# Emotional communication between dogs and humans

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2014

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# 1 General introduction

## 1.1 About emotions

Although emotions are commonly studied in psychology, there is still confusion even in the definition of emotion and there are many competing theories regarding e.g. the components, the function or the emergence of emotion. In 1981 Kleinginna and Kleinginna collected 92 definitions from the literature, and even when they classified them on the basis of the emotional phenomena or the theoretical issue they emphasized, they got 11 different categories. This confusion may partly be attributed to the fact that researchers have focused on different components of the emotional reaction such as expression, behavior or physiology. Perhaps the complexity of the phenomenon which the former facts illustrate makes the definition and the modeling of emotion such difficult.

If we look at the word's etymology we see that the term "emotion" dates back to 1579, when it was adapted from the French word émouvoir ("to stir up"). However, synonyms of the word likely date back to the very origins of language (Merriam-Webster, 2004).

Emotions were the subject of reflections of not lesser philosophers than Aristotle, Plato, Descartes, Spinoza or Hume. From the perspective of natural science, and ethology, the most important early impact has to be assigned to Darwin. Due to him emotions became no longer seen as dysfunctional, in the sense as something to reject or control (as some philosophers thought, e.g. Plato or Hume), but instead as something being functional and essential for survival (Kappas, 2002). He stated that signals in humans and animals are reflections of their internal state, and he also put an emphasis on the social and communicative function of emotions (Darwin, 1872).

In psychology, after famous debates whether emotion or the physiological arousal is the first (James-Lange vs. Cannon-Bard theories; James, 1890; Lange, 1885; Cannon, 1929, 1931), or whether emotions are results of a cognitive evaluation of general physiological arousal (e.g. Schacter and Singer, 1962) or they have distinctive autonomic patterns (e.g. Alexander, 1950), today a more or less general consensus is formed that emotion is a complex phenomenon (an umbrella concept) consisting of more components: expressive behavior, cognition, autonomic nervous system activity and subjective experience (e.g. Scherer, 1984; Panskepp, 2005; Plutchik, 2001).

## 1.2 A suitable definition

We chose Izard's definition of emotion because it emphasizes many aspects of emotions that we will discuss in the following sections. Firstly, it mirrors the functional-evolutionary approach of emotion, secondly, it could be applied to animals and humans as well, and finally, it emphasizes the complexity of the phenomenon (different components): „emotions are specific neuropsychological phenomena, shaped by natural selection, that organize and motivate physiological, cognitive, and action patterns that facilitate adaptive responses to the vast array of demands and opportunities in the environment" (Izard, 1992, p561).

## 1.3 Conceptualization of emotional states

It is debated whether an emotion is a position in a continuum or whether emotions are distinct states. According to the followers of the first idea, emotions are not discrete phenomena, but they can be located in an abstract space constituted by two or more dimensions. This implies that the differences among emotions are not qualitative but quantitative. For example, some authors think that one scale is the arousal or the strength of the emotion, whereas the other represents the valence of the emotion (e.g. Russel, 1980; Rolls, 2000). Emotions occupy a position on that 2-dimensional space, e.g. fear is characterized with high arousal and highly negative valence.

Other scientists claim that emotions are separated states with distinctive behavioral and physiological correlates. They support the existence of a small number of basic or primary emotions. According to the most accepted theory of Ekman (1992) these are fear, happiness, sadness, disgust, surprise and anger; but there are some other approaches, e.g. the one of Plutchik (2001) who supposed two additional primary emotions: trust and anticipation. Primary emotions are characterized with distinctive universal signals, distinctive physiology, special antecedent events, quick onset and brief duration, distinctive cognitive processes and unique subjective experience (Ekman, 1999, Izard, 1992). They are supposed to have evolved in the past to cope with fundamental life tasks (Ekman, 1999, Plutchik, 2001). They are assumed to have innate neural substrates (Izard, 1992), hence they have a primacy in development (Izard & Malatesta, 1987).

Complex or secondary emotions (such as jealousy or guilt) are believed to be a mixture of primary ones (Plutchik, 2001) or to arise from higher cognitive processes (Lewis and

Michalson, 1983; Becker-Asano and Wachsmuth, 2008), and in most cases to contain a self-conscious or self-evaluative element (Morris et al., 2008). They are generally presumed to have a relatively lately onset in development (Lewis et al., 1989) which is explained by the required cognitive skills and that they are based largely on learning and socialization (Kemper, 1987).

## 1.4 Emotions in humans and animals

Although since Aristotle (384 BC – 322 BC) emotions played a key role in human thinking about animal behavior, and Darwin (1872) also stated that the behavioral displays of non-human animals are mapped into emotions, in the decades of behaviorism it became unacceptable to study or even to assign emotions to animals. The second major behavioral school—European ethology—similarly abandoned anything considered as sentimental and imprecise as the emotions in a reaction against the subjective "animal psychology" of the time (Burkhardt, 1997). Even the Oxford Companion to Animal Behavior from 1987 urges ethologists to avoid references to emotions, because "It does nothing to promote our understanding of behavior to attribute it to an emotion if our only evidence of the emotion is the very behavior the emotion is supposed to explain" (McFarland, 1987). Even today, there is still no clear consensus about the appropriateness of attributing emotions to animals (Hauser, 2000). The functionalist approach of ethology consider emotions as irrelevant, it prefers functional labels which are devoid of intentionality (deWaal, 2011). Researchers of animal behavior still often avoid the usage of the term 'emotion' with respect to animals because direct evidence is lacking (but see Bekoff, 2000; Panksepp, 1994; Plutchik, 2001). However, outright denial of the existence of emotions in animals is rare, and this „leaves us with the curious situation that a widely recognized aspect of animal behavior is deliberately ignored or minimized" (deWaal, 2011, p191).

Neuroscience is the discipline that can dispel skepticism about animal emotions as the argument from homology in the brain is immensely powerful (deWaal, 2011). Today extensive research, among others on neural circuits in the brain has shown that for example the limbic system concerned with the experience and expression of emotions exists also in animals (LeDoux, 1994). As a consequence, our understanding of the neural substrates and mechanisms of emotions has increased and research (mainly) in affective neuroscience has been growing. Animal welfare is another discipline which is interested in animal emotion,

however, most research is still restricted to negative emotions, such as fear, stress or pain (Boissy et al., 2007).

As basic or primary emotions are viewed as biologically based states that have an evolutionary history (they contributed to survival in the past), the attribution of basic emotion to animals is more supported among scientist (e.g. Ekman, 1992; Izard, 1992; Plutchik, 2001). Complex or secondary emotions are less frequently attributed to non-human animals as they are thought to require a degree of self-awareness, self-consciousness, or a cognitive complexity not proven to exist in any non-human animal (Drewett, 1983). Although extensive anecdotic data is available on secondary emotions in many species (Masson & McCarthy, 1996), few empirical studies have been carried out in the topic. For example, the existence of secondary emotions in animals has got some experimental support in the following studies: jealousy in titi monkeys (*Callicebus moloch*) (Cubicciotti & Mason, 1978); jealousy in dogs (*Canis familiaris*) (Harris & Prouvost, 2014); or empathy in chimpanzees (*Pan troglodytes*) (Parr, 2001) and in mice (*Mus sp.*) (Langford et al., 2006). However, it was also demonstrated that the attribution of secondary emotions to animals can be sometimes false (guilt in dogs (*Canis familiaris*) (Horowitz, 2009, see also Hecht et al., 2012)).

## 1.5 Arguments on the continuity between human and animal emotions

To review the evidence which support the evolutionary continuity between human and animal emotion, we can consider the components of emotion one after other and look whether the given component may exist in animals or not. There is a general agreement that the main components of emotions are the following: (1) expressive behavior, (2) autonomic nervous system activity, (3) cognitive evaluation/appraisal and (4) subjective experience (e.g. Scherer, 1984; Panskepp, 2005; Plutchik, 2001). In the following I will briefly review what support the existence of these components in animals:

(1) Darwin was the first to describe in detail similarity in emotional expressive behaviors in humans and in non-human animals. He suggested that the principle of antithesis -which states that opposing internal (emotional) states are likely to manifest in opposite physical forms- is true for both humans and non-humans (vertebrates). For example, while dominant or aggressive animals usually attempt to make themselves appear larger, submissive or fearful animals act the opposite way, by generally trying to make themselves look smaller (Darwin,

1872). He also described other similarities e.g. in expressions of humans and primates. For example, human smile and laugh have homologies in primate species (Darwin, 1872) with similar forms and more or less overlapping functions (van Hooff, 1972).
Morton (1977) argued that the auditory signals of different species across mammals (including humans) and birds show some parallel features. Low frequency vocalizations indicate threat, aggression or confidence, whereas high frequency vocalizations relate to submission or fear. This so called structural-motivational rule can be explained by adaptive processes because due to physical laws of acoustics large (and potentially more threatening) body produces low frequency sounds.

