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CONTENT

1 INTRODUCTION: WHY DOGS?

The idea of robotic social companion is quite old, and various fictions have found their way to the popular media. Sometimes these ideas have been combined even with some form of extra-terrestrial intelligence which was also not the result of a carbon-based biological evolution. Getting in a communicative (and collaborative) contact with other “intelligent” creatures has always excited the public and the scientists. The famous experiments with the language-trained apes were also driven partly by such curiosity: If apes could learn human-like language then they may “tell” us about their (inner) life. Despite all such efforts no such cross-species talk has taken place. The apes did not acquire human-like linguistic skills and no encounter with “other intelligent” beings has taken place.

These goals become somewhat more realistic with the advent of artificial intelligence, and there have been hopes for creating machines with which one could communicate “seriously”. In recent years a special field in robotics has emerged in which researchers aim to build a robot that possesses a range of social skills (Fondon et al 2003). It is hoped that if these robots reach a certain level of sophistication people may regard them as companions. There is however an important problem! There is no scientifically established knowledge about what makes an agent an acceptable companion. One solution to such problems is if one can find a good model for “companionship” on which the robotic design could be based.

Not surprisingly, most models are based on companionship in humans. Although, we have some (at least) implicit understanding about the significance of human companion, it is often difficult to describe it by criteria (see also D2.1). Human-human companionship is also complicated by complex communicative and collaborative interactions, by temporal (short and long) aspects, cross-cultural differences etc. Moreover it is unlikely that socially interactive robots will in short-term reach even a lower level of complexity that is characteristic for human-human companionship. Thus there is a need for an alternative model of companionship.

One of the basic statements of LIREC is that some features of the human-dog companionship may provide important insights for the engineering of a “companion robot”. Indeed, apart from other humans, is most languages there is some phrase which refers to the human-dog relationship as being “special” (Dogs are men’s best friends). According to archaeological data this relationship has a long history, probably over 10,000 years, and thus should not be regarded as “accidental” and “fashionable” but rather as a biologically advantageous “alliance” that may provide benefits for both partners involved.
Research at the Ethology Department has aimed at looking at the behavioural (and cognitive) underpinnings of the human-dog relationship in the last 15 years (Miklósi 2007). We have claimed that dogs provide a very interesting model for understanding social cognitive evolution in biological systems with particular reference for understanding early human cognitive evolution.
Dogs have three basic features, which make the species unique for studying the evolution of complex social behaviour. First, during evolution the behaviour of dogs changed in a way that made them successful in the human social environment. Second, the behaviour of dogs’ ancestor species can be reconstructed from the behaviour of the wolf. Therefore, one can trace the changes that occurred during domestication that led to the emergence of a unique companion species for humans. Third, the natural socialization of dogs in the human environment offers a parallel between them and human children. Thus we suggest that the detailed ethological study of dog behaviour could provide a functionally analogous model to the early evolutionary stages of human socio-cognitive behaviour.
It follows that the study of dogs could provide a insightful animal model for the development of first generations of socially interactive companion robots. In following we will summarize up to date knowledge that has been accumulating on behavioural and cognitive mechanism which make dogs apt for a companion-type relationship with humans.

2 HOW DID DOMESTICATION CHANGE THE BEHAVIOUR OF DOGS

2.1 Domestication as an evolutionary process

Domestication can be viewed as a special case of evolution, where the most important changes of a species’ morphology, behaviour patterns, physiology etc. are governed by human selection. It is important to differentiate between taming and domestication: while the previous happens during an individual animal’s lifetime, the latter is a genetic process, which alters a whole group of animals during many generations of selection. Taming is an epigenetic change, where an animal basically being habituated to the presence of humans, or, sometimes, being imprinted during a sensitive period to humans – both cases result in non-inheritable modification of the behaviour, which will not be given further to the possible offspring of this animal. Domestication on the other hand, happens along such forces of selection, which eliminate particular specimens from the population and favorize others. Obviously, those animals will mostly reproduce, which does not show the disadvantageous features, but express the desired ones.
Domestication is traditionally distinguished from natural selection because it is the human (or ‘artificial’) selection, which shapes the genetic variability of the particular population. In general, there are a well defined ‘set’ of characteristics, which seem to be cardinal in the history of each domesticated species. Most importantly, domestication resulted in a heightened level of tolerance against human presence, or at least an easy way for being tamed in young age. Most probably parallel with this human- and conspecific-directed aggression was selected against also. When the manageable population of genetically ‘tame’ animals was present, domestication could switch to the next gear, which was the species-specific alteration of such features, like productivity, size, coat quality, speed etc.

Selecting for only one, or a very few genetic traits causes a so-called relaxed selection on other features in a population. This process, which is very similar to the genetic drift, or founder effect, could have an important role during the early stages of development of domesticated species, too. A longitudinal investigation on Siberian silver foxes showed that within a relatively short time (5-10 generations) animals, which were selected only for the lack of fear against humans, start to show new anatomical and behavioural features. These characteristics (like hanging ears, curly tail, white patches on the fur, excessive barking and two estrus cycles per year instead of one) can be regarded as a by-product of strict selection for an independent trait, tameness. However, if we regard this experiment as a model of early domestication process, we can hypothesize that selection against individuals, which avoided humans, could boost indirectly variability of other morphological and behavioural features. Of course, we have to keep it in mind that in the nature this process might took much longer time than in the case of the silver fox experiment.
Most of the domesticated animals can be attributed with an obvious reason why humans turned them from game to livestock. This way of traditional thinking (rendering some kind of purpose behind each animal) defined the theories about the origin of the domestication of the dog also for a long time. It was obvious from the archeological records that dogs are almost surely the oldest of the domesticated species, but the approach to this process was still human-centered ("what and why humans did with the wild ancestor of the dog for getting an useful watch-, hunting-, fighting-, herding- etc. animal?"). This could not (and seemingly did not want to) explain neither the early and worldwide appearance of ancient dogs, nor the many unique behavioural traits of canines.

2.2 How long ago were dogs domesticated?

For a long time dating and locating a species' domestication was possible only on the base of archeological records. The two earliest such remains (one from Germany, the other is from the Middle-East), which were clearly showing dog-characteristics, showed that dogs were besides the humans as far as 12-15 thousand years ago. However, the rapid development of mitochondrial DNA analysis made a totally different approach possible. Comparative surveys on dog, wolf and jackal MtDNA solved unambiguously not only the long debate on about the ancestry of the domestic dogs (jackal vs. wolf, where it was proven finally that dogs originated only from wolves), but these studies dated the genetic separation of dogs and wolves surprisingly back in time. Even by the more conservative genetic results estimate that dogs evolved more or less isolated from wolves since 25-30 thousands years ago.
There is an obvious discrepancy between the 'dates of domestication' by archeological and genetic sources. If dogs became genetically isolated from their wild ancestors, the wolves tens of thousands years earlier than they actually started to look like dogs, what happened during this long time? As we explained above, current theories of domestication predict rapid morphological changes, either by direct human selection, or by genetic drift / relaxed selection. In the case of the dog we hypothesize a unique way of domestication, which also can be called 'self-domestication'. To understand, how dogs were formed to our most versatile companions, the comparative and cognitive ethology might hold the answer.

2.3 Dog-wolf differences in behaviour

2.3.1 Unique evolutionary history in the human niche

Some researchers assume that dogs' domestication started with a population of wolves that became able to exploit food resources provided by humans (Coppinger & Coppinger, 2001).

Later humans encouraged these wolves to join them. Subsequent selection for different behaviours and certain preferred appearances concluded with the emergence of dog breeds. It is interesting to note that dogs usually found their way to join human groups despite the variability in human social systems and cultural traditions around the world.
Additionally, it is remarkable that dogs developed close contact with humans some 3,000-5,000 years earlier than any other species. As far as we know, dogs were not domesticated for any direct benefit (e.g., food). As early dog fossils from burials indicate, dogs had a special, probably partly spiritual, relationship with humans from very early on (Morey, 2006).

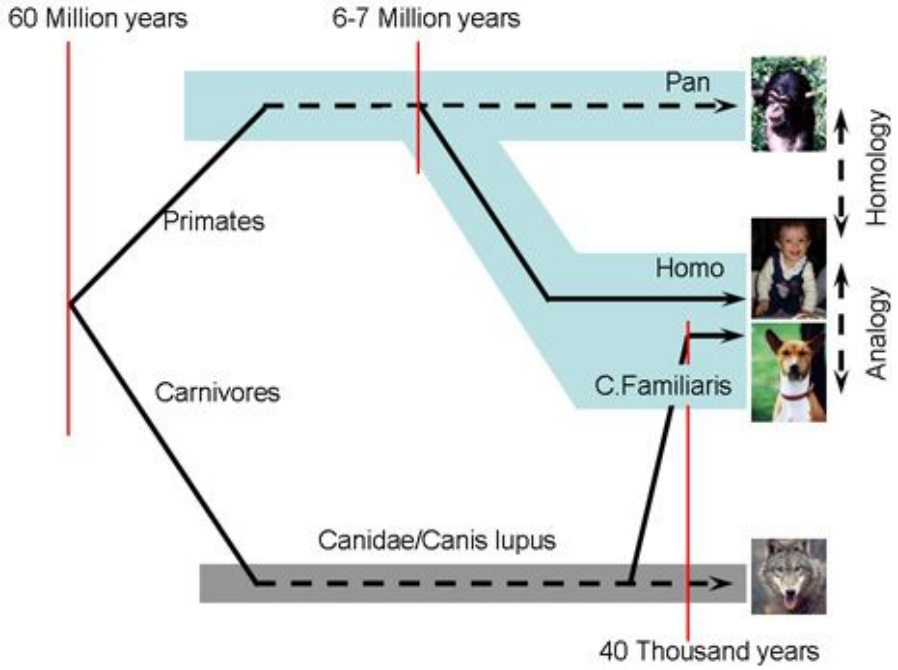

Figure 1. Phylogenetic tree showing the evolutionary interrelationships among species (lines) and their ecological niche (colored areas). Approximately 40,000 years ago, dogs entered the human social environment (from Kubinyi et al 2007)

2.3.2 Behavior of the ancestor

Genetic research identified the wolf as the nearest evolutionary relative of the dog (Vilá et al., 1997). This fact provides a very effective comparative background. The evolution of the wolf resulted in a set of complex social skills which probably contributed to the success of this species. The presence of these behavioural features provided a fortunate situation in which, by changing some aspects of their social behaviour, wolves were able to adapt to the human social niche during an early phase of the modern Homo's evolution. Given that environmental factors and experiences of the individual are comparable, the differences in socio-cognitive behaviour between dogs and wolves should point to those behavioural aspects that were affected during the domestication process.

