisation hypothesis in case of infants (see Main

introduction, 5.1.3.) and we have no specific knowledge about generalization skills in dogs. This study compares dogs' and infants' choice behaviour in communicative and non-communicative situations in a container transposition test (see in Haun et al. 2006). The purpose of the study is to reveal whether the subjects follow the feature or the location of the object depending on the communicative nature of the demonstration.

In order to test the effect of the communicative cues on the behaviour of dogs and infants I vary communicative vs. non-communicative contexts through the demonstration situations of all studies. Further question is relating to the natural pedagogy theory whether it is a generally active context that influences the learners' behaviour independently from other internal or external factors (such as the age, previous knowledge, cognitive background or the certain social context of the situation). Alternatively, this is rather a 'social support' the subject relies on under certain conditions. In order to get an answer I use different age groups of infants and dogs and I vary some of the social contexts of the situation (demonstrator's presence/absence during the trial) or the complexity of the task (see in **Study 2** & **3**).

Study 1: Dogs' gaze following behaviour depends on the communicative context of the demonstration

In our first study my colleagues and I establish the video-based eye tracker technique to study dogs' social skills through their eye movements. To our knowledge, this is the first study using this method to follow the eye movement of freely moving dogs without any bounding or the fixation of the head (head-mounted eye tracker was successfully used on freely moving dogs by Williams et al. 2011).

We order to test whether we can use eye tracker for studying dogs' social skills we analysed their gaze following behaviour on a short video. Gaze following behaviour seemed ideal to test with this paradigm for two reasons. First, recent studies suggest that dogs are able to interpret gazing as a referential cue (Soproni et al. 2001; Agnetta et al. 2000). However, their performance in gaze following tasks is usually poorer than in pointing tasks (Bräuer et al. 2006; Kaminski et al. 2012). Using the eye tracker system we have the possibility to detect precisely the eye movement of dogs and test whether they follow the direction of a human gaze without the necessity of making an active choice. Second, as I previously mentioned we have the possibility to indirectly compare infants and dogs gaze following behaviour and look for new evidence of dogs' infant-analogue behaviour. Recent eye tracker study on infants revealed that their gaze following behaviour is demonstration sensitive; they were more likely

to follow the gaze direction in a communicative, than in a non-communicative situation (Senju & Csibra 2008, see also Main introduction 5.1.1). Since dogs – similarly to human infants – turned out to be sensitive on the human communicative cues we presume that they will show parallel behaviour to human infants in this situation.

Questions of the study:

1. Can we use video-based eye tracker without any extra training to detect eye movement of non-bounded family dogs?
2. Do dogs show infant-like sensitivity (Senju & Csibra 2008) on the human communicative cues; namely are they more likely to follow the direction of a human demonstrator in a communicative, than in a non-communicative demonstration context?

Study 2: The effects of human demonstrator and communicative cues on the choice behaviour of dogs and infants: a comparative study

The social context of a demonstration affects the imitative/emulative behaviour of infants. Selective imitation depends on the presence or absence of communicative cues (Gergely & Csibra 2006; Nielsen 2006; Brugger et al. 2007) or on the social context (presence/absence of the demonstrator) during re-enactment (Learmonth et al. 2005; Király 2009). Communicatively accentuated action demonstration often triggers "efficiency blind" imitative behaviour in infants (Király et al. 2004, see Main introduction 5.1.2). Infant-like selective behaviour between communicative and non-communicative demonstration contexts also occurs in dogs (Range et al. 2007, Topál et al. 2009b). Dogs show "efficiency blindness" in their behaviour when they observed a communicative demonstrated action (Szetei et al. 2003; Erdőhegyi et al. 2007).

However, it is not known whether the demonstrator's presence or absence during the test influences the effect of the communicative or non-communicative aspect of the demonstration in case of dogs' and infants' behaviour. Additionally, "efficiency blindness" in dogs is yet to be examined systematically in communicative and non-communicative demonstration contexts.

Questions of the study:

1. Does the demonstrator's presence/absence affect the choice behaviour of infants and dogs after a communicative and a non-communicative demonstration?
2. Do dogs show infant-like features in their choice behaviour, such as selective copying behaviour in a tool-use task?
3. Is "efficiency blindness" in dogs and infants driven by social factors such as communication and demonstrator's presence?
4. Are there any differences between two different age groups of infants (14- and 18-month-olds) in their sensitivity to or reliance on the ostensive-communicative and referential cues?

Study 3: Feature or location? Effects of the ostensive-communicative and referential cues on the learning and searching strategy of infants and dogs

The natural pedagogy theory suggests that in a communicative situation learners are more likely to learn about the constant and generalizable properties of objects, such as the feature. Whereas in a non-communicative situation they tend to learn about the episodic 'here-and-now' information of the demonstration, such as the location (see Main introduction 5.1.3).

In order to test this hypothesis we created a 'Container transfer' experiment (see Haun et al. 2006); we used two containers of different in their colours or transparency and after demonstrating a bait of (or a retrieve from) one of them we invisibly switched the locations of the two containers. In this way we had possibility to test whether subjects search for the hidden object based on the colour of the baited container (which was in a different location at the time of the choice – feature-based search) or based on the location where the baited container was seen at the time of the hiding event (location-based search). In **Experiment 1** we tested dogs and infants understanding of a simple switch event between a transparent and an opaque container after they observed a direct bait of the opaque one. The hiding event was demonstrated either in a communicative or in a non-communicative way. In **Experiment 2** we tested whether subjects can generalize a tool-use task. The subjects observed a demonstration where manipulation on the empty and transparent container resulted in the appearance of the reward object from the baited and opaque container – when the locations of the containers were invisibly switched after the demonstration. In **Experiment 3** we used two

opaque containers painted with different colours. The main question was which strategy the subjects use to find the hidden reward in a situation: feature-based or location-base strategy.

In all three experiments we varied the presence / absence of the ostensive-communicative and referential cues during the demonstration of the bait (or retrieve) in order to examine the possible effect of these cues on their choosing strategy.

Questions of the study:

1. Is the searching behaviour of dogs and infants influenced by the presence/absence of the communicative cues during the baiting action in a situation where the presence of the object is deducible (the empty container is transparent; Experiment 1)?
2. Does communicative demonstration help dogs and infants to learn and apply the observed tool-use action in a situation where the location of the manipulation and the location of the result action are switched for the test event (Experiment 2)?
3. Does the communicatively demonstrated hiding event evoke feature-based whilst a non-communicative demonstration evokes location-based searching behaviour in case of dogs and infants in a situation where the reward object was placed under one of two featurally different containers during the demonstration before the containers were invisibly switched?

Study 1: Dogs' gaze following behaviour depends on the communicative context of the demonstration

Téglás, E., Gergely, A., Kupán, K., Miklósi, Á., Topál, J. (2012). Dogs' gaze following is tuned to human communicative signals. *Current Biology*, 22, 1-4.

Introduction

The social skills of dogs, such as their comprehension of the human communicative cues have been studied most prevalently by choice behaviour measuring tasks (see Main introduction, 6.1.2). The principle of these studies is that the demonstrator presents communicative signals toward one out of more possible locations or objects (e.g. containers) (Reid 2009) or alternatively one out of more models presents cues toward the dog (Virányi et al. 2004; Gácsi et al. 2004) and the choice behaviour of the dog is coded. However, the individual effect of each of these cues on the behaviour of dogs is still unclear. It is a further problem that the information which dogs use from the demonstration in order to make their final decision cannot be inferred only from this choice answer. Whether this decision is the result of a process whilst the dog ponder over all information it retrieved from the demonstration or, an automatic answer for one or all of the elements of the demonstration is unknown (see Williams et al. 2011).

The eye movement of dogs during the demonstration and the time period they spend on observing certain elements of it can provide us with information what might have been in the focus of their attention. However, following dogs' eye movement is a challenging task. Head or body orientation of dogs during the demonstration can be measured in order to test their attention level (e.g. how often the subject turns away from the demonstration), however, localizing the focus of their attention is very difficult if not impossible.

The eye tracker technique has been already a well-tried method to follow the gaze direction of humans and one of the most important techniques in developmental psychology (reviewed by Aslin & McMurray 2004; Gredebäck et al. 2009).

Video-based eye trackers such as the 'Tobii Eye Tracker' are used in screen watching situations. The principle of this method is that the eye tracker equipment emits infrared rays and detects their reflection from the cornea and from the skin around the eyes. Thus, the eye tracker program can detect the subject's eye movement on the screen with high accuracy.

However, this method has some difficulties; first, the system does not allow for much moving during the test period, subjects must stay still. Furthermore, since all subjects have individual differences in their eye and face build-ups every subject has to be calibrated individually. This eye tracker method has been tried on several non-human animals, like cats, dogs and macaques, however, most of these studies were executed on drugged or tightly bonded and head-fixed animals (reviewed by Williams et al. 2011). These invasive techniques in unnatural circumstances are very likely to produce deviations from the animals' normal behaviour; furthermore, they raise animal welfare questions (Williams et al. 2011).

Another eye tracker technique, the so-called head mounted eye tracker has been recently used successfully on dogs (Williams et al. 2011). This non-invasive method (developed originally for humans – Franchak et al. 2010) contains the eye tracker equipment attached to a muzzle and positioned on the dog's head together with a screen camera, an eye camera and a mirror system. This technique has the advantage that it can be used on free moving subjects and it can detect eye movement not only on a computer screen. However, it requires a certain amount of training to habituate the dog for the apparatus (Williams et al. 2011).

In our experiment we used the video-based eye tracker technique ('Tobii Eye Tracker') in order to analyse the looking behaviour of dogs in a gaze following situation.

Recent studies revealed that dogs are able to share attention with humans, and they are skilful in using human gaze in object choice situations (Kaminski 2009). Moreover, increasing evidence suggests that dogs show early (Riedel et al. 2008) and infant-like sensitivity (Topál et al. 2009b) to cues that signal the human's communicative intent. These findings raise the possibility that, independently from the actual underlying mental mechanisms, dogs display analogue functioning in terms of performance to preverbal infants in ostensive-communicative situations. Although recent research has provided important evidence about dogs' social communicative skills (Topál et al. 2009b) it is still unclear whether dogs' gaze following is tuned to cues that signal the human's communicative intent.

Recently Senju and Csibra (2008) found that 6.5-month-old infants' responsiveness to the direction of the human gaze depends on the communicative aspect of the demonstration. They presented a human model on a screen gazing toward one of two containers in communicative or non-communicative context and then recorded the infants gaze direction with an eye tracker. They showed that infants were more likely to follow the direction of the model's gaze in an ostensive-communicative situation than in a non-communicative one. They interpreted the results as evidence for the comprehension of ostensive-communicative

(e.g., eye contact, verbal addressing) and referential cues (gaze alter) as a communicative intention as early as 6.5-month of age.

In our study we investigated whether dogs' gaze following ability parallels human infants' behaviour. We adapted the method of Senju and Csibra (2008) and similarly to their study we used the eye tracker technique to study dogs' comprehension of the gaze cue. We exposed dogs to watch a model person on a screen who showed gazing toward one of two containers in a communicative or a non-communicative situation and detected the eye movements of dogs with an eye tracker.

Methods

Subjects

Sixty-one pet dogs were recruited to this experiment (33 males and 28 females; mean age = 3.46 years, range = 1 – 11 years). They included twenty-three different recognized breeds* and twenty-two mongrels. All were recruited from the Family Dog Research Database maintained by Department of Ethology, Eötvös Loránd University. In order to be selected for this study the subject had to be naïve to the task, and older than a year. We invited owners who had dogs with basic obedience training and which were reported by the owner as "watching TV or computer screens" for short periods of time.

Thirty-three dogs were excluded from the experiment because of inattentiveness (N = 13 or unsuccessful calibration (N = 20).

All dogs of the experimental group participated in both communicative and non-communicative trials that differed only in the addressing phase (see below).

Eye-gaze data of 28 dogs (15 participated in the experimental group and 13 in the baseline control group) were considered for analysis. The experimental group (8 males, 7 females; mean age = 3.1 years; range = 1 – 5 years) were consisted of seven different breeds (2 Yorkshire terriers, 1-1 Beagle, Border collie, Cavalier King Charles spaniel, Golden retriever, Hungarian vizsla, Labrador retriever) and seven mongrels. However, not each subject that was analyzed in the cueing phase contributed eye gaze data to other sequences of the stimulus presentation. As a consequence the analysis of eye gaze data in the addressing phase involved different number of participants. We obtained valid data for analysis from 13 dogs in the communicative and 14 dogs in the non-communicative condition; however, only 11 of them provided valid data in each of these conditions.

The baseline control group (5 males, 8 females; mean age = 2.77; range = 1 – 7) consisted of six different breeds (2 Poodles, 1-1 Beagle, Schipperke, French bulldog, Basset hound, English bulldog) and six mongrels.

* Airedale terrier, English bulldog, Basset hound, Beagle, Border collie, Cavalier King Charles spaniel, Dachshund, English cocker spaniel, Fox-terrier, French bulldog, German shepherd, Golden retriever, Labrador retriever, Lurcher, Hungarian vizsla, Mops, Pointer, Poodle, Rottweiler, Schipperke, Staffordshire terrier, West highland terrier, Yorkshire terrier

Experimental arrangement and apparatus

The experiment was carried out between October 2009 and December 2010.

The fifteen dogs in the experimental group participated in a balanced order with at least 1 week break between the two sessions. Dogs were tested at the Department of Ethology, Eötvös Loránd University in a testing room (3,5 x 4,5 m). The room was empty except for the monitor and the eye tracker device. An Experimenter (E1 - who was the same young woman for all dogs) ran the warm-up trials before the tests, gave a guideline for the owners how to behave during the test and supervised the calibration. After the warm-up trial E1 left the room and only the owner was present with the dog during the test. Another Experimenter (E2) operated the eye tracker program form a computer which was connected to the test monitor and to the eye tracker device and was situated in the next room. E2 could observe the dog and the owner by the means of a camera system during the test. This camera system recorded also the dog and the owner.

The gaze data was collected at 50 Hz by a Tobii X50 Eye Tracker (Stockholm, Sweden). The eye tracker had 0.5–0.7 degree accuracy, 30 x 16 x 20 cm freedom of head movement. The stimuli were presented on a 17-inch LCD monitor positioned behind the eye tracker device.

The owner made the dog stand, sit, or lie down in order to get optimal eye-gaze data at a distance of approximately 60 cm. The owner sat behind the dog and nodded his/her head while looking down and avoiding verbal interactions.

Procedure

I. <u>Warm-up phase</u>

Warm-up trials were designed to elicit the dogs' interest towards the plastic pots that were shown on video during the experimental trials.

Before the experiment dogs participated in a 10-trial warm-up session. E1 put a piece of dog chow in a plastic container in full view of the dog and then hid it behind her back. After a few seconds she brought the pot and offered it to the dog by holding it up (1 m above ground level) either in her left or right hand (5-5 trials in a counterbalanced order) while making noise by shaking the container. In the first trial E1 gave the food to the dog immediately after the dog looked at the container. In the later trials, however, she gradually increased the dog's looking time toward the container (up to 5 seconds) by increasing the delay interval between showing and shaking the container and giving the food.

Steps of the trials were as follows:

1. E1 stood facing the dog and holding a plastic pot in front of the subject.
2. E1 took out a piece of dry food from her waist bag, showed it up while saying, "Listen!" in a tone that did not resemble motherese.
3. E1 put the food in the plastic pot clearly visibly to the dog.
4. E1 hid the pot behind her back while saying „Where is the food?". If the dog was not attentive to her, she made a conspicuous noise with the dry food (shaking the container behind her back).
5. E1 brought her left or right hand (holding the container) out from behind her and attracted the dog's attention by shaking the pot again.
6. Finally (after a few seconds), the pot was offered to the dog who was allowed to eat the food.

II. Calibration phase

The eye-gaze recording was preceded by a five-point calibration phase following the infant calibration protocol of software Clearview 2.5.1. The same software presented the video clips in the test trials. Dogs participated in the test trials only if contributed to minimum four calibration points.

III. Test phase

In the experimental group dogs were exposed to both communicative and non-communicative conditions received two blocks of six trials. The blocks were composed of video materials containing ostensive-communicative cues (Figure 1A, 1B, and 1D) and non-

communicative cues (Figure 1A, 1C, and 1D). The blocks were presented in counterbalanced order, and the direction of the model's gaze was also counterbalanced.

Each trial presented video recordings that started with an introductory phase. The model had two pots on each side and faced down in a still position for 2s (Figure 1A). The second, so called "addressing phase" lasted for 3s and differed according to the experimental conditions. In the communicative (A, B, D) condition, the model raised her head, looked straight at the dog, and addressed the subject (''Hi dog!'') in a high-pitched voice (B). In the non-communicative (A, C, D) condition, with her head facing down, the model addressed the dog using low-pitched voice (''Hi dog!'') while a salient moving image was overlaid on the head (C). This attention-getter was present for 2s and served to make the attention shown by the dogs comparable to the other condition. The verbal utterance had similar duration and intensity in the two conditions but differed in pitch. In the last, cueing phase (6s), the model turned her head toward one of the two containers (1s) and remained motionless (5s) while showing neutral facial expression (D) (Figure 1).

One possibility is that not the absence of ostensive-communicative cues in the non-communicative condition but the artificial nature of the attention-getter stimulus contributed to the reduced gaze following in the non-communicative condition. To exclude this, we measured the gaze-following behaviour of 13 additional experimentally naive dogs in the baseline control condition in which (1) the human actor turned her head without providing any ostensive cues (eye contact and addressing), (2) the salient attention-getter was removed from the addressing phase, and (3) the verbal addressing was replaced with neutral beep sound of similar duration and intensity in order to keep the auditory marking of this sequence comparable, while attracting the dogs' attention to the screen. Subjects assigned to baseline control group received only one block of six trials (Figure 1A and 1D, but never the attention-getter in phase C).

The experimental stimuli were blocked into two sequences of 6 trials according to the experimental conditions (communicative, non-communicative, baseline control) and tested in different sessions. The direction of the model's gaze was counterbalanced in RLLRLR or LRRLRL order. For half of the participants the trial sequences were started with leftward gaze and for the other half with rightward gaze.

In order to avoid learning transfer between the warm-up and experimental contexts (i.e. formation of unwanted associations between the model's ostensive facial cues and food) we built in several procedural differences between the warm-up phase and experimental trials. First, the experimenter who participated in the warm-up trials (E1) and the model who was

shown on the video clips were not the same individuals. Second, E1 was looking at the dog throughout the trials with the head held stationary (she did not turn her face towards the pot etc.). Third, E1 used extensive hand gestures while she manipulated the pot and food during warm-up trials. In contrast, on the experimental videos the human model did not use her hand, instead, she used her face and eye gaze only for communication.

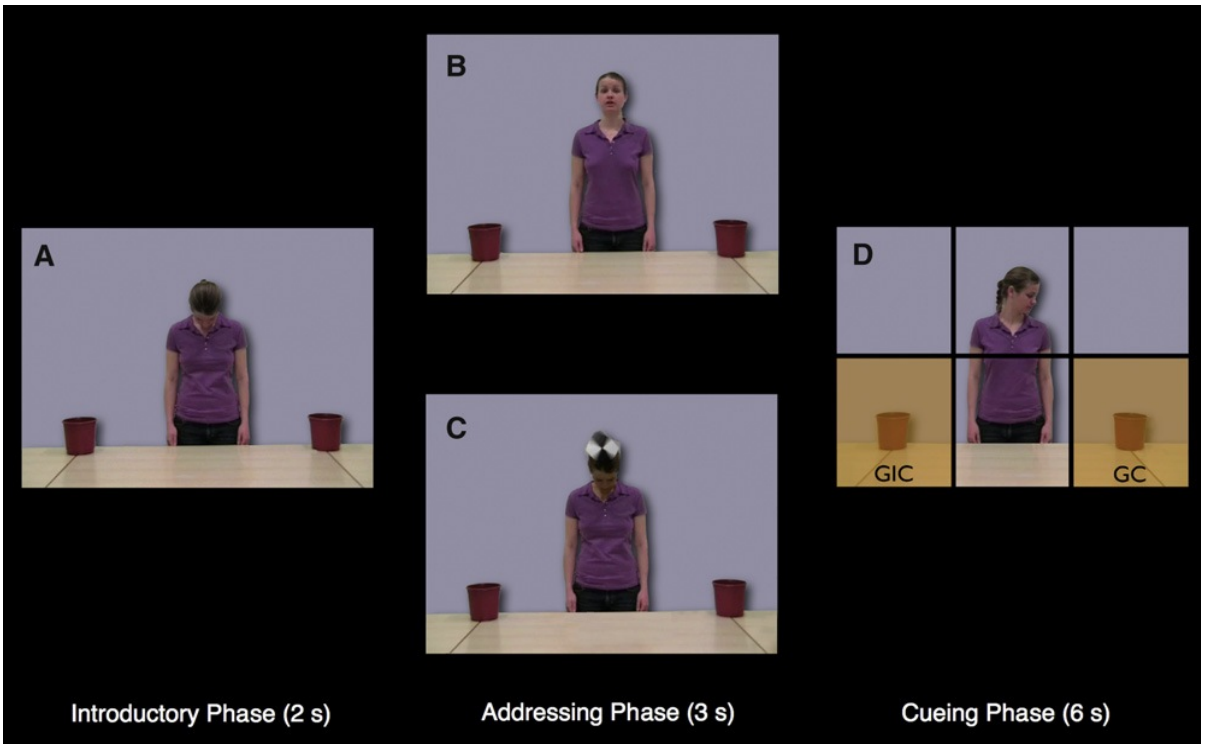

Figure 1. Selected frames from the stimuli in the communicative and non-communicative conditions. GC indicates the gaze congruent and GIC the gaze-incongruent regions of interest (ROI) on the monitor.

Coding and data analysis

Data collection: The screen was divided on the horizontal axis into three equal areas: left, middle, and right (see Figure 1D). Our statistical analysis was based on the eye gaze collected from the lower half of the lateral (left and right) areas (10.5° x 13° visual angle) that were defined as regions of interest (ROI) during the cueing phase. Trials were accepted as valid if they provided more than 200ms eye-gaze data from the ROI. These criteria were implemented in order to exclude short transitions of the gaze that just happened to pass the ROIs. Although during the cueing phase eye gaze was recorded from the regions of interest in 69% of the

trials, taking these criteria into consideration, dogs provided 27% valid trials in the communicative and 34% in the non-communicative conditions. For dogs that participated in baseline control condition, eye gaze was recorded from the target regions of interest in 60% of the trials, out of which 35% were valid trials.