(2) Emotional behavior in humans and animals is accompanied by a range of changes in the autonomic nervous system (hormones, cardiovascular phenomena such as heart rate or blood pressure). If a (functionally similar) stimulus induces a similar behavioral reaction in an animal species and in humans, and the accompanying autonomic nervous system activity is also similar, we have stronger evidence that the respective emotion may also exist in the animal. In accordance with this, behavioral reactions to stressors were found to be paralleled by an increase in the corticosteroid hormone level and heart rate in humans (Epel et al., 2001; Esse et al., 2002), pigs (e.g. White et al., 1995) or dogs (e.g. Beerda et al., 2000). Similarly, affiliative behavior was found to be associated with increased oxytocin level in humans (e.g. Guastella et al., 2008), dogs (e.g. Mitsui et al., 2011), rats (Pedersen and Prange, 1979; Witt et al., 1992) or rhesus monkeys (Winslow et al., 2003).

(3) Cognition is involved in the emergence of emotions as the process of appraisal (Schachter & Singer, 1962). This often rapid and automatic evaluation process (which may nevertheless involve reference to memories) is known to exist in animals. For example, the conditional fear reaction (characteristic for all vertebrates, see LeDoux, 1994) suggests that learning can modify or trigger emotions in animals. For example, Moe et al. (2006) found that the anticipation of different (positive versus negative) rewards caused different emotional expression in silver foxes (*Vulpes vulpes)*. (Emotions can also influence cognitive processes: they can cause different cognitive biases, that is, biases in the interpretation of ambiguous stimuli. This phenomenon is also demonstrated in animals (for review, see Mendl et al., 2009).)

(4) Emotional experience/ subjective experience (or ‘feeling’ which William James considered to be the essence of emotion; James, 1916) is the most debated component of

emotion in animals. It is generally supposed that humans can access their feelings directly (experiential knowledge) so self-reports are usually used in psychology to measure emotional experience (e.g. Robinson and Clore, 2002). As animals are not able to provide self-reports on their emotional feelings as humans, the existence of emotional experience in animals can probably never be proved. In addition, one may argue that animals do not have the linguistic–symbolic cognitive skills to have conscious experiences. However, Panskepp (2005) indicates that lower levels of consciousness do not require expansive neocortical tissues and sophisticated cognitive skills: primary-process consciousness may reflect raw sensory/perceptual feelings and internal emotional experiences, so "primary process affective consciousness" is „shared homologously by all mammalian species" (Panskepp, 2005). In addition, neurological data on brain activity accompanying certain affective experiences suggest that there may be similarities between human and animal experience of emotions (for a review, see Panksepp, 2005). Panskepp argues that, for instance, if the (chemical or electrical) stimulation of certain brain areas increases or reduces e.g. playfulness or separation distress vocalizations in animals (e.g. Burgdorf and Knutson, 2001; Knutson et al., 2002), and the stimulation of the same brain regions (e.g. with drugs, e.g. Drevets et al., 2001) would elicit the predicted increases or decreases in feelings of e.g. joy or sadness/fear in humans, our hypothesis concerning the existence of affective experience in the animal would be supported. Similarly, animals seek for the (chemical or electrical) activation of those brain areas the activation of which is also rewarding for humans (Panksepp, 2005).

## 1.6 Function of (both human and animal) emotions

Today, many researchers agree that emotions have adaptive values in terms of survival. As Cabanac (1992) argued, 'pleasant is useful' and guides human and non-human animals to perform behavior that serves to enhance their fitness (Cabanac, 1992). Panksepp (1994) suggested that emotions have evolved in animals from mechanisms that play a role in avoiding harm/punishment or seeking valuable resources/reward (see also Boissy et al., 2007). For example, fear activates behaviors that protects the animal from threats and maximize safety and security (Bowlby, 1973; Balcombe, 2009). Positive emotions or positive affective motivational states are functional in that they direct behavior towards for example eating, mating, playing and exploring (Balcombe, 2009). Sadness elicits empathic and

altruistic behavior from others (Barnett et al., 1979), helps to conserve resources (Beck, 1996) and inhibits actions that would be dangerous (Nesse, 2000). Disgust motivates avoidance of contamination (Rozin & Fallen, 1987); anger serves to destroy obstacles (Plutchik, 2001) or to defend resources (Frijda, 1986). Affiliative emotions (e.g. stress in separation from important others, and joy at reunion with them) serve to maintain social bonds (Rolls, 2000) or- in case of offspring- to protect against predators and maintain the supply of resources for offspring (Bowlby, 1973).

Plutchik (2001) stated that the function of emotion is to reserve the homeostatic equilibrium state of the organism. Although emotions may have different forms of expressions in different species, Plutchik argued that there are common elements, or prototype patterns that exist in all evolutionary level. In Table 1 these prototype patterns (prototypical stimulus events, cognitive appraisals, subjective and behavioral reactions, and functions of the emotions) are presented regarding the eight primary emotions Plutchik postulated.

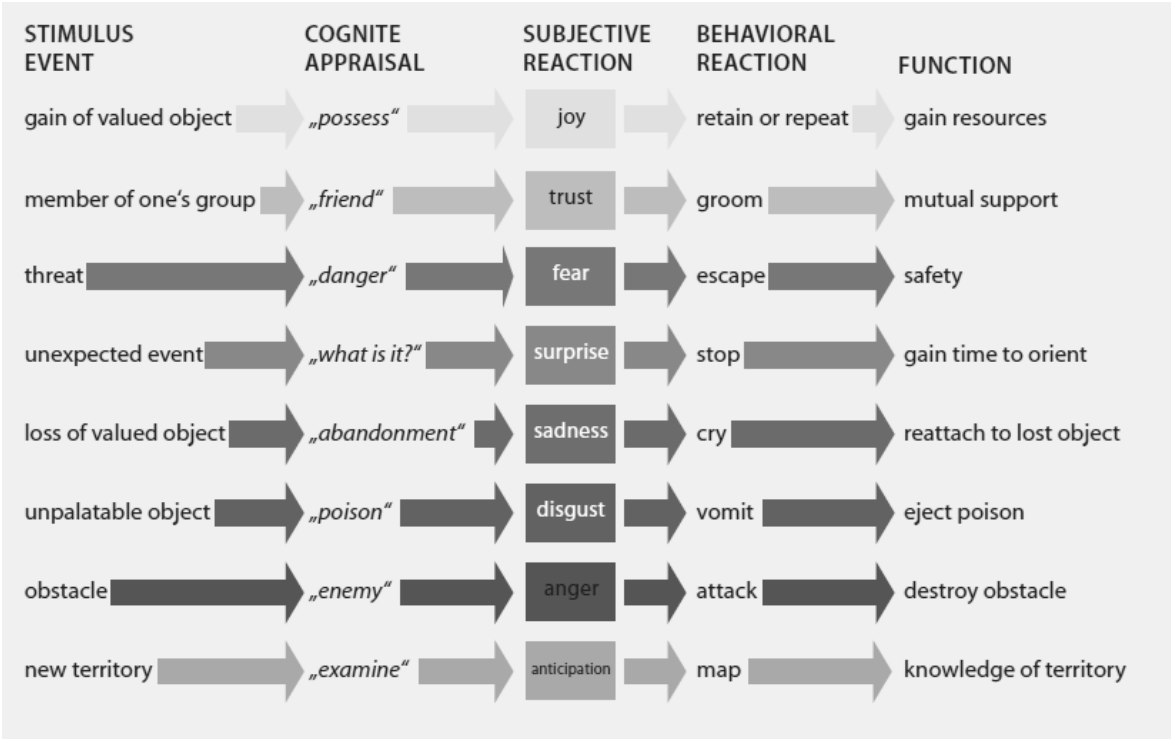


Table 1. Prototype patterns of emotions regarding the eight primary emotions postulated by Plutchik (2001). The illustration is based on the Book „EMOTION: A Psychoevolutionary Synthesis“ by Robert Plutchik; Harper & Row, Publishers (1980) Visualization by Markus Drews, University of Applied Sciences Potsdam, Germany, February 2007. Retrieved from http://www.adliterate.com/archives/Plutchik.emotion.theorie.POSTER.pdf

Others argue that the main function of emotion is that they lead to a more flexible way of reacting. In contrast to mechanisms that trigger inflexible behavior patterns in response to certain types of stimuli, emotions induce action tendencies (Frijda, Kuipers, & ter Schure, 1989) rather than rigid actions. In this way they make a more flexible adjustment to the environment possible. Emotions allow flexibility both in the response and in the event interpretation (Ellsworth & Scherer, 2003).
Additionally, emotions enhance memory: there is considerable evidence that events which induce positive or negative emotions are more easily remembered than those which are emotionally neutral (Paul et al., 2005). This emotional memory enhancing effect is most likely adaptive because emotionally arousing stimuli, both positive (e.g. sexual, food related) and negative (e.g. predation threat) are more likely to contribute to survival and reproduction, than emotionally neutral stimuli (Paul et al., 2005).