2.3.3 Naturalistic socialization with humans

Socialization in the human environment can be regarded as a natural process in the dog. In contrast to wolves, whose socialization to humans has to begin before day 10 (eye opening) (Klinghammer & Goodmann, 1987; Frank, Frank, Hasselbach, & Littleton, 1989), the time window for socialization in dogs (Scott & Fuller, 1965), probably closes at around 12 weeks (Freedman, King, & Elliot, 1961). Social attraction to humans develops even after 20-minute encounters twice a week, or daily eye contact with humans (Scott & Fuller, 1965). Moreover,

approach tendencies toward the human cannot be diminished by punishment (electric shocks) of the puppies (Fox & Stelzner 1966) (see also below).
The socialization level of dogs varies among individuals (just as is the case with children), but exposure to the human social environment is a natural consequence of their evolutionary history and not merely an experimental or procedural variable. In addition, dogs' social environments and experiences in many respects correspond to that of children (see below in the "Present niche of dogs" chapter).

2.3.4 Overview on the Wolf-Dog Comparative Data

Raising wolf cubs and dog puppies in an identical way revealed many specific social behavioural differences between the two species, especially with regard to their interactions with humans (for a review see Kubinyi et al., 2007). Even at an early age (3-5 weeks), dogs displayed more communicative signals (e.g., vocalization, tail wagging, gazing at the human's face) and were less aggressive and avoidant than wolves, although the general activity level did not differ between the two species (Gácsi et al., 2005).
Due to human fostering, 5-week-old wolves showed a clear preference for their caregiver in an object preference test, if the other stimulus-object was another human (Gácsi et al., 2005). However, in contrast to dogs, wolves' preferences for the caregiver did not develop into a behavioural pattern that could be categorized as attachment. Hand-reared dogs and pet dogs, but not individually socialized, hand-reared wolves, exhibited highly different responsiveness to their caregiver compared to an unfamiliar human as early as at the age of 16 weeks (Topál, Gácsi, et al., 2005). While wolves did not display characteristic patterns of attachment toward their caregiver, their preference for her remained strong at the age of 1 or 2 years (Virányi et al., 2002).
Many assume that domestication affected dogs' ability to communicate with humans. Wolves, given that their socialization is comparable to that of dogs, were able to follow human cues that have a local enhancement or food-hand association component (e.g., touching, proximal pointing; Miklósi et al., 2003; Virányi et al., 2006a). Recent results for farm-reared foxes not selected or trained at approaching humans (Hare et al., 2005), show that they too were able to follow human proximal pointing and gazing (Hare et al., 2005). In this context it is important to recall that our hand–reared dogs, but not wolves, were able to use more difficult human pointing gestures (e.g., momentary distal pointing) spontaneously and that wolves needed more training to reach the same level of success that dogs reached instantly. The reason for this difference might be that in contrast to dogs it was very difficult to establish gaze-to-gaze contact with the wolves; therefore, wolves were less able to attend to an experimenter's gestures for an extended duration (Miklósi et al., 2003; Gácsi et al., 2005; Virányi et al., 2006a). Dogs are inclined to look at our faces, and this inclination provides them with a broadened opportunity for learning about human gestures. However, socialized adult wolves can utilize human communicative signals. Thus the dog-wolf difference should be interpreted as a developmental change in timing rather than an overall difference in the ability (Gácsi et al., 2009).

3 THE HUMAN-ANALOGUE BEHAVIOUR-COMPLEX IN DOGS

It is almost unlikely that the ancestors of dogs would only undergone a quick selection for tameness, and it would been enough for preparing them to occupy successfully the multiple and complex role of a working companion beside the humans. As we have seen on the base of comparative ethological results, dogs are not merely tame wolves. The key of the canine success lays in the altered socio-cognitive skills, which can be understood maybe the best along the analogy of the Human Behaviour Complex (HBC).

The HBC (Csányi, 2000) is the collection and system of the species-specific features of human behaviour, and it gives also an indirect explanation for human evolution. Many theories exist for creating an evolutionary connection between modern humans and their common ancestor with the great Apes. Most of them concentrate on one or a handful key features (like language, tool making, walking on two legs etc.). Contrary to these, the HBC argues that such an evolutionary process, which led to the emergence of humans, cannot be imagined without the multi-level system of changes. These changes affected mostly the social behaviour and social cognitive capacities of our ancestors, and the result of this evolutionary process is the HBC. This complex has three distinct components; each refers to many behavioural traits: (1) Sociality; (2) Synchronization; and (3) Constructive activity. As earlier we argued that the evolution / domestication of dogs could also happen as a complex transformation of their socio-cognitive skills, we can investigate the existence of these skills using the framework of the HBC. The validity of such an approach is strengthened by the fact that the natural environment for dogs is the human group since several thousands of years, and being a companion of humans, the most adaptive changes would been those which lead to social features matching to the human ones.

Sociality – there is a plenty of commonly known examples of canine loyalty to humans, and it is also a trivial fact that dogs rarely show serious aggression against humans, especially in the owner's family ('sociality to the 'group'). Recent investigations also proved that dogs form strong bonds of attachment to humans, and they maintain this ability in their adulthood, too (Topál et al., 1998).

Synchronization – it is a very important feature of effective groups. Dogs can synchronize their activity with the humans' through rule learning and following (Kubinyi et al., 2003b); various forms of social learning (Kubinyi et al., 2003a; Pongrácz et al., 2001, 2003; Topál et al., 2006). There are experimental evidences that dogs possess ability for modeling human thinking and knowledge ('mind reading' Gácsi et al., 2004; Virányi et al., 2006).

Constructive activity – although the communicative skills of dogs are far beyond humans, they show considerable ability for understanding or utilizing human communicative cues. These can be visual, like pointing (Soproni et al., 2002, Lakatos et al., 2009); or verbal (for example Pongrácz et al., 2001). Additionally to the communicative signals, dogs are very sensitive to the expressions of human intention also (Gácsi et al., 2004; Pongrácz et al., 2004).

3.1 Dogs in the human society

Within no more than 20 thousand years human society became the most complex and most widespread biological system of our planet. While at the end of the Stone Age modern humans represented a basically rare species, with minor geographical variation in their cultures, just within a few thousand years hundreds of different cultures emerged, and humans appeared on each inhabitable continent. A brand new phenomenon, cultural evolution joined to the biological evolutionary processes, and the course of constant cultural changes still accelerates today, seemingly parallel with the human population on Earth.

We have a good reason to say that dogs accompanied the modern Homo sapiens everywhere during his early conquest of the Earth. We do not know about such society, modern or tribal, which would not involve dogs. If we consider the global human presence as one species' domain, we can say that this is the possible most complicated and multi-faced environment to live in and adapt to for another species – the dog. At the same time, on a much narrower scale, even the smallest human group, a village or a family represents a very complex network of social relationships and system of rules for a companion, like the dog. We should mention here that although for us it is natural to base our opinion on our most convenient experiences of our own Western societies, there are markedly different cultures exist and thrive around the world, which may provide more or less different niches for dogs. In the following paragraphs we will discuss the characteristics of dog-human relationship of

the urbanized western world, with a note that by our knowledge the companion status in its broader sense is true for the dogs in all human societies.

3.2 Dogs' role in the human family

The vast majority of dogs in Europe, North-America, Australia, Japan etc. is living as the sole property of a small human unit, the family. The number of stray, feral and community owned (like police, military etc.) dogs can be regarded as only a fragment of the so-called 'family dogs'. Of course there can be strong differences between families regarding the declared and/or actual purpose of having a dog (watchdog, working dog, breeding dog, sports dog, helper dog, companion, pet etc.), but the general status of these animals on the functional level is being the member of the family. The social relationship between humans and dogs can be investigated from at least two points of view: (a) as humans deal with their dogs; and (b) as dogs behave / function among humans.

Humans tend to involve their dogs in almost every aspect of their lives and activities, from the everyday life to the work, from work to social events. This fact in itself suggests that dogs may have a more special role in the human family than being equal with other livestock, or pet species. There are several questionnaire studies, which revealed that dogs represent not 'only' a companion or pet for a considerable proportion of the population, but they regard dogs as family members, with comparable status to a child, for example. What is more interesting perhaps, many humans tend to attribute dogs with higher social and mental skills also, like for example understanding human speech 'quite well' (Pongrácz et al., 2001). Of course, 'mentalization' of dogs is not so surprising, if we take in consideration the above mentioned, humanized status of these animals.

On the other hand, from the dogs' side their role in the human group can be investigated through ethological experiments. As the individual dog's tasks can vary considerably in the given family, the special skills it has been trained for can be very different, too. Therefore ethologists concentrate mostly on the general social abilities of dogs, which may characterize each of them. The most important human-directed skills of dogs are the attachment behaviour, the ability of receiving and sending communicative signals, the rule learning and following, and the ability for understanding and predict human intentions.

4 PRESENT NICHE OF DOGS: DEMOGRAPHIC STUDIES

Dogs are present in almost every human society around the world. In parallel with the history and present organisation of these societies the role of dogs and their involvement in the economy or culture varies tremendously. Although, most people refer to the extreme variation in the appearance of dogs with regard to size and look, and behaviour, this is put only rarely in the perspective of the manifold relationships that exists between man and his dog (Miklósi, 2007).

The percentage of dog-owning households varies across countries. While approximately 40% of households in the Czech Republic and Australia include a dog (Houpt, et al., 2007; Marston & Bennett, 2003), only 14% of Austrian households do so (Kotrschal, Bromundt, & Foger, 2004). In spite of the prevalence of dogs around the globe, little is known about dog-keeping practices.

The reason for living with a dog is a key factor in the human-dog relationship. Companionship is a common reason for acquiring a dog – approximately 80% of a UK sample reported this as the main motivation (Jagoe and Serpell, 1996). This number was 98.2-100% in the Czech Republic (Houpt, et al., 2007). In a random sample from Australia, 52% of owners reported that companionship was the reason for getting the dog, and 74% said companionship was the main benefit of having a dog (Kobelt et al., 2003). Dogs chosen for companionship showed lower rates of competitive aggression than dogs acquired for

protection, breeding or exercise (Jagoe and Serpell, 1996), in contrast Kobelt et al. (2003) did not find such associations. In our questionnaire, the categories for the function of the dogs were not exclusive, so perhaps it is not surprising that 93.3% of the 14,004 respondents marked the 'family member' category as the function of their dogs. This suggests that German-speaking Western European residents' attitudes towards their dogs can be characterized as affection and sympathy, rather than as economic self-interest (Serpell, 2004).
Some data suggest that there is a close similarity between how humans interact with young infants and with dogs (Mitchell, 2001). If questioned, dog owners regard their dog (although with marked variation) not only as a member of the family but they also felt, their relationship with their dog was similar to the relationship they maintained with their own child (Berryman, Howells, & Lloyd-Evans, 1985). Additionally, 6.5% of randomly selected veterinary center clients said they could imagine certain circumstances in which they would give a scarce drug to their pet dog in preference to a person outside the family (Cohen, 2002). Therefore, the comparison of human infants and dogs raise the possibility to investigate how two organisms with very different evolutionary paths behave after having been exposed to a similar social environment (Gomez, 2005).