Scoring: The gaze following was tested along two measures; cumulative accuracy and first look toward the gaze-congruent region. These indexes correspond to those presented by Senju and Csibra (2008). For each of these measures, difference scores were calculated. For instance, trials in which dogs looked only to the side congruent with the model's gaze were coded as correct (c), whereas if the dog did not look at the correct side, the trial was coded as incorrect (i). When dogs looked at both sides, the trial was classified according to the longer look. Thus, the difference score (d) for the cumulative accuracy was calculated by subtracting the incorrect from the correct trials and dividing the result by the total number of trials where the participant provided valid ROI data [$d = (c–i)/(c+i)$]. The first look was analyzed in a similar fashion, but instead of the time spent in one or the other ROI, only the first gaze record toward these ROIs was considered. We used paired t-test and one sample t-test for statistical analyses.

Furthermore, we analysed whether there was an order effect in the presentation and the latency of eye movements toward the Gaze-Congruent Region using 2 x 2 ANOVA.

Results

In the addressing phase, dogs spent similar amounts of time gazing toward the human actor in the two conditions (mean ± SEM: 1088.8 ± 181.1ms in the communicative and 980.9 ± 267.8ms in the non-communicative conditions, ns) and invested a comparable amount of time scanning the region containing the model's face relative to the whole body (mean ± standard error of the means (SEM) = 0.46 ± 0.09 in the communicative condition and 0.55 ± 0.10 in the non-communicative condition; paired t test: $t = 20.88$, $df = 10$, $p = 0.39$) showing that in the addressing phase, the human actor evoked the same level of visual attention in both conditions.

Next we analyzed whether dogs looked longer at the gaze-congruent area (Figure 1D) as compared to the gaze-incongruent area (cumulative accuracy). We found that subjects looked longer to the gaze-congruent area than to the gaze-incongruent area after having seen communicative addressing (one sample t test: $t = 2.382$, $df = 12$, $p = 0.034$). However, this

was not the case for the non-communicative condition in which the difference score did not differ from zero (one-sample t test: t = 20.756, df = 13; p = 0.46), indicating no tendency to follow the human's gaze in the absence of communicative addressing (Figure 2).

A similar analysis on dogs' first look did not reveal any significant bias toward the gaze-congruent area in communicative or in the non-communicative conditions (one-sample t test: t = 1.167, df = 12, p = 0.266; t = 20.105, df = 13, p = 0.91, Figure 2).

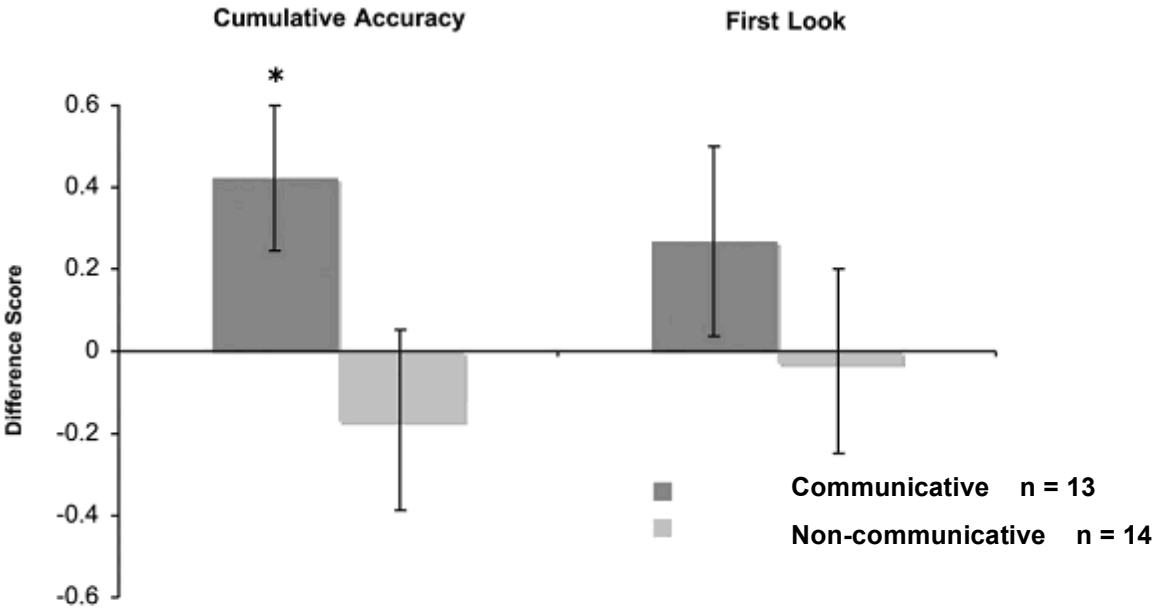

Figure 2. Difference scores calculated in communicative and non-communicative conditions for different measures of gaze following
* p < 0.05; error bars represent SEM.

A within subject analysis of the difference scores for cumulative looking time in the two experimental conditions was run on the 11 subjects that gave valid data in both conditions. This analysis shows that dogs were more likely to follow the model's gaze in a gaze-congruent manner in the communicative than in the non-communicative condition (t = 2.49, df = 10, p = 0.03) and the effect was independent of presentation order. However, no difference was found between conditions for the first look (t = 21.21, df = 10, p = 0.25).

We also explored the spatiotemporal pattern of eye movements during cueing phase, investigating how the gaze points move away from the midline of the display and approach the target objects. Gaze points were averaged into 1s bins and were projected to the x axis of

the display (Figure 3). The averaged eye movements showed a greater proximity to the target object only in the communicative condition.

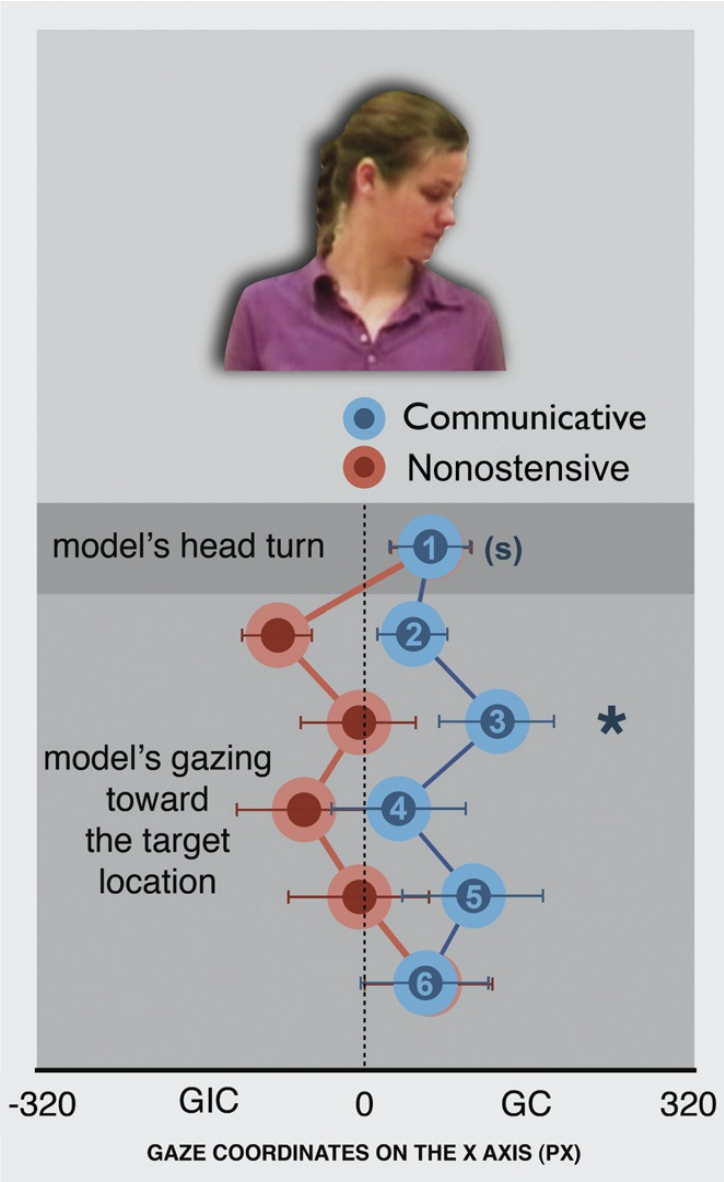

Figure 3. The temporal dynamic of the eye movements during the cueing phase in communicative and non-communicative (nonostensive) conditions (* $p < 0.05$; error bars represent SEM, 1° visual angle is approximately 40 pixels; y axis represents time).

The gaze data recorded from the lower half of the screen capture the main trends of eye movements (with gaze coordinates projected to x axis; resolution X = 1,280 pixels) as the mean gaze points move away from the midline of the display toward the GC or GIC region. After the model's head movement, there is a peak that differs significantly from the central axis of the display only during the ostensive condition.

The results of dogs in the control group showed that gazing toward the region containing the actor's face relative to the whole body in the addressing phase was comparable to that found in communicative and non-communicative conditions (mean ± SEM = 0.60 ± 0.07). However, dogs looked longer toward the body of the model in both communicative and non-communicative conditions than in baseline control situation (400.2 ± 106.9ms; two-sample t tests: communicative versus baseline control: $t = 23.44$, $df = 21$, $p = 0.002$; non-communicative versus baseline control $t = 22.187$, $df = 21$, $p = 0.04$). Thus, the combination of visual and audio components of the stimuli available in the addressing phase of communicative and non-communicative conditions (direct gaze and infant-directed speech or visual grabber and adult-directed speech) attracted more attention toward the human actor. Importantly, however, the accuracy indexes calculated for the cueing phase did not capture gaze following in baseline control (mean ± SEM of cumulative accuracy = 20.06 ± 0.14; one-sample t test: $t = 20.433$, $df = 12$, $p = 0.67$; first look: 0.11 ± 0.16; one-sample t test, $t = 0.695$, $df = 12$, $p = 0.5$). Furthermore, dogs followed the actor's gaze significantly less in the baseline control compared to the communicative condition (cumulative accuracy, two-sample t test: $t = 22.107$, $df = 24$, $p = 0.045$). These data suggest that the lack of gaze following, when there are no ostensive-communicative signals, cannot be accounted for by the confounding effect of ''artificial'' salient attention getter used in the non-communicative condition. This provides further support for the significant role of ostensive-communicative signals in dogs' gaze response.

Analysis of the order of presentation

In the communicative and non-communicative conditions eleven dogs contributed with valid data to the final within subject analysis of cumulative accuracy and first looks: 6 dogs started with ostensive-communicative and 5 dogs with non-ostensive blocks of trials. Analysing the cumulative looking time in an 2x2 ANOVA with order of presentation as between subject and experimental condition as within subject factors revealed no main effect of order ($F(1,9) = 2.548$; $p = 0.14$) nor interaction of order with the experimental conditions ($F(1,9) = .867$; $p = 0.376$). Thus we concluded that the order of presentation played no role in our study.

Analysis of the latency of eye movements toward the Gaze-Congruent Region

Given the absence of a difference in first looks (see Figure 2) we analysed also the latencies of first saccades toward the gaze-congruent region of interest. Latencies were not

significantly different (Mean (communicative) = 1397ms, SEM = 524.01; Mean (non-communicative) = 1757ms, SEM = 431.39; $p > 0.05$).

Discussion

In this study we investigated dogs' sensitivity and reactivity on the direction of the human gaze with an eye tracker method. Our study on dogs' gaze following behaviour in communicative versus non-communicative demonstrations has two major results. First, this is the first evidence to show that eye-tracking technique can be used for studying dogs' social skills in a naturalistic setting and second, dogs' exploitation of human gaze cues as a referential signal depends on the presence of ostensive-communicative and referential cues. Our findings give further support to the existence of a functionally infant-analogue social competence in this species (Range et al. 2007; Topál et al. 2009b; Lakatos et al. 2009).

Our results indicate striking similarities between adult pet dogs and preverbal infants (Senju & Csibra 2008) regarding their context-specific responsiveness to human referential signals. This is supported by the bias of dogs to look longer toward the gaze-congruent area in the cueing phase of the communicative conditions but not under non-communicative conditions. However, first-look measures did not show significant context-specific differences despite the fact that this test variable is usually reported to be one of the strongest indexes to capture human gaze following in presence of ostensive-communicative cues. The discrepancy between the two measures seems to suggest that although being overall sensitive to the ostensive-communicative signals, dogs, in contrast to 6.5-month-old infants (Senju & Csibra 2008), might be less responsive to the actual onset of these cues. At an earlier age, even human infants show similar patterns: although they generally prefer to fixate on gaze-congruent objects, this bias is not reflected in their first gaze shifts (Gredebäck et al. 2008). In line with results from a recent study (Williams et al. 2011) one may also argue that dogs are generally less accurate in their first fixations. Finally, it is also possible that our subjects, by being allowed to move their head freely, might have produced discontinuous eye-gaze recording that introduced more noise in the first-look analysis.

In this study eye contact was used in combination with ostensive-communicative addressing. Therefore the question about the contribution of different communicative cues to dogs' tendency to follow human gaze is still unanswered. Whether these cues act independently or in combination and whether they can be ranked according to their efficiency

in eliciting the communicative understanding of certain social interactions should be targets of further investigation.

Our result shows that dogs understand human communication through a screen (Pongrácz et al. 2003), even if the screen was presented in smaller size than the live demonstrator (Lakatos 2010).

In live demonstrations the performance of dogs to find hidden objects was poorer (though still higher than chance level) in a gaze following tasks than in a pointing task (Kaminski et al. 2012; Bräuer et al. 2006). One explanation for this is that although dogs may understand the referential meaning behind the cue, it does not generate a choice behaviour answer. Gazing per se is typically used to direct someone's attention to a certain object or location but rarely used to make someone move to the object or location. Therefore it is possible that in these situations where they compared the reaction of dogs on pointing and gazing not the most relevant behaviour has been coded as an answer. We suggest gaze following behaviour would be a more suitable answer to analyse.

In a live situation, furthermore, dogs might expect pointing, touching or reaching gesture in parallel to gazing and in such case only gazing may not be sufficient to generate a behavioural answer. On the screen, however, they see only the upper body of the model including the arms, and importantly the model never moves (e.g. they don't see her coming in or leaving the room). Thus, gazing is the only possible information dogs can expect. We assume that this non-moving and statue-like upper body of the model might make the gazing of the model more salient in comparison to similar demonstrations in live situations.

Therefore, following dogs gaze direction with an eye tracker technique can give us more detailed information about dogs' reliance on human gazing. It is possible to precisely record their gaze direction and not only their choice behaviour. Furthermore, it is possible to make gazing more salient communicative gesture than in a live situation.

Finally, it is important to note that gaze following behaviour of dogs cannot be explained by only local enhancement (the model's turning head leads their attention toward the side-congruent container) because dogs follow the gaze only in the communicative situation.

Thus, we may conclude that dogs' context-dependent responsiveness to human head turning mirrors the specific effect of human ostensive communication on dogs' cognitive processing. These results provide further support for the notion that dogs might have evolved a special, functionally infant-analogue „cognitive mindset", which facilitates the emergence of communicative interaction with people as a result of proper socialization to human

environments. However, such socially motivated „cue-driven" gaze following displayed by preverbal infants and dogs is a necessary but probably not a sufficient precondition for a deeper understanding of the intentional-communicative nature of referential signals.

Study 2: The effects of human demonstrator and communicative cues on the choice behaviour of dogs and infants: a comparative study

Kupán, K., Miklósi, Á., Gergely, G., Topál, J. (2011). Why do dogs (*Canis familiaris*) select the empty container in an observational learning task? *Animal Cognition*, 14, 259-268.

Kupán, K., Krekó, K., Gergely, G., Király, I., Miklósi, Á., Topál, J. (under submission). Imitation versus emulation: communication signals and demonstrator's presence during re-enactment affect infants' response.

Introduction

Infants as young as 14 months may interpret ostensive-communicative demonstrations as a learning situation when the demonstrator mediates new and relevant knowledge to the observer (Király et al. 2004; Gergely & Csibra 2006; Csibra & Gergely 2009; see also Main introduction 5).

The social influence that the demonstrator has on the learner is evident during teaching; however, it is also highly important when the emphasis on the learner is to present his/her knowledge. Despite of that only a few studies have focused on the demonstrator's social role at re-enactment (Learmonth et al. 2005; Király 2009).

When the social context during test phase was manipulated 15- and 18-month-olds imitated the new action only in the presence of a demonstrator with whom they had previously been familiarized. In contrast, imitative behaviour of infants significantly decreased in the presence of an unfamiliar experimenter (Learmonth et al. 2005). The authors explained these results by neophobia and xenophobia, emphasizing the adaptive value of restricting knowledge transmission to members of the same group only. Furthermore, the presence of a familiar demonstrator during re-enactment may act as reminder cue for the observer, which – similarly to other environmental cues – helps to recall the action demonstration. This extra reminder role of the demonstrator was further supported by another study. Király (2009) reported that 14-month-old infants were more inclined to imitate tool use when the demonstrator was present during testing and the relevance of the tool use behaviour was emphasized by a failed attempt demonstration. The demonstrator's function may be twofold in the testing situation: first, the demonstrator is a source of information that reminds

the learner that its actions are worth to copy or follow; and furthermore the demonstrator functions as a communicative partner who can modulate or help to acquire new knowledge by giving feedback (Király 2009).

In most studies, however, the effect of the demonstrator during the re-enactment was only tested after one type of demonstration context. For instance, in the study of Király (2009) the demonstration was always communicative, and the demonstrator in the present situation always had a communicative, encouraging attitude toward the subject. This makes it difficult to infer, whether the communicativeness of the demonstrator or the presence itself affected the behaviour of the infant subjects.

Imitating a demonstrated behaviour at the absence of the demonstrator can be interpreted as learning, since the interpretation that the copy happened for the sake of the demonstrator can be excluded. However, copying the demonstrated action during the presence of the demonstrator but not in its absence suggests that the re-enactment was motivated by social reasons rather than learning. If a communicatively (but not a non-communicatively) presented demonstration is imitated at the absence of the demonstrator that can be important evidence pro the natural pedagogy theory. However, according to our knowledge no systematic testing has been conducted on the communicative cues related to the presence/absence of the demonstrator.

There are several examples that dogs show a sensibility toward the human ostensive-communicative and referential cues (see Main introduction 6.1.2). However, in case of dogs it is not clear whether ostensive-communicative and referential cues have a predestined role to mediate knowledge about the new and relevant part of the observed action like in infants or, rather transmit episodic here-and-now information that has a social effect to generate re-enactment. Similarly to infants, studying the observational learning behaviour of dogs under the presence/absence of the demonstrator during the test phase can be important in order to get an answer.

Another similarity between dogs and human infants is the “efficiency blindness” of both groups in a communicative situation. Dogs also tend to perform a less efficient but ostensively disposed action (Szetei et al. 2003; Erdőhegyi et al. 2007). However, it is still an open question whether “efficiency blindness” in dogs is the result of the diverting effect of the communicative cues (they cannot follow the demonstration itself with full attention because of the cues). In this case following communicative cues should be considered as stimulus enhancement. Alternatively, communicative cues have a higher social meaning for dogs and - similarly to infants - they interpret them as the communicative intention of the demonstrator.

Overall it is unclear how the two potentially interacting factors; the ostensive-communicative signals of the demonstration context and the presence of the human instructor during the re-enactment contribute to the emergence of the aforementioned "efficiency blindness" in the dog.

Experiment 1: The effects of the presence/absence of the demonstrator and the communicative cues on the choice behaviour of infants and dogs

In the first experiment we created a comparative situation to examine the joint effect of two social factors on the choice behaviour of dogs and infants; 1) *presence/absence of ostensive-communicative and referential cues* and, 2) *presence/absence of the demonstrator* during the re-enactment.

We compared the behaviour of three subject groups in this experiment: adult dogs, 14- and 18-month-old infants. We chose these two age groups of infants in order to examine possible developmental effects. In previous experiments these age groups showed different imitative performance in a tool-use task (Király & Gergely 2004).

We designed a conflicting situation where subjects could re-enact with a less efficient, cognitively opaque but communicatively accentuated action or, emulate the goal by performing a more efficient "rational" but not demonstrated alternative solution to the problem. In the demonstration situation subjects could repeatedly see how a toy object can be retrieved from under an opaque container by the manipulation of a distant and apparently empty and transparent one. The exact causal mechanism how the manipulation of the distant container brought into action the other container was hidden from the subjects' view. This less efficient and causally opaque solution to the problem was presented by a female adult demonstrator who either manifested her communicative intent during demonstration ('ostensive-communicative') or avoided to use any ostensive communicative referential signals ('non-communicative condition'). Moreover, during the re-enactment phase subjects were allowed to manipulate the experimental set up either in the presence or in the absence of the demonstrator.

On the basis of the recent findings we predicted that for dogs, human ostensive communicative cues serve as a primarily imperative function that triggers the motivation to replicate the observed action. Moreover, as an imperative order is usually associated with a specific 'instructor' we expected the highest tendency to re-enact the human's less efficient

action, i.e. manipulating the empty container, if it was not only accentuated by ostensive-communicative signals but the demonstrator was also present during the test phase.

For infants we predicted that both age groups would provide an imitative answer after a communicative demonstration, independently from the presence/absence of the demonstrator in favour of learning the observed action. However, their behaviour after a non-communicative demonstration context was less predictable. The presence of the demonstrator may generate imitative answer; however, whether this is valid after a non-communicative situation is questionable. Furthermore, the complexity of the task could have an effect on the infants' imitative/emulative behaviour, thus we expected differences between the age groups because of their different level of causal understanding.

Methods

Subjects

Dogs. Ninety-seven dogs (*Canis familiaris*; 49 males and 48 females; mean age = 3.93 years; range = 10 month – 14 years) and their owners were recruited from various dog training schools in Austria and Hungary. Participation in tests was voluntary and the only criterion for selection was that the dogs had to be highly motivated to play with a tennis ball and be older than 10 months. Owners were instructed verbally before the experiment about what to do and what to say during the demonstration and the test phases.

In total six dogs were excluded from the final analyses either because of inaccurate demonstration (N = 3), a technical problem with the recording (N = 1) or because the owner did not act in line with instructions (N = 2). Nine dogs did not pass the motivation criteria of the pre-test (see section Procedure below) and additional twenty-one dogs passed the criteria but later did not make a choice in the test-phase.

Sixty-two dogs (33 males and 29 females; mean age = 3.8 years, range = 1 to 14 years) were included in the final analyses. These dogs were randomly assigned to four experimental groups (Table 1). Each dog was tested in one group only. Various breeds were included into the experiment (43 purebred dogs from 24 different breeds* and 18 mongrels).