Emotions are also functional in communication and management of social relationships. Communication is a process when the sender changes the behavior (and the inner state) of the receiver by means of specific behavior patterns ('signals') in a way, which is adaptive at least for the sender (or for both parties) (Endler, 1993; Krebs and Davis, 2009). Signals can refer to the environment (referential communication), to the inner state (emotional communication) of the sender, or both of them (Seyfarth and Cheney, 1990). In each case information is considered as 'predictive information', meaning that it can be used to predict something else (Piccinini and Scarantino, 2011). In some cases the communication of emotion can be advantageous because it predicts the future behavior of the sender and in this way alters the behavior of the receiver. For example, the signals of aggression (the communication of „anger") predict the future attack of the signaler and in this way alter the receiver's behavior (e.g. emitting submissive signals), with which both parties can avoid fights, so the communicative interaction is advantageous for both of them. In other cases, however, it is advantageous for the sender to hide or fake one's emotions or future behavior. It is argued that in evolution both the signalers and the receivers are engaged in an armament race in which they act in their own interests while communicating, in order to maximize their fitness benefits. While signalers intend to elicit a response in the receiver that is advantageous to themselves ('manipulators'), receivers are selected to effectively assess and evaluate these signals, to their own advantage ('mind-readers') (Krebs and Dawkins, 1984). In this sense, communication (also of emotion) is an information-based form of influencing other's behavior (Stegmann, 2013). It was demonstrated that emotional communication is often

intentional (not automatic) and used for manipulating others even by the faking of emotional signals (Seyfarth and Cheney, 1990).

## 1.7 How can we study animal emotion?

In psychology, emotions are often investigated through the subjects' verbal reports. In animal research we have to rely on other measures. First of all, we can make predictions about various emotions by observing animal behavior. Approaching or showing preference for an object may indicate some sort of positive emotion, whereas avoidance responses may reflect a negative emotion such as fear (Kittilsen, 2003).

In addition, with presenting stimuli of a certain character we can induce a specific emotional state in animals. For example, fear is thought to be elicited by sudden, unpleasant, unfamiliar and unpredictable stimuli (Desire et al. 2002). By presenting stimuli with such characteristics and observe behavior we can gain knowledge of the animal's particular emotional state.

Physiological parameters such as increased heart rate, elevated blood pressure and the release of adrenalin or cortisol are also often used as indicators of some emotions (e.g. Desire et al., 2004; White et al., 1995). Additionally, the development of affective neuroscience and neuroimaging devices gives us an opportunity to observe also brain activities after presenting certain emotion-inducing stimuli to the animal. Panskepp (2004, 2005) argued that if a similar stimulus induces a similar behavioral, physiological and neurological response in non-human animals and in humans, we can assume that similar mechanisms play role in both of them. For example, if humans report high anxiety while showing amygdala activation and rats exhibit flight and freezing responses when their amygdala is electrically stimulated, it is hard to avoid the conclusion that we are dealing with one and the same state, that is, fear (Davis, 1992).

However, if we have no opportunity to measure brain activity and physiological responses, the behavioral indices alone with the proper selection of the stimulus and the functional analysis of the behavior give also strong support for the existence of the specific emotion. For example, jealousy is supposed to serve a function of protecting social bonds from interlopers, so a prediction is plausible that jealousy should exist in non-human social species in which emotional bonds between individuals develop and can be threatened by third parties (Harris and Prouvost, 2014). If we present the appropriate social stimulus (a situation when an

attachment figure shows affection to a potential interloper) for an animal, we could observe whether it would engage in behaviors which in humans are indicative of jealousy (e.g. attention-seeking behavior, aggression toward the interloper, getting between the partner and the interloper to prevent or break up the "liaison"). If it does so, we can conclude that the animal experiences (at least a primordial form of) jealousy. With this logic Harris and Prouvost (2014) gave strong evidence for the presence of a primordial form of jealousy in dogs *(Canis familiaris)* in connection with their owners (who are the primary attachment figures for them, Topál et al., 1998; Prato-Previde et al., 2003). Similarly, jealous behavior was found in titi monkeys (*Callicebus moloch*) (Cubicciotti & Mason, 1978) by presenting a stranger of the subjects' sex in proximity to its mate.

Besides the behavioral studies, an alternative method of studying animal emotion is to rely on systematized collection of reports of humans who have direct access to animals. This is especially true for people who share their life with domestic animals, especially pets. Questionnaires have been frequently used in human psychology, for example in personality studies, where people often have to give reports about others (family members, friends, or children) (e.g. Cohen et al., 1977) similarly to the case when owners have to describe their pets (e.g. Kubinyi et al., 2009). Questionnaire studies have the advantage of gaining large amount of data, they are less invasive and they save money and time. One can assume that the usage of human reports on animal emotions has the risk that such insights are influenced by anthropomorphism. The problem of anthropomorphism has been debated for long and arguments both in favor and against it have been put forward (e.g. Wynne, 2007). We support a balanced view, that is, (critical) anthropomorphism (Burghardt, 1991) can provide useful hypotheses for looking at animal behavior and these types of studies represent only the first step in this direction, which should be followed by more experiment-oriented approaches. According to Bekoff (2000), a combination of "hard" and "soft" interdisciplinary research is necessary to advance the study of animal emotions, which is still in its infancy. He says that scientists should pay closer attention to anecdotes along with empirical data and philosophical arguments as heuristics for future research. Panksepp (1998) also claims that all points of view must be tolerated as long as they lead to new approaches that expand human understanding of animal emotions.

In line with this, Morris et al. (2008) carried out a questionnaire study to collect data on emotional behavior in various animals via owners report. In their first study they asked

owners of dogs, cats, horses, rodents and birds, whether their pets have ever experienced certain emotions. Their questionnaire listed 10 primary emotions (anger, fear, surprise, joy/happiness, sadness, anxiety, disgust, interest, love/affection, and curiosity; based on Ortony & Turner, 1990; cited in Morris et al., 2008) and 7 secondary emotions (empathy, shame, pride, grief, guilt, jealousy, and embarrassment; based on Lewis, 2002; Tangney & Fischer, 1995; cited in Morris et al., 2008). The results showed that owners attributed emotions to their pets with high frequency (including many secondary emotions).

## 1.8 The domestic dog (*Canis familiaris*) as a subject of scientific investigation

Recently, scientists started to recognize that dogs are examinable and interesting subjects in behavior studies (Miklósi and Topál, 2013). Dogs' adaptation to the human environment caused a convergent evolutionary process, resulting in analogue behaviors of dogs and humans. Because of this dogs can be used as a model species of human evolution (Miklósi, 2007, Miklósi and Topál 2013).

Furthermore, we have an extraordinary chance to conduct comparative research with a species and its ancestor, namely dog and the wolf. In this way we may observe homologies in their social life and gain knowledge about the effect of domestication on dogs' behavior (Miklósi, 2007).

Dogs are also practical subjects because it is easy to access them (they live in our households) and they are one of the most common domesticated pet animals (along with cat, see surveys, e.g. American Pet Products Association, 2011). As our human environment is their natural niche (Miklósi et al., 2004; 2007; Topál et al., 2009), we can carry out not only laboratory experiments, but those conducted in natural habitats, without the usual difficulties of field studies.