Previously there were little data on the relationship between the gender of the owner and the dog's personality. Bennett and Rohlf (2007) found that men reported having more disobedient dogs. By comparing the opinions of 2146 men and 8372 women about the behavior of their adult dogs we found that women's dogs were more trainable, more sociable and less bold than men's dogs. However, neither of these findings show whether the difference is in the eyes of the beholder or indeed if interactions between dogs and humans might be influenced by human sex differences.
We have to note here, that women were considerably more frequent in our sample. This could be explained by assuming that women keep dogs more frequently than men, are more willing to fill in questionnaires, or use the Internet more frequently. However, the latter assumption might not be relevant because other authors who did not require their subjects to use the Internet for filling in questionnaires published very similar gender rates (e. g. 85% of respondents were women in Bennett and Rohlf, 2007).
Older participants in Bennett and Rohlf's study (2007) reported that their dogs were more likely to appear anxious. In our sample, people aged between 19-30 years reported having the least calm dogs. The most trainable and sociable dogs could be found in the 31-60 year-old owner-group. However, the boldness scores of 31-60 year-olds' dogs were lower than those of dogs with 19-30 year-old owners.
We did not find previous data in connection with dog-owners' educational history and their dogs' behavior. In our case primary-school educated owners reported having less trainable and less social dogs than others. People with university degrees judged their dogs to be more social dogs in comparison to secondary-school educated owners.
Number of people in the household is another variable that can influence the behavior of dogs but has received little attention so far. In an Australian sample, dogs from larger families were rated as more disobedient and more unfriendly/aggressive (Bennett and Rohlf, 2007). Based on our sample, we can confirm that dogs in larger families were reported being less social toward theirs conspecifics than dogs living in smaller families. In female dogs the number of people was positively correlated with the calmness score: more people around was related to higher calmness. Additionally, a higher number of people in the household was associated with significantly bolder dogs. One possible explanation could be that people in larger families, which usually have one or more children, show less care and devotion towards their dogs. This seems to be supported by the finding that families with infants and children express a low degree of attachment towards their pets (including dogs), and the opposite is true for single or divorced people (Albert and Bulcroft, 1987).
In a similar vein, people living without children are more devoted to their dogs according to Marinelli et al. (2007). Thus, the family size, and potentially, the quality and quantity of interaction between family members and dogs has an influence on the personality traits of

dogs. This suggests that it would be advisable to take this variable into account in future studies.

It is not surprising that owners who spend more time together with their dogs report to have calmer, more trainable, more sociable and less bold individuals. Since more time together generally means that the dog is kept in the house or in a flat rather than in a garden or a kennel, the result suggests that housing conditions probably affect the investigated traits.

Dog owners who engaged in training activities reported that their dogs were less disobedient, less nervous and more friendly towards people and dogs (Jagoe and Serpell, 1996; Kobelt et al., 2003, Bennett and Rohlf, 2007).We found that people who played every day with their dog perceived their pet to be calmer, more trainable and more social than those who played less. Importantly, this could be interpreted in two ways. People may prefer to play with calmer, more sociable dogs, or dogs could become calmer and more sociable as a result of frequent play.

The association between dogs and humans is one of the few cross-cultural features of human societies (Podberscek et al 2000), despite that some traditions or taboos suppress the public expression of human affection. Even in the most “dog-loving” societies a considerable part of the human population does not develop individual social relations with dogs but they cannot really avoid getting in regular contact with them. For some dogs the situation is just the opposite. Although at most places dogs are more or less part of the human society, there are populations which live outside the boundaries of human dominated environment (Miklósi, 2007). In spite of the prevalence of dogs around the globe, little is known about dog-keeping practices and the function of dogs in different societies, because comparative data on dog-human relationships in different cultures, gathered by the same methodology, is limited (Miklósi, 2007).

One example of such a study was presented by Fielding (2008). By using a similar set of questions as Carlisle-Frank and Frank (2006), Fielding was able to compare pet-keeping beliefs and practices in the Bahamas and the United States. He found similar rates of agreement with statements about animal welfare, such as “Animals have feelings with needs/interests of their own” and “Long-term chaining of dogs should not happen.” However, there were large differences in pet-keeping practices and in owners’ relationships with their pets. For example, the percentage of owners reporting that they felt attached to their pets, considered them to be members of the family, and permitted them to live indoors was much higher in the United States than in the Bahamas. Unfortunately, the author did not report whether the differences found between the countries were statistically significant, suggesting that he did not have access to all of the data from the American sample collected by Carlisle-Frank and Frank.

In contrast, Miura, Bradshaw, and Tanida (2002) found significant differences in pet-keeping beliefs and practices across cultures. These researchers asked college students in the United Kingdom and Japan about animal-related experiences in childhood and about their current attitudes towards pets. Compared to the Japanese students, the British students had significantly more childhood experiences with animals and were more likely to have considered a childhood pet to be a friend. In addition, the British students had significantly more positive attitudes about pets than the Japanese students. A similar study focusing on attitudes towards dogs in particular found that British college students were significantly more accepting of the practice of euthanasia than Japanese college students (Miura, Bradshaw, & Tanida, 2000).

In addition, there have been several studies finding possible ethnic differences in pet ownership and pet-related attitudes within the United States (Brown, 2002; Friedmann, Katcher, & Meislich, 1983; Katcher, 1982; Siegel, 1995). These studies reported that white Americans had more experience with pets and were more attached to pets than African Americans.

Despite the large population of domestic dogs around the world, the literature on cultural differences in dog-keeping and dog behaviour remains small. Additional work is clearly needed. To that effect, we surveyed German Shepherd owners in Hungary and the United States about their dog-keeping practices and the behaviour of their dogs (Wan et al.,

submitted). The German Shepherd Dog is a popular breed in both countries and is often used as a working dog (police, guide, search and rescue).
Owners provided information about their dog-keeping practices, as well as reports of their own German Shepherds' behaviour and temperament. Owners from the United States were more likely to keep their dogs indoors during the day and at night, to report that their dogs were kept as pets, and to engage their dogs in a greater number of training varieties (e.g. conformation training, agility training). In addition, American owners reported higher scores than Hungarian owners on the confidence and aggressiveness scales of the Budapest Canine Personality Survey. In contrast, scores on the liveliness and attachment scales of the Budapest Canine Personality Survey, as well as scores on the Dog-ADHD questionnaire, were not predicted by country. In addition, country was not significantly associated with the length of daily human-dog interaction, dog's age at acquisition, and the number of previous dogs owned. Findings for the emotional predisposition questionnaire were similarly mixed. Like much cross-cultural work, these results suggest that there are both differences and similarities between Hungary and the United States in owner reports of dog-keeping practices and dog behaviour. Future cross-cultural studies on dogs should combine the use of surveys with observational methods.

5 ON THE METHODOLOGY OF BEHAVIOURAL STUDIES IN DOGS

5.1 Describing behaviour

One key innovation of ethology was to introduce the method of measuring observable categories of natural behaviour which are based on well-described behavioural units defined by their form. The full description is called an "ethogram" (list of behaviour units with definitions). The ethological method is often referred to as being "objective". This means that (1) the evaluation is based on clear definitions for the directly observable behaviour units, (2) the data collection is done by qualified (trained) personnel (reliability measures are provided), (3) the behavioural data are expressed in quantitative form and usually include some aspect of time. Ethograms are often organised hierarchically by decomposing functional units of behaviour (e.g. feeding, aggression) into subcategories (flight, fight) and action patterns (bite).
Ethologists have argued that the continuous stream of behaviour can be divided into sequential elements (units) which start and end. Thus one can measure (mean) duration, frequency, bouts (distribution of duration of individual unit), intervals (duration between elements of the same type), latency (first time emergence from the start of the observation) (Lehner, 1996).
In principle the behaviour can be described as sequences of elements at any level, e.g. gross body movement, or actions of limbs in relation to each other. The trick is to find the right level of description for a given research question. These units can be non-overlapping e.g. subject either "walks" or is "passive", or overlapping e.g. "walks" and "talks". These aspects should also be stated in advance when developing the ethogram. In order to make the experiment repeatable a detailed description of the element is needed. One disadvantage of this method is that it is relatively insensitive for the dynamics of the behaviour and the aspects of intensity. For example, we can define "walking" but it would be difficult to define "slow walk" and "rapid walk" because the observer does not have the means to differentiate objectively simply by watching a video. (Of course it is possible to do by counting frames etc. but then the work gets very elaborate!)
The best way of coding behaviour is to use some sort of software. Most labs use the "Observer" (Noldus Ltd) but it is very expensive. In any case it is important that we get a quantitative output that shows what action was initialized and finished when. From this the duration and frequency of the behaviour during the test can be calculated.

The application of such coding system is not easy, observers need to be trained and assessed for reliability. In addition there is no generally useful categorisation of behaviour, and often the ethogram has to be re-developed for particular research questions. Despite all of these hurdles, if applied carefully the ethological method provides the richest description of behaviour. Ethologists advise that at the beginning of behavioural analysis one should prefer "splitting" to "lumping". Pilot observations can help to reduce the number of observed behavioural variables, or if this is not an option multivariate statistical methods can offer some simplification by introducing secondary variables. Some ethologically derived ethograms for the dog can be found in, for example, Fox 1970; Schenkel 1967; Feddersen-Pedersen, 2001).

In other experimental systems arbitrary categories of behaviour is used mostly because the behaviour of the dog is canalized by the experimenter. For example, Scott and Fuller (1965) used five categorical variables with 3 demerits to describe the behaviour of the puppy during walking on leash (e.g. “inference with experimenter). Such behavioural categories are often divided into scores, which could either indicate the intensity or presence/absence. The use of such scoring system results often in adding scores of different behavioural categories without any real evidence. When employing a behaviour scoring system it is problematic that researchers often provide only the range of scores and describe the behaviour only for the extremes (e.g. 1 and 7) and do not give definitions for the categories in the middle range (form 2 to 6).