* Airedale terrier, Appenzeller sennenhund, Basset hound, Border collie, Briard, Cocker spaniel, Dachshund, English bulldog, Fox-terrier, German shepherd, Golden retriever, Groendael, Hovawart, Hungarian vizsla, Jack Russel terrier, Kelpie, Labrador retriever, Malinois, Miniature pinscher, Mudi, Parson Russel terrier, Rough collie, Staffordshire terrier, Transylvanian hound

Infants. Eighty-one 14-month-old (39 boys and 42 girls; mean age = 1.16 years; range = 1.08 – 1.25 year) and eighty-five 18-month-old (48 boys; 33 girls and 4 missing information; mean age = 1.5 years; range: 1.42 – 1.58 years) infants with their parents participated in this experiment. Parents from Budapest and the surrounding areas applied voluntarily for participation after a newspaper announcement. Parents were instructed verbally before the experiment about what to do and what to say during the demonstration and the test phases.

Twenty-five infants were excluded from the analysis because of either parental interference (14-mo.: 7; 18-mo.: 7), failed demonstration (14-mo.: 4; 18-mo.: 7) or missing or damaged videos (18-mo.: 3).

Each infant was tested in only one experimental condition and was assigned randomly to one of the four experimental groups. Infants who did not make a choice within 90 s were scored as 'non-responsive' (14-mo.: 21; 18-mo.: 13). Forty-nine 14-month-olds and fifty-five 18-month-olds were included into the final analysis (Table 1).

Demonstration phase	**Test phase**	**Dogs**	**Infants Number of boys / girls**	
		Number of males / females	**14-m-o.**	**18-m-o.**
Communicative condition	Demonstrator present	7 / 10	6 / 6	7 / 8
	Demonstrator not present	8 / 9	9 / 3	7 / 7
Non-communicative condition	Demonstrator present	8 / 6	4 / 9	7 / 6
	Demonstrator not present	8 / 6	8 / 4	7 / 6

Table 1. Overview of experimental groups and conditions including sex / gender of subjects ('responsive' only). The table lists only those dogs that passed the motivation criteria.

Experimental arrangement

The experiments were carried out between February 2005 and September 2008.

Dogs were tested either at the laboratories of the Department of Ethology, Eötvös Loránd University Budapest (N = 88) or at the Department for Behaviour, Neurobiology and

Cognition, Vienna University (N = 9).

All infants were tested at the laboratories of the Comparative Behaviour Research Group of the Institute for Psychology, Hungarian Academy of Sciences. The experimental room was a friendly milieu for infants equipped with different toys. Adjacent to the experimental room was a concealed room, separated by a built in detective mirror to observe the experimental room from the outside.

The Demonstrator (D) was the same woman in all experiments.

Experimental set up and apparatus

The experimental set up and the apparatus were the same at all locations (the two dog labs and the infant lab) (Figure 1a, b). The apparatus was set up in one corner of the experimental rooms. An orange curtain was hung in front of the apparatus to hide containers and the pulleys if necessary. When the subjects came into the room the curtain was closed, thus it hid the apparatus from the subjects until the beginning of the experiment.

The apparatus was made up from two bell-shaped containers (12 cm high and 8 cm radius) that were placed upside down about 60 cm from each other. Each of the containers were placed on a black platform (15 x 15 x 6 cm; Figure 2) and connected to each other by a string, passing through 2 pulleys. The pulleys were fixed to the ceiling with another string. When one of the containers was moved ahead, the other one rose up. One of the containers was non-transparent and was baited with the reward (tennis ball) whereas the other one was transparent and empty. We used a tennis ball as a bait object for both the dogs and the infants throughout the experiment.

One camera recorded the facing subject, a second one recorded from an angle that showed the subject's back (from the detective room in case of the infants). The two cameras were connected to a splitter.

Figure 1: The set up (a) dog lab (b) infant lab

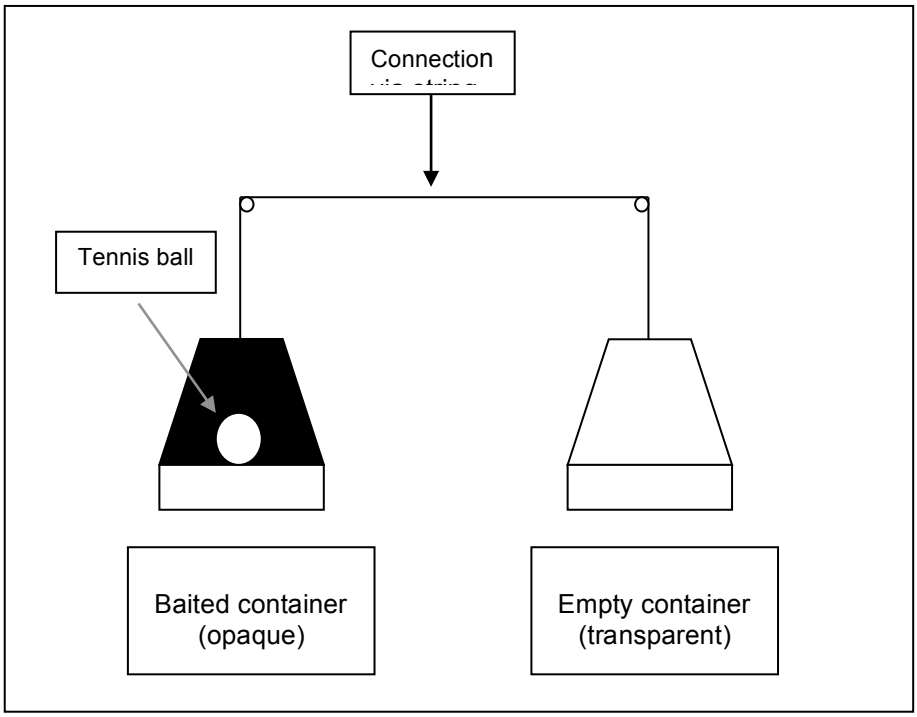

Figure 2: A schematic drawing of the apparatus showing the mechanism of operation

Procedure

I. Motivation tests and warm-up phase

The first part of the experiment was different for dogs and infants.

Dogs: Motivation tests

Dogs had to pass two criteria for participating in the final analysis: pass a pre-test and show attention during all the three demonstrations. During this period the experimental apparatus was covered by the curtain. Subjects who failed on one of the criteria were excluded from the analysis.

1. Pre-test: The dog was led into the experimental room and allowed to explore the room (without going behind the curtain) for one minute whilst the D initiated a short play with the tennis ball. Then D asked the owner to play a fetching game with the tennis ball. The owner was instructed to throw the ball away and to encourage verbally the dog to fetch it. Dogs showing attention and retrieved the ball three times were regarded as 'strongly motivated' (N = 62). Subjects showing attention for less than three times but at least once, and retrieved the ball at least once were regarded as 'motivated' (N = 25). Subjects who did not pay attention to the ball or never take the ball into their mouth were regarded as 'non-motivated' (N = 9). Only 'strongly motivated' and 'motivated' dogs passed the pre-test and could participate in the experiment.

2. Attention criteria: Dogs were divided into three categories based on their attention stage during the demonstration phase. A subject was regarded as 'very attentive' if it watched all three demonstrations with full attention. Subjects were regarded as 'attentive' if they followed all three demonstrations with attention and turned their head away for no more than once during a demonstration and for no longer than one second. Subjects were regarded as 'non-attentive' in the demonstration phase if there was at least one demonstration during which they did not follow with attention or turned their head away more then once for more than a second. Only the 'very attentive' and 'attentive' subjects included in the final analyses that made a choice in the test phase (Table 2).

Pre-test:	Motivated			Strongly-motivated		
Test:	Non-attentive	Attentive	Very attentive	Non-attentive	Attentive	Very attentive
Made a choice (N = 62)	0	1	11	0	1	49
Made no choice (N = 21)	0	1	12	1	0	7

Table 2: Overview over the number of dogs who participated in the tests (passed the motivation criteria). For further explanations see text.

Infants: Warm-up phase

The experiments with infants were started with a 10-15 min warm-up phase to make the subjects relaxed and familiar with the room and the Demonstrator (D). During this time the infants could play with toys and walk around in the room. The parent was present during the whole procedure. After the warm-up phase D put the toys into a cupboard so the infant could not see them during the test.

II. Demonstration phase

Demonstration and test phase were executed similarly for dogs and infants.

Owners of dogs led the dogs to a predetermined point at a distance of 3 meters from the apparatus and held them by their collar.

In case of infants parents were asked to take a seat into a provided chair at the distance of 3 meters from the apparatus facing it and hold their infant in their laps.

Communicative condition: In this condition D used ostensive-communicative cues toward the subject to raise his/her/its attention and she accompanied the demonstrated action with referential cues (Figure 3a). She stood between the two containers facing the subject, pulled the curtain open, made eye-contact with the subject, called him/her/it by the name and said: „Look!". D said additionally only for the infants: "I am going to show you something

interesting! We are going to play with a tennis ball!". This part was omitted in case of dogs because we could not be sure that they understand it and too much gibberish might have beet disturbing.

After that she touched the two containers simultaneously in order to control for local enhancement but this time she did not look at the subject. Then she called the subject's attention again (getting eye-contact and saying „Look at this!"), grasped the empty and transparent container and pulled it to the ground in front of the platform. As a consequence the baited container rose up and the tennis ball rolled out (Figure 3a). D turned her head towards the emerging ball and glanced at it for one second. Finally, she picked up the ball and dropped it to the ground two times, but she did not hand it over to the subject. She closed the curtain and removed the ball from the non-transparent container hidden from the subjects view.

Non-communicative condition: The procedure was identical to that described in the communicative demonstration above, except that D was not facing to the subjects but turning her back to them in the case of infants (Figure 3b). Turning the back to the subjects was necessary to prevent the subjects from seeing eye-gaze and gaze shifts two important referential cues. In case of dogs, however, she was facing to the subjects but looking down the ground during the entire demonstration. This adjustment was necessary because dogs might not understand a demonstration with a back-turned D.

Importantly, there was no ostensive-communicative and referential cueing during the action-demonstration (i.e. she did not look at the subject and did not use verbal directed speech) but instead she mumbled a short meaningless poem during the whole procedure to keep up the subjects' attention. We chose a meaningless poem in order to avoid that some of the infants know the poem which would raise increased attention.

In each condition the action demonstration was repeated two times. The side of the baited container was assigned randomly and counterbalanced between subject groups.

Figure 3. (a) Communicative demonstration (b) Non-communicative demonstration

III. Test phase

The demonstration was immediately followed by the test event. There were two different test conditions:

Demonstrator present condition: After the demonstration D let the curtain open, stood to the left side of the apparatus and encouraged the subject by saying: "Now it's your turn!" to explore the containers after the communicative demonstration. After a non-communicative demonstration she sat onto a chair in case of infants (set to the same location where she would stand in the communicative situation) or stood to the same place as in the communicative situation, and was pretending to read a newspaper.

Demonstrator absent condition: In this situation D left the curtain open and left the room after the demonstration without looking or talking to the subject.

Then the parent/owner let the infant/dog freely examine the apparatus with predetermined commands such as "You can try it!" or "Play with it!". Dogs had 20s and infants had 90s to explore the apparatus. The parent/owner was asked not to comment on the object, the location or the observed action (eg.: "Where is the ball?" or "Remember how she got the ball?"). Furthermore, owners/parents were not allowed to point at the containers. In cases when the parents/owners did not act in line with these instructions subjects were later excluded from the analyses.

Coding and data analysis

After the demonstration dogs had 20s whereas infants had 90s to make their first choice, otherwise they were regarded as non-responsive. The different intervals were chosen on the basis of the obvious differences between the motor abilities of human infants and adult dogs. Behaviour was considered as choice only if the subject touched (infants by hand and dogs by muzzle or front paw) one of the containers because we wanted to see whether the subjects have the intention to manipulate the containers. Proper manipulation was not necessary because – especially for dogs and the younger age group of infants – manipulation (garbing and moving the container) seemed to be challenging. However, we did not accept pointing as a choice behaviour. Although making a clear discrimination between the containers pointing can be interpreted as an order to the parent or the demonstrator to manipulate a certain container ('imperative pointing') rather than an intention to copy the observed behaviour. Therefore pointing was considered as 'non-responding' behaviour (14-mo.: n = 2; 18-mo.: n = 2). The test was ended after the first choice.

Proportions of non-responsive infants and dogs, proportions of responsive infants and dogs who made a choice between the empty or baited container, and duration of hesitation (i.e. the time elapsed between releasing and touching a container) were recorded and analysed in each condition.

In order to assess inter-observer agreement for the infants' choice behaviour a second person blind to the action demonstration scored a randomly selected sample of 90%. Cohen's kappa value was 0.927 showing high level of reliability. In case of dogs a randomly selected sample of 63% was coded by a person blind to experimental conditions. Cohen's kappa value was 0.954 showing a high level of reliability.

Statistical tests were computed using SPSS version 17.0. Subjects' first choices (choice behaviour) were analysed using non-parametric tests: Binomial test, χ^2 test, Generalized Linear Models for binary data. The latter method uses χ^2 test for the analysis of the main factors (subject group; demonstration context; presence of the demonstrator during the test phase) and for the post-hoc planned pair-wise comparisons. To correct for multiple comparisons we used False Discovery Adjustment (FDA) for the correction of the significance thresholds (Benjamini & Hochberg 1995).

Since the duration of hesitation data of infants and dogs are not comparable we analysed them separately. Dog raw data were reciprocally transformed (1/x) to comply with

normality tests. Mean latency of the dogs' first choice in the five groups was analysed by univariate ANOVA models.

Duration of hesitation in infants deviated significantly from normal distribution (normality tests, Shapiro-Wilk test) in some of the four groups. Therefore we employed a natural log transformation (ln(x)) to the raw data and the transformed data did not deviate significantly from normality. A univariate ANOVA was used to test for effects of demonstration context and the presence of the experimenter during the test phase. We analysed the proportion of non-responsive infants and dogs using χ^2 test and binomial tests.

Results

I. Proportion of responsive and non-responsive dogs

The majority of dogs (75%) that participated in the test phase made their choice within 20 seconds, thus they were categorized as 'responsive'.

The proportion of non-responsive and responsive dogs showed significant differences through the four experimental conditions (11 - 44%; $\chi^2 = 7.953$, df = 3, p = 0.047). This difference came from the increased number of non-responsive dogs in the 'non-communicative / present' and 'non-communicative / not present' groups. In the two communicative situations majority of the dogs proved to be significantly more responsive than expected by chance (Binomial tests: 'communicative / present': p = 0.003; 'communicative / not present': p = 0.001). By contrast, in the two non-communicative groups dogs were not different than expected by chance (Binomial tests: 'non-communicative / present': p = 0.69; 'non-communicative / not present': *p* = .064, Table 3).

II. Proportion of responsive and non-responsive infants

The majority of infants in both age groups (73% of the 14-month-olds and 84% of the 18-month-olds) made their choice within 90s and was categorized as 'responsive'. There was no difference between the two age groups in responsiveness ($\chi^2 = 2.200$, df = 1, p = 0.138). The proportion of non-responsive participants did not show significant differences between the four experimental conditions. Only 25-32% of the 14-month-old infants ($\chi^2 = 0.311$, df = 3, p = 0.958) and 6-32% of the 18-month-olds ($\chi^2 = 4.288$, df = 3, p = 0.232) were non-responsive in the different experimental contexts. In the 18-month-old groups responsive infants represent the majority in all but one condition. (Binomial tests: 'communicative /

present': p = 0.001, 'communicative / not present': p = 0.004, 'non-communicative / not present': p = 0.049, 'non-communicative / present': p = 0.167, Table 3). 14-month-olds, however, tended to have a reduced responsiveness to select a container: in all cases the responsiveness was not significantly different from 0.5 and only 12-13 infants were willing to make a choice (Binomial tests: 'communicative / present': p = 0.167, 'communicative / not present': p = 0.143), 'non-communicative / not present': p = 0.077, 'non-communicative / present': p = 0.238, Table 3).

	'Communicative / Present	'Communicative / Not present	'Non-communicative / Present	'Non-communicative / Not present'
Dogs	85*	89*	56	74
14-month-olds	68	71	67	75
18-month-olds	94*	88*	68	76*

Table 3. Percentage of responsive dogs and infants under different experimental conditions. Asterisk indicates significant difference to 50% test proportion. * represents significant difference from chance level.

III. Choice behaviour of dogs and infants

In the first part of the choice behaviour analysis subjects were compared using a GLM with binomial error structure (0 = baited, 1 = empty). 'Subject', 'demonstration context' and 'presence of D' were included as main factors into the model.

The analysis of the main factors revealed a significant effect of the demonstrational situation (communicative vs. non-communicative: $\chi^2 = 14.906$; df = 1; $p < 0.001$) which refers to the general tendency of the subjects to choose the empty container in the communicative situations. Furthermore, we found effect of the subject factor ($\chi^2 = 22.799$; df = 2; $p < 0.001$); higher number of dogs chose the baited container than any of the infant groups. But we found no effect of the presence / absence of the demonstrator as a main factor($\chi^2 = 1.211$; df = 1; p = 0.271).

We found marginally significant two-way interaction between 'subjects' and 'demonstrational situation' ($\chi^2 = 5.640$, df = 2, p = 0.06). Post-hoc exploration of this marginally significant interaction revealed that dogs and 18-month-old infants were affected by the communicative cues; in both groups more subjects chose the empty container after a communicative demonstration, than after a non-communicative one (dogs: $\chi^2 = 11.060$; df =

1; p = 0.001, adjusted α = 0.01; 18-mo.: χ^2 = 11.684; df = 1; p = 0.001, adjusted α = 0.02). However, there was no difference in the choice behaviour of 14-month-old infants (χ^2 = 0.168; df = 1, p = 0.682, adjusted α = 0.05).

Furthermore, we found a significant three-way interaction of the main factors ('subjects' x 'demonstration context' x 'presence of D': χ^2 = 16.575; df = 6; p = 0.020). Significant three-way interaction suggests that two of the main factors have a significant interaction on one level of the third factor, but not on another level of that. Expanding exploration of the three-way interaction revealed significant interaction between the 'demonstration context' and 'presence of D' factors in case of 18-month-olds (χ^2 = 5.581; df = 1; p = 0.018) but neither in 14-month-olds (χ^2 = 0.814; df = 1; p = 0.367) nor dogs (χ^2 = 1.396; df = 1; p = 0.237, Figure 4a).

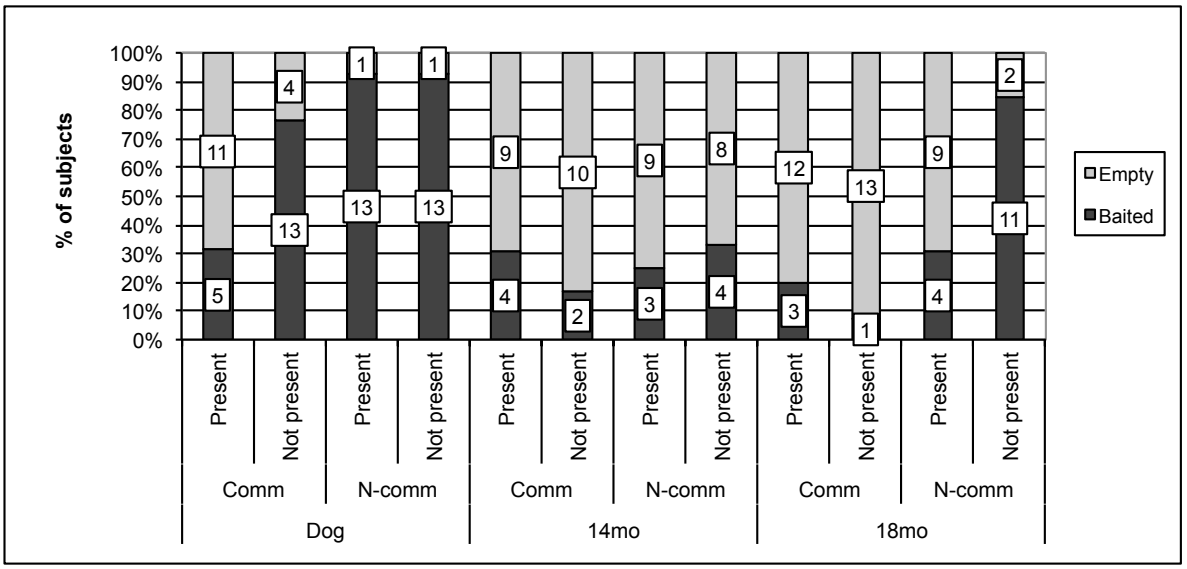

Figure 4a. Percentage of subjects choosing empty or baited containers according to different experimental situations. Numbers on each bar refer to number of subjects in each category.

Post-hoc analyses of the 18-month-old group showed that there was a significant difference between the 'non-communicative / present' vs. 'not present' groups where higher number of infants chose the empty container in the 'non-communicative / present' group (χ^2 = 7.721; df = 1; p = 0.005; adjusted α = 0.029). Furthermore, there was a significant difference according to communication context; more infants chose the empty container in the 'communicative / not present' group than in the 'non-communicative / not present' group (χ^2 = 16.385; df = 1; p < 0.001; adjusted α = 0.007). However, there was no difference between the 'communicative / present' vs. 'not present' groups (Fisher's Exact Test = 0.598) nor

between the ‘communicative / present’ vs. ‘non-communicative present’ groups (Fisher’s Exact Test = 0.670, Figure 4b).