However, in the past decades dogs received relatively little attention from ethologists or comparative psychologists in contrast to other species, for example honeybees or chimpanzees (Miklósi, 2007). This can be due to several facts. Firstly, dogs are often considered as 'artificial animals' because of the goal-directed selective breeding they have gone through during the process of domestication (which indeed started much later than has been assumed) (Miklósi, 2007). Secondly, the study of dogs has not fit in well in the stream of

behavior ecology emphasizing functional analysis of behavior and studying survival issues (e.g. Tinbergen, 1963). Indeed, dogs are special as they are not faced with survival challenges in the nature in the same way as other animals do but this does not mean that they are artificial (Miklósi, 2007). Finally, tricks of „dog artists" led some earlier workers to attribute higher cognitive skills (e.g. counting) to dogs which later revealed to be result of „Clever-Hans effect" (the animals responding the human instructors' bodily cues) (e.g. Pfungst 1912, Grzimek 1941) and because of this, dogs have been considered as suspicious or unreliable subject of scientific investigation. Fortunately, recent research on dogs' behavior seems to dispel these doubts.

## 1.9 Emotions of the domestic dog

In his book "*The expression of emotion in man and animals"* (1872) Darwin gave several descriptions about the emotional behavior of the domestic dog. He speaks for example about the expressions of "love and humility" in the dog when "with drooping ears, hanging lips, flexuous body, and wagging tail, he meets his beloved master" (p10). Darwin illustrated his principle of antithesis (see in earlier section) with drawings (Figure 1) and detailed behavioral descriptions about how dogs behave in two opposite state of mind: "one in a hostile and the other in a humble and caressing frame of mind" (p19), or one in "pleasure" and the other in "dejection" (p36). He writes, for example, that when a dog approaches a strange dog or a man in a hostile frame of mind, it "walks upright and very stiffly; his head is slightly raised, (…) the tail is held erect (…); the hairs bristle (…); the pricked ears are directed forwards". If the dog suddenly discovers that the man he is approaching, is not a stranger, but his master; his whole bearing is completely and instantaneously reversed: "instead of walking upright, the body sinks downwards or even crouches, and is thrown into flexuous movements; his tail (…) is lowered and wagged from side to side; his hair instantly becomes smooth; his ears are depressed and drawn backwards (…)" (p35)

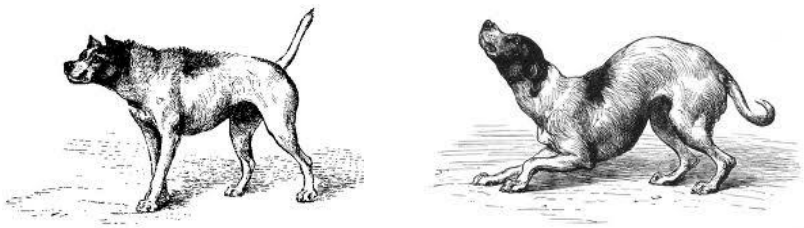

Figure 1. Drawings from the book of Darwin (1872) illustrating the principle of antithesis.

After Darwin, from the middle of the 20st century, ethologists have given detailed descriptions of social behavior of dogs and other *canids* (e.g. Schenkel, 1947; Scott & Fuller, 1965; Fox, 1969; 1973; Kiley-Worthington, 1976). One of the biggest merits of them is that they catalogued the behavior of *canids*, with detailed ethograms, containing also emotional expressive behaviors. For example, head and body posture, ear and tail posture and tail movement have been frequently described for indicating signs of aggression, fear or confidence (Schenkel, 1947; Scott & Fuller, 1965; Fox, 1969; 1973; Kiley-Worthington, 1976).

Despite Darwin's and later ethologists' observations and besides some sporadic early experimental studies (Maslow, 1932, Melzack, 1954, Elliot & Scott, 1961), the rigorous experimental investigation of dogs' expressive behavior related to supposed emotional states has started only recently and the studies in the topic are still limited. Some examples are the observation of fear (Ley et al, 2007), positive emotion on achievement (McGowan et al, 2014), jealousy (Harris and Prouvost, 2014), guilt (Horowitz, 2009, Hecht et al., 2012), tail-wagging responses to different emotive stimuli (Quaranta, Siniscalchi & Vallortigara, 2007) in dogs.

Some studies have been carried out on dogs' recognition of conspecifics' expressive behavior as well (Bálint et al, 2013; Molnár et al, 2009; Racca et al., 2010; Siniscalchi et al, 2013). Another direction of investigation is constituted by veterinary research on emotion-related behavioral disorders in dogs, like anxiety disorders, phobias, aggression, etc. (e.g. Guy et al., 2001; King et al., 2000; Overall et al., 2001; McGreevy and Masters, 2008)

Besides these experimental studies there are some investigations on humans' view of dogs' emotions or emotional expressive behavior. For example, in the study of Morris et al. (2008) mentioned earlier, owners' attribution of emotions to their dogs was measured, and additional situational and behavioral descriptions were asked from the owners regarding their dog's jealous behavior. In another study (Tami & Gallagher, 2009) people were asked to label the emotional behavior of dogs on video clips. In the studies of Pongrácz and his colleagues (2005, 2006) human listeners were required to classify dog barks recorded in different situations and judge the emotional content of them. Bloom and Friedman (2013) asked subjects to classify dogs' facial expressions from photographs. Besides that these studies may establish future experimental investigations on dog's emotions, they are also important from

the perspective of studying humans' interspecific emotion-recognition or emotion-attribution abilities.

## 1.10 Emotional communication between dogs and humans -the interspecific emotion-recognition

Dogs and humans have been living together for at least 14,000 years (Nobis, 1979), and domestication might have predisposed dogs to form attachment relationships with humans (Topál et al, 1998, 2005; Prato-Previde et al, 2003; Palmer & Custance, 2008). Humans also form an attachment relationship with their dogs (Archer and Ireland, 2011; Kurdek 2009; Serpell 1996). During domestication dogs may have been selected for being able to develop specific inter-specific communication skills with humans (Hare et al., 2002; Gácsi et al., 2009; Lakatos et al, 2007; Miklósi and Soproni, 2006; Topál et al, 2009).

Domestication might have favored convergent processes in emotional behavior of dogs and humans (Miklósi, 2007), leading to behavioral analogies between them (Topál et al., 1998). Communicative signals of the dog may have been shaped by (natural and/or artificial) selection in the human environment so that they gained functional significance in human-dog relationship (Feddersen-Petersen, 2000; Pongrácz et al., 2010). For example, humans could have preferred dogs that showed variability in the acoustic structure of barking which variability indicate different inner states (Pongrácz et al., 2010).

It is even more likely that there are homologue emotional behavioral features in the two species. This notion can be supported by correspondence in the brain structures underlying emotional behavior in mammals (Panskepp 2005), and that mammals (including humans) share some similar patterns in their emotion expression (e.g. Darwin, 1872; van Hooff, 1972; Morton, 1977).

Finally, the effect of common experience through ontogenetic ritualization (a process in which particular social behaviors come to function as intentional communicative signals in the context of regularly occurring dyadic interactions) may be a third process besides homology and domestication that supports the emotional communication between the two species (Miklósi, 2007). Molnár et al. (2008) reported that some types of barking are more uniform, whereas others show greater individual variance (e.g. those emitted during ball play,

before going for a walk or in requesting situations). The increased variability of these barks may be the result of idiosynchronic learning processes, that is, the interactions between the dog and the owner may shape the acoustic form of the bark (Pongrácz et al., 2010). The result of this can be that owners induce expressions in their dog through operant learning that resembles more to human expressions.

Homologue and analogue emotional behaviors between dogs and humans, common experience and learning can all contribute to that humans and dogs may communicate effectively their emotions to each other. The lay observations of dog-owners also show that dogs and owners can recognize many emotional expressions of each other (Vitulli, 2006).

### 1.10.1 Dogs' discrimination and recognition of humans' emotional expressions

Recently, it was demonstrated that dogs can discriminate between different emotional expressions of humans. For example, they react differently to photographs of different facial expressions (e.g. angry and happy faces vs. neutral faces) of humans (Deputte and Doll, 2011; Nagasawa et al., 2011; but see Hori et al., 2011) or they react differently when their owners are in different emotional states (Morisaki et al., 2009). However, difference in reaction (e.g. that dogs gaze more to one expression compared the other) does not tell much about emotion-recognition, but only that dogs are able to differentiate between these emotional expressions (e.g. based on visual patterns of the human face). The evidence for recognizing an emotional expression is stronger if dogs' behavior alters in a preliminary predicted and meaningful way. In Deputte and Doll's study (2011) dogs reacted more with avoidance to the angry human face compared to neutral faces which is in line with expectations.