Other methods, which have been derived mainly from personality research, rely on subjective assessment of dog behaviour. In this case the observer rates the behaviour by the means of general descriptors as “fearfulness”, “assertiveness” or “friendliness” etc. which are explained usually by a behavioural definition. Applying this method to dogs Gosling et al (2003) found that observers were accurate and consistent in evaluation individual dogs for various behavioural traits. In other experiments and further studies it have also been shown that the judgement of observers predicts relatively well the future behaviour and also correlates with objective behavioural measures (Vas et al 2005).

This method is based on the well developed social skills of humans to process rapidly complex behavioural cues and evaluate individuals on the basis of high level categories. When used for describing one’s own dog this method also offers the advantage that the evaluator can rely on a very long track record in his memory which is not an option for the observational methods. However, observers can also give similar assessment on dogs “in situ” by observing an unfamiliar animal for a short period. Thus subjective assessment seems to save the painful step of the direct observational method to get from the behavioural units to higher levels of behavioural organisation. However, in contrast to observational categories these descriptors are based on a relative scale because scores can depend on the definition provided, on the experience of the rater, and on the relative behavioural difference between the subjects included in the study.

In summary, this assessment method is useful when one knows the behaviour of the species, and when one needs an overall characterisation of the individual but it cannot replace detailed observational analysis of behaviour.

5.2 Asking about behaviour

The possibility that many dogs share their lives with humans prompted researchers to look for alternative (and cheaper) form of data collection by asking the owners. In general questions target one of four topics: (1) description and characterisation of living conditions (e.g. How often do you walk your dog?), (2) description of behavioural or personality traits (e.g. Is your dog jealous when you pet another dog?), (3) description of the perceived relationship with the dog (e.g. Does your dog mind to be left alone?) and (4) opinions about over certain behavioural traits, abilities (e.g. Could your dogs’ cognitive skills be equated

with that of a 4 year old child?). In addition questions of type 1, 2, and 4 could also be put in general form asking about one's opinion on dogs in general or with regard to special breeds. Before pointing out some problems with this sort of approach one should mention that asking people about their experience and opinions with regard of their companion could be useful for getting ideas. If one has limited possibilities for uncovering problematic issues, getting such input can be very valuable. However, it should be never assumed without testing that owners, handlers or other informant provide reliable and valid information (Taylor and Mills 2007). Thus information collected by questionnaires can turn out to be very useful for formulating hypotheses but this indirect method should not used to replace methods relying on direct observational evidence.

Problems with the sample: Questionnaire studies are based on a very different kind of human populations (readers of a dog magazine, internet users, visitors to vets, university students, any group of dog owners or professionals, e.g. dog handlers, trainers, behaviour counsellors), however only very rarely is it made clear why the particular sample was chosen as reference. Various biases can distort the obtained results in many directions. For example, readers of a particular dog magazine might have a particular attitude to dogs.

Problems with causality: Many questionnaire studies result in some findings suggesting that one environmental factor or variable is in a correlative relationship with behaviour. Although, researchers are aware that such correlations never refer to causal relationship, this might misled less knowledgeable people. For example, finding that aggression correlates negatively (Podperscek and Serpell 1996) with grooming could either mean that people avoid grooming aggressive dogs or dogs are more likely become aggressive if they are not groomed.

Owner biases: The cooperation of owners might depend on their relationship with the dog. A more "satisfied" owner is more likely to respond and might also provide a more positive picture about the pet, and the negative aspects of the relationship are less likely to be reported honestly (e.g. biting dogs).
The comparison of two or more populations of dogs reflects also two or more different populations of owners. Thus any difference in the dogs could be either due to the differences between the dogs, the owners or both. For example, based on owner's answer to a questionnaire, Serpell (2006) reports that "field" Springer spaniels have a better trainability than "show" Springer Spaniels. This is a quite straightforward interpretation of the results but it could be also that owners of "show" Springer spaniels never bothered with training their dog, and/or owners for field dogs are more inclined to report higher levels of trainability just because this is expected from this "bloodline".

Folk knowledge: Very often even researchers rely on general folk knowledge of dog behaviour which led to very confusing results. One such misused concept is that of "intelligence" which was implicated as being different in various breeds (Cohen 1994). Careful reading of the original questionnaire it turns out that by "intelligence" the author means "obedient behaviour at dog school". Even if this was the original intention of the investigators one wonders rightly how easy it would be to train the top ranking Border collie to pull a sledge for 10 km-s (Coppinger and Coppinger 2001). Similarly problematic is the comparison of breeds for trainability on the basis of questions that refer to a particular kind of behavioural response. Thus it is not surprising that Siberian huskies and Bassett hounds scored low on a "trainability" questionnaire which had an item on "fetching objects" (Serpell and Hsu, 2005).
In summary, even if done with care questionnaire studies can only give a first hint about the nature of phenomena or problem but are by no means the solution. In contrast to recent suggestions these methods have actually very little "ethological validity" and have not the potential to replace observational and experimental studies.

6 ETHOLOGICAL ANALYSIS OF INTER-SPECIFIC SOCIAL INTERACTION

6.1 Questionnaires

These tools may be useful in collecting data on the independent variables about the subjects (humans, and dogs) but also to use them as means for describing experimental variables.

There are two main ways of applying this method:
Ad hoc questions:
Especially in new fields of science one has to find out what and how to ask a question in order to get useful information. This is actually more difficult than one might think, and there is a complicated methodology behind this. Thus it is useful, for example, to try out on a pilot sample whether the questions are "good", and also interview people what they think about a given scenario.
Sometimes simple questions will do the job but more often things become very complicated because there are too many questions and one get into statistical problems. For example, one could ask general questions whether people "like" something or not, but in the case of negative results one will not know what the problem was.
Validated questionnaires:
Over the years psychologists have developed many questionnaires that can measure various aspects of human character or interaction with the environment. Most of these published questionnaires are validated, which means, that the result of these studies was more-or-less tested against other known factors.

6.2 Ethological behavioural description ("ethogram")

Various methods have been used to describe the behaviour of dogs. The wide ranging possibilities of describing agonistic behaviour in dogs or wolves are presented as an example (see Table 1.). Note, that the description of the behaviour (even in the form of an ethogram) can take place at different levels of complexity, and depends very much on the question of the researchers. Accordingly, the same behavioural interaction between dogs or humans and dogs could be represented in very different ways. It is also not rare that the same behavioural interaction will be analysed by very different methods, and at very different levels of exactitude. The level of detail could be important if there is a practical application of the knowledge gained. If the human-dog interaction is to be used as a behavioural model for robot design.

Table 1. Different ways of using ethograms for describing aggressive behaviour in wolves of dogs.

Method	Short description	Explanation of the code	Behavioural context used
1. Single discontinuous categorical scale	Scaling along a single dimension of aggressiveness	No aggression (1) – threat display (5)	Personality tests
2. Sum of scores scale	The total score of whether the subject displays an item out of 10 aggressive	Staring = 1 Stiff posture = 1 Bark = 1 ...	Testing for aggression in Golden retrievers

	behaviour elements	Snapping = 1 .... Total score: XX	
3. Three-way categorisation	Each category is characterized by a list of behaviour units	*Fight:* (chase, face off, holding bite etc) *Defensive:* bark, crouch, gape, growl etc) *Flight*: (avert-gaze, avoid, crawl, … etc)	Social interactions in captive wolves
4. Independent two-way categorical scaling	A list of 15 behaviour categories can be used to classify dominant or submissive state	*1. Ears:* Erect and forward (aggressive) or flattened and turned down side (fearful/submissive) *2. Mouth:* opened (aggressive) or closed (fearful/submissive) *3. Neck*: arched (aggressive) or extended (fearful/submissive) …. *15…...*	Not applied
5. Action centred	The "position" of head, ear, tail, leg was used to put seven action (e.g. approach, follow, retreat..) into 3 categories (low, neutral, high)	*E.g.* *Low posture approach*: head low, ears backwards, tail bent low and legs bent. …	Social interaction in captive wolves
6. Pattern coding	The changes at six regions of the face (mouth corner, forehead skin, eye form etc) are categorized independently by using region-specific coding categories	E.g. Forehead skin: (A) smooth (B) wrinkled; ….	Social interaction in captive wolves

6.3 Physiological variables

There is the possibility to take physiological measures from humans (and dogs) during interactions. These methods are non-invasive, and perhaps the measure of heart rate (HR) would be the easiest to do, which could be sensitive enough to react to environmental effects. Because the HR could change in seconds it is important to be able to synchronise the HR measures with the behavioural observation (Maros et al 2008).

7 SOCIAL BEHAVIOUR

7.1 Attention and attention-getting behaviour

7.1.1 Attention getting behaviour in human-dog dyads

The recognition of the other's attention could be very important in the communicative context when the sender of the signal needs to ensure that the receiver is in a position to attend to it. This ability is especially important in the visual modality of communication when the orientation of the receiver is crucial, unlike in the auditory modality where one could assume that in most cases the mere presence of the receiver in the vicinity of the signaller ensures successful transmission. Therefore, when communicating by visual signals the sender either has to wait (passively) until the receiver's visual attention is directed at him/her, or alternatively he/she should modify his/her own behaviour (actively) to become the focus of the other's attention. This could be achieved by producing attention-receiving signals, which direct the other's attention to the signaller or, alternatively, the signaller moves into the actual visual field of the receiver.
Although animals (including humans) probably use both strategies, especially the latter is taken as evidence for the recognition of attention.
The ability of dogs to use behavioural/facial cues in detection of human attention has been investigated in a test series (Gácsi et al. 2004), where we studied the ability of dogs to recognize human attention in different experimental situations. The attentional state of the humans was varied along two variables: (1) facing versus not facing the dog; (2) visible versus non-visible eyes. In the first set of experiments (fetching) the owners were told to take up different body positions (facing or not facing the dog) and to either cover or not cover their eyes with a blindfold. In the second set of experiments (begging) dogs had to choose between two eating humans based on either the visibility of the eyes or direction of the face. Results showed that the efficiency of dogs to discriminate between *attentive* and *inattentive* humans depended on the context of the test (game or task), but they could rely on the orientation of the body, the orientation of the head and the visibility of the eyes. With the exception of the fetching-game situation, they brought the object to the front of the human (even if he/she turned his/her back towards the dog), and preferentially begged from the facing (or seeing) human. There were also indications that dogs were sensitive to the visibility of the eyes because they showed increased hesitative behaviour when approaching a blindfolded owner, and they also preferred to beg from the person with visible eyes. Thus dogs are able to rely on the same set of human facial cues for detection of attention, which form the behavioural basis of understanding attention in humans. Showing the ability of recognizing human attention across different situations dogs proved to be more flexible than chimpanzees investigated in similar circumstances.
Dogs' ability to consider cues of human visual attention during interactions was studied by Virányi et al. (2004). They assessed the dogs' responsiveness to their owner's tape-recorded verbal commands (Down!) while the Instructor (who was the owner of the dog) was facing either the dog or a human partner or none of them, or was visually separated from the dog. Results showed that dogs were more ready to follow the command if the Instructor attended them during instruction compared to situations when the Instructor faced the human partner or was out of sight of the dog. Importantly, dogs showed intermediate performance when the Instructor was orienting into 'empty space' during the re-played verbal commands. This suggests that dogs are able to differentiate the focus of human attention.
This suggests that dogs are evolutionary prepared to learn to use cues of the human's gaze to interpret human action (i.e. intention to reach for an object or communicating with a subject), and they may also used these cues to extrapolate information from human attention. Thus we may well assume that dogs have the ability to understand the communicatory nature of such situations.
Miklósi et al (2003) found that, after undergoing a training to solve a simple manipulation task, dogs that are faced with an insoluble version of the same problem look/gaze at the