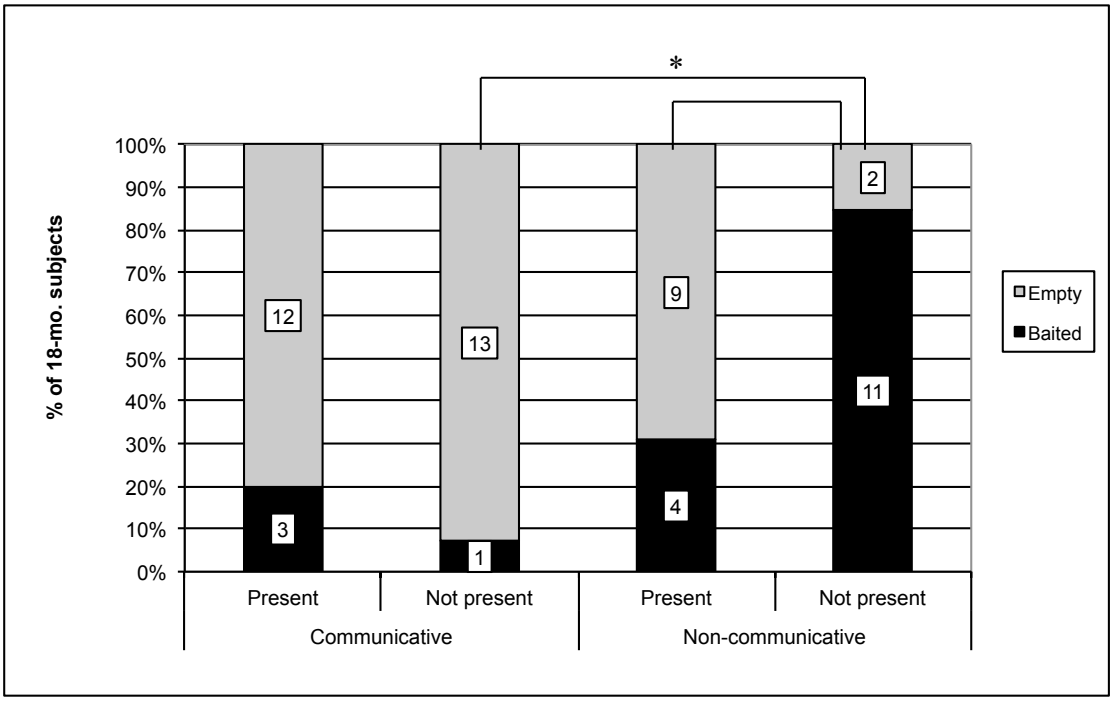

Figure 4b. Percentage of 18-month-old infants choosing empty or baited containers according to different experimental situations. Numbers on each bar refer to number of subjects in each category. Asterisk represents significant difference between the connected groups.

Further exploration of the three-way interaction revealed that there was significant interaction of the ‘subjects’ and the ‘presence of D’ factors in the communicative context (χ^2 = 7.122; df = 2; p = 0.028) but not in the non-communicative one (χ^2 = 3.250; df = 2; p = 0.197) (Figure 5a).

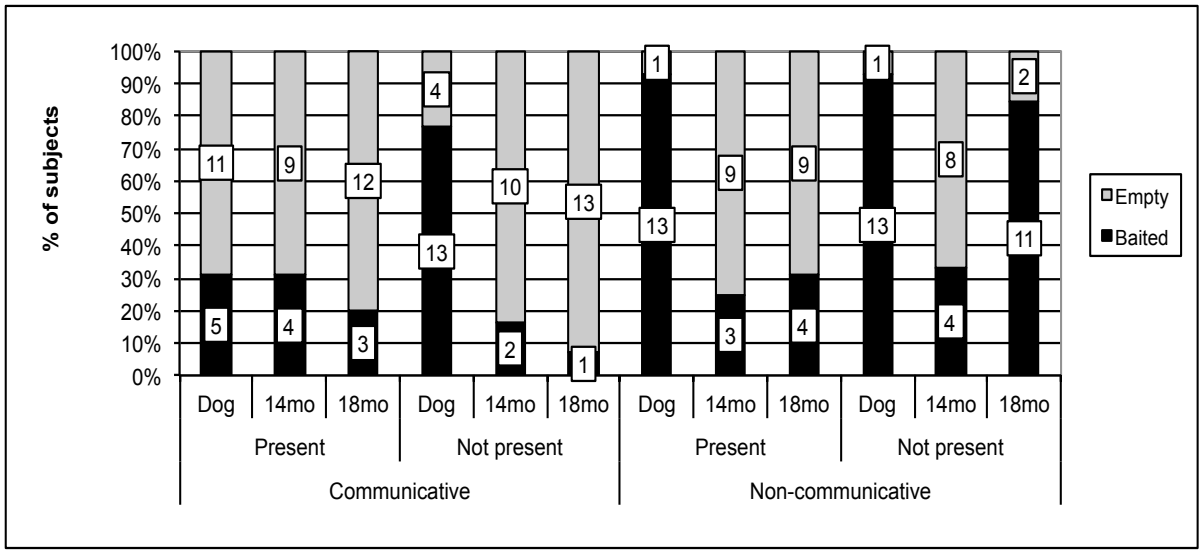

Figure 5a. Percentage of subjects choosing the empty or baited containers in different experimental conditions.

The post-hoc tests showed significant differences between subject groups when D was absent in the communicative context; dogs went to the baited container more often whereas both infant groups preferred the empty container ($\chi^2 = 18.800$; df = 2; $p < 0.001$; adjusted $\alpha = 0.014$). However there was no significant difference between the subject groups at the presence of the D in the communicative context ($\chi^2 = 0.608$; df = 2; $p = 0.738$; adjusted $\alpha = 0.05$; Figure 5b). There was no similar pattern found in the non-communicative situation.

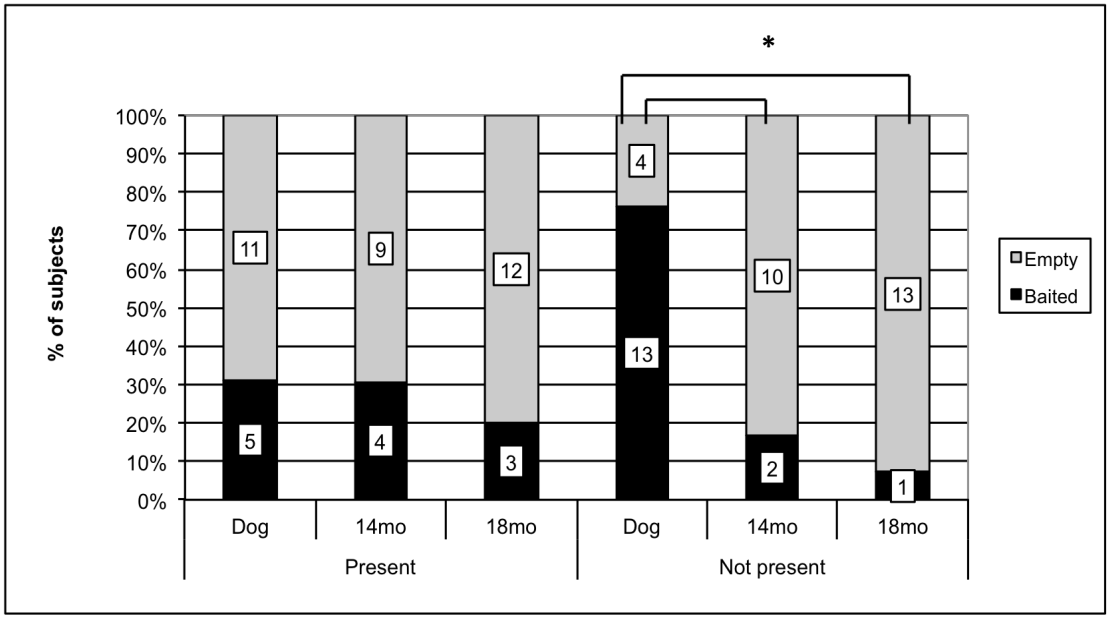

Figure 5b. Percentage of subjects choosing the empty or baited containers in the different conditions ('present' vs. 'not present') of the communicative context. Asterisk represents significant difference between the connected groups.

Finally, there was a significant interaction between 'subject' and 'demonstration context' when D was present during the test phase (χ^2 = 6.284; df = 2; p = 0.043) but not when D was absent (χ^2 = 4.546; df = 2; p = 0.103; Figure 6a).

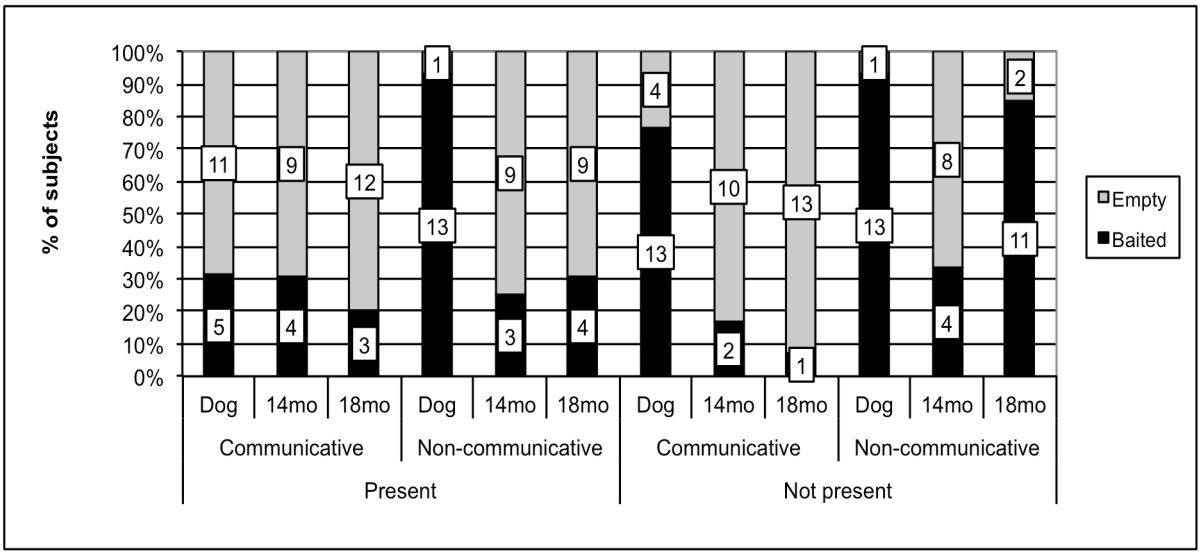

Figure 6a. Percentage of subjects choosing the empty or the baited containers in the different experimental conditions.

Post-hoc analyses showed a significant difference between the subjects in the 'non-communicative / present' situation ($\chi^2 = 15.193$; df = 2; p = 0.001; adjusted α = 0.021). Again dogs went more often to the baited container whereas both infant groups preferred the empty one (Figure 6b).

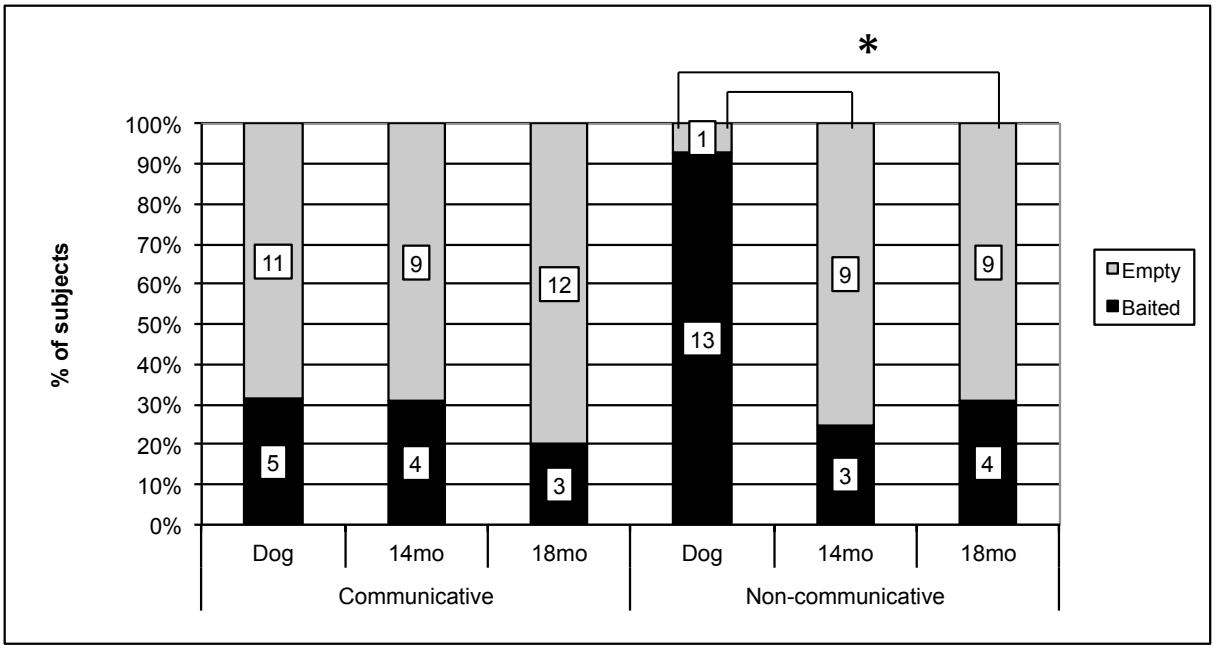

Figure 6b. Percentage of subjects choosing the empty or baited containers in the different conditions ('communicative' and 'non-communicative') in the D present situation. Asterisk represents significant difference between the connected groups.

In the second part of the choice behaviour analysis we compared the empty and baited container choices within each experimental groups. The purpose of this was to see whether subjects in certain situations show preference toward one of the containers.

Comparing the empty and baited container choices in case of dogs revealed significant differences between two experimental groups ('non-communicative / not present': p = 0.002, adjusted α = 0.0042; 'non-communicative / present': p = 0.002, adjusted α = 0.0083). In one situation dogs showed a non-significant tendency toward the baited container ('communicative / not present': p = 0.049, adjusted α = 0.0292) whereas the container choice of dogs appeared to be random at the final container ('communicative / present': p = 0.210, adjusted α = 0.0375).

18-month-old infants chose the empty container significantly more often in communicative situations when D was not present (p = 0.002, adjusted α = 0.0125). They had

a tendency to choose the empty container more often in the 'communicative / present' situation ($p = 0.035$; adjusted $\alpha = 0.0208$) and the baited container in the 'non-communicative / not present' situation ($p = 0.022$, adjusted $\alpha = 0.0167$) although the differences were not significant after correcting for multiple testing. Their choice behaviour appeared random in the 'non-communicative / present' situation ($p = 0.267$, adjusted $\alpha = 0.0458$).

14-month-olds did not show any consistent choice behaviour under any experimental condition ('communicative / present', $p = 0.267$, adjusted $\alpha = 0.0417$; 'non-communicative / not present', $p = 0.388$, adjusted $\alpha = 0.05$; 'communicative / not present': $p = 0.039$, adjusted $\alpha = 0.025$). However, there was a non-significant tendency to visit the empty container in the 'communicative / not present' situation ('non-communicative / present': $p = 0.164$, adjusted $\alpha = 0.0333$).

IV. Duration of hesitation

The mean duration of hesitation of subjects whether they chose the empty or the baited containers were similar for all three subject groups (14-mo.: $t = 1.833$, $df = 47$, $p = 0.073$; 18-mo.: $t = -0.151$, $df = 53$, $p = 0.880$; dogs: $t = -1.654$, $df = 60$, $p = 0.102$).

Duration of hesitation for the first choices was dependent on 'demonstration context' (GLM, $\chi^2 = 8.464$; $df = 1$; $p = 0.003$). Infants made significantly faster decisions in communicative context. 'Age' and 'presence of D' factors did not affect hesitation time (age: $\chi^2 = 0.303$; $df = 1$; $p = 0.561$; presence of D: $\chi^2 = 0.277$; $df = 1$; $p = 0.578$). There was no significant interaction between the factors.

In case of dogs none of the main factors or interaction had a significant effect on the duration of hesitation (GLM, 'demonstration context': $\chi^2 = 0.004$; $df = 1$; $p = 0.771$; 'presence of D': $\chi^2 = 0.002$; $df = 1$; $p = 0.842$).

Experiment 2: Dogs' and 14-month-old infants' choice behaviour in a ghost situation

Experiment 1 revealed that the different subject groups (dogs, 14-, and 18-month-old infants) differed in their choosing patterns through the experimental conditions. The choosing pattern of 18-month-olds was different between the experimental situations; they preferred the empty container over the baited one in all but one situation. In contrast in dogs, more subjects chose the empty container in the 'communicative / present' situation, and in the other three situations subjects preferred the baited container even if these differences were not significant.

14-month-olds showed relative blindness to the demonstrational contexts and showed the same choice pattern through the four experimental situations; they preferred the empty container over the baited one in all cases.

The test results of 18-month-olds suggest that they were sensitive to the communicative cues and aware of the presence/absence of the demonstrator. Their context-sensitive choice behaviour suggests that they learned about both events which were involved in the demonstration; the manipulation on the empty side and the appearance of the ball on the baited side.18-month-olds actively changed their decision according to the communicative nature of the demonstration or the presence/absence of the demonstrator; they chose the reward object directly only in the least social context.

The results of dogs and 14-month-old infants, however, provide no information about their perception or understanding of the events or the social contexts which were involved in the test. First, it is possible that these subject groups cannot memorize and recall the location of the tennis ball. Furthermore, even if they can recall the container with the reward it is possible that the movement of the empty container itself is more interesting to them than the reward.

To examine the learning process of these two ambiguous subject groups we created a 'ghost situation' that matches the demonstrational contexts in **Experiment 1** but we eliminated the social factors. Subjects could see the same movements of the same containers but it was an automatic movement directed by an experimenter out of their sight.

Methods

Subjects

Dogs. Twenty-three dogs (*Canis familiaris*; 13 males and 10 females; mean age = 3.95 years; range = 1 – 10.5 years), accompanied by their owners, were recruited from various dog training schools in Austria. The recruitment and the criteria of participation were similar to **Experiment 1**.

In total five dogs were excluded from the final analyses because the owner did not act in line with instructions. Four dogs did not pass the motivation criteria of the pre-test (for details see Experiment 1) and there were no dogs which passed the motivation tests and made no choice in the test phase ('nonresponsive' dogs; n = 0).

Fourteen dogs were included into the final analyses (7 males and 7 females; mean age = 3.85 years; range = 1 – 10.5 years). Various breeds were included into the analyses (8 purebred dogs from 8 different breeds* and 6 mongrels).

* Australian cattle dog, Cocker spaniel, Havanese, Labrador retriever, Maltese, Miniature pinscher, Rottweiler, West Highland white terrier

Infants. Nineteen 14-month-old infants (11 boys and 8 girls; mean age = 1.16 years; range = 1.08 – 1.25 year) with their parents participated in this experiment. The recruitment and the criteria of participation were similar to **Experiment 1**.

Three infants were excluded from the analysis because of parental interference (n = 2) or failed demonstration (n = 1).

Those infants who did not make a choice within 90s were scored as 'non-responsive' (n = 7) and 9 infants made a clear choice between the two containers, they were coded as 'responsive'.

Experimental arrangement

The dog experiments were carried out in June 2007 and the infant experiments were carried out between May and September 2012. Dogs were tested at the Clever Dog Lab of Department for Behaviour, Neurobiology and Cognition, Vienna University. Infants were tested at the lab of the Comparative Behaviour Research Group of the Institute for Psychology, Hungarian Academy of Sciences.

Experimental set up and apparatus

The experimental set up and the apparatus were exactly the same as in **Experiment 1** expect for one change: there was no human demonstrator but an automatic mechanism executed the movements of the containers. An invisible string was attached to the empty container and a small and invisible weight was hidden in this container. The experimenter stayed out of sight of the subjects. In case of dogs she was standing behind the dog covered from sight by a barrier, in case of infants she was in the detective room (see Experiment 1). When the string was pulled by the experimenter the empty container fell from its small platform to the front and in consequence of this the baited container rose up. In this way the apparatus repeated exactly the same movements as in **Experiment 1** but without a visible manipulation by the demonstrator. Similarly to the previous experiment the baited container contained a tennis ball, which rolled out when the container rose up.

In order to get the subjects' attention to the moving containers the experimenter rang a small

hidden bell which was fixed to the string that connected the two containers. The bell was also operated with an invisibly sting by the experimenter.
Dog owners were asked not to allow the dogs to move away or turn back to see the experimenter during the test. Therefore owners sat behind the dogs and held them facing to the apparatus.

Procedure

I. Warm-up phase and motivation test

Details for these tests are given in the respective section of **Experiment 1** (see above).

II. Demonstration phase

Demonstration and test phases were executed similarly for dogs and infants.
Owners with their dogs and parents with their children were asked to go to the predetermined point, same as in **Experiment 1**. Then the hidden experimenter pulled the string of the bell three times. She then immediately pulled the string attached to the empty container that fell of the platform whilst the baited container rose up revealing the tennis ball. After every demonstration the experimenter went to the apparatus. She picked up the ball and dropped it to the ground two times, closed the curtain and placed the ball under the opaque container.
She did not communicate with dogs during this process she avoided eye contact and did not give the ball to the dog. However, in case of infants she addressed them before she went to the hiding place by saying: "You will see something very interesting!". Furthermore, any time she came out from the room after replacing the ball and the curtain was closed she smiled at the infants. This was necessary because in pilot studies infants turned out to be non-responsive in the completely non-communicative situation. However, she avoided any kind of allusion of what the demonstration was about, thus none of the actions were enhanced by her communication.
Demonstrations were repeated twice.

III. Test phase

The demonstration was immediately followed by the test.

After the last demonstration the experimenter re-baited the opaque container behind the curtain once more, she opened the curtain and left the room. In case of dogs this happened without looking or talking to the subjects. In case of infants she smiled at the subject and said: "Now, it's your turn!" whilst turning her back to the apparatus.

Then the owner/parent let the dog/infant freely expose the apparatus with some predetermined commands such as "You can try it!" or "Play with it!". Dogs had 20s and infants had 90s to explore the apparatus. The owner/parent was asked not to comment on the object, the location or the observed action (eg.: "Where is the ball?" or "Remember how she got the ball?"). Furthermore, owners/parents were not allowed to point at the containers. The dog/infant of the owner/parent who did not act in line with these instructions were later excluded from the analyses.

Coding and data analyses

In order to characterize the dogs' performance in the non-social control condition we analysed the choice behaviour of subjects. The coding system was similar to the one used in **Experiment 1** except for that we coded all choices within the 20s.

Results

Dogs in most cases (11 out of 14) selected the baited container for the first choice and this tendency was marginally significant (binomial test, $n = 14$, $p = 0.057$). This preference for the baited container is further supported by the finding that all subjects inspected the baited container during the 20s test phase and many of them (6 dogs) visited only the baited one (i.e. did not proceed to the empty container). None of them inspected only the empty container.

In infants only 9 out of 16 made a choice, thus 44% (7 out of 16) proved to be 'nonresponsive'. Furthermore, most of the responsive subjects selected the empty container (8 out of 9; binomial test, $n = 9$, $p = 0.039$). There was only one infant who visited both containers.

Discussion

In this study we investigated the effect of two social factors; 1) the presence/absence of communicative and referential cues during the demonstration and, 2) the presence/absence of the human demonstrator during the test phase on the choice behaviour of dogs and 14-, 18-month-old infants.

Our results support several of the predictions made by natural pedagogy theory. First, communication has a strong influence on choice behaviour; generally more subjects chose the empty container in the communicative situation than in the non-communicative one independently from the presence/absence of the demonstrator. However, this preference is significantly different from chance only in case of dogs and 18-month-old infants.

Infants' duration of hesitation data also supports the natural pedagogy theory; they make their first choice faster after a communicative demonstration than after a non-communicative one. This suggests that communicative cues help them to make a decision and probably provide guidance on how to behave.