Other experiments used two-way choice tests to observe whether dogs choose the object to which the human experimenter or the owner reacted with a positive emotional expression compared to the object to which (s)he expressed a negative or neutral expression. Thus, the human's referential emotional expression was supposed to influence the dog's behavior toward the object (social referencing). These studies showed that dogs chose (in case of food) or retrieved (in case of plastic bottles) the object with the relatively positive (happy vs. disgusted, happy vs. fearful or happy vs. neutral) emotional expression (Buttelmann and Tomasello, 2013; Merola et al., 2014; Turcsán et al., 2014). These experiments are also more lifelike as they used not still photos of facial expressions as stimuli, but dynamic, both

acoustic and visual expressions of the experimenter (although here, the “Clever-Hans effect” can influence the results).

Additionally, it was shown that dogs can distinguish between emotionally different tones of voice (Ruffmann and Morris-Trainor, 2011), that is, they were slower to take a piece of food when commanded to leave it with an ‘angry voice’ compared to a ‘happy voice’. In contrast, Mills et al. (2005) found no difference in the latencies to obey when the ‘sit’ and ‘come’ commands were given in different emotional tone of voice.

Dog-owners hold that dogs not only recognize their emotions but they often show empathic behavior toward them (Vitulli, 2006). In line with this, Custance and Mayer (2012) found empathic-like responding by dogs to distress of humans (e.g. they approached and touched the distressed human even when it was a stranger), although –as the authors admit- this response can be interpreted as emotional contagion (when the other’s emotional state triggers a similar emotional response in the observer, without the empathic concern for the other) coupled with a previous learning history in which dogs have been rewarded for approaching distressed human companions.

### 1.10.2 Humans’ recognition of dogs’ emotional expressions and emotion-attribution to dogs

It was demonstrated that humans can classify dog barks according to the context it was emitted and tell the emotional state of the signaler (Pongrácz et al., 2005, 2006). Furthermore, people are similarly capable of judging the emotional behavior of dogs irrespectively of their experience with dogs (Molnár et al., 2010; Pongrácz et al., 2005, 2006). Similarly, in the field of visual communication, it was demonstrated that human observers show a relatively high agreement with each other or with dog-experts in their assessment of dogs’ emotional behavior (Walker et al., 2010), although some behaviors were less easy to identify than others (Tami & Gallagher, 2009). Both experienced and inexperienced people were able to read the dog’s emotions when photographs of a dog’s face displaying different emotions were presented to them (Bloom and Friedman, 2013).

All these studies showed that –both in the case of acoustic and visual communication- people are similarly capable of judging the emotional behavior of dogs irrespectively of their

experience with dogs. This suggests that in the recognition of dogs' emotion, direct learning may play a smaller role than phylogenetic factors such as homologies, but we need more experimental data on this question to support this hypothesis.

Dog-owners attribute the same emotions to dogs in a large percentage (e.g. 99% of them think that their dogs feel joy) and they agree on the situational and behavioral aspects of emotions (Morris et al., 2008). However, people may sometimes attribute certain emotions to dogs the existence of which is questionable (Horowitz, 2009, Hecht et al., 2012) so these attributions can be the result of anthropomorphism. Nevertheless, studies on emotion-attribution to animals are useful as they set out a profitable direction for further experimental studies.

## 1.11 Humans' emotion attribution to social robots- dog as a model for social robotics

Social robotics is a rapidly emerging field of science aiming to design robots that can be immersed in human social networks and are able to interact with humans in a meaningful way (Fong et al., 2003; Dautenhahn, 2007). It is generally expected that in the not-too-distant future such robots will play an important role in helping humans in various tasks. The chance to construct agents that can engage in meaningful social interaction with humans presents new challenges for engineers (Miklósi and Gácsi, 2012). Given that ethology deals with a wide perspective of social behavior of all living beings, it can contribute to the modeling of social robots (Miklósi and Gácsi, 2012).

A general requirement for social robots is that they should be able to participate in different interactions with humans. Many scientists in social robotics agree that the main requirements of a complex social interaction include communication, some rudimentary form of personality and the recognition and expression of emotions (Becker-Asano, 2008; Fong et al., 2003; Padgham and Taylor, 1997). These features are widely thought to increase the believability of artificial agents [e.g. Fong et al., 2003; Padgham and Taylor, 1997; Bates, 1994; Becker et al., 2005) and enhance the long-term engagement of people toward artificial companions.

Many robots and virtual agents (e.g. Kismet, Yuppy, Max, Greta, Probo, EDDIE, Feelix; Becker et al., 2005; Breazeal, 2003; Poggi et al., 2005; Velasquez, 1999; Saldien et al., 2010; Sosnowski et al., 2006; Kühnlenz et al., 2010; Canamero, 2002) have been supplied with

affective expressions to examine the contribution of emotional expressions to livingness or to observe humans' perception of the expressive behaviors of robots. Although, it is important to note that most of these studies used only facial expressions to express robotic emotions and they used only questionnaires to analyze the recognition rate of the different emotions. Direct human-robot interactions analyzing humans' reactions also on the behavioral level are relatively rare (e.g. Becker-Asano, 2008, Bruce et al., 2002; Leite et al., 2008).

Additionally, many of the present day social robots have humanoid embodiments and their behavior is designed on the basis of human psychological models. The application of animal models for the behavioral design could provide an important alternative in the development of future social robots (Miklósi and Gácsi, 2012). Similarly to human-robot interactions human-animal interactions are asymmetric, they are much simpler than human-human interactions, and do not require the usage of language. Thus, the design of human-robot interactions may benefit better from models of human-animal interaction than from human-human interaction.

Domestic animals seem to be the best candidates for providing the inspiration to design robot behavior because they are able to develop effective social interaction with humans (Miklósi and Gácsi, 2012). Human-dog interaction has already been suggested as a framework to model human-robot interactions before (Miklósi and Gácsi, 2012; Dautenhahn, 2004). Indeed, dogs excel with their social skills from domestic animals (Topál et al., 2009) and they achieve a relatively complex level of social interaction with humans (Miklósi and Gácsi, 2012), hence we (Lakatos et al., in press) assume that dogs provide an appropriate animal model for building social robots.

We have seen that owners can recognize the emotional behavior of dogs (see previous section). Moreover, humans are willing to attribute a wide range of emotions to dogs (e.g. Morris et al., 2008) even those the existence of which is questionable (Horowitz, 2009, Hecht et al., 2012). Hence, dogs seem to present such social cues which provoke the anthropomorphizing tendency in humans, what roboticists also want to provoke in the users of social robots.

## 1.12 Aims of the studies

The following studies aimed to take different perspectives on how we can conceptualize emotional behavior in dogs, using different methodological approaches.

In Study 1 our aim was to obtain a detailed picture about dogs' emotions (the whole spectrum if possible) relying on the receiver's (humans) perspective. Questionnaire data supplied by the owners (see also Morris et al.'s, 2008) were analyzed quantitatively in order to see whether the affective space of emotion in dogs (as represented by humans) is similar to the human affective space (as reflected in earlier studies). So far, the dimensional approach of emotion (the "affective space") has not been applied to animal emotions, so our study is the first in this field.

In Study 2 we combined the humans' perspective with experimental validation of the dogs' expressive behavior. Our aim was to observe dogs' emotional behavior related to their relationship (attachment) with the owner: separation and greeting behavior. We addressed the question whether owners can judge correctly the separation and greeting behavior of their dog, and also the separation-related disorder of the dog.

In Study 3 we tested whether dogs' separation-related disorder is associated with their owners' own attachment style and personality. Such associations were found between human infants' separation anxiety and parents' personality, attachment and other characteristics. Dogs could serve as a behavioral model for infant-parent attachment, and these results also help in managing separation-related disorder in dogs.

In Study 4 we investigated whether emotional behavior of dogs can provide a model for expressive behavior of social robots. We studied whether humans attribute emotions and how they react to a robot equipped with dog-like emotional expressive behavior. This study is the first that tests human subjects' behavioral reaction to dog-like emotional expressions of a robot in a human-robot interaction test.

## 2 General method and ethical statement

We conducted non-invasive experiments and questionnaire studies in each of the following four studies. Human subjects participated in the studies voluntarily. All studies were undertaken with great care, e.g. by ensuring the privacy and confidentiality of subjects, explaining the research process to them and assuring them of using the data only for scientific purposes. The conducted research was neither physically nor emotionally demanding for the human participants.