human, while socialized the wolves do not. Thus the key difference between the behavior of young dogs and wolves seems to be the dogs' willingness to look at the human's face. Since looking behaviour has an important function in initializing and maintaining communicative interaction in human communication systems, we suppose that by positive feedback processes (both evolutionary and ontogenetically) the readiness of dogs to look at human face has lead to complex forms of dog-human communication. By having flexible looking (gazing) behaviour dogs can also use it for communication of affiliative intent.
Miklósi et al. (2000) also investigated whether dogs engage in functional referential communication with their owners in an experimental analysis of the "showing" behaviour in the dog. *Showing* is defined as a communicative action consisting of both a directional component related to an external target and an attention getting component that directs the attention of the perceiver to the informer or sender. In the experimental situation dogs showed a target object to the naïve owners performing "gaze alternation", that is changing the direction of the gaze from the location of the target to looking at the owner (or vice versa) within 2 seconds. Vocalisations that occurred in this phase were always associated with gazing at the owner or the location of the target (see also the section "visual communication").

7.1.2 Attention getting behaviour in dog-dog dyads

In a recent paper Horowitz et al (2009) reported on research of dog behaviour in a natural setting, which shows sensitivity to the visual attention of their partners when engaged in dyadic rough-and-tumble play. The sequential behaviours and head-direction of both dogs were noted throughout the bouts. The behaviours were differentially used according to the partner's posture. Play signals were sent nearly exclusively to forward-facing conspecifics; attention-getting behaviours were used most often when a playmate was facing away, and before signalling an interest to play. In addition, the mode of attention getter matched the degree of inattentiveness of the playmate: stronger attention-getters were used when a playmate was looking away or distracted, less forceful ones when the partner was facing forward or laterally. In other words, these dogs showed attention to, and acted to manipulate, a feature of other dogs that mediates their ability to respond: which feature in human interaction is called "attention."

7.2 Individual recognition

There are multiple factors that a domestic animal could use to recognize its human handler including face recognition, speech patterns, olfactory signals, and movement style.
The purpose of a study (Lomber & Cornwell, 2005) was to examine if either cats or dogs are able to identify their handler using only face recognition. In a visual discrimination test dogs chose the face of their handler versus an unfamiliar face at 88.2%, while the cats chose their handler only at 54.5%. Therefore, dogs are able to discriminate their handler from another human based solely upon face recognition.

In another study Adachi and colleagues (2009) suspected that dogs might have evolved the ability to form mental images of individual humans. The researchers played a recording of either the owner or a stranger saying the dog's name five times through speakers in the monitor. Finally, the researchers removed the screen to reveal a still image of either the owner's face or the face of a stranger. When the owner's voice preceded the owner's face, dogs looked at the screen for about 6 seconds on average. The same was true when the researchers paired a strange voice with a strange face. But when a stranger's face followed the owner's voice (or vice versa), the dogs spent an extra second or two staring at the monitor, suggesting that they realized something was amiss. (Similar methods have been

used to test face recognition in human infants). It is suggested that the sound of an owner's voice conjures up a mental image of the owner's face, and this leads to confusion when another face appears instead.

7.3 Attachment behaviour in dogs

Although the construct of attachment was first used to explain the affectional bond that develops between a human infant and its caregiver (Bowlby, 1958), this concept has been elaborated for behavioural phenomena that are fundamental in social species and has been approached in a number of ways over the years. Although the operational criteria of attachment have been developed from research on humans and other primates, they can be applied to other species. Attachment presumes (a) the ability to discriminate and respond differentially to the object of attachment (i.e., the secure-base effect), (b) a preference for the attachment figure (e.g., proximity and contact seeking and maintenance of proximity), and (c) a response to separation from and reunion with the attachment figure that is distinct from responses to others (Rajecki et al., 1978).
Presumably as a result of domestication, the pursuit of social contact with humans has genetic bases in dogs (Zimen, 1987). In their study Topal et al. (1998) investigated the human-dog relationship by means of Ainsworth's (1969) Strange Situation Test that was originally worked out for the assessment of mother-infant attachment. As the results show, the experimental conditions of the test proved to be effective in activating the attachment behaviour of owner-dog dyads, despite the fact that dogs were all physiologically adults, and attachment behaviour is usually regarded as a feature of childhood, as a part of parent-offspring interactions. The strange situation behaviour was influenced by different factors, including the dogs' reaction to a separation from the owner (contact seeking, following, proximity seeking), the unfamiliar environment (exploration, stress), and the dogs' responsiveness to the stranger (play, contact seeking). The human-dog relationship was described by means of a factor analysis in a 3-dimensional factor space: Anxiety (in the unfamiliar environment), Acceptance (of an unfamiliar person), and Attachment (to the owner). A cluster analysis revealed 5 substantially different classes of dogs. A dog's relationship to humans proved to be analogous to child-parent attachment behaviour because both the observed behavioural phenomena and the classification are similar to those described in mother-infant interactions.
Although the ability to form attachments is usually associated with an early sensitive period, it was demonstrated that in certain conditions a short responsive interaction with an unfamiliar human individual may result in attachment behaviour even in adult dogs (Gácsi et al. 2001).
Recent results support that dogs have evolved a unique attachment system not present in wolves, which shows convergent features of human attachment behaviour. The attachment system in dogs could serve as the scaffolding on which many forms of complex social behaviour between dogs and humans can develop (Topál et al.,2005).

7.4 Visual and acoustic communication

The biological definition of communication is not easy, because depending on the different approaches, many concurrent theories exist about what can we consider as a communicative act. Among dogs and humans, we stay with a simple and technical description of communication: there are at least two parties involved (the sender and the receiver); the sender shows or emits a signal; and the signal changes the behaviour and/ or the mental state and/ or the knowledge of the receiver. Usually we hypothesize that during communication the sender had the intention to cause some kind of change in the receiver’s above mentioned attributes, which will be somehow advantageous for the sender.

Dogs and humans are both highly social species, with well developed communicative systems. Ethologists are mostly interested in how they solve the problems of inter-specific communication. Although both are mammalian species, dogs and humans have very different anatomy, which can make understanding of each others signals difficult. But perhaps there is an even more interesting question about inter-specific communication: in which extent the two parties can 'understand' the mental representations, the intentions of the other.
The ability for understanding particular signals can be based on genetic predispositions, in this case we expect that humans and dogs will be able to communicate in particular situations without specific a priori training. In other cases dogs or humans learn the meaning of particular signals, and only after some experiences will they be able to react correctly. Although we do not exclude the importance of learned signals in dog-human communication, somewhat bigger emphasis is being put on the intrinsic capacities here, as these can tell more about the common evolutionary past of the two species.

7.4.1 Dog-initiated interspecific communication

One of the main communicational channels of dogs, chemical signals, does not work with humans. Therefore the other two channels, visual and acoustic communication can be regarded as the way how dogs communicate with us.

7.4.1.1 Visual communication

Dogs have a large set of visual signals for affective communication, in other words to express their inner states like aggression, fear, playfulness. As these signals most probably do not differ from the ones dogs use among their conspecifics, their understanding by humans will depend on (a) if humans can decipher the meaning of these signals based on their experiences; or (b) if humans can recognize these signals on the base of some generalized (and therefore inheritable) pattern of aggression, for example. However, from the point of view of cognitive ethologists, the role of other, possibly more intentional signals is more important.
On the functional level, humans become aware the location of something, which the dog wants to obtain, or wants to approach. As it happens by following of the dog's visual signals (usually the turning of the head and/or the body towards the indicated direction), again, on the functional level one can say that the dog "shows the direction to the human". Of course the existence of real intentions would be very difficult to test in dogs, this is why we emphasize the 'functional level', when we talk about 'showing', or 'pointing' behaviour in animals.
There are several papers, which report about pointing in dogs. Miklósi and colleagues (1998, 2000) tested dogs in a situation, where dogs could not reach a desirable treat on a high self, but they had learned earlier that their owners are able to give it to them. If the owner pretended ignorance (read a newspaper), while the treat was placed up to the shelf, dogs started to produce shift alternations between the location of the treat and the owner. Gaze alternation is a typical sign of dogs' 'pointing behaviour', and by the results humans can extract effectively information from it about the actual location of something, which the dog wants to obtain.
Visual signaling behaviour was used also in those experiments, where dogs' ability to understand human knowledge (or the lack of it) in a spatial task was tested (Virányi et al., 2006). In this case the owner obtained a treat with the help of a long stick after the dog had showed to him/her the location of the treat. However, in some cases the stick was relocated by an assistant, before the owner would came in to use it. The dogs always witnessed this relocating event, while the owners did not in one of the experimental groups. Dogs'

behaviour was different in the test phase. Only those dogs started to look eventually towards the new location of the stick, which owners had not seen the relocation earlier. Therefore, the authors concluded that dogs understand to a given extent, if humans do not know something.
There are many experimental evidences that one of the most typical behavioural element of dog-human interactions is the gazing at the human, more correctly is the seeking for and maintaining the eye contact. This is probably an inborn trait of dogs, which evolved during the domestication to serve the purpose of attention getting and communication with humans. To strengthen this theory, maybe the most striking evidence came from the comparative experiments between hand-raised wolves and dogs (Miklósi et al., 2003), where dogs showed eye-contact with the humans from very young age, while the tame wolves did not. From evolutionary aspect, the eye contact as a positive communicational signal is a very important step, because among wild canids, and also among the dogs themselves, staring into the eyes of the opponent is an agonistic signal. However, regarding humans, who communicate mostly referentially, and not emotionally, eye contact and gaze direction has also a different meaning. Dogs might be adapted to the human environment on this way, too.