We found significant differences in the choice behaviour between the subject groups; dogs generally chose the baited container more often than the empty container. In contrast, 14- and 18-month-olds preferred the empty one independently from the experimental situations.

We found no effect of the demonstrator per se on the subjects' behaviour.

<u>Selective choice behaviour of 18-month-old infants</u>

Probably the most striking result of **Experiment 1** is the selective behaviour of the 18-month-old infant group. We found evidence that both communicative cues and the presence of the demonstrator during the test phase affected their choice behaviour. In the communicative situations infants had a tendency to choose the imitative-like solution, namely to go to the empty container that had been manipulated by the demonstrator during the demonstration. In the non-communicative situations the infants had a non-significant preference toward the baited container when the demonstrator was absent during the test, which can be considered as an emulative-like behaviour. In the 'non-communicative / present' condition their choice behaviour appeared random, however, it was significantly different from the 'non-communicative / not present' experimental situation.

Here we call the empty container choice 'imitative-like' behaviour as we suppose the motive of the choice behaviour was to imitate the previously observed action on the empty container

in order to reach the same goal. However, in most cases the demonstration performance was not copied perfectly and infants only touched the manipulated container. Infants who gave up the further exploration of the apparatus after the first touch may not have been able to recall the exact manipulation on the object, or they where not able to execute the action since the manipulation required complex motoric movements. Instead the infants only indicated where the action should be executed by touching the container object. Alternatively, is possible that the infant subjects were too shy to execute the action.
Similarly, we call the baited container choice 'emulative-like' behaviour because we suppose that the infant subjects tried to copy the achieved goal of the demonstration without copying the observed action (i.e. retrieving the tennis ball from the baited container).

The high proportion of non-responsive infants shows that infant subjects were not only affected in their choice behaviour by the social factors but also their willingness to make a choice varied between experimental conditions. Whereas most infants made their choice in communicative situations, the proportion of non-responsive and responsive infants in the 'non-communicative / present' situation was similar. This supports the claim of the theory of natural pedagogy that ostensive-communicative and referential cues give a guide to the observer how to behave, and also inform the recipient what is worth to learn from the demonstration. Thus, they help to interpret the situation and help to develop a certain behaviour.

However, the outcome of the communicative situation can be explained alternatively. After communicative demonstration we found no difference in 18-month-olds choice behaviour; they rather preferred the empty container regardless of the presence / absence of the demonstrator. It can be argued that the communicative cues transfer the attention of the subjects from the appearing ball on the baited side and infants focusing only on the manipulated side; the empty container. Therefore they may not have knowledge about the two spatially separated happenings. We argue that this alternative is unlikely of major importance for at least three reasons. First, the demonstrator said at the beginning of the demonstration before touching the containers: "We are going to play with a tennis ball!". Therefore, infants had knowledge about the reward object. Second, after pulling down the empty container the demonstrator immediately turned to the baited container and picked up the ball. The empty container stayed on the ground and the baited was left in the air. This difference should also rather help the subjects to infer that the ball came from the baited container. Subjects saw the demonstrator turning to the baited side to pick up the ball as the last action of the demonstration and we think that this should rather turn the focus toward the baited side of the

apparatus. Finally, the two containers were relative close to each other (60cm apart) and infants watched the demonstration from a short distance 3m away from the apparatus with the same distance from the two containers). Therefore they had no difficulty to follow the actions on both sides visually.

Another alternative explanation could be that, although infants have information of the actions on both sides (manipulation on the empty side and the appearance of the ball on the baited side) they had no understanding of the causality between them. Therefore, they might have attempted to copy the action *per se* without the intention of obtaining the tennis ball. In this case choosing the empty container would not be regarded as an intention to imitate the demonstrator's mean action to obtain the reward. (Since the experiment terminated after the first choice we have no further information whether the infants would have started to investigate the baited container or would have continued to get the tennis ball from the empty container.) Indeed, it has been shown that the invisibility of the connection between two actions (manipulation and outcome) does weaken the expectation of causal connection between the two actions especially at a young age (see in Bonawitz et al. 2010).

However, the choice behaviour of 18-month-olds does not support these predictions. Agent mediated actions, in particular verbally reinforced causal connections should make the causality well recognizable for infants at 18-month of life (Bonawitz et al. 2010; Brugger et al. 2007). In our case the action was mediated by the human demonstrator, and the connection was presented verbally in communicative situations ("We are going to play with the tennis ball!"). Because the action-manipulation itself may have been interesting for infants we cannot completely exclude the possibility that this was the reason why they went to the empty container. However, this interpretation is not supported by the observed differences in selective choice behaviour across experimental groups since they chose the baited container in the least social situation.

We argue that 18-month-old infants actually have an understanding of the causal interference between the action and the outcome although they probably did not understand the mechanism of the apparatus. We think that infants interpret the manipulation of the empty container as a means action to obtain the reward.

Infants showed 'emulative-like' behaviour in one of the non-communicative situations; when the D was absent during the choice. Choosing the baited container and therefore preferring the individual over the observed solution can be explained in two ways. First, because of lacking communication between the subject and the demonstrator they did not pay attention to the demonstration and focused only on the emergence of the ball. In this

case infants showed 'real emulation' in a sense that by ignoring the action they copied only the outcome and reached it with an individual solution. The definition of goal emulation (Want & Harris 2002) (see Main introduction 2) refers to a learning process when subjects learn about the goal of a performed action but neither about the action itself nor about how that action leads to the desired goal. However, in this case the presence/absence of the demonstrator during the test should not influence their choice behaviour. Second explanation can be, infants had knowledge about both the demonstration and the outcome and therefore they chose the emulative-like solution (going straight to the ball) because they considered this as the more rational solution. However, this behaviour can be expressed only in the least social circumstances ('non-communicative / not present'), where the demonstrator does not influence their choice. This should not be considered as 'real emulation' by definition, because the subjects did have knowledge about the action demonstration but their own solution overwrote it. Here, emulation should be considered rather as 'insightful' in the sense they actively choose it after pondering between the two possible (individual or observed) solutions.

We suggest that therefore infants followed both, the action manipulation and the emergence of the tennis ball, with full attention independently from the context. After observing the demonstration they actively choose between the two possible solutions based on whether the demonstrator stays or leaves the room. This is in line with the interpretation of results from other studies that found evidence for selective processes in infants as a function of earlier experience (Williamson et al 2008); and as a function of the communicatively exposed goal hierarchy (Király 2009). Our results support the notion that 18-month-olds actively and selectively make their choice between emulative and imitative solutions to reproduce the goal depending on communicative cues and social reinforcement (see also Williamson & Markman, 2006; Want & Harris 2002). Their reliance on the communicative cues is even more expressed when the causal understanding of the means action is cognitively opaque (Brugger et al. 2007).

The demonstrator's effect on the behaviour of 18-month-old infants

The presence of a human demonstrator during the test can have multiple effects on the imitative behaviour of humans. Király (2009) showed that the demonstrator's presence during the test increased the imitative behaviour of 14-month-old infants, which she interpreted as: a.) the demonstrator acts as a reminder cue, who evokes the demonstrated action at the test

phase; b.) the demonstrator acts as a communicative partner or helper who gives feedback about the performance of the learner.

Importantly, that study differed from ours in several key aspects. First, in that experiment there was 1 week delay between the demonstration and the test event. Therefore, the demonstrator's role as a reminder cue during the test phase might have had an increased significance. In our study the test immediately followed the demonstration; therefore the demonstrator's role as a reminder cue probably has less importance.

Second, in Király's experiment the demonstrations were always communicatively presented and the demonstrator during the test acted communicatively and encouraging. In our study demonstration was carried out either communicatively or non-communicatively and the demonstrator's behaviour during the test was or communicative or non-communicative depending on the demonstrational context.

Here, the demonstrator's presence or absence did not influence the choice behaviour of infants in communicative situations but only in non-communicative situations. The communicative cues during the demonstration probably have a higher meaning for infants; learning the new and relevant part of the demonstration. The presence/absence of the demonstrator does not interfere with this message. The communicative partner role of the demonstrator when present can be a possible explanation for the behaviour of infants in the non-communicative situation. Here although the demonstrator stayed passive during the test (she did not look or talk to the subject) copying behaviour can be interpreted as a communicative gesture to affiliate connection between the demonstrator and the subject (Uzgiris 1981). Alternatively, the presence of the demonstrator may act as an imperative which assesses the behaviour that was demonstrated before. Thus, even though she has no communicative connection to the infants she may affect their behaviour by her presence.

It is important to note that choice in the 'non-communicative / present' situation appeared random, thus not all infants may be sensitive to these social cues.

Condition blind behaviour of 14-month-old infants

In contrast to the behaviour of 18-month-olds there was no effect of the two social factors on the behaviour of 14-month-olds. This difference between the two age groups suggests that sensitivity for communicative cues and demonstrator presence is not only exclusively human but a characteristic of a certain developmental stage.

The apparently "condition blind" and random choice behaviour of the 14-month-olds can have several possible interpretations. First, 14-month-olds are overwhelmed by the two

actions on both sides of the apparatus and they are only able to follow one action with attention. Alternatively, they have input about the ball, but they do not remember the location where it was appearing. It is also possible that they are simply more interested in one of the two actions. The result of the automatic ghost study (**Experiment 2**) does suggest either that they have no input about the action on the baited side or that they are not interested about the ball. If they do not remember the place of the ball, we would have expected a random choice; however, in the ghost situation most of the responsive infants chose the empty container and rather seemed to ignore the baited one. Therefore we think that this explanation is unlikely. Lastly, it is possible that the automatic movement of the empty container in the ghost situation could have raised the infants' curiosity and that is why they preferred that container.

We do not think that the lack of input about the appearing ball or difficulties in the recall of the location would explain the choice behaviour of 14-month-old infants (for similar reasons as in case of 18-month-olds). We rather suggest that in contrast to 18-month-olds 14-month-olds do not understand the contingency between the two actions and cannot rely on the cognitive inferential processes to efficiently evaluate the observed cognitively opaque means action.

The relative high number of the non-responsive 14-month-old subjects in each experimental group and in the automatic ghost situation also suggests that they have cognitive limitations to interpret the situation. We presume because of the incomplete causal understanding between the two actions they do not fully understand the aim of the manipulation. It appears that infants relied on their own interpretation of the task and ignored the social factors.

Our results of no effect of the communicative cues on the behaviour of 14-month-old infants seem to contradict the results of previous studies (see Main introduction 5.1.2; Király et al. 2004; Brugger et al. 2007). However, we suggest that the complexity of the task has a strong influence on infants' cognitive understanding of the situation. Communicative cues inform infants about what is worth to learn from the observed demonstration. Without the lack of a well-defined goal – which would be worth to learn – the communicative cues are meaningless, thus they have no effect on their behaviour (Kupán 2005). Further studies on the reliance of communicative cues of this age group are necessary.

Selective choice behaviour of dogs in comparison to infants

Recent studies reveal that dogs have an infant-like sensitivity to human communicative and referential cues (Range et al. 2007; Topál et al. 2009b; Lakatos et al. 2009). In our study we noted both similarities and differences in the behaviour of dogs and infants. In line with other studies (listed in Main introduction 6.1.2) we showed that dogs are sensitive to communicative cues; we found that – similarly to 18-month-old infants - they were more likely to choose the empty container in communicative situations than in a non-communicative ones and this was independent of the presence or absence of the demonstrator. However, in contrast to the choice behaviour of 18-month-old infants we found no significant interaction between 'demonstration context' and 'demonstrator's presence' in dogs.

Comparing dogs to the infant groups in each condition revealed that dogs act similarly to 18-month-old infants in the most social ('communicative / present') and in the least social ('non-communicative / not present') condition. In the most social one higher proportion of both subject groups choose the empty container in comparison to the least social condition where both groups chose the baited one. However, their choice behaviour was different in the two 'medial' social groups ('communicative / not present' and 'non-communicative / present'). Whereas one social factor (communicative demonstration or the presence of the D) was enough for infants to shift their choice behaviour toward the imitative-like choice behaviour (empty container), dogs kept on preferring the baited container choice and changed their behaviour only when both social factors were present.

The differences in behaviour of 18-month-old infants and dogs in the communicative situations suggest that communicative cues are differently interpreted in the two groups.

18-month-old infants intended to imitate the demonstrators' action after communicative demonstrations even in the absence of the demonstrator. This suggests that they copied the observed action in order to *learn* it. They copy the action for themselves and not for the sake of the demonstrator. This interpretation is further supported by the result of the 'non-communicative / not present' situation where they did not copy the demonstrated solution. This is in line with the natural pedagogy theory that suggests that ostensive-communicative demonstration can be interpreted as teaching manifestation that triggers imitative response. In contrast, the non-communicative demonstration focuses infants' attention to the goal that can be best achieved by emulation.

The selective choice behaviour of dogs in the two communicative contexts suggests that copying the demonstrated solution in the 'communicative / present' condition is not the result of learning. Importantly - in contrast to infants - dogs would have a more difficulties to obtain

the ball by manipulating the empty container than infants. Nevertheless, comparable proportion of copying behaviour to infants in the 'communicative / present' situation seems to be triggered by the common presence of both the communicative cues and the presence of the demonstrator during the test since it disappears if either of the factors is missing.

One possible explanation is provided by differences in motivational accounts. Recent evidence suggests that in social learning situations ostensive-communicative cues may trigger higher levels of arousal and activity in dogs (Range et al. 2009). Thus, the change in the dogs' search pattern may be caused by differential motivational effect under different demonstration conditions. Dogs may have been better motivated to participate in the task, they were more willing to approach and inspect the apparatus as a whole in the communicative demonstration situation especially when the demonstrator is present. Incidentally, this could have led to a higher probability of visiting the empty container. However, this is not supported by the latency results that showed that dogs made their choice shortly after being released (within 3–5s on average) in each condition, and there were only three dogs out of the 76 (2 in 'communicative / present' and 1 in 'non-communicative / present' groups) that did not make their first choice within 10s. Therefore we argue that dogs were similarly motivated to participate in the task, although there could be specific differences in their decision-making processes across contexts.

An alternative explanation could be provided by differences in dogs' attention and memory processes under different experimental conditions. Recently, it has been shown that attention is an important variable when testing dogs in social situations (Range et al. 2009). In our set up it means that communicative signals expressing the demonstrator's intent focused the dog's attention to the steps of the demonstration and therefore enhanced the capacity of the dog to encode the human's actions during the observation and display a more effective recall during the test phase (see also Pongrácz et al 2004). Moreover, the presence of the human demonstrator in the testing phase could act as a 'reminder cue', which facilitated recalling the demonstration. Therefore, the presence of the human demonstrator in the test phase and the communicative cues as a part of the demonstration could have had an independent (additive) effect leading to a decrease in goal-directed search behaviour (i.e. selecting the baited container). However, our results do not support this explanation as we did not find an effect of the human's presence during the test phase on the choice behaviour of dogs.

Importantly, the result of the automatic ghost study (**Experiment 2**) suggests that dog subjects could recall the place of the reward, they were motivated to retrieve it, therefore they

were motivated to participate in the study and obtain the reward even without any social factors.

We suggest an alternative hypothesis of the selective behaviour of dogs. We argue that the communicative manifestation of the action and the presence of the human act as an 'episodic imperative' for the dogs ('Go to the empty container!'). When both social cues are present the dogs' behaviour is driven by a motivation to satisfy communicatively signalled human imperatives in the 'here-and-now' (Topál et al. 2009b). Furthermore, the ostensively communicated human action-demonstrations can be functionally interpreted as imperatives for dogs to perform the observed action in the presence of (and 'for') the human demonstrator. Previous studies showed specific sensitivity to human's communicative cues in dogs (Erdőhegyi et al. 2007; Kaminski et al. 2009; Riedel et al. 2008) we propose that for dogs the function of human demonstration is not (or not only) transferring knowledge but disposing behaviour actions.

The selective behaviour of dogs in the communicative situations might be parallel to the selective behaviour of 18-month-old infants in the non-communicative situations. The empty choice behaviour of 18-month-old increased significantly when the demonstrator stayed present during the test in contrast to the situation when she has left the room. One possible explanation can be that infants who copied the observed action in the present situation interpreted the demonstrator's presence as an imperative to act in line with her behaviour (see above at 'The demonstrator's effect on the behaviour of 18-month-old infants'). In this case copying behaviour – similarly to the behaviour of dogs - cannot be interpreted as an intention to learn the action but following a socially ordered imperative in the 'here and now'. However, this effect of the demonstrator might be overwritten by the effect of the communicative cues in the communicative situations.

"Efficiency blindness" in dogs and infants

Communicative cues related "efficiency blindness" in case of 18-month-old infants can be confirmed by our study. The communicative cues appear to encourage infants to choose the demonstrated successful solution even if it appears less efficient. However, without the communicative cues infants seem to have a tendency to try the more efficient and direct way even without having it observed previously.

"Efficiency blindness" in dogs influenced by communicative cues was found previously (Szetei et al. 2003; Erdőhegyi et al. 2007; Marshall-Pescini et al. 2011; Prato-Previde et al. 2008). However, we show a new aspect of this phenomenon; in our study the

presence of the demonstrator person *together* with communicative cues during the test phase are important facilitators of this behaviour. The results of the 'communicative / not present' condition where dogs were more likely to choose the baited container suggest that dogs are not always misled by communicative cues and therefore they are not real *blind* for the more efficient solution. In contrast, they seemed to have clear knowledge about the location of the reward. We interpret these results as socially ordered behaviour that is dominant over the individual apparently more efficient solution.

This interpretation is backed up by the duration of hesitation results. Infants are more puzzled in a non-communicative situation and communicative cues help them to execute a faster response. In contrast, hesitation times were not different in dogs. Therefore they make their decision within the same time in both contexts. Whereas after non-communicative demonstration where the location of the ball is revealed the dog will go directly there in order to obtain it, in the communicative situation the demonstrator teaches the dog to go to the manipulated container. They seem to have no difficulty to understand this information and act immediately according to them.

Conclusion

In this study we found support for the natural pedagogy hypothesis although we found differences in behavioural patterns across species and age. Infants of different ages have differences cognitive abilities to understand a certain task and they are therefore they showed different level of sensitivity to the social cues. The similarities between dogs and infants in their response to social cues confirm another infant-like analogue in the behaviour of dogs. However, differences between dogs and infants suggest that different cognitive processes are used in the interpretation of the task. Following the communicatively demonstrated task refers to a long-term learning process in 18-month-old infants but rather to a 'here-and-now' interpretation of the episodic instruction in dogs.

Study 3: Feature or location? Effects of the ostensive-communicative and referential cues on the learning and searching strategy of infants and dogs

Introduction

Humans live in complex environments surrounded by many objects of different feature properties and functions. Acquiring the necessary knowledge to effectively navigate in such a rich culture of artefacts poses a great challenge for the infant mind. Infants need to acquire the basic skill of segregating the environment into distinct objects as well as the more sophisticated skill of understanding object categories and/or function.

One of the basic and earliest emerging competencies in reasoning about objects is object individuation. Previous research has identified characteristics that help infants to draw distinctions between objects as well as described the developmental pattern of these processes. It is now a consensus that from a very early age infants are able to use spatiotemporal information to individuate objects, whereas the ability to solve such tasks based on feature properties alone develops only later (e.g.; Kellman & Spelke 1983; Bushnell et al. 1995; Xu & Carey 1996; Newcombe et al. 1999; Káldy & Leslie 2003). At the age of one year infants are able to use both location and feature information for object representation and identification (Xu & Carey 1996; Wilcox & Baillargeon 1998a, b; Wilcox 1999; Tremoulet et al. 2000). Object individuation is "the capacity to determine whether an object currently in view is the same object or a different object than seen before" (Wilcox et al. 2008, p. 2). During object individuation and identification (i.e. the representation of two objects with a feature that was observed during demonstration) children use features such as shape developmentally earlier than, for example, colour) (e.g. Wilcox 1999; Tremoulet et al. 2000; Káldy, & Leslie 2003). This division of the two different strategies (location- vs. feature-based identification or individualization) may reflect certain traits of the neurophysiologic development of the infant brain (Kaufman et al. 2003; Mareschal & Johnson 2003).

In this study we investigated the question of location- vs. feature-based individualization from the point of the natural pedagogy theory (see Main introduction, 5.1.3). According to natural pedagogy, communicatively demonstrated action transfer generic

information is valid through time and space. Therefore communicative cues rather emphasize the feature of objects than the location as the generalizable information. Recent evidence indicate that similarly to adult already 9-month-old infants attend to featural properties of objects in an ostensive-communicative context whereas they rely on the location information in non-communicative setting (Yoon et al. 2008, Marno et al. submitted). However, these two previous experiments which examined feature- or location-based searching strategy of infants and adults from the point of the natural pedagogy both tested subjects in a screen watching experiment where looking time was measured. Here we tested subject in live choice task. Furthermore, whereas the previous experiments were run under two separate conditions (feature-changed and location-changed), we used a single experimental arrangement to disentangle those effects. We achieved this with a container transposition situation by switching the location of the two different experimental containers. In this way the location of the containers and the feature of the container on a certain location changed simultaneously.

Experiment 1: Feature or Location? Comprehension of an invisible switch in dogs and infants

In this experiment we examined the understanding of dogs and infants of an invisible container transposition event. The same two containers (one opaque and one transparent) were used as in the experiments of **Study 2** but the connection between the containers was eliminated. During the demonstration the opaque container was directly baited with a tennis ball three times by the demonstrator. In this way the location of the action and the reward were not spatially separated (as in Study 2). To test the influence of communicative cues on the subjects' choice behaviour we demonstrated the bait either in a communicative or a non-communicative way.

We predicted that in a transposition event where the empty container is transparent, furthermore the opaque container is directly baited during the demonstration is cognitively not demanding for infants after the first year of life. Therefore they would choose the opaque and previously baited container. However, given that little is known about the cognitive understanding abilities of dogs we had no clear prediction for this test group.

Methods

Subjects

Dogs: Thirty-five pet dogs (19 males and 16 females; mean age: 4.24 years, range: 8 month – 14 years) from eleven different pure breeds (n = 20) and mixed breeds (n = 14) participated in the experiment*. Owners were recruited from the dog database of the Ethology Department, ELTE. The conditions of participation and processes were identical to **Study 2**; only dogs who were motivated to play with the tennis ball and were older than 10 months participated in the experiment. The motivation test was carried out the same way as in **Study 2**.

One dog was tested but later excluded from the final analysis because it did not make a choice during the test phase (Table 1).