The experiment involving dog subjects fulfilled the requirements of the ASAB/ABS Guidelines for the Use of Animals in Research, the Hungarian legal requirements on protecting animal welfare, and the ethical guidelines of the University. The degree of distress dogs were exposed to in Study 2 is experienced frequently by the dogs in everyday life. Dog participants of our studies were well-socialized family dogs, recruited from the database of the Family Dog Project at the Department of Ethology (http://kutyaetologia.elte.hu/).

In case of the questionnaire studies the filling out of the questionnaires was anonym so the study does not violate respondents' privacy. The Ethical Committee of Eötvös Loránd University provided an ethical approval for the study. Informed written consent was not obtained from the participants because the data were anonymized at collection (although elements of informed consent were included in the introductory letter of the questionnaire).

The experiments took place at the Family Dog Project laboratory, Eötvös Loránd University (Budapest, Hungary), in a testing room (4.6 m x 3.8 m), which had 3 doors on 3 different walls. The room was equipped with 4 cameras (one camera on the top of each wall).

# 3 Study 1: How do humans represent the emotions of dogs? The resemblance between the human representation of the canine and the human affective space

## 3.1 Introduction

As (critical) anthropomorphism may provide useful hypotheses for looking at animal behavior, people's report about how they see animals' emotions can provide a starting point for the direction of experiment-oriented studies. The usage of questionnaire data has the advantage that the full spectrum of emotion can be assessed in a relatively large sample.
As we have seen above, Morris et al. (2008) have carried out a questionnaire study on owners' emotion-attribution to their pets. He listed 17 human emotions which owners had to decide whether their pet ever experienced it or not. This indirect study of animal emotion covered a wide range of emotions, however, the analysis lacked quantitative methods as there was only a qualitative, descriptive statistics.

There exists no direct or indirect (questionnaire based) quantitative study on the full range of emotions in any animal species. Such research is more prevalent in humans that make also efforts to reveal certain patterns and regularities (similarities and dissimilarities) among emotions in order to discuss them in a coherent framework, which is often referred to as an 'affective space'.

As mentioned earlier (see section "Conceptualization of emotional states"), the dimensional approach of emotion (e.g. Cabanac, 2002; Russell, 1980) assumes that emotions are not discrete phenomena (in contrast to e.g. Panskepp, 1994), but they can be located in an abstract space constituted by two or more dimensions (named the "affective space"). It is assumed that in humans affective experience or affective behavior (facial expression, body movements, etc.) can be reduced to some underlying dimensions. Emotions that are regarded as more similar according to one or more characteristics are placed closer to each other in the affective space. Similarities between emotions (emotional expressions, emotional words, etc.) are determined by different indices, for example similarity ratings of the subjects or neural activity parameters. Different techniques are used for the statistical modeling such as multidimensional scaling (MDS), discriminant function analysis (DFA), or principal component analysis (PCA), to establish the affective space and find the underlying dimensions (e.g. Abelson & Sermat, 1962; Calder, Burton, Miller, Young, & Akamatsu, 2001; Fontaine, Scherer, Roesch, & Ellsworth, 2007; Russell, Lewicka, & Niit, 1989; Wallbott, 1998).

Although, many of such studies (for reviews, see Russell, 1980) used very different type of data, such as self-reported feelings to film or music clips (Christie & Friedman, 2004), semantic description or similarity ratings of emotional terms (Fontaine et al., 2007; Katsikitis, 1997; Russell, 1980; Russell et al., 1989), ratings of facial expression of emotion (Abelson & Sermat, 1962; Calder et al., 2001; Russell & Bullock, 1985) or ratings of arm movements (Pollick, Paterson, Bruderlin, & Sanford, 2001), the results were quite similar. Most investigations revealed two (bipolar) dimensions: arousal/ activation or behavioral activity and pleasantness or valence (e.g. Christie & Friedman, 2004; Pollick et al., 2001; Russell et al., 1989; Stephens, 2007). In some cases additional dimensions were also reported such as potency/control, predictability or approach/avoidance (Fontaine et al., 2007, Wallbott, 1998).

Owners spend a lot of time with their dogs thus they may have substantial experience on emotional behavior of dogs. Owners know that body language of the dog indicates different emotional states. Morris et al. (2008) report that owners attribute a wide range of emotions to

their dogs including an array of secondary ones. Thus we have reasons to believe that dogs are good subjects for investigating how animal emotion is represented by humans. It was also shown that dog-owners agree on the situational and behavioral aspects of an emotion (jealousy) of their dogs (Morris et al., 2008).

By integrating animal-questionnaire studies and the human dimensional approaches, we wanted to see whether humans' attribution of emotions to family dogs results in a similar emotional space to those found in the human studies.

Here we report two studies aimed at revealing the human point of view on dog emotions in a quantitative manner.

In the first study we collected data in a Hungarian sample of dog owners by the means of the same emotion list that was used by Morris et al. (2008). Owners had to decide which emotions they think humans can recognize in dogs and dogs can recognize in humans. We predicted that owners would think that humans can recognize many emotions in dogs, especially the primary emotions - similarly to Morris et al.'s (2008) results. We assumed that humans would also think that dogs can recognize many human emotions (although not as many as humans can recognize in dogs), especially the primary ones, again- in agreement with findings that dogs can discriminate some human emotions (Morisaki et al., 2009; Nagasawa et al., 2011; Racca et al., 2010).

In the second study we asked the owners to characterize a small set of emotions by the means of a list which contained non-exclusive emotional-expressive behavior patterns of dogs. Owners had to tell which behavior elements characterize dogs during certain emotional states. The data from the second questionnaire were entered into a statistical model to see whether these emotions occupy a similar affective space to that revealed for humans. We predicted that we would find similar underlying dimensions as the ones found in human dimensional studies.

## 3.2 Method

### 3.2.1 Subjects

Dog-owners were recruited from the dog-owner database of the Department of Ethology (Budapest, Hungary). They were either asked by email to fill in the questionnaires; or were invited to the department with their dog to participate in behavior tests and then additionally

asked to fill out the questionnaires. Dog-owners were asked to fill out one or two of the questionnaires: the Emotion Reporting Questionnaire (ERQ) and/ or the Emotional Behavior Questionnaire (EBQ). There were eight version of the EBQ: with eight different emotions which owners had to characterize (see below).

83 owners filled out the ERQ (11 men, 68 women, the gender of four owners are missing). 125 owners filled out the EBQ (18 men, 101 women, six owners' gender are missing). Owners got three out of the eight different EBQ's (they had to characterize three emotions) resulting 50 ± 2 (mean ± SD) questionnaires/emotion. The participating owners had various pure breed dogs and mongrels.

The filling out of the questionnaires took approximately 15 minutes. Owners were not paid for the participation in the test.

### 3.2.2 Questionnaires used

3.2.2.1 Emotion Reporting Questionnaire (ERQ)

The questionnaire (see Appendix 1) was based on the same set of emotions listed by Morris and his colleagues (2008) (10 primary emotions based on Ortony & Turner, 1990: anger, fear, surprise, joy/happiness, sadness, anxiety, disgust, interest, love/affection, and curiosity; seven secondary emotions based on Lewis, 2002; Tangney & Fischer, 1995: empathy, shame, pride, grief, guilt, jealousy, and embarrassment). Owners had to indicate for the 17 emotions separately whether they think humans can recognize that emotion in dogs. We phrased the question in this way (and not as 'which emotions do dogs possess' or 'which emotions you experienced in your dog' or as Morris et al. asked: 'is your dog ever …?') because we wanted to ask the question also in the reversed way: we were also interested in owners' opinion about what kind of emotions dogs can recognize in humans. So we asked two symmetrical questions ('What do you think which emotions humans can recognize in dogs/dogs can recognize in humans?', see Appendix 1). We used the same set of emotions for the two questions. We are aware that the meaning of our question is not exactly the same as if we had asked subjects about what kind of emotion they themselves attributed to dogs, but we think that when judging which emotions humans (in general) can recognize in dogs subjects rely on their own

concepts about/experience with dogs' emotions. So we think that the difference is slight, hence we can make inference about humans' emotion attribution from the answers.