7.4.1.2 Acoustic communication

The basic meaning of acoustic signals seems to be highly generalized among mammalian species. As Morton (1977) summarized, certain acoustic parameters refer to particular anatomical features of an animal – for example large animals emit deep and harsh sounds, and large animals tend to be the dominant, aggressive ones; the high, clean vocalization of other animals correlate with their young age and small body sizes. These so-called structural-motivational rules result in a highly stereotype manner of acoustic communication, where agonistic intentions are expressed by harsh and deep sounds, and the lack of aggression (like fear, subordinance, etc.) are signaled with tonal and high pitched sounds.
To investigate dog-human acoustic communication, at least two basic questions emerge: (1) Do humans understand the motivational and contextual meaning of dog vocalizations? (2) Does experience count for human understanding of dog vocalizations?
Dogs have a broad set of distinct vocalization types. To find out, if the acoustic signals of dogs have significant relevance for humans, we investigated the most dog-specific vocalization, the bark. Dogs bark more abundantly and in much more contexts, than their wild relatives, the wolf and the coyote, for example (Tembrock, 1976). Therefore it was reasonable to predict, that barking might be that kind of vocalization, which changed the most during domestication.
In a series of experiments, we proved that humans understand well above the chance level the context of dog barks, and they do it independently from their previous experiences with dogs (Pongrácz et al, 2005). Humans can decipher unambiguously the motivational state of dogs on the base of the acoustic parameters of their barks, in accordance the Morton rules (Pongrácz et al., 2006). With a computer based, machine learning approach we also found that dog barking carries individual specific characteristics (Molnár et al., 2008).
As a summary, we can say that acoustic signals may be the most natural way of dog-human communication, where the signal production and the understanding of these signals could evolve mutualistically during domestication of dogs. Just as with the joint attention at visual communication, dogs were not selected systematically for emitting more variable and expressive barks, but the relaxed selection for vocal hypertrophy could create a useful raw material for later diversification of useful signals.

7.4.2 How to describe and measure human-directed communication in dogs?

As we mentioned above, dogs can communicate by visual and acoustic signals with humans. Here we give a list of the most important signal types and also describe, how to measure them.

- Gazing at, staring at somebody: the dog's head points at the human, so the longer axis of the head is between 0-5 degrees of angle with the direction of the human. Gazing lasts usually for several seconds. Eye contact is usually involved, but it is not necessary, because dogs can stare at somebody, who turns his/her back towards them, too. Gazing usually measured in duration (from the onset of the behaviour till the termination of it). Latency until the dog start to gaze can be also important. Sometimes we count occurrence of gazing also, which can be turned later to frequency, too.
- Glancing at somebody: similar to the gazing, but shorter in duration, usually not longer than 1-2 seconds. Again, eye contact (glancing to the human's eyes) can occur, but it is hard to code reliably. Glancing can be the part of gaze alternations. Glancing is usually counted as occurrence, then turned into frequency. Latency until the dog start to glance at the human can be also important
- Gaze alternation: the dog repeatedly looks back and forth between the human and something or somebody else. The minimum number of gaze shifts is three in an unit of gaze alternation; for example the dog looks at a bowl of food, then to the human, and then back to the food. After this, each pair of gaze shifts counts as a new gaze alternation. Importantly, the durations of individual gazings cannot be too long, in the case of gaze alternation usually not longer than 2-3 seconds. Gaze alternation is counted as occurrence and usually turned into frequency, and the latency before the first gaze alternation can be important, too.
- Moving back and forth: similar to gaze alternation, with the exception that the dog moves repeatedly between the human and something or somebody else. Gazing, gaze alternations can occur at the end points of the run. Occurrence and frequency can be counted and calculated.
- Looking back: the dog is engaged in an activity or staring at something, then suddenly stops and looks back to the human. Eye contact occurs usually, and longer bouts of gazing at the human can happen, too. Latency is an important parameter before the first looking back, and also the occurrence and frequency can be collected.
- Barking: we found three parameters as very informative for humans.
    - Interbark interval – the average duration (s) of silence between individual barks. Short interbark intervals convey aggression, slow ones convey lack of aggression (fear, despair), unewen interbark intervals can be the sign of playfulness.
    - Harmonic-to-noise ratio (HNR, tonality) – describes the harshness of the sound. Tonal signals, where the noisy parts are rather irrelevant, convey lack of aggression, mostly fear and despair, partly playfulness also. Atonal signals, with lots of noisy component, convey aggression.
    - Fundamental frequency – describes the frequency (Hz) of the first harmonic component of the sound, which has the strongest intensity. Deep pitched voices convey aggression, high pitched signals convey lack of aggression, also happiness and playfulness.

8 INTER-SPECIFIC COOPERATION

In 1989, Boesch and Boesch introduced four dimensions for analysing co-operation according to the similarity or dissimilarity of actions of individuals, and their orientation and relation in space and time. Congruence in co-operation can be defined as the interactants

performing similar or dissimilar behaviours in their joint action. Synchrony describes whether the two actions are performed in parallel, or sequentially (are non-simultaneous), i.e. the two individuals act at the same time or the action by one individual is followed by an action of the other. Whether the co-operative actions are co-ordinated in space and/or are performed independently is also a useful indicator. By definition, co-ordinated actions might be executed while being in close spatial proximity (i.e. within the individuals range; (homospheric) or when individuals move off from each other (heterospheric). Using these parameters, co-operative actions in various species can be easily classified and compared to each other.
Co-acting individuals should achieve a common goal. We should, however, distinguish whether their action is aimed at their goal directly or whether they act indirectly, for example, by manipulating their social companions.
Strong dominance hierarchy can inhibit the emergence of co-operative actions, and many forms of co-operation can only emerge if there is a flexible dominance hierarchy and/or there is some form of attachment between individuals in the group.

8.1 Inter-specific cooperation between dogs and humans: A potential model for complementer cooperation

Although many still believe that dogs were originally domesticated to assist our ancestors in their hunting ventures, this turned out not to be the case (see Vilá et al., 1997, Coppinger & Coppinger 2002). In the second phase of the domestication, however, many dog breeds were selected – and this way successfully displayed – complex cooperative actions while helping their human companions in herding or hunting. Even nowadays, when they are already not under such selection forces, the performance of these ‘cooperative’ working dog breeds (selected for intense visual contact with the owner) proved to be better in the utilisation of the human distal momentary pointing gesture than those selected for working independently of or visually separated from the owner (Gácsi et al 2009). This difference is assumed not to be attributable to differences in the cognitive abilities of, for example, gundogs versus terriers, per se, but rather reflects a genetic tendency to be more responsive to social stimuli in a cooperative context.
Besides their traditional cooperative tasks, recently dogs proved to be extremely useful partners in brand new areas, such as assisting people who lost their sight or are disabled. In case of the guide dog and owner dyads, at the action-level, both participants need to follow (and copy) the action(s) of the initiator. For example, if seeing an obstacle in their way the dog starts an avoiding action, the blind person has to perform the same action. The failure of following the dog's action would cause the blind person to stumble across the object. Based on this descriptive model, at this level their cooperation can be categorised as being congruent (actions are similar), sequential (one's action is followed by an action of the other) and homospheric (actions are performed in close association). At the program-level, the cooperation consists of a chain of different actions each of which has its most likely (but not exclusive) initiator. For a continuous cooperation to take place both parties must realise who is initiating when, and they must be able to accept a continuous turn in taking the initiations of actions. Here, one might note that since for most actions we could identify a leader of the initiations, at the program-level the concept of complementary cooperation can be invoked.
It is important to realise that in many cases only one member of the dyad has got at his/its disposal the full information that is needed for the successful completion of the task ahead. In other words, the dog does not know about the planned actions of its owner, in contrast, the owner is restricted of the visual information provided by the environment. Interestingly, however, each party seems to be willing to provide and accept the information that is made available by the other. Members of the dyad should be able to adjust their behaviour to the behaviour of the others, i.e. cooperation here is viewed as an ability that allows for fast interchange of situation-dependent leadership. Effective interaction can only take place if at

given actions each party is able either to accept the other's leading role or to take the lead if necessary. Without the mutual ability of shifting the role of the initiator for short intervals this would not be possible.
In order to test this theoretical model, Naderi et al. (2001) investigated the cooperative behaviour between guide dogs and their owners. They supposed that cooperative behaviour is an inherited trait in dogs, and is a major contributing factor in the development of successful guide dog performance. The results supported their hypotheses, as both dogs and humans were found to initiate more often in some types of actions, and the role of the initiator was kept only for short durations. In the case of leading the blind, information was not only be provided but also accepted by both parties in the course of the joint actions, therefore, the leadership (the role of the initiator) indeed varied form one action to the next.

9 INTER-SPECIFIC PLAY

Although complex social play is one of the most striking phenomena of mammalian behavioural development, its adaptive function is still a kind of mystery. Thus Coppinger and Smith (1990) developed theories suggesting that play could have been originated by the need to reorganise the behaviour of the mammalian neonate into the adult pattern. Most researchers however maintain that the costs involved in play indicate some adaptive function, which could be different according to species and ecology. In social mammals with complex behavioural patterns play could facilitate the establishment of behavioural routines, provide physical and/or mental exercise and strengthen individual relations (e.g. Bekoff and Byers 1981).
Specific functional considerations gained some support by finding that in canids the amount of play correlates with the sociality of the species. Jackals and coyotes, which are considered to be less social, play occurs less frequently in contrast to wolves and dogs. In addition in coyotes and to some extent in jackals hierarchical relationships develop before the increased playing activity, which suggest that play has a little role in the establishment of social relationships. In dogs and wolves intensive playing precedes the establishment of social hierarchy, which offers the possibility for the development of social ties independent from the subsequent social relationship.
However there are also differences between the two species. First, although in both species adults do show play, this activity is more pronounced in dogs, and is not only evident in relation to humans but remains a characteristic behaviour in adult dogs. It should be also added that whether dogs or wolves play more “in general” also depends on the breed used for comparison. For example, Bekoff (1974) reported increased play frequency in beagles in comparison to wolves, whilst poodles played less than wolves of the same age (Feddersen-Petersen 1991). Second, there are differences in the pattern of play behaviour both in the type of play routines utilized and also in the use of signalling behaviour used for elicit play. Unfortunately, there is no comparative study but wolves and dogs might differ in “projects” utilized during play (e.g. in wolves: keep-away, tag, wrestling king-of-the mountain; in dogs: chase object, compete for object, object-keep-away, tug-of-war (and more see Mitchell and Thompson 1991)). Beagles incorporated also sexual behaviour patterns (e.g. mounting, clasping) in play sequences which was not observed in wolves. In addition there is some variability in the signals used during play. Fedderson-Petersen (1991) reported that wolves show expressive facial signals, which she defines as “mimic-play” and, which seems to be absent in poodles. In contrast, beagles studied by Bekoff (1974) used a somewhat wider range of signals for initiating play and were also more successful in eliciting a response in the companion than wolves. Both studies also note that dogs often use barking as play signals which was not observed in the case of wolves.
Studying the signalling pattern of play Bekoff (1977) emphasised that some play signals are able to modify the effect (“meaning”) of preceding or subsequent actions (“meta-communication”). Observing playing dogs and wolves Bekoff (1995) noticed that play bows