* Groenendael, Border collie, Boxer, Cairn terrier, German vizsla, Golden retriever, Hungarian vizsla, Mudi, Poodle, Rottweiler, Yorkshire terrier

Infants: Ten 12-month-old (5 girls, 5 boys; mean age = 1.05, years; range =1 – 1.17) and thirteen 18-month-old (7 girls, 6 boys; mean age = 1.52, years; range =1.5 – 1.58) infants were tested in this experiment. The recruitment of the infants was carried out as described in **Study 2**. Parents were given detailed instruction what to do and how to behave during the test. We tested each infant only in one condition.

One 18-month-old infant was tested but later excluded from the final analysis because he did not follow the demonstration with attention (Table 1).

Demonstration condition	Number of subjects		
	Dogs (males/females)	12-mo. (boys/girls)	18-mo. (boys/girls)
Ostensive-communicative condition	10 / 8	4 / 2	3 / 4
Incidental observational condition	9 / 7	1 / 3	2 / 3

Table 1. Experimental conditions and number of males/female dogs and infant boys/girls tested successfully. Only responsive subjects are given and the table contains all dogs that passed the motivation criteria.

Experimental arrangement

The experiments were carried out between March 2009 and November 2009.

The majority of the dogs was tested in the lab at of the Department of Ethology in Budapest (n = 23) but some of the dogs were tested in the Summer Dog Camp of the Ethology Department, Budapest (n = 12). All infants were tested at the same laboratory as the ones in **Study 2**. In case of infants the Demonstrator (D) was the same person as in the previous study, whereas for dogs two female Ds (one in the laboratory and one in the camp) carried out the tests.

Experimental set up and apparatus

The experimental set up was the for both subject groups and very similar to **Experiment 1 / Study 2** except for lack of strings connecting the two containers.

For tests with infants the containers were turned upside down as in **Study 2**. However, for dogs the containers were standing upward with their opening and a lid was placed onto the baited one. This alteration was necessary because the previous study suggested that dogs can have difficulties to obtain the tennis ball from up-side-down container and we wanted to increase their chances in success of getting the ball.

In both laboratories an orange curtain hung in front of the objects to hide them from the subjects when required. However, in the dog camp there was no curtain but instead the owners were asked to hide the dogs' eyes or turn them away when necessary.

One camera recorded the facing subject, a second one recorded from an angle that showed the subject's back (from the detective room in case of the infants) and recorded the choice behaviour of the subjects. The two cameras were connected to a splitter.

Procedure

I. <u>Warm-up phase and motivation tests</u>

Details for infant warm-up phase and dog motivation tests are given in **Experiment 1 / Study 2**.

II. Demonstration phase

Communicative condition: In this condition D used ostensive-communicative and referential cues toward the subjects during the demonstration. She stood behind the containers on the midline facing the subject. The tennis ball was placed on the ground between the containers. She made eye contact with him/her/it, called him/her/its by the name and said „Look!" and additionally for infants: "I am going to show you something interesting! We are going to play something!". After that she touched the two containers simultaneously in order to control for local enhancement but this time she did not look at the subject. Then she called the subject's attention again (getting eye contact and saying „Look at this!") picked up the tennis ball, snapped it two times and put it into the baited container. Then she closed the curtain (or the owner covered the dog's eyes) and took the ball out from the container. She repeated the demonstration twice.

Non-communicative condition: The procedure was identical to the one for Communicative demonstration (see above), except that D was not facing the subjects. In case of infants D was turning her back to them. In case of dogs she was facing toward the subjects but was looking down to the ground during the whole demonstration (for detailed explanation see Experiment 1 / Study 2). There were no ostensive-communicative and referential cues upon action-demonstration i.e. she did not look at the subject and did not use verbal directed speech. Instead she mumbled a short meaningless poem during the whole procedure to get the subjects attention. She repeated the demonstration two more times.

III. Test phase

The demonstration was immediately followed by the testing. For this, D stepped to the left side of the apparatus and stayed there. Then she encouraged the subject to explore containers after the communicative demonstration by saying: "Now it's your turn! You can go!" before the subjects were released. With infant subjects she sat on a chair behind the starting point and read in a newspaper in the non-communicative condition (whereas with dogs she was standing at the same place as in the communicative condition but looked at the floor).

Coding and data analysis

For the analyses we recorded the first choice of the subjects, i.e. whether they first inspected the baited or the empty container. We also noted whether they switched between the containers to inspect the other one and if they retrieved the tennis ball.

A container was regarded as chosen by the infant if he/she touched or pointed at it during 90s test phase. In contrast to **Experiment 1 / Study 2**, pointing action was also accepted as behavioural response. The reason is that we were interested in the container choice of the subjects and not what they had learned about the action of the manipulation. For the choice, pointing can be considered as a clear discrimination between the containers. In cases where both touching and pointing appeared, touching choice had priority over pointing or an approaching behaviour and the touching was regarded as the first choice (n = 1).
A container would be regarded as chosen by dogs if they touched it with its paw/muzzle or at least approached it (its paw/muzzle was closer than 5cm to the container) within the 20s exploration period. All dogs made a clear touching choice.

We also measured the duration of hesitation of selecting the baited or empty containers. This was calculated as the time elapsed between the moment when the parent/owner released the infant/dog and the subject approached the firstly selected container. Only touching was involved into the latency data because pointing could happen from further distance and often preceded touching.

Statistical analyses were computed using SPSS version 17.0. Comparative choice data were analysed with GLM using χ^2-test, and Fisher's exact tests. Side preference and container choice was examined using binomial tests. Normality tests (Shapiro-Wilk test) for the duration of hesitation data showed significant deviations from normal distribution in at least some conditions for all subject groups, therefore we transformed data using natural logarithm transformation (ln x). Mean latency of the subjects' first choice was analysed using a t-test on the transformed data.

Results

I. Choice behaviour

We found no significant difference between the two age groups of infants in their choice response (Fisher's exact test: $p = 0.293$) therefore we pooled them into one group for the further analysis.

Infants chose the baited container more often than dogs independently from the demonstration context (GLM: $\chi^2 = 5.274$; df = 1; $p = 0.022$). 'Demonstrational context' did not have a significant effect ($\chi^2 = 0.013$; df = 1; $p = 0.91$) and there was no significant interaction between the two factors.

Infants generally chose the baited container more often (Binomial test: $p = 0.004$; adjusted $\alpha = 0.025$) whereas dogs did not show a preference toward any of the containers (Binomial test: $p = 1.000$; adjusted $\alpha = 0.05$) (Figure 1).

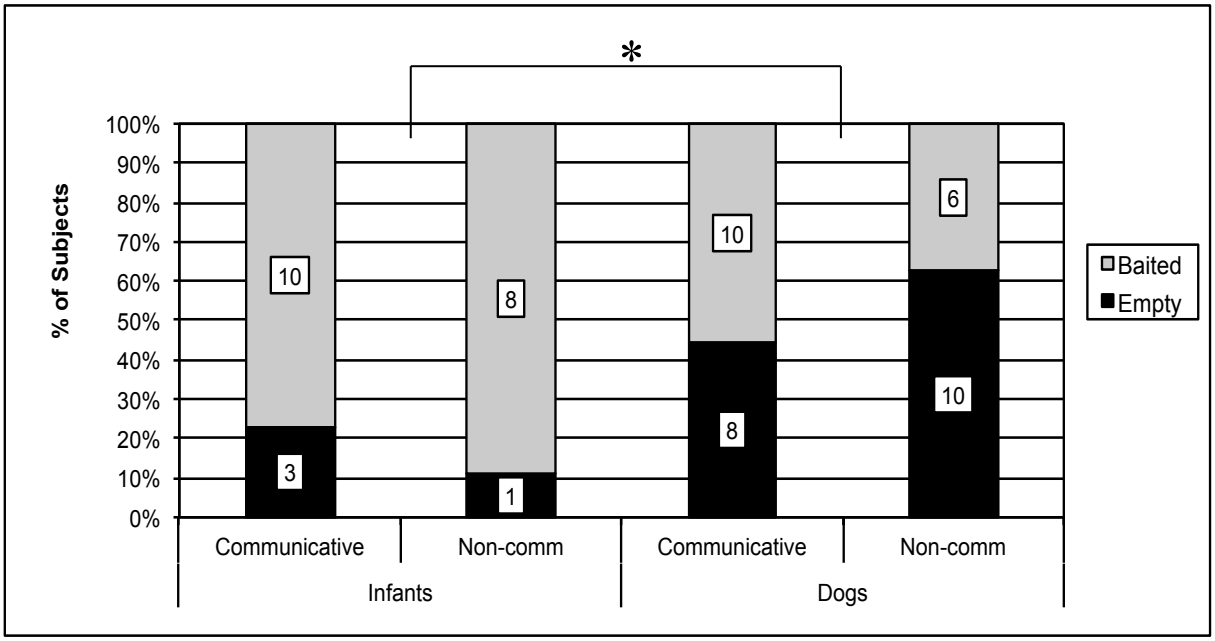

Figure 1. Choice of the empty or baited container of dogs and infants after communicative or non-communicative demonstration. Asterisk represents significant difference between the two subject groups.

II. Duration of hesitation

Duration of hesitation data was analysed separately for the three subject groups since they have major differences in their motoric abilities. There was no significant difference in

duration of hesitation choosing either empty or baited containers in dogs ($t = -0.696$, $df = 32$, $p = 0.491$ or infants (12-month-olds: $t = 0.014$, $df = 8$, $p = 0.990$; 18-month-olds: $t = 1.772$, $df = 9$, $p = 0.110$). This suggests that subjects in all groups were similarly motivated to inspect the two containers.

Discussion

In **Experiment 1** dogs and infants had to find a reward that was hidden in one out of two containers and the locations of the containers were switched invisibly after the demonstration of the hiding event. The task was apparently simple since the non-baited container was transparent whereas the baited one was opaque.

There was no difference in their responses between the communicative and non-communicative situations in infants. The majority of infant subjects chose the baited container independently from the way of the demonstration. This means that (a) the subjects are motivated to obtain the ball, (b) in a simple situation like the present one infants have no difficulty to follow the hidden object or to infer the location of it and they do not rely on communicative signals.

In contrast, dogs' choice behaviour was random after both communicative and non-communicative demonstration. Dogs proved to be able to infer for the place of a hidden reward when they are demonstrated that one out of two containers is empty (Erdőhegyi et al. 2007). Our result of the ghost study in **Experiment 2 / Study 2** suggests that dogs are able to find a ball after a simple hiding event, when there was no switch event included. However, in this experiment dogs neither preferred the location where the ball was observed to be hidden - which would refer to the fact that they did not follow the invisible switch – nor did they follow the switch. It is possible that some of the dogs noticed the switch and some of them not. Since the two containers were identical except for their transparency and the non-transparent was white presumably some of the dogs simply did not notice that the containers were different.

We presume that the decreased performance of dogs is not the result of the fact that they cannot recall the location of the reward but rather that some dogs did not notice or did not understand the invisible switch event.

Experiment 2: Feature or location? Examining infants' learning strategy in a tool-use task

In this experiment we tested the earlier paradigm of **Experiment 1 / Study 2** from the point of the generalisation hypothesis; we examined whether infants learn about the location of the manipulation or about the feature of the manipulated container during demonstration. Furthermore, we examined whether this learning strategy depends on the communicative nature of the demonstration.

Natural pedagogy theory suggests that infants are more likely to learn about the featural information of an object in a communicative situation whereas in a non-communicative situation they would rather learn about the location. We aimed to test this in a complex tool-use task situation (same as Experiment 1 / Study 2) where subjects had to learn that the manipulation and the result of it are spatially separated. Two featurally different containers were used in the task; one was the manipulated one and the other was the one baited with the reward objects. Therefore learning about the manipulation and about the result events can mean learning about the location of the containers or learning about the feature of the containers.

With the following experiment we tested whether subjects can generalize the learned action to the new situation after learning the tool-use task from the demonstration. We also explored whether the communicative cues help to generalize the observed method into a changed situation.

We used a very similar experimental set up introduced in **Experiment 1 / Study 2**: two containers - one transparent and one opaque - were invisibly connected. The opaque one was baited with the reward object (tennis ball) and the transparent one was empty. The demonstrator manipulated the empty container that resulted that the reward appeared from the opaque one. However, there was one additional modification; after the demonstration the containers were switched behind the curtain hidden from the subjects view. As previously, demonstration either happened in a communicative or in a non-communicative way.

We tested only 19-month-old infants in this situation because in **Experiment 1 / Study 2** only the older age group (18-mo.) showed some level of understanding of the tool-use action of the demonstration; they chose the baited or empty containers based on the experimental context. **Experiment 1 / Study 3** had shown that for infants following a simple switch between a transparent and an opaque container was not problematic even when the

switching event was hidden from them. We did not test dogs since dogs seemed not be able to comprehend the simple invisible switch even (see Experiment 1 / Study 3 above).

In order to see whether their choice behaviour was effected by the switch event we compared the equivalent groups with the previous study as control groups (Experiment 1 / Study 2; 18-month-olds' 'communicative / present' and 'non-communicative / present' groups). In these situations no container switch was implemented in the experimental procedures.

Our prediction was that communicative cues help infants to follow the switch and they will be more likely to choose the empty container than in a non-communicative one.

Methods

Subjects

Switch conditions: Thirty-three 19-month-old infants (16 boys and 17 girls; mean age = 1.62 years; range = 1.5 – 1.81 years) participated with their parents. Recruitment of the subjects was carried out as in previous experiments (see Experiment 1 / Study 2).

Five infants were tested but later excluded from the final analysis; because they did not choose during the exploration period (n = 3) or technical errors during demonstration or test phase (n = 2).

Twenty-eight infants were included in the final analysis. Each infant was tested in only one condition and was assigned randomly to one of the two experimental groups (Table 2).

No switch (control) conditions: Forty 18-month-old infants (23 boys, 15 girls and 2 missing information; mean age = 1.5 years; range: 1.42 – 1.58 years). The subjects are the same as the 18-month-old 'communicative / present' and 'non-communicative / present' groups in Experiment 1 / Study 2.

Twelve infants tested but later excluded from the analyses because the parent did not act in line with the instructions (n = 10) or because of technical problem (n = 1). Further one infant gave no answer during the test phase.

Twenty-eight infants were included into the final analyses (Table 2).

Demonstration condition	'Switch conditions' Number of subjects boys / girls	'No switch conditions' Number of subjects boys / girls
Communicative	7 / 7	7 / 8
Non-communicative	8 / 6	7 / 6

Table 2. Experimental conditions and number of 'responsive' infants (boys / girls) assigned to each condition in the tool-use task. Infants in the 'No switch group' are identical to the 18-month-old 'communicative / present' and 'non-communicative / present' groups in Experiment 1 / Study 2.

The following parts of the Methods refer to the 'Switch conditions' only. For the corresponding parts of the 'No Switch (control) conditions' see **Experiment 1 / Study 2**.

Experimental arrangement

The experiments were carried out between February and December 2008.
All the infants were tested at the lab of the Comparative Behaviour Research Group of the Institute for Psychology, Hungarian Academy of Sciences. The lab was identical with the one in **Study 2**.

Experimental set up and apparatus

Experimental set up and apparatus are described in detail in **Experiment 1 / Study 2**.

Procedure

All phases of the procedure (Warm-up phase, Demonstration phase, Test phase) followed those of 'communicative / present' and 'non-communicative / present' situations outlined in **Experiment 1 / Study 2** with one modification: at the end of the third demonstration the demonstrator switched the containers invisibly behind the curtain.

Coding and data analysis

Responsive infants who selected the empty or baited container were recorded and analysed in each condition. Details of recording and the coding of the choice behaviours are given in **Experiment 1 / Study 2**.

We used chi-square tests (χ^2) and GLM (χ^2) for comparisons of the main factors and binomial test for comparisons of different groups.

Results

The choice behaviour of tested infants in the 'Switch' conditions was not different from random expectations across all situations. In the communicative condition 43% chose the empty container after the invisible switch (Binomial test: $p = 0.791$) whereas in non-communicative situation this proportion was 71% (Binomial test: $p = 0.180$). There was no significant difference in choice behaviours of the two test groups ($\chi^2 = 2.333$; df = 1; $p = 0.127$).

In contrast in the 'No switch' control conditions infants had a significant preference toward the empty container in the communicative context; 80% of them chose the demonstrated side (Binomial test: $p = 0.035$). In the non-communicative situation infants choice behaviour was random; 71% of them chose the empty container (Binomial test: $p = 0.180$). There was no significant difference in choice behaviours of the two test groups (Fisher's Exact test: $p = 0.682$).

In the following we compared the 'Switch conditions' to the 'No switch (control) conditions' in order to see whether they followed the invisible switch event.

The two main factors' ('demonstration context' and 'effect of the switch event') had no significant effect on the empty vs. baited container choice of the subjects ('demonstration context': $\chi2 = 0.383$; df = 1; $p = 0.536$, adjusted $\alpha = 0.005$; 'effect of the switch event': $\chi2 = 1.990$; df = 1; $p = 0.158$; adjusted $\alpha = 0.0375$). In other words there was no significant difference in the proportion of the empty and the baited container choices between the switched and the non-switched situation. The interaction of the two factors proved to be non-significant either (Figure 2).

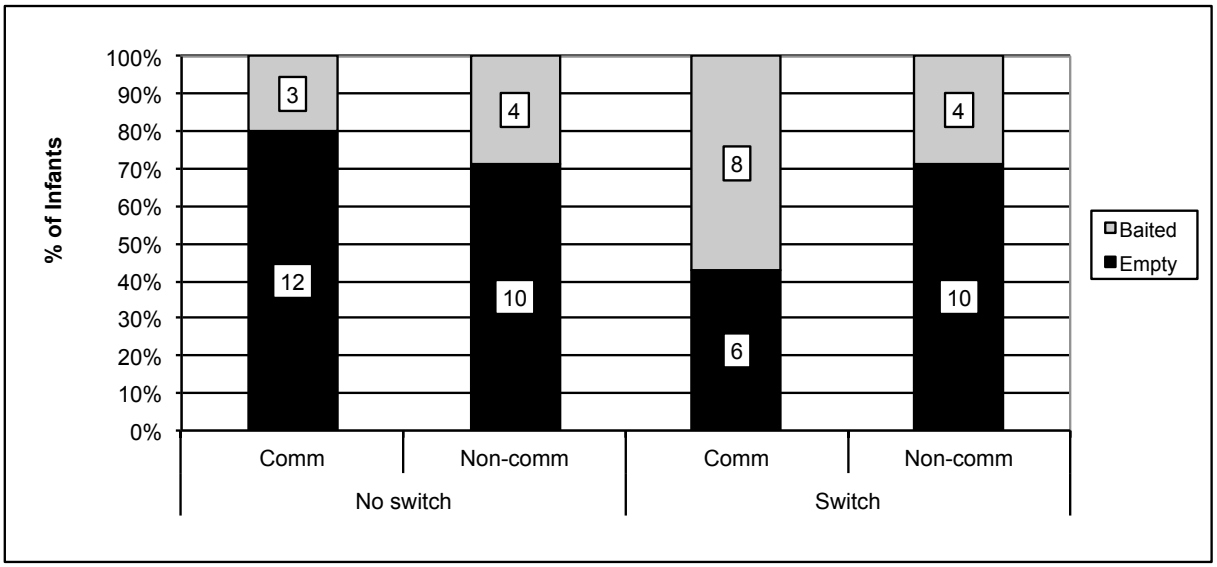

Figure 2. Effects of 'demonstration context' and 'container switch' on the choice behaviour of infants. Percentages of subjects choosing the empty and the baited container. (Data of the 'No switch conditions' come from the 'communicative / present' and 'non-communicative / present' groups of 18-month-olds in Experiment 1 / Study 2.)

Choosing the empty container in the two experiments, however, means going to different locations. Therefore we prepared a separate set of models with the location of the choice ('not demonstrated side' or 'demonstrated side') as response variable in order to see whether infants chose the same location with and without the switch or they followed the container transposition. We used the same two main factors as in the previous analysis. We found no significant effect of the demonstration of the experiment ($\chi 2 = 1.990$; df = 1; $p = 0.158$, adjusted $\alpha = 0.025$) but we found marginally significant effect of the 'switch / no switch' factor ($\chi^2 = 6.101$; df = 1; $p = 0.014$, adjusted $\alpha = 0.0125$). This means that infants were more likely to go to the 'not demonstrated side' after the containers were switched invisibly. The interaction of the two factors was not significant (Figure 3).

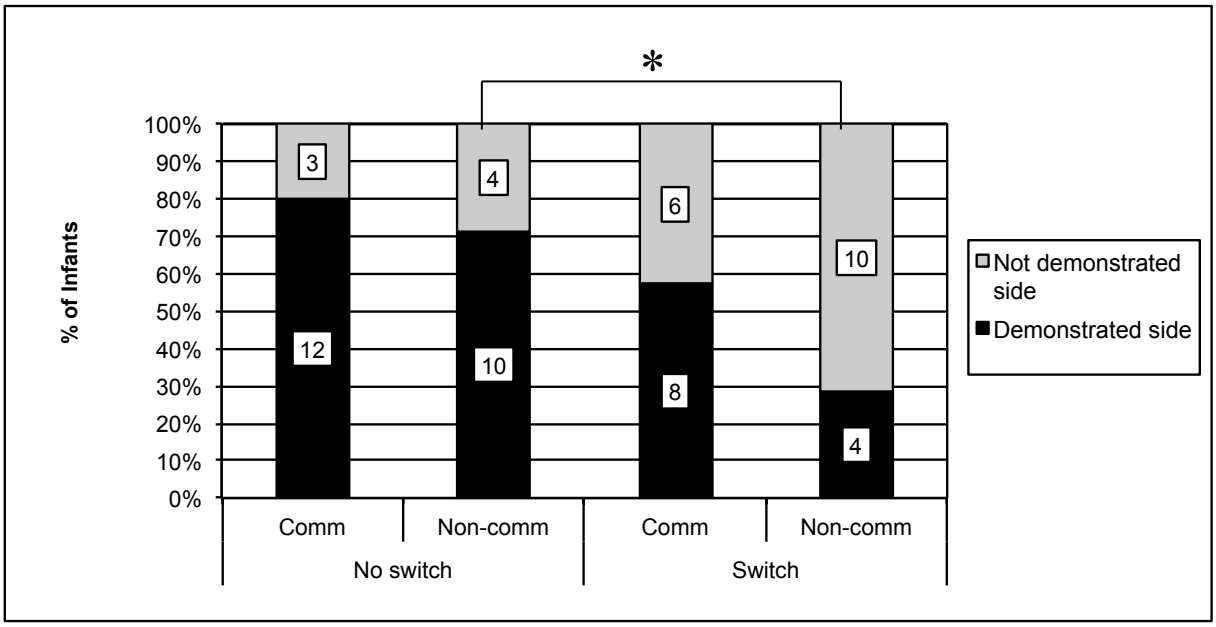

Figure 3. Percentages of subjects went to the demonstrated and the not demonstrated sides after the switch event in the different demonstration contexts. (Data of the 'No switch conditions' come from the 'communicative / present' and 'non-communicative / present' groups of Experiment 1 / Study 2.) Asterisk represents marginal difference between the 'Switch' and 'No switch' conditions.