#### 3.2.2.2 Emotional Behavior Questionnaire (EBQ)

By the means of the EBQ we wanted to reveal whether owners rely consistently on behavioral cues in their attribution of dog emotions. We tested this idea for eight emotions (sadness, fear, disgust, surprise, anger, joy, shame, jealousy), and for each of them 33 behavior elements were listed (Appendix 2). Owners had to mark which of them are characteristic for the dog during the respective emotional state. The eight emotions include the six primary emotions (sadness, fear, disgust, surprise, anger, joy) according to Ekman (1992), and two secondary emotions: shame/guilt and jealousy. Guilt and jealousy were the two secondary emotions that dog-owners reported most frequently in the study of Morris et al. (2008), and Horowitz (2009) found also that owners readily attribute guilt to their dogs in an experimental study (see also Hecht et al., 2012). Jealous behavior of dogs was examined recently in an experimental study (Harris and Prouvost, 2014). The behaviors listed belonged to one of the following categories: distance (from the owner), head and body posture, tail posture and wagging, ear posture, vocalization, looking (at the owner), activity of moving, contact (with the owner).

Most of these categories and behavior elements listed are regularly defined as part of the ethogram for dogs or wolves (e.g. Döring et al., 2009; Feddersen-Petersen, 2000; Goodwin, 1997; Ley et al., 2007; McLeod, 1996; Scott & Fuller, 1965; Tami & Gallagher, 2009). Head and body posture, ear and tail posture and tail movement have been frequently used for indicating signs of aggression, fear or confidence (Schenkel, 1947; Scott & Fuller, 1965; Fox, 1969; 1973; Kiley-Worthington, 1976). In addition we included behaviors (distance, looking, contact) related to affiliative tendencies of dogs toward their owner. These behaviors were found to be useful indicators of attachment (Topál et al., 1998) and dependency (Topál et al., 1997). The categories contained three to six behavior units, and for each category owner could suggest additional behavior units if they felt none of the listed ones appropriate.

### 3.2.3 Statistical analysis

During the analysis of the ERQ ‘yes’ and ‘no’ votes for each emotion were summed (‘yes’ was given to a certain emotion if the dog owner thought humans recognize it in dogs or dogs recognize it in humans and ‘no’ was given if the emotion was not selected). For the comparison of owners’ view on primary versus secondary emotion-recognition we summed all ‘yes’ and ‘no’ votes for primary emotions and for secondary emotions separately. We compared the level of average emotion-recognition (how many dog emotions subjects think that people can recognize) in our Hungarian sample and the level of average emotion-attribution to dogs in the English sample in Morris et al (2008) study. For this comparison the total number of ‘yes’ and ‘no’ votes given by the English and Hungarian dog-owners (to all of the 17 emotions) were compared by using Fisher exact test. Fisher exact tests were also conducted for comparing owners’ view on the recognition of primary versus secondary emotions (by humans and dogs, too), and owners’ view on dogs’ and humans’ emotion recognition abilities.

In the data of the EBQ we had two categorical (nominal) variables with several response categories: emotions had 8 values (categories), and behavior elements had 33 values. To explore the relationships among our categorical variables correspondence analysis was conducted using R 2.12.0 statistical software (Ihaka & Gentleman, 1996) package anacor (de Leeuw & Mair, 2009). Correspondence analysis (CA) is a multivariate descriptive method based on a data matrix with non-negative elements (e.g. frequencies formed by categorical data). It is conceptually similar to principal component analysis, but applies to categorical rather than continuous data. In a similar manner to principal component analysis, it provides a means of displaying or summarizing a set of data in two- or three-dimensional graphical form. It is traditionally applied to contingency tables – in our case contingency table is formed by the contingencies of the different categories of the two variables, that is, the overall frequencies with which subjects (as a total) reported a certain behavior element for a certain emotion (the contingency table can be seen in the results section, in Table 2). CA decomposes the chi-squared statistic associated with this contingency table into orthogonal factors. From a contingency table we can see the similarities and differences among the categories (e.g. the emotions), but multidimensional similarities are difficult to comprehend. The goal of CA is to find a lower-dimensional space in which to position the row and column points (emotions and behavior elements, in our case) in a manner that retains all, or almost all, of the information about the similarities/differences between the columns/rows. The graphical representations of

the results produced by CA illustrate the most important relationships among the variables' categories (Sourial et al., 2010). The measure of association used in CA is the chi-square distance between the response categories. The closer the response categories are located to each other, the more similar they are to each other. In the biplot a joint display of points represents the rows and columns of a table, and the scalar products between row and column points reconstruct the original data in the table. To visualize the distances between the row or column profiles separately, symmetric maps were used (both variables were in principal coordinates). To be able to interpret row-column relationships asymmetric maps were used, where the two clouds of points have different normalizations/ scalings. The column points are represented as profiles in principal coordinates and the row points (behavioral elements) as vertices in standard coordinates because we were more interested in the column analysis (emotions). In this map the column points are at weighted averages of the row points using the elements of the column profiles as weights. This way we can get information about the distances between the column profiles and the optimal row–column relationships as well (Greenacre, 2007).

## 3.3 Results

### 3.3.1 Emotion Reporting Questionnaire

Owners think that people can recognize many (72.9% on average) of the listed emotions in dogs, ranging from 39% (empathy) to 99% (fear) (Figure 2, black columns). Dog-owners in Morris et al.'s (2008) study attributed emotions to their dogs in a similar ratio (72% on average, ranging from 30% to 99%). The levels of attribution/recognition of emotions to/in dogs did not differ significantly between Hungarian (in total 1028 'Yes' and 417 'No' votes) and English (4141'Yes' and 1588 'No' votes - from Morris et al., 2008) nations (Fisher-test: p=0.394, odds ratio=0.9).

Based on responses to the questionnaire it was also possible to compare how much - according to the responders- humans and dogs recognize each other's emotions (see Figure 2). Subjects reported that humans can recognize 72.9% of dogs' emotions on average (1028 yes and 383 no), while 51.3% of human emotions (724 yes and 687 no) were reported to be recognizable by dogs. This means that according to the owners humans are able to recognize

emotion in dogs with a 2.6 times greater odds compared to recognizing emotions in humans by dogs (Fisher-test, p<0.001).

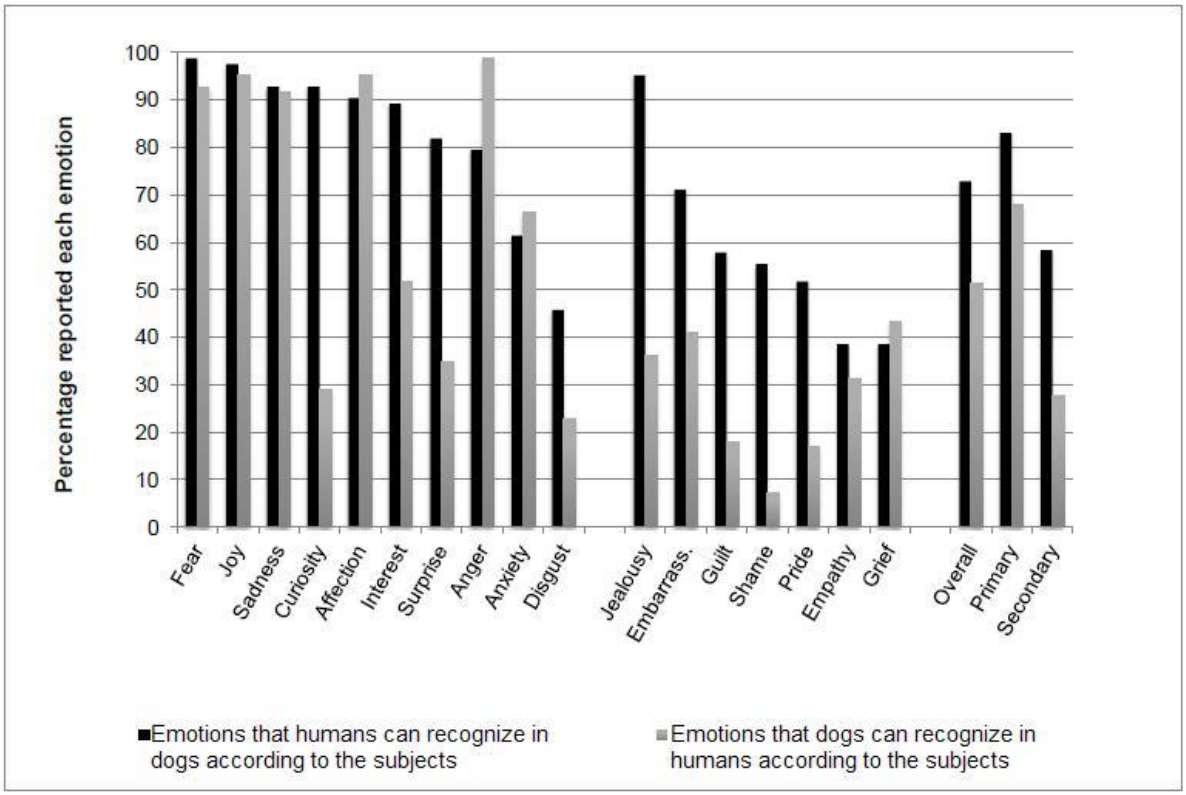


Figure 2. Percentage of people reporting that the listed primary (first ten) and secondary (last seven) emotions (based on Morris et al, 2008) (and emotions as a total) humans can recognize in dogs (black columns), and dogs can recognize in humans (grey columns).