do not occur at random but are displayed after or before actions (bites) which have the potential to be misinterpreted by the partner.
The fact that dogs play both with humans and conspecifics, offers an interesting possibility to investigate how they decode human behaviour signals. Rooney et al (2001) tested systematically the reaction of dogs to various play signals (play bow, lunge, and both actions presented with inviting verbal utterance). Each signal (which has been derived from a previous study observing large number of dog-human games) was effective to induce play in the dogs. It is interesting to see a parallel that vocalisation on the part of the human had a facilitating effect on play just as it is the case in conspecific dog-interactions. This study also provided support that dogs have the ability to rely on a very diverse set of play signals. This seems to be a manifestation of ontogenetic ritualisation (Tomasello and Call 1996) when a behavioural action becomes a part of a communicative signal set through the habitual interactions of two individuals. This might also explain why some dogs use barking as a play signal. At early stage of play development barking might just be one expressive behaviour resulting form the excited state of the dog. But later, after repeated playful interactions the player might learn mutually to use it as a signal. The possibility of ontogenetic ritualisation makes is also difficult to investigate whether visual (bodily) similarity of the play signal in humans and dogs contributes to its effectiveness.
It is a returning assumption in the literature that “winning” games affect the hierarchical relationship between man and his dog. Apart from the fact that there are no data supporting this idea (Rooney and Bradshaw 2003), it goes also against the logic of play because according to what has been noted above in dogs play signals help to ensure that any harmful action is/should not taken seriously. In addition play is characterized by alternation of roles played, and animals avoid interacting with players that are not willing to engage in role changes. However, it is not rare that some playful interactions turn into serious fights which can affect the relationship. Thus from the perspective of the participants it seems to be more important to keep on signalling playful intent that lessens the negative influence of these interactions on the relationship. However, there might be differences in dog breeds as they might be restricted in their ability to display playing signals.
Unsatisfied with the simplistic description of complex activities during play Mitchell and Thompson (1991) developed novel behavioural models. Accordingly, play partners usually have two tasks to accomplish during any kind of social play. They have a goal to participate in the interaction by utilizing a specific pattern of behaviour (“project”), but they also aim at contributing to a common goal in order to maintain play activity. Interacting dogs might have an individual preference for engaging in certain play projects, which, however, might be or might not be compatible with the actual project played by the partners. Thus the task of the players is both to indicate preferred projects but also to respect indications by the other for other projects. Play interactions can be extended if players initiate (“suggest”) compatible projects (e.g. dog runs, human chases) but they should also be ready to either give up their own project or entice the other in order to engage in its project.
Observations of dog-human play found that both partners performed enticements in the form of refusal to continue participation, self-handicapping but only humans performed truly manipulative actions. Thus it seems that both partners recognize not only the common goal of playing but also that either their own goal should be changed or they have to make the other to change its goal. Mitchell and Thompson (1991) suggested that play activities of dogs might be described in terms of intentions, which include having a goal/intention to engage in a given project and also to recognise similar goals/intention on the part of the partner. In similar vein others argued that playing offers a natural behavioural system in which problems regarding intentionality can be investigated. Whilst in case of agonistic situations it would be disadvantageous to reveal future intentions, collaborative interactions might have selected for ability in representing the other in terms of intentions. Thus playing between dogs and especially playing with humans might increase the skills of the dog to attend the behaviour of the other, and even represent it in terms of intentions.
In recent investigations Rooney at al (2000) compared dog-dog and dog-human object play and found that the same dogs were less competitive and more interactive with humans (in

contrast to playing among themselves). Dogs offered an object more often to humans and also gave up possession of an object sooner. These differences led the authors to argue that dog-dog play is under different behavioural control than dog-human play. As a support for this idea Rooney et al (2000) refer to Biben (1982) who found that social hunters are less competitive during object play. This suggests that the observed difference could be explained by the lack of cooperative hunting among dogs and the possibility of selecting dogs for cooperative hunting with humans. Although this model fails to account for cooperative hunting abilities in wolves but it seems to indicate that dogs use different mental representations for framing play with conspecifics and humans. This is also underlined by the finding that dog-human play might influence the relationship between the partners.

10 PERSONALITY MODELS IN DOGS

Personality is often defined as an individual's distinctive pattern of behavior (besides feeling and thinking) that is consistent across time and situations (e.g. Pervin and John, 1997). Human personality is one of the most frequently investigated fields of psychological researches since decades. It is widely accepted, that individual differences in human personality can be classified into five broad dimensions (Five Factor Model -FFM): Neuroticism, Extraversion, Openness to experience (or Intellect), Agreeableness, and Conscientiousness (John and Srivastava, 1999). FFM is a hierarchical model; each factor summarizes several more specific traits.

Neuroticism contains items like nervousness, jealous, or anxious.

Extraversion contains items like energy, talkative, bold.

Openness (or Intellect) factor consists of items as imaginative, artistic, or uncreative.

Agreeableness is related to items like altruism, kind or warm.

Conscientiousness contains items like systematic or sloppy (Gosling and Bonnenburg, 1998).

Contrary to humans, the importance of animal individual behaviour differences and the animal personality conception was controversial. However, in the last decade several studies provided evidences for the existence of distinctive individual's behaviour pattern in animals, too. As a result, most of the researchers accept, also in case of animals, the concept of personality (Gosling and John, 1999). In these studies the consistent behaviour pattern of individuals often labelled as temperament (e.g. Ruefenacht et al., 2002); behaviour syndrome (Sih et al., 2004); behaviour strategies, coping styles (Janczek et al., 2003) or animal personality (e.g. Gosling, 2001).

10.1 Personality studies in dogs

Personality studies in dogs have become very popular in the last decade. Extensive reviews have also been published recently (e.g. Jones and Gosling, 2005, Diederich and Giffroy, 2006). This indicates that dog personality is a matter of great public concern, and besides theoretical interest, it has a wide range of practical applications, including significant influence on the dog-human bond.

Jones and Gosling (2005) reviewed more than 50 dog personality surveys and identified 7 main personality dimensions which were frequently found in dogs. These are: Reactivity, Fearfulness, Sociability, Responsiveness to training, Aggression, Dominance and Activity.

Reactivity was related to the approach/avoidance of novel objects, raised hackles, and activity in novel situations. This trait was frequently labelled as ‘‘excitability’’ or ‘‘nerve stability”.

Fearfulness was frequently overlapped with Reactivity. For example tendency to avoid novel stimuli are associated also with high levels of Fearfulness. Fearfulness were sometimes labelled as ‘‘Courage’’, ”Self-confidence” or ‘‘Boldness”.

Sociability was indexed by such behaviours as initiating friendly interactions with people or other dogs, this trait was frequently labelled as ‘‘Extraversion’’.
Responsiveness to Training was studied in 34 of the articles reviewed by Jones and Gosling, and was related to such behaviours as working with people, learning quickly in new situations and playfulness. This trait is also labelled as ‘‘Problem solving’’, ‘‘Willingness to work’’ and ‘‘Cooperative’’.
Aggression was related to behaviours such as biting, growling, and snapping at people or other dogs. Aggressive behaviour was sometimes divided into subcategories on the basis of the cause of the aggression or of the target of aggressive behaviour.
Dominance was reflected in such behaviours as refusing to move out of a person’s path, or ‘‘self-right’’.
Activity has often been assessed by the locomotor activity in open-field or open-field-like tests. There is some debate about whether the Dominance and Activity should be considered independent personality traits (Gosling and John, 1999). Nevertheless, both traits are found in numerous studies investigated by Jones and Gosling, which support the relevancy of these personality dimensions in dogs.

So far, dog personality research has focused on (1) developing tools for characterizing behavior (e. g. Sheppard and Mills, 2002; Hsu and Serpell, 2003, Ley et al., 2008), (2) looking at breed (genetic) differences (e.g. Wilsson and Sundgren, 1997; van Oers et al., 2005; Svartberg, 2002; 2006; Strandberg et al., 2005), and (3) studying the effect of development or stability of the behavior characteristics over an extended time. In the latter case, individuals are repeatedly tested in early puppyhood, at a juvenile age (time of sexual maturation) and later in adulthood with the aim of evaluating the predictability of certain early behavioral characteristics (e.g. Wilsson and Sundgren, 1998; Slabbert and Odendaal, 1999).

10.2 Methods in personality studies

Measurement is the foundation on which the field of animal behavior is built. That is, the core empirical task for researchers is to capture how animals behave. Two main methods are used for recording information about the behavior of individual animals: Behavioral coding and subjective ratings (Gosling, 2001). The two methods reflect different resolutions to the supposed trade-off between quantifying behavior in terms of objective acts and using humans to record and collate information more subjectively (Kubinyi et al., 2009, manuscript).
Behavioral-coding approaches, rooted in the tradition of Ethology, aim to capture as faithfully as possible what an animal does on a particular occasion; for example, researchers might count the number of times an animal performs an act (e.g., charges at another), the latency to do something (e.g., time taken to approaching a novel object), or the duration of a behavior (e.g., time spent looking at another animal). Coding approaches are widely thought to be objective because they are not influenced by observer biases. In dog personality studies, breed clubs' character-tests or working field trials provide large sample size and supports the investigation of dogs over a long period of time e.g. in investigating the heritability of the traits (Goddard and Beilharz, 1986; Wilsson and Sundgren, 1997b; Ruefenacht et al., 2002; Strandberg et al., 2005; Saetre et al., 2006). In these studies, because of the standard circumstances and the large number of dogs, the evaluation of behaviour is based on subjective judgement of several observers or judges. Although the judges are mostly well trained and practised, there could be significant differences in their assessments (e.g. Murphy, 1995; Ruefenacht et al., 2002; Lindberg et al., 2004). As the reliability of behaviour tests require inter-observer agreement (Murphy, 1998; Miklósi, 2007), these methods could be also considered as "subjective", and it can measure behaviour only in a few controlled test situations (Svartberg, 2005).