Discussion

In **Experiment 2** we investigated whether communicative cues help to generalize a previously learned tool-use task into a changed situation. We asked whether infants can apply the observed method to get the reward when the baited and the manipulated containers are switched.

We found that infants' behaviour was random in both demonstrational situations in the 'switch' condition and did not differ significantly between communicative and non-communicative demonstrations. However, comparing the results to the control situation, where there was no switching event (Experiment 1 / Study 2) we found that they tended to follow the switch and chose the empty container rather than visiting the location of the manipulation. This tendency was independent from the demonstrational context. This suggests that noticing and understanding the transposition per se was not difficult for infants (even though the containers were connected by a string that came from above that may have suggested that the containers are fixed to the location).

However, in contrast to our prediction, that communicative cues help infants to follow the switch we experienced rather the opposite. In the non-communicative condition the same percentage of infants in the 'switch' condition chose the empty container as in the 'non-switch' control condition. However, in the communicative situation infants' copying performance decreased; whereas significant proportion of infants chose the empty container in the 'no switch' control condition this proportion reduced to the random level in the 'switch' condition. This suggests that in complex situations communicative cues can be rather disturbing than helpful and might drive the observer's attention away from certain parts of the demonstration.

Importantly, we pooled data from different experiments; therefore the results should be treated with caution and seen rather as preliminary results. Nevertheless, given the ambiguous outcome we do not think that it fruitful to pursue this experimental line in this set up much further.

Experiment 3: Feature or location? The effect of the communicative cues on the searching strategies of infants, children and adults

In this experiment we tested the searching strategies of infants, young children and adults to find a hidden object from the point of the predictions of the natural pedagogy theory. Searching strategies can be tested in an object searching situation where a reward object is being hidden into one out of several featurally different containers during the demonstration. After the demonstration the containers are switched out of sight of the observer. The observer can search for the object based on the location where it was last seen (location-based searching strategy) or based on the feature of the baited container (feature-based searching strategy; see in Haun at al. 2006). However, very little is known about which factors might influence that what strategy we use.

In an experiment of Haun and colleagues (2006) have found that the developmental stage of the subjects affects the searching strategy; 1-year-old infants showed location-based, whilst 3-year-olds showed feature-based searching strategy in a container transposition task. In their study a toy object was hidden into one out of three containers with distinctive shapes and colours. The baited container was switched with one of the other containers out of the sight of the subjects. The reward either moved with the container to a new place or remained

in its original place but the container changed. The demonstration of the hiding even was always presented in a communicative way.

In this ambiguous object-search task 3-year-olds showed a clearly different searching strategy as compared to the younger ones; 1-year-olds tended to use a location-based strategy (they found the reward more often when it was left in its original location), whereas 3-year-olds preferred to rely on a feature-based strategy and performed better if the reward moved with the container. They suggested that this may be a consequence of the cognitive development, i.e. the development of social and cultural skills, understanding of others' mental states and language abilities of children (Haun et al. 2006).

The natural pedagogy theory suggests another factor which might influence our searching strategy; the communicative nature of the demonstration of the hiding event. The theory suggests that communicative demonstration emphasize the generalizeble property of an object; the feature. Therefore it helps to develop feature-based strategy. On the other hand without the communicative cues infants tend to learn about the location of an object which is only here-and-now valid information of both the container and the object (Csibra & Gergely 2009; see in Main introduction 5.1.3).

In this experiment we aimed to investigate the possible role of the communicative cues on the searching strategy choice of infants, young children and adults.

We used the experimental set up of Haun and colleagues (2006) with the modification of entering a new demonstration context (non-communicative demonstration) to the experiment, therefore we created demonstration context as independent variable. To make the situation simpler we used only two containers that were completely identical in shape and size but differed in their colours (white & brown). We tested four age groups: 1) 13-month-old infants: the same age group used in the original experiment of Haun et al.; 2) 19-month-old infants: an age group that fell between the ones applied in the study of Haun and colleagues (2006); 3) 5-year-old children: an age group which we expected to behave similarly to 3-year-olds based on the developmental effect theory of Haun et al. (2006) and 4) a group of adults (> 19 years old): to test whether communicative cues still have an effect on adults in an object hiding situation. We used several age groups including adults in order to test whether communicative cues specifically help learning processes in infancy and early childhood or they have a more general role in creating selective attention states in humans.

Our prediction was that the youngest infants use location-based search strategy independently from the presence/absence of the communicative cues because they struggle with feature representation and in contrast to the task in **Experiment 1 / Study 3** they have no

possibility to infer the place of the ball. We predicted, furthermore, that the older infants and the children group who are already able to represent based on both the location and the feature in a communicative situation, will be demonstration sensitive; they will choose location-based search strategy in a non-communicative situation and feature-based search in the communicative context. Previous study on adults (Marno et al. submitted) suggests that adults are also sensitive to the demonstration context. Therefore adults were predicted to choose the same (or very similar) search strategy as older infants and the children.

Methods

Subjects

Infants: Thirty-eight 13-month-old (20 boys and 18 girls; mean age: 1.13 years, range: 1.00-1.17 years) and thirty-eight 19-month-old (26 boys and 12 girls; mean age: 1.57 years, range: 1.5-1.71 years) infants participated in the experiment.

Parents of the infants from Budapest and the surrounding areas applied voluntarily after a newspaper announcement. Parents were given detailed instruction before the observations regarding the rules of the infants' behaviour during the test.

Four 19-month-old and eight 13-month-old infants were tested, but later excluded from the final sample due to passivity (19mo.: 3; 13mo.: 5), damaged video material (19mo.: 1), inappropriate demonstration (13mo.: 2) or, because the parent did not cooperate with the instructions (13mo.: 1). Thirty 13-, and thirty-four 19-month-old infants were included in the final dataset and (Table 3).

Children: Twenty-six 5-year-old (15 boys and 11 girls; mean age: 4.9 years; range: 4.3 – 5.4 years) children participated in the experiment. They were pupils of a kindergarten in Budapest and participated with the permission of their parents. None of the children was excluded from the analyses.

Adults: Forty-one adults (30 women, 11 men; mean age = 24 years; range = 19 – 36 years) were tested in this experiment. All adult subjects were recruited from different faculties of the ELTE and participation was voluntary.

Subjects were given detailed instruction about what is their task and how they should behave during the test and randomly assigned into one of the two experimental conditions. Subjects were not made aware about the real goal of the experiment. One adult was tested but later

excluded from the analysis because of an inappropriate demonstration. Forty adults were retained in the final dataset (Table 3).

Each subject was assigned randomly into one of two experimental conditions and tested only in this condition.

Demonstration condition	Number of males / females			
	13mo. infants	19mo. infants	5yo children	Adults
Communicative	6 / 9	13 / 4	6 / 7	5 / 15
Non-communicative	9 / 6	11 / 6	9 / 4	6 / 14

Table 3. Experimental conditions and the number of male / female subjects assigned to each group in the toy hiding experiment. Table contains only subjects from the final dataset.

Experimental arrangement and set up

Experiments were carried out between October 2009 and May 2013. Infants were tested in the infant lab of the Institute for Psychology, Hungarian Academy of Sciences, children were tested in their kindergarten in Budapest in a separate room whereas adults were tested in the lab of the Ethology Department. Demonstrators (D) were two young women in the infant and children studies and a young man in the adult study.

The experimental set up and the apparatus were similar at all locations (infant lab, kindergarten and the university lab). The set up was deposed to one corner of the experimental room and hidden from the subjects by a closed curtain or a folding screen at the beginning of the experiment. In case of children the set up was placed onto a table and a folding screen was used to hide the apparatus. Children sat on a chair placed in front of the table.

The apparatus was made up of two bell-shaped containers (10cm high and 8cm radius). The containers were placed about 60cm from each other, turned upside down. They had the same shape but different colours: one of them was white and the other one was brown. A tennis ball was used as a reward for all subject groups.

One camera recorded the facing subject, a second one (from the detective room in case of the infants) recorded from an angle focussed on the subject's back in the beginning of the experiment. The two cameras were connected to a splitter.

Procedure

I. Warm up phase:

Details for infant warm-up phase are given in **Experiment 1 / Study 2**.

II. Demonstration phase:

Parents of infant subjects were asked to take a seat onto a blanket on the ground (at the distance of 3m from the apparatus facing to it) and hold their infant in their lap. Children and adults sat on a chair 3m from the apparatus facing to it.
The process of the demonstration was the same for infants, children and adults. Colour and side of the baited container were counterbalanced between the subjects.

Communicative condition: In this situation D used ostensive-communicative and referential cues during the demonstration. D went behind the curtain, pulled it away and stood between the two containers facing the subject. The reward object (tennis ball) was placed on the ground between the two containers in front of D. D made eye contact to the subject and simultaneously touched the top of both containers in order to avoid local enhancement. Then D called the subject's attention by saying its name and said: "Look! I will show you something interesting!". D dropped the tennis ball to the ground two times, called the subject's attention again by making eye contact and said: 'Look!', and put the tennis ball under one of the containers. Then D pulled the curtain together. Behind the curtain D took the ball out from the container, pulled the curtain away again and repeated the whole procedure two more times.

Non-communicative condition: In this situation D did not use any communicative cues toward the subject; D avoided eye contact by turning her/his face toward the ground. In order to control for the possibility that subject were simply more attentive in the communicative situation because of the vocal cues D mumbled a short nonsense poem during the part of the

demonstration in which D had spoken in the communicative situation (see above). Otherwise the demonstration was exactly the same as the communicative one.

III. Test phase:

The demonstration phase was followed by the test phase immediately. D switched the location of the two containers behind the curtain, placed the ball under the one which was originally baited during the demonstration and pulled the curtain away. D then left the apparatus and stepped to one side of the room (always the same side) and said: "It's your turn now!". In case of infants the parent was allowed to encourage the infant but it was not allowed to point to one of the containers or to drive the infant's attention to any of the containers. In case of the adults, D answered all potential questions by repeating the instruction but nothing else.
Subjects of both groups were given 60s for free exploration.

Coding and data analysis

For the analyses, we recorded subjects' first choices between the two containers. Choice was usually defined as the container touched by the subject. However, for infants who were too shy to approach the set up and make physical contact with the containers, we accepted an overt pointing or reaching gesture towards a container as a choice (N = 4). Furthermore, to test whether subjects were motivated and regarded finding the tennis ball as the aim of the task, we recorded whether subjects obtained the tennis ball and whether the retrieval terminated the manipulation of the containers.

In order to assess inter-observer agreement with respect to infants', children's and adults' choice behaviour, a second person, who was blind to experimental condition, scored a sample from each age group (13mo.: 76%; 19mo.: 100% and adults: 100%). Cohen's Kappa values showed high level of reliability across all subject groups (13-m-o.: Kappa = 0.946; 19-m-o.: 0.901; adults: Kappa = 1) (Landis & Koch 1977). There were in total three discrepancies between the scorers. In two cases the subject was coded as 'not giving answer' by the main coder and 'choosing a container' by the blind coder (one 13-m-o. and one 19-m-o.). These infants had left the experimental area and started to play with the toys after the demonstration and only after urging by the demonstrator and the parent they came back and

gave a choice. Because it is questionable whether the infants' choice can be considered as an answer to the demonstration, we excluded the samples form the final analyses. In case of one 19-month-old infant the coders coded different containers as an answer. Here the infant's first reaction was reaching toward the brown container but later touched the white one. When subjects showed both pointing/reaching and touching actions to different containers we usually considered the touching action as the 'answer'. However, in this case the infant was very shy and after the reaching action he did not explore the apparatus alone anymore. Only after D manipulated the containers he touched the white one. We therefore considered the reaching action as choice.

Proportions of subjects selecting the empty or the baited container were analyzed by non-parametric methods: Generalized Linear Models (SPSS 17), χ^2 tests and binomial tests (test proportion: 0.5) for binary data. We used False Discovery Adjustment after Benjamini and Hochberg (1995) (FDAbh) for the correction of the data.

Results

First we wanted to test whether subjects understood that the purpose of the task was to find the ball and whether they were motivated to look for it. We analyzed a) whether infants continued searching until they managed to retrieve the ball and b) whether locating the ball terminated the manipulation of the containers.

We found that 4 of 30 (in non-communicative condition) of the 13-month-olds and 5 of 34 (n = 2 in non-communicative and 3 in communicative conditions) of the 19-month-olds did not manage to obtain the tennis ball eventually. However, even infants who were unsuccessful exhibited some interest in the set up by pointing to one of the containers or by touching one without lifting it. All infants and children stopped manipulating the containers after they retrieved the ball. All of the 5-year-olds and all but two adults continued searching after checking the empty container, and all of them stopped manipulating the containers after they managed to retrieve the ball. One adult went on to manipulate the empty container after a correct choice because he had not noticed the ball that was rolling out from the container. Most adults (34 of 41) answered that 'finding the ball' as the goal of the study in the questionnaire whereas 4 adults answered that the purpose was to copy the demonstrator's behaviour and 3 adults thought that it was something else, i.e. they assumed there was some higher purpose in the task that they couldn't understand.

A GLM analysis of the possible effects of the two main factors ('age' and 'demonstration context') on subjects' first choices revealed a significant effect of the demonstration context; subjects chose based on the location more often in the non-communicative context than in the communicative one (communicative vs. non-communicative: $\chi^2 = 4.523$; df = 1; p = 0.033). However, there was no difference between the age groups in their searching strategy (age groups: $\chi^2 = 5.939$; df = 3; p = 0.115), and there was no significant interaction between the two factors.

Analyses of the container choices within each groups revealed that none of the groups in any demonstration conditions showed preference toward any of the containers, the choices of subject groups in both communicative and non-communicative situations were not different from the random expectation (Binomial test: 13mo./communicative: p = 0.629; 13mo./non-communicative: p = 0.210; 19mo./communicative: p = 0.648; 19mo./non-communicative: p = 0.064; 5yo./communicative: p = 0.774; 5yo./non-communicative: p = 1.000; adult/communicative: p = 0.115; adult/non-communicative: p = 0.824; Figure 4).

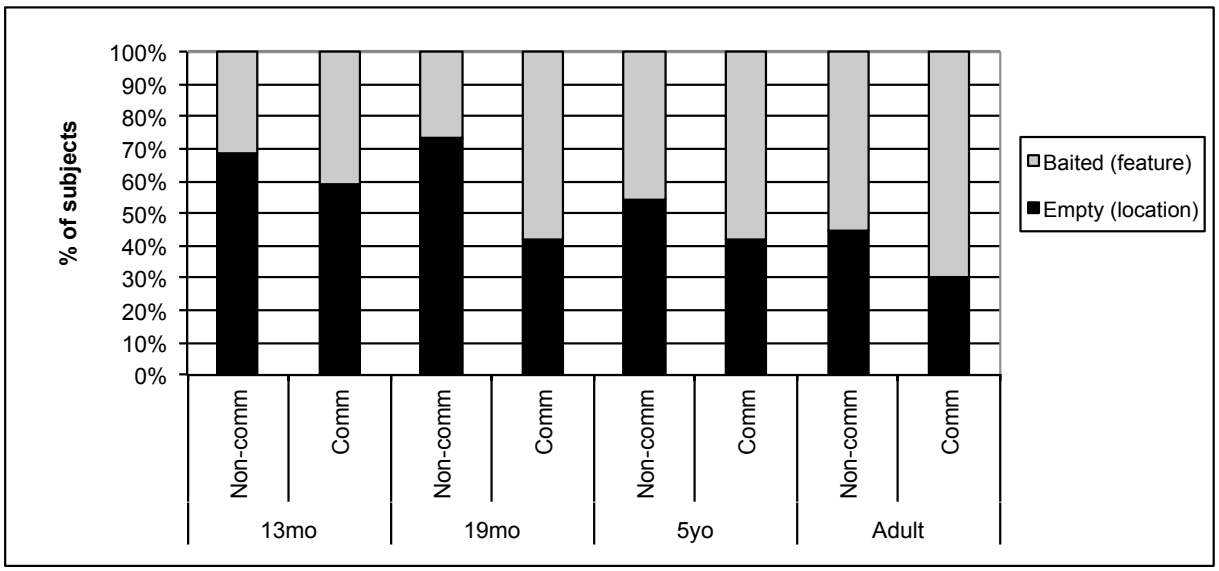

Figure 4. Location vs. feature choices of the different age groups. Percentage of subjects choosing the empty container (i.e. they followed the location of the hiding in the demonstration) or the baited container (i.e. they followed the feature of the baited container) after communicative and non-communicative demonstrations.

Discussion

In **Experiment 3** we tested whether infants, young children and adults attend to different properties of an object in a searching experiment, depending on the social context of the hiding event (communicative vs. non-communicative). This experiment was different from the previous ones (Experiment 1 & 2) from that point that infants could not infer to the location of the reward because both containers were opaque. Therefore, we tested their searching strategies rather than their knowledge about the location of the reward.

We predicted that in a non-communicative context subjects would be more likely to learn about the location of the container and use this information to look for the hidden reward (location-based strategy), whereas in a communicative context we expected - especially older - subjects to search for the reward based on the features of the container (feature-based strategy) (see Yoon et al. 2008).

To rule out the possibility that failure in finding the toy is due to a lack of motivation or to misinterpretation of the situation, we also analyzed whether participants kept searching as long as they found the ball, and whether they stopped manipulating the containers after finding it. Our results suggest that participants perceived the attainment of the tennis ball as the goal of the task, because most of the subjects stopped their search after they had found the ball. Adult subjects who were additionally explicitly asked about their interpretation of the task answered that the goal of the task was to find the hidden object.

Our results are not fully concordant to our predictions. First, we expected different searching strategies of the different age groups; we predicted that while younger age groups will generally prefer the location-based strategy, older ages will follow the feature of the container (see in Haun et al. 2006). However, we did not find significant difference between the searching strategies of the different age groups. There is a tendency that younger age groups rather follow the location whilst older ages (especially adults) prefer to choose based on the feature of the containers this difference is not significant (see Figure 4; feature-based strategy in communicative context: 13mo. vs. adults: 41% vs. 70%).

Second, our results provide only partial support for the natural pedagogy theory. One the one hand we found that communicative cues generally affected the subjects' behaviour; subjects tended to go more to the location of the hidden reward after a non-communicative demonstration than after a communicative demonstration. However, we neither found clear location-based nor feature-based searching strategy in any of the experimental groups which

was predicted based on the natural pedagogy theory. Subject groups searching behaviour was not different from random expectation in any demonstration contexts.

Haun and colleagues (2006) found location-based search in 1-year-olds and feature-based searching strategy in 3-year-olds. However, they used containers of different shapes and colours whereas we used container of the same shape but with different colours. Infants as young as 12 months have been reported to be capable of object individualization (representation of the number of objects) based on their differing colours (Wilcox 1999; Wilcox at al. 2008). In tests where two objects of different colours appeared after each other infants expected to find two objects behind the screen when the objects had disappeared (Wilcox 1999; Tremoulet et al. 2000). However, infants of this age group failed to identify object that differed only in their colours. When infants observed two objects with different colours appearing from behind a screen after each other they were not surprised to find two identical coloured object behind the screen (Tremoulet et al. 2000). In other experiments 1-year-old infants used colour to identify objects only when they had clear spatiotemporal information about the existence of the two objects, i.e. at the beginning of the trial infants had the possibility to see the two objects simultaneously for a few seconds (Xu & Carey 1996; Xu at al. 2004). These results suggest that although infants can clearly distinguish between the different colours at this age maybe they do not use colour information to individualize objects. Therefore one could argue that they might have not noticed or ignored the switch event.

We propose that this is not the case. First, in an experiment Káldy and Blaser (2009) showed that infants even at the age of 9-month-old are capable of identifying objects with more salient colour differences. Furthermore, there are some evidences that 3-year-old children showed random searching behaviour in a similar container transposition experiment after a communicative demonstration of the hiding event where the containers differed both in colour and shape (Pfandler unpublished data). Our results did not fully confirm that subjects did not notice the switch of the containers either, since we found random choice behaviour in all experimental groups. We would have expected mainly location-based searching behaviour in case if subjects had not noticed the switch of the containers. These results challenge the suggestion that the containers are simply not different enough for subjects to be able to follow the switch between them.

On the other hand, one could argue that even if the subjects had noticed the switch they might have thought that the location of the ball is independent from the containers. The prediction of the natural pedagogy theory contradicts this supposition at least in the case of the communicative situation. A communicatively manifested hiding event is suggested to

teach that the certain (baited) container is ordered to contain the certain objects (Topál et al. 2008). Therefore they communicate about the feature of the container and encourage learning about the featural properties in order to find the hidden object in that container in the future, even if it was transposed to a new location. However, we did not find a clear feature preference in any cases, only a general tendency of the subjects, independently from their age. One possibility is that colour - as a featural property - is appropriate for object identification, however, not a generalizable property. It might be that the emphasized feature of the container has to be connected to some function or property of the hidden object. For example, in case of a hidden ball a round shape and a square shape container would enhance generic learning since round shape container is suitable for containing a ball but not a square shape one.

We suggest that it is still possible that there is an effect of the age of the subjects (developmental stage) and the demonstration context (communicative vs. non-communicative) on the searching strategy of humans. However, there is probably a strong individual preference for location- or feature-based search which shadows the effect of these other factors. Furthermore, individuals (at different ages) might be distinctly sensitive on the communicative cues in a searching situation like this. Therefore, we suggest that with a sample size like in our experiment it is difficult to unequivocally prove the effect of the age and the demonstration context on the searching behaviour of humans at different ages.

General discussion

The natural pedagogy theory suggests a human specific way to transfer knowledge to the naïve individuals in a fast and efficient way (Gergely & Csibra 2006; Csibra & Gergely 2009). The theory has been supported by the results of many recent studies. It has been demonstrated that infants show increased attention to ostensive-communicative cues (Senju & Csibra 2008), that their imitation selectively depends on the presence/absence of the communicative cues that accompany the demonstration (Király et al. 2004; Brugger et al. 2007; Yoon et al. 2008; Southgate et al. 2009) and that infants generalize attitudes toward objects after a communicative but not after non-communicative demonstration of the attitude (Egyed et al. 2007; Gergely et al. 2007). Communicatively manifested teaching-learning interactions seem to have great importance for the fast and relevancy-driven learning of human infants (Gergely & Csibra 2006).