Rating approaches, rooted in the tradition of Psychology, aim to capture what an animal does at a higher level of abstraction than specific behaviors; for example, rather than record the number of times in which an individual engages in specific acts of aggression, raters would use their judgment to rate the general frequency of aggressive acts (e.g., a rating from "rarely" to "often") or to rate an animal's standing on a trait (e.g., a rating from "unaggressive" to "aggressive). Rating approaches, which intrinsically rely on the experience and judgment of observers, are widely considered to be less objective than coding approaches; indeed, they are often referred to as "subjective ratings" (e.g., Stevenson-Hinde & Zunz, 1978). This based on the assumption, that each owner assess or interpret the dogs' behaviour differently. There can be large variance among owners, e.g. in experience level, but it cannot be excluded that some other demographic variables of owners (e.g. age, gender) have an effect on the assessment, too. As a result, ratings are sometimes thought to be an inappropriate method for scientific measurement (Uher et al., 2008; Vazire et al., 2007). However, several researchers argue that aggregated observations of multiple observers are reliable and independent of the peculiarities of individual observers (Block, 1961; Buirski et al., 1978). Many studies argued that owners' rating are reliable information source about dogs' behaviour, and could be useful in ethological surveys (Gosling et al., 2003; Meagher, 2009 in press; Kwan et al., 2008). For intrinsically broad constructs like personality, collating information about animals from experienced observers via broad ratings is very efficient compared to the time-consuming behavior codings.

There are some evidence on the relationships between owners' rating and behaviour observation (Vas et al., 2007; Gosling, 1998; Gosling et al., 2003; Hsu and Serpell, 2003, Svartberg, 2005, Kubinyi et al., 2009, manuscript), however, these correlations are usually relatively weak (0,2-0,3).

The advantages of using questionnaires are numerous. The owners knows the best of his/her dogs' typical everyday behaviour (Gosling et al., 2003; Hsu and Serpell, 2003), thus, we can collect information about the dog's behaviour not only in test situations but from its everyday life as well. Questionnaire-based personality surveys are frequently used in psychology (Gosling and Vazire, 2002), so there are elaborated criteria and judgement procedures. With questionnaires, we are able to survey such characters, that we can't measure with behavioural tests (mostly, the dogs fail to show this behaviour in test situations, e.g. certain types of aggression, Duffy et al., 2008). Additionally, by using questionnaires we can investigate sample sizes that far exceed those obtained with traditional test methods and that is important if we investigate breeds' behaviour in general. Finally, the owner observes the dog's behaviour continuously, so she/he can assess the dog on the basis of many similar situations and conduct a 'mental factor analysis' (Miklósi, 2007). These features makes questionnaire suitable for measuring personality, since, according to the definition of personality, the extracted personality traits should be stable and consistent across time and situations (Pervin and John, 1997; van Erp van der Kooij et al., 2002).

Questionnaires have been developed mainly for investigating behaviour problems of dogs (Hsu and Serpell, 2003; Kobelt et al., 2003), for selecting dogs on special purpose (Wilsson and Sundgren, 1997b; Serpell and Hsu, 2001; Rooney and Bradshaw, 2004, Gazit and Teckel, 2003) or for analyzing one single personality trait (e.g. aggression: Podberscek and Serpell, 1996; Duffy et al., 2008) or for the comprehensive investigation of animal personality (Gosling et al., 2003a; Jones, 2008, Sheppard and Mills, 2002).

But before questionnaires can be adopted in research they must be shown to be reliable and valid.

10.3 Accuracy criteria of the measurement

Reliability can be evaluated a number of ways, including interobserver agreement (judgement of independent observers must be in agreement), internal consistency (judgments about an individual's personality are consistent across items, mostly measured

with Cronbach's alpha coefficient), and and test-restest reliability (stability of the measurement over time). One comprehensive review of animal personality ratings showed that reliabilities were generally strong (Gosling, 2001) but varied considerably across studies. More recent reviews of narrower taxa, such as dogs (Jones & Gosling, 2005) and primates have yielded similar findings.
Surprisingly, the validity of ratings has only rarely been evaluated in the animal-personality literature. Validity shows how well the instrument is measuring what it is meant to be measuring. Validity has two subtypes: internal and external validity (Taylor and Mills, 2006; Meagher, 2009 in press). The former relates to the validity of the measurement, the latter reflects the degree to which results can be generalized across studies. Within internal validity there are three different categories.

Content validity refers to the measurement's scientific relevancy, for example the questionnaire contains only items which are relevant to its aims.

Construct validity investigates the degree to which the measure correlates with others to which it is theoretically related (convergent validity) and the independence from other to which it is not related (discriminant validity).

Criterion validity refers to the predictive ability of the measurement. Both Gosling et al. (2003a) and Meagher (2009, in press) have shown that if the questionnaire fulfils all these criteria, the judgments of dogs were as accurate as judgments of humans.

Personality traits or factors are usually identified from factor analysis or principal component analysis (or other data reduction method) by examining the correlation pattern between narrow behaviour variables (test variables or questionnaire items). The score of the dog on each factor is calculated by statistical software (e.g. Kubinyi et al., 2009 in press), or summarize the score of the loaded items (Svartberg and Forkman, 2002) or calculate the average score from the loaded items (Gosling et al., 2003a).

11 RELEVANCE TO THE PROJECT AND FUTURE PROSPECTS

This deliverable summarized the main features of dogs that contribute to their changes of being accepted as companions by humans. Importantly, most of these biologically relevant behavioural traits provide only the necessary features and do not ensure or determine unconditionally that companionship emerges. Many dogs (as also humans) live without human companions for most of their life, although members of both species retain their ability to develop novel social relationships with other partners.

11.1 On the ethological concept of companionship

The qualitative categorisation of social relationships is problematic both in the ethological and in the psychological literature. The advantage of the animal behavioural approach is that it has to take a functional aspect, and look at the survival value of different types of social relationships. In this case we can rely only on behavioural measures to differentiate among various types of social relationships, however, this is a rather complicated process. Even in the case of chimpanzees, in which very complex social interactions have been described, researchers still debate whether there are different types of social relationships among group mates, and whether some of these could be described as "friendship" (Silk 2002).
It is also clear that there is both a qualitative and quantitative difference among different types of social relationships ranging from incidental social interaction (even if it is regular), through some sort of companionship to a friendship. For this discussion we may describe companionship as step toward a friendship which is based on repeated social interaction between biologically unrelated partners (1) who provide mutual support ("helping"), (2) whose interactions stretches over long time, (3) who does not expect any investment to be

returned immediately (memory), (4) who acquire, maintain and actively update knowledge about each other, (5) who show an increasingly complex tendency in their social interactions. Depending on other inner or external factors companionship may develop into friendship or is terminated.
Naturally, such complex social inter-dependency can only be maintained by an array of behaviourally controlled social interactions. Thus any companion should be able to exhibit skills for communication, including expression of inner ("emotional") states, should have behavioural variability and servitude to subordinate his behaviour to the goals of the partner. It has to be able to show synchronicity both at the level of emotions and behaviour. All these mechanism together ensure that companions are able to engage in beneficial (immediate gain) meaningful (social gain) actions. Note that humans evolved to act collaboratively which is supported by the socially (psychologically) perceived reward of the social interaction. To some extent dogs have also selected in this direction.
This means that companionship does not emerges rapidly ("out of nowhere") but depends crucially on the interaction of the partners, and is very sensitive to both the material aspects (social skills) of the partner as well as the gains (either material or psychological) that emerge as a results. In dogs we have both forms of gains because in many dogs the companionship is dominantly based on an emotional bond whilst in other dogs the material gain (working for the human) plays a similarly important role. Of course these gains are not mutually exclusive and, actually, it is the most beneficial for most partners if material and social (psychological) gains emerge in parallel.

11.2 How to measure companionship in a meaningful way?

11.2.1 Indirect behavioural (psychological) assessments

In the case of LIREC we might think about developing a pool of questionnaires that each partner can use freely. In the long-term we should be able to decide what we want to measure by such means. So far the following needs emerged:
(1) *Companionship*: This concerns aspect of the problem of "companionship", and especially with the aim of comparing different types and forms of companionship. What sort of human traits are to be measured (e.g. "attachment/friendship", "machiavellism", "family networking"; "attitudes to robots") in order to judge the human aspect of "companionship"?
(2) *Personality*: It might be useful to converge on one type of measure personality because there are many models (questionnaires) (e.g. "Big five"; MMPI, TPQ, etc.) that are not interchangeable. At present both human and dogs studies utilize the questionnaires of the "Big five" model.
(3) Subjective anticipatory assessment: In some cases it might be a useful idea to collect data prior to testing about the attitudes of the participants about (1) robots and related topics in general; (2) about the actual experiment. For example, "Do you like programming computers?" "Do you like sci-fi"? "Which is your favourite sci-fi movie character?" or "Have you seen this and this robot?" etc
(4) Subjective post hoc assessment: In other cases the opinion/feeling etc of the human participant is assessed after the experiment or sometimes after each trial within an experiment. For example, Dauenhahn et al (2006) asked questions on "feelings" after the participants had been approached by a robot from various directions. Questions that interrupt the testing could confuse the person, and make the whole experiment less natural. Questions after the whole experiment could be problematic because the subject might have biases in remembering.
(5) Subjective observer: This approach is based on the fact that people are usually good at judging social scenarios by observing them. In this case many judges are asked to watch an experimental scenario (either "live" or on video). Judges should be naive in relation to the

goal (hypothesis) of the experiment. Questions can either ask for some direct behavioural description (e.g. “How active is the human?”), the opinion of the (e.g. “Does the human appear happy in video?”) which should be answered during or after the viewing. This method is used often with dog owners (owners “characterize” their dog), but probably has not been used in H-C/R-I. The advantage of this method over the objective one (below) is that it uses human terms which are often easier to interpret, and it is much less time consuming. However, we do not know in what respect observer biases influence the results, and maybe the results are not very specific.

11.2.2 Direct behavioural observations

We suggest that ethograms should be developed for human/dog and robot for WP-experiments and showcases-scenarios. Such ethograms are relatively easy to construct for humans and robots (based on experience and literature). In the case of robots bit of the ethogram could be found in the manuals (e.g. AIBO, PLEO) but the best is to observe the free running behaviour of the robot (and its interaction with humans) in order to document the actual behavioural units. In the case of robots utilized by LIREC there is also a need to watch free-actions and interactions with people before making up a list of behavioural units for the robot. Crucially, sensor and motor capacities of the robot should be known in advance (just as we know that dogs can see, and have a tail etc.).

11.2.3 Robot data output

If the behaviour of the robot is not totally deterministic and no WoZ is used, then it might be useful to utilize some outputs from the robot. For example, distance travelled, or time spent in eye contact with human etc. could be very interesting. All this will critically depend on the robot used and the scenarios but in principle we could develop a list of such outputs. Ideally, the robot should produce the raw data for its inner “states” continuously which needs to be synchronized with the behavioural measures. The quantification of behavioural and other measures could be done subsequently. Time stamping of data (sensor as well as video data) from various sources is important in order to synchronize the data for later analysis, cross-referencing etc.

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