However, the conditions under which this unique 'teaching-learning' interaction works are still poorly explored. In my thesis I attempted to close some of the gaps in our understanding. The purpose this thesis was to test the concept of natural pedagogy theory under a wide range of experimental situations, and to examine factors that may modify or influence this teaching-learning interaction.

In most studies presented here I tested human infants because the natural pedagogy theory is most relevant for their learning. In addition, in one experiment I tested young children and adults (Experiment 3 / Study 3) to control for possible age effects. However, I also extended the experiments to dogs. This is important because as a result of their shared evolutionary history and selection through domestication dogs show functional similarity to human infants in their comprehension of ostensive-communicative and referential cues.

Results of the comparative work at three cognitive levels

The comprehension of human ostensive-communicative and referential cues by dogs was documented by several recent studies (see Main introduction 6.1). It has been shown that the sensitivity and responsiveness of communicative cues by dogs show 'infant-like' analogues (Range et al. 2007; Topál et al. 2009b; Lakatos et al. 2009). However, only very few studies have directly compared the sensitivity and interpretation of the communicative cues in dogs and infants (Lakatos et al. 2009, Topál et al. 2009b). The importance of

comparative studies between dogs and infants in systematically manipulated social situations has been emphasized by Miklósi & Topál (2013). Behavioural similarities between dogs and infants might refer to functional analogies that probably evolved because of the similar environment they share. However, differences in their behaviour provide important information about the cognitive and motivational mechanisms controlling behaviour that is not necessarily the same in both species. Comparative studies may also facilitate critical thinking with reference to the abilities of human infants. To reveal the impact of communicative cues on these subjects I used direct and indirect comparative methods; I compared behaviour of infants at different ages, furthermore, I compared the comprehension and interpretation of communicative cues of infants to dogs in the same (or highly similar) experimental set ups.

I assigned the comparative work to three cognitive levels (each level is represented as one study of the thesis – see also in Objectives); 1) level of sensitivity and responsiveness (Study 1); 2) level of interpretation of the cues (Study 2) and; 3) level of interpretation of the transmitted information – the generalization hypothesis (Study 3).

Study 1. On the level of sensitivity and responsiveness using indirect comparative analysis I found high level of similarities between dogs and infants in line with earlier studies (Lakatos et al. 2009, Topál et al. 2009b).

In an experimental situation where a human demonstrator presented a gaze shift on a computer screen dogs follow the direction of the human gaze. Using the eye tracker technique I revealed that gaze following behaviour in dogs is, however, context dependent; the dogs followed the gaze of the human demonstrator only in a communicative situation. This is strikingly similar to the behaviour of human infants, since 6.5-month-olds showed the same pattern of gaze following behaviour in an eye tracker study (Senju and Csibra 2008). This supports the hypothesis that during the socialization process infant-analogue communicative system developed in dogs as a result of sharing the same socio-cognitive environment. This provides a basis for communicative interaction between dogs and humans (Topál et al. 2009a, Miklósi & Topál 2013).

The result confirms that 1) communicative cues evoke selective attention in dogs as in human infants; dogs are more likely to follow referential cues when those were introduced with communicative cues (see also Pongrácz et al. 2004; Kaminski et al. 2012); 2). this selective responsiveness based on the presence/absence of the communicative cues might be

interpreted as evidence that dogs – similarly to infants - comprehend them as communicating intentions (see also Senju & Csibra 2008; Lakatos et al. 2009).

We have incomplete knowledge about whether these cues are equally effective to generate responsiveness or some have more explicit effect than others (Kaminski et al. 2012). The results of the eye tracker study suggest that two-way choice task situations might not be suitable to compare reliance on pointing and gazing gestures since they generate different behavioural responses (see Study 1). Systematic analyses of the different ostensive-communicative and referential cues with the eye tracker technique are necessary to compare the effects of each different cue.

Study 2. On the level of interpretation of the cues the results suggested that there can be different motives behind similar reactions in case of dogs and infants (Topál et al. 2009b). In the experiment both dogs and older infants preferred the demonstrated choice in a communicative situation more often than in a non-communicative one. However, I found that the behaviour of the subject groups was comparable only when the demonstrator stayed after a communicative demonstration but not when she was absent. Infants in both situations preferred the imitative like solution, while dogs' choice was comparable only at the presence of the demonstrator. When the demonstrator was absent dogs performed the individual, emulative solution.

The results of the older infant groups are in line with the suggestion of the natural pedagogy theory as they have strong expectation that communicative demonstration teaches something new and relevant for them, and they copy the demonstrated action in order to learn from it (Király et al. 2004; Király 2009; Csibra & Gergely 2009). In contrast, in case of dogs copying the demonstrator's behaviour is probably driven by the motivation to synchronise behaviour or to fulfil a higher imperative given by the demonstrator (Topál et al. 2009a, b).

The association between cue following behaviour of dogs and the specific context of the situation was also documented by Topál and colleagues (2009b). They described 'infant-like' sensitivity for the ostensive-communicative cues in the so called 'A-not-B' experiment. In a communicative situation infants and dogs similarly had a higher tendency to commit perseverative searching errors than in the non-communicative or non-social context. However, while infants committed the searching error independently from the demonstrator, the performance of dogs improved when a new demonstrator conducted the choice part of the experiment. Topál et al. (2009b) concluded that dogs probably interpret communicative cues as an imperative order to act in the demonstrated way that is strongly connected to the

situational context. In contrast, infants learnt from the communicative demonstration a general rule that is independent from the experimental context or from the person who demonstrated it. Dogs are known to follow less efficient or even completely inefficient solutions when those are presented with communicative cues (Szetei et al. 2003; Erdőhegyi et al. 2007; Marshall-Pescini et al. 2011; Prato-Previde et al. 2008). In line with these studies I found that dogs followed the demonstrated solution after the communicative demonstration in spite of the fact that they could not (or would have difficulties) meet the observed outcome in that way. Infants on the other hand proved to be less likely to imitate actions which did not lead to the desired goal or sub-goals which proved to be redundant in reaching it (Brugger et al. 2007). Infants furthermore, refused to imitate when they could not understand the connection between the manipulation and the outcome (see the results of the 14-month-old infants in Experiment 1 / Study 2; Bonawitz et al. 2010), even if it was demonstrated in a communicative way (Kupán 2005). These results provide further support for our argument that the primary motive for dogs is to execute the higher imperative that was ordained by the communicative cues. This motive can suppress the urge to attain the reward in the easiest way, or to attain the reward at all. In contrast, infants copy the observed solution in order to reproduce the same goal even if this is a less effective solution (Király et al. 2004).

This form of social influence by humans on the behaviour of dogs may be advantageous to avoid conflicts between dogs and their owners. Furthermore, it helps increasing cooperation in joint actions without any deeper insight into the knowledge content of the other's mind or the causal structure of the action (see also in Miklósi & Topál 2013).

However, some social learning studies in dogs provide evidence that learning can be triggered by human communicative cues (Pongrácz et al. 2001; 2003). These results suggest that following the human demonstrator's order might be a primary motive to copy his/her demonstrated solution but not the only one. Further investigation is needed, particularly for situations where communicative cues cannot be interpreted as imperatives but rather as accentuations of information transmission (e.g. demonstration of the solution of a problem).

Study 3. The natural pedagogy theory predicts feature learning in communicative situations as this is the generalizable property of the objects. However, on the level of the ability for generalization my results did not provide clear support for the theory neither in dogs nor in infants.

Dogs failed to follow the container switch and did not find the hidden object in communicative and non-communicative situations. This might be the result of their

incapability for generalization, however, it may also be attributed to their perceptual difficulties to notice the switch between the containers. Infants were successful in following the container switch, however, their choice behaviour in the communicative and non-communicative demonstration situation do not fully fit into the natural pedagogy theory. I will discuss the question of generalization in infants more detailed in the following part of the General discussion.

Evidence and constraints of the natural pedagogy theory in infants

Both studies of my thesis that were carried out on infants (Study 2 and 3) provide evidence for the sensitivity of infants to ostensive-communicative and referential cues. However, some of the experiments revealed conditions in which the predictions of the natural pedagogy were not fully supported. These results suggest that certain (inner and external) factors might influence infants' reliance on these information transmitting signals.

The overall results of **Study 2** suggested that communicative demonstration generally evoked the copying of the demonstrated solution in infant subjects independently of the other social factor; the presence/absence of the demonstrator. However, when examining the subject groups more closely I found demonstration selective behaviour only in 18-month-old infants. In this age group there was an interaction between the demonstration context (communicative vs. non-communicative) and the presence/absence of the demonstrator. This group of infants showed imitative-like behaviour even in the absence of the demonstrator after a communicative demonstration. This supports the suggestion of the natural pedagogy theory that communicative cues generate learning in infants.

However, I failed to detect imitative or emulative tendencies in case of 14-month-olds independent of the social factors of the demonstration. The least social situation ('non-communicative / not present') showed that they failed to understand the causality between the two actions (manipulation and appearance of the goal) probably because the actions where not visibly connected. However, in contrast to my expectations communicative cues did not improve their performance. The causal understanding of a task was reported to have a strong influence on infants' imitative performances (Brugger et al. 2007; Bonawitz et al. 2010); even older toddlers (2-year-olds) were less likely to imitate actions when the connection between the action and the outcome was invisible (Bonawitz et al. 2010). However, it was previously shown that communicative demonstration increases imitation in infants even when the

causality is opaque (Brugger et al. 2007; Bonawitz et al. 2010). In the experiment of Bonawitz et al. (2010) the performance of infants improved when they received verbal description of the task previously. Furthermore, older children (4-year-olds) actively combine the causal and social information what they received during the task to decide which parts of an action series have to be imitated (Buchsbaum et al. 2010).

Without an understanding of the causal connection between the demonstrated action and the outcome of the demonstration there was no visible goal for the group of 14-month-olds. Verbal description of the task probably did not help either because of their rudimentary language abilities. Therefore, communicative cues had nothing to teach about for this group and the cues lost their relevance. The results of 14-month-old infants, thus, did not necessarily contradict the natural pedagogy theory as it predicts that communicative cues generate *learning* about a desired goal. Rather I interpret the results of this study as that the communicative cues used in this experiment were not adequate for the age group of 14-month-olds.

Previous studies have shown that communicative demonstration transmits generalizable information (Gergely et al. 2007; Egyed et al. 2007; Yoon et al. 2008; Topál et al. 2008; Marno et al. submitted). However, I did not find support for a generalization of information in the experiment conducted with infants, children and adults in **Study 3**.

In the complex tool-use task (Experiment 2 / Study 3) where infants had to adapt their previously learnt knowledge into a changed situation, the communicative cues appeared to be rather confusing and infants managed to perform the learnt solution better in the non-communicative situation.

In case of searching strategy (Experiment 3 / Study 3) all subjects generally preferred the feature-based search over location-based in the communicative situation, however, this preference disappeared when I analysed each subject group separately. Furthermore, in contrast to previous studies I did not find a preference for the feature-based search nor for the location-based one in any of the subject groups (Haun et al. 2006).

I conclude that communicative cues might influence the subjects' searching strategy; however, individual preferences for a certain strategy may modulate this effect. Alternatively, the effect of the communicative cues may only be detected in a bigger sample size. The experimental set up may also miss a distinctive goal that is clear to all subjects in order to able to learn generalizable information. Possibly, the subjects in this experiment were not able to associate any of the visible features of the containers (the colour) to a certain function. The imitative tendency may increase if the feature differences between containers refer to

functional differences (e.g. different shapes that are appropriate to contain different objects). In this case colour (which was the only discriminative feature used in this experiment) might not be a generalizable feature. Therefore, the lack of obvious goal of the hiding action leads to misinterpretation or ignorance of the communicative cues (see also Topál et al. 2008, 2009b).

The results of both infant studies suggest that infants rely on the ostensive-communicative and referential cues flexibly and selectively, based on their existing cognitive abilities and their understanding of the demonstrated action. From my studies I concluded that reliance on these cues is not automatically triggered but rather an active decision of the subjects (Király 2009; Buchsbaum et al. 2010). Infants presumably rely on these cues when the demonstration has a well-defined goal and they have the cognitive capacity to understand the causality between the manipulation and the appearance of this goal, however, they need external guidance for the execution. In the situation when the efficient solution was not demonstrated (retrieve the tennis ball directly from the baited container – Experiment 1 / Study 2) 18-month-old infants preferred the less efficient but demonstrated solution in a communicative context. On the other hand, when the task is cognitively too complex, infants ignored the communicative aspect of the demonstration ("context-blind" behaviour of 14-month-olds in Experiment 1 / Study 2).

This age- and/or task-dependent reliance on ostensive-communicative and referential cues might provide an explanation to criticism of the natural pedagogy theory with regard to over-imitation (see Main introduction 5.3.2.). Selective imitation suggested by the natural pedagogy theory does not necessarily contradict over-imitation (Whiten et al. 2009, 2011; Buchsbaum et al. 2010). Based on my results I consider natural pedagogy as mechanism to mediate new and relevant knowledge to infants at a certain developmental stage (assuming a certain cognitive understanding of the task). Infants may show selective imitation at one developmental stage but show over-imitation in another one in the same task. For example, younger infants who have less understanding of a situation might over-imitate the observed action independently from the communicative nature of the situation (see Brugger et al. 2007). At the other extreme, older infants, for whom the task is cognitively not challenging, might perform over-imitation because of the social effect of the demonstrator. Therefore, context-dependent selective imitation may only be found at an intermediate age group, when infants have some level of understanding of the task and therefore can show an individual solution but still look for guidance for the correct choice. This is supported by results from a study conducted by Nielsen (2006). In this study a complex action was demonstrated with relevant and irrelevant sub-actions in order to reach the desired goal. He found that 12-month-old infants imitated only the necessary steps independently from the communicative context of the demonstration. 18-month-olds copied selectively; they imitated all steps in the

communicative but only the necessary steps in the non-communicative situation. 24-month-olds imitated in both situations.

Taken together, the number of studies focusing on the interaction of the causal understanding of the task (or the age of the infants) and the communicative cues is very small (see also Bonawitz et al. 2010). The fact that several other - social or non-social - factors may influence infants' imitative behaviour (see Main introduction, 4.1) makes it even more difficult to disentangle their effects at present. The possible interaction of these factors is studied even less (Buchsbaum et al. 2010). However, the deviation I found in the choice behaviour in the different age groups of infants suggests that further investigation on the age- or complexity-relatedness of the reliance on the communicative cues is needed. Studies should be carried out on different age groups of infants in the same tool-use learning tasks to evaluate the relevance of age. Similarly, systematic testing of infants at the same age in tool-use tasks with different difficulty levels is required. These studies will establish whether infants rely on the communicative cues selectively, and to what extent their response depends on their cognitive understanding of a certain task.

Summarizing the results of the studies of the thesis to the predictions made by the natural pedagogy theory I argue that the negative results I found do not refute the theory as a whole. They rather suggest that some conditions constrain the effectiveness of information transfer by the means suggested by the natural pedagogy model. This is not surprising if we consider natural pedagogy as a guidance that helps the learner to acquire a technique or behaviour in an ambiguous situation. Communicative demonstration helps to learn about the demonstrated action when the infants are cognitively prepared to learn. They rely on the signals selectively, when they need guidance for a task. Natural pedagogy suggests that learning with the guidance of ostensive-communicative and referential cues is significant during any age; however, the subjects are not prepared to learn everything at any age. Communicative cues cannot generate learning when the subjects are cognitively not ready to acquire certain knowledge. Natural pedagogy probably has the highest impact on learning when the recipient of the knowledge transmission is just about to step into the developmental stage where specific knowledge can be exploited.

In this thesis I reveal new and relevant aspects about the natural pedagogy. The results provide deeper insights how this important mechanism of social learning works. This work provides the basis for further future studies to increase and refine our understanding about the importance of ostensive-communicative and referential cues in information transferring situations of dogs and infants.

Acknowledgements

There are many people I owe a great debt of gratitude for all the help and support they provided me through my work. Without them this thesis would have been never completed!

In the first place I would like to thank my supervisors; Ádám Miklósi and Gergely György. Gyuri's encouragement put me on the way of the PhD and his creativity helped me to design my first studies. Ádám's professional comments and advice helped me through my entire doctoral work. His comments and suggestions guided me to get my thesis into the final shape. I am very grateful for all the time and energy he spent on it.

I would like to say a very special thank for József Topál who never refused to help me improving my work despite not being an official supervisor of my PhD work, and who was instrumental during the write up of my papers.

I would like to say thanks to all of my co-authors and colleagues who worked together with me; Andor Csík, Antal Dóka, Kata Egyed, Anna Gergely, Ildikó Király, Kata Krekó, Katalin Oláh, Ernő Téglás, Tímea Vándor. It was a pleasure to work with them.

I thank for Ludwig Hubert to make it possible for me to work in the Clever Dog Lab of University of Vienna, Faculty of Life Sciences.

I also would like to express my gratitude to all the parents, babies, dog owners and dogs who participated enthusiastically in my tests.

Finally I would like to say thanks to my family; my Mum, my Dad and my Sister who always supported me throughout my work and studies. To my two little daughters; Réka and Rosa letting Mami working occasionally and for showing me that child development is not only some mystical phenomenon in the scientific papers but very much real and wonderful.

And last but not least to my husband Clemens for all the support, all the professional and personal help and all the encouragement he provided to me. Thank you for believing in me!

Through my PhD work I was founded by the following projects:

EDICI Project (European Community's Sixth Framework Programme, NEST 012929) and Interpretation of conventional actions and the mechanisms of human cultural knowledge transfer in 3.5 and 5 years of age (**OTKA-76043**, Supervisor: Dr. József Topál).

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Summary

Knowledge transmission between individuals or groups of humans and non-human animals is one of the hottest topics in cognitive ethology and experimental psychology. Human social learning is widely considered to possess unique characteristics. One of these is the presence of ostensive-communicative and referential cues in certain knowledge transferring situations. According to the natural pedagogy theory of Csibra and Gergely (2009) non-verbal communicative and referential cues have a special role to guide imitative learning of infants; these cues arouse increased attention level and evoke long-lasting learning of the new and relevant, moreover generalizable information. In my thesis I test predictions of this theory experimentally and investigate factors or conditions that may influence pedagogical learning in infants. Interestingly, family dogs that share the social environment with humans also proved to be sensitive for these cues. This offers the possibility to compare the reliance and interpretation of communicative cues of dogs and human infants to obtain a deeper understanding of the functions and mechanisms involved. In **Study 1** we demonstrate using eye tracker technique that dogs selectively follow the human gaze after a communicative but not after a non-communicative demonstration of a gaze shift. This behaviour of dogs shows similarities to the behaviour of infants in a similar situation. In **Study 2** we prove that the presence/absence of a demonstrator does not influence 18-month-old infants' imitative behaviour after a communicative demonstration of a tool-use task. However, in a non-communicative situation this imitative tendency disappears at the absence of the demonstrator but not at the presence of her. In the same situation dogs show comparable choice behaviour to infants in the 'communicative / demonstrator present' situation, and they rather followed the demonstrator's solution whereas in the other three conditions they chose the individual emulative solution. I conclude that infants learn from the communicative cues, independently from the presence/absence of the demonstrator whereas copying behaviour of dogs can be interpreted as the execution of a command given by the demonstrator. In **Study 3** we fail to detect evidence in infants, children and adults that they learn about the feature (the generalizable property) of a container that had been communicatively baited with a reward object. However, we found a general tendency among all subject groups to search for the feature rather than the location in a communicative situation. In conclusion, my results give some new evidences for the natural pedagogy theory; however, suggest some factors which might influence the occurrence of learning in a pedagogical situation.

Összefoglaló

Általánosan elfogadott nézet, hogy a humán szociális tanulás egyedi jellegzetességekkel bír. Az egyik ilyen jelleg az osztenzív-kommunikatív és referenciális jegyek jelenléte bizonyos tanulási/tanítási helyzetekben. A természetes pedagógia elmélete szerint (Csibra & Gergely 2009) bizonyos nem verbális kommunikatív és referenciális jegyeknek speciális szerepe van a csecsemők utánzásos tanulásában; fokozott figyelmi állapotot váltanak ki, és az új és releváns, továbbá generalizálható információ hosszú távú tanulását eredményezik. Disszertációmban ennek az elméletnek a hipotéziseit tesztelem, továbbá olyan egyéb tényezőket keresek, melyek valószínűsíthetően befolyásolják a csecsemők pedagógiai helyzetben történő tanulását. Az emberrel egy szociális környezetben élő családi kutya érdekes módon szintén érzékenynek bizonyult ezekre a kommunikatív kulcsokra. Ez lehetőséget biztosít arra, hogy összehasonlítsuk kutyák és csecsemők érzékenységét ezekre a kulcsokra, valamint értelmezésbeli hasonlóságokat és különbségeket keressünk. Ezáltal pontosabb képet kaphatunk a kommunikatív jegyek funkciójáról és hatásmechanizmusáról. Az első tanulmányban 'eye tracker' módszer segítségével bemutatjuk, hogy a kutyák a csecsemőkhöz hasonlóan követik az emberi tekintet irányát egy kommunikatív, de nem egy nem kommunikatív tekintet váltás bemutatója után. A második tanulmányban bebizonyítjuk, hogy a bemutató személy jelenléte/távolléte kommunikatív bemutató helyzetben nem befolyásolja 18 hónapos csecsemők utánzásos tanulását. Egy nem kommunikatív bemutató után azonban az utánzásos viselkedés eltűnik, amikor e bemutató személy nincs jelen a teszt alatt, de megmarad, amikor e személy jelen van. Ugyanebben a kísérletben a kutyák hasonlóan viselkednek a csecsemőkhöz a 'kommunikatív / jelen' helyzetben, ahol ők is inkább a bemutatott megoldást követik. Ellenben más helyzetekben ők inkább az egyéni, emulatív megoldást választják. Ezekből az eredményekből arra következtettem, hogy míg a csecsemők valóban tanulnak a kommunikatív jegyekből (ami független a bemutató személy jelenlététől) a kutyák a kommunikatív bemutatót inkább egyfajta parancsként, viselkedés előírásként értelmezik, ami szorosan a bemutató személyéhez kötődik. A harmadik tanulmányban nem sikerült egyértelműen igazolnunk, hogy csecsemők a természetes pedagógia hipotézise alapján a külalakról (vagyis a generalizálható tulajdonságról) tanulnak a kommunikatív helyzetekben. Összefoglalva, az eredményeim alátámasztják a természetes pedagógia elmélet számos hipotézisét, azonban bemutatnak bizonyos tényezőket, melyek hatással vannak a csecsemők pedagógiai helyzetben történő tanulására.