Owners think that humans recognize 83% (141 no and 689 yes) of the primary emotions (based on Morris et al.'s list) and 58.4% (242 no and 339 yes) of the secondary emotions in dogs (see black columns in Figure 2). The odds of recognizing primary feelings in dogs by humans is 3.5 times greater, compared to recognizing secondary feelings (Fisher-test, p<0.001).

According to the human responders dog recognize on average 67.8% (267 no and 563 yes) of the primary human emotions versus 27.7% (420 no and 161 yes) of the secondary emotions. The odds of recognizing human primary emotions by dogs (according to the human responders' opinion) is 4.8 times greater (Fisher-test, p<0.001) compared to recognizing secondary emotions.

### 3.3.2 Emotional Behavior Questionnaire (EBQ)

Contingency table (Table 2) was computed from the overall frequencies with which subjects (as a total) reported a certain behavior element for a certain emotion (i.e. from the contingencies between behavior elements and emotions). The correspondence analysis of the EBQ shows that the first dimension ($\chi^2$=905.92) accounts for 55.5% of the total $\chi^2$-value (i.e. inertia), and the second explains 16.3% ($\chi^2$=266.97). Two dimensions together account for 71.8% so we included only the first two dimensions in our interpretations. On the graphical representation the column plot including 95% confidence ellipsoids (Figure 3) and the joint plot (Figure 4) is shown, where both emotions and behavior elements are visualized simultaneously.

The most prominent (more than 40% of dog-owners selected it) behavior elements which were selected for a given emotion can be seen in Table 3.

| Category | Behavior element | Anger | Disgust | Fear | Jealousy | Joy | Sadness | Shame | Surprise |
|---|---|---|---|---|---|---|---|---|---|
| **Body** | **Bodyhigh** | 24 | 2 | 4 | 22 | 24 | 2 | 0 | 30 |
| **Body** | **Bodysmall** | 5 | 27 | 22 | 7 | 5 | 32 | 33 | 8 |
| **Body** | **Shake** | 10 | 3 | 20 | 6 | 10 | 2 | 2 | 0 |
| **Contact** | **Jump** | 11 | 1 | 8 | 9 | 31 | 0 | 1 | 9 |
| **Contact** | **Nose** | 2 | 5 | 10 | 22 | 16 | 26 | 10 | 14 |
| **Contact** | **Paw** | 0 | 4 | 3 | 11 | 14 | 6 | 6 | 5 |
| **Contact** | **Rub** | 2 | 5 | 10 | 19 | 23 | 8 | 9 | 5 |
| **Distance** | **Far** | 11 | 10 | 3 | 1 | 0 | 6 | 21 | 1 |
| **Distance** | **Near** | 6 | 5 | 35 | 33 | 28 | 12 | 7 | 17 |
| **Distance** | **Nocome** | 15 | 8 | 6 | 1 | 1 | 10 | 11 | 14 |
| **Ears** | **Earback** | 8 | 6 | 15 | 5 | 11 | 2 | 10 | 0 |
| **Ears** | **Earforw** | 15 | 3 | 2 | 7 | 9 | 2 | 0 | 9 |
| **Ears** | **Earhang** | 1 | 17 | 6 | 13 | 3 | 28 | 17 | 0 |
| **Ears** | **Earlow** | 3 | 9 | 14 | 3 | 5 | 8 | 13 | 7 |
| **Ears** | **Earsharp** | 12 | 1 | 6 | 9 | 20 | 2 | 0 | 24 |
| **Head** | **Headlow** | 2 | 23 | 23 | 12 | 4 | 34 | 37 | 4 |
| **Head** | **Headtilt** | 2 | 5 | 0 | 3 | 5 | 5 | 1 | 17 |
| **Head** | **Headup** | 33 | 4 | 12 | 19 | 33 | 2 | 1 | 21 |
| **Intensity** | **Moveno** | 0 | 7 | 10 | 7 | 0 | 26 | 9 | 20 |
| **Intensity** | **Moveslow** | 9 | 26 | 23 | 10 | 0 | 22 | 33 | 13 |
| **Intensity** | **Movevigi** | 28 | 5 | 9 | 22 | 40 | 1 | 0 | 10 |
| **Looking** | **Eyeavoid** | 6 | 10 | 4 | 2 | 0 | 5 | 17 | 0 |
| **Looking** | **Gaze** | 4 | 1 | 9 | 19 | 25 | 7 | 6 | 8 |
| **Looking** | **Look** | 21 | 22 | 27 | 15 | 15 | 29 | 18 | 27 |
| **Tail** | **Tailfast** | 5 | 0 | 2 | 18 | 38 | 0 | 3 | 6 |
| **Tail** | **Tailhigh** | 17 | 2 | 2 | 7 | 6 | 2 | 0 | 14 |
| **Tail** | **Taillow** | 4 | 16 | 29 | 3 | 0 | 8 | 17 | 6 |
| **Tail** | **Tailno** | 13 | 19 | 7 | 4 | 0 | 29 | 9 | 15 |
| **Tail** | **Tailslow** | 1 | 3 | 4 | 8 | 0 | 6 | 17 | 5 |
| **Vocalization** | **Bark** | 26 | 3 | 6 | 6 | 25 | 0 | 1 | 10 |
| **Vocalization** | **Growl** | 13 | 6 | 6 | 8 | 4 | 1 | 1 | 5 |
| **Vocalization** | **Moan** | 0 | 5 | 4 | 10 | 1 | 25 | 14 | 4 |
| **Vocalization** | **Whine** | 3 | 5 | 11 | 13 | 21 | 4 | 2 | 7 |

Table 2 - Contingency table of the Emotion Behavior Questionnaire (EBQ): distribution of frequencies with which subjects (as a total) reported a certain behavior element for a certain emotion. Abbreviations of behavior elements are defined in Table 3.

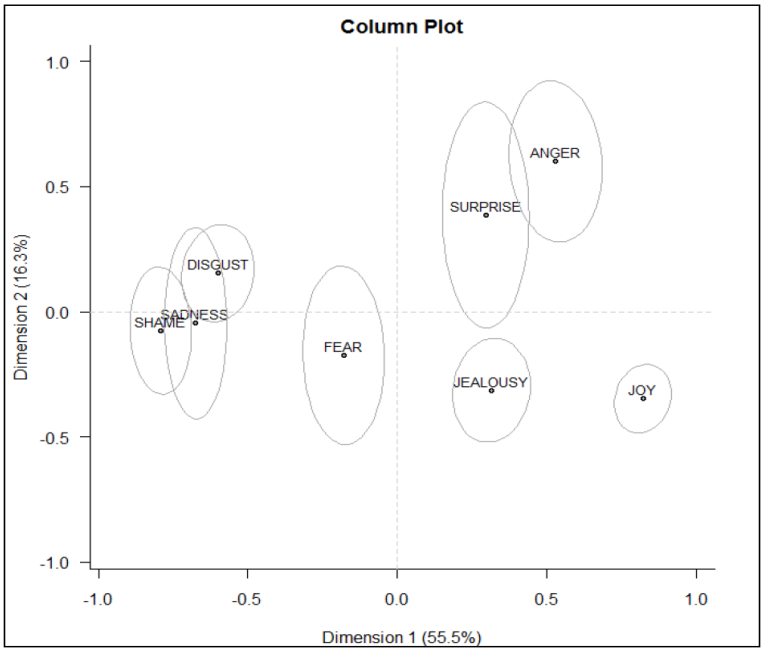


Figure 3. The results of the Correspondence Analysis of the Emotional Behavior Questionnaire are shown. Distances of the eight emotions represent the degree of similarity between them. Dimension 1 was interpreted as 'activity', Dimension 2 as 'assertiveness'. The ellipsoids represent 95% confidence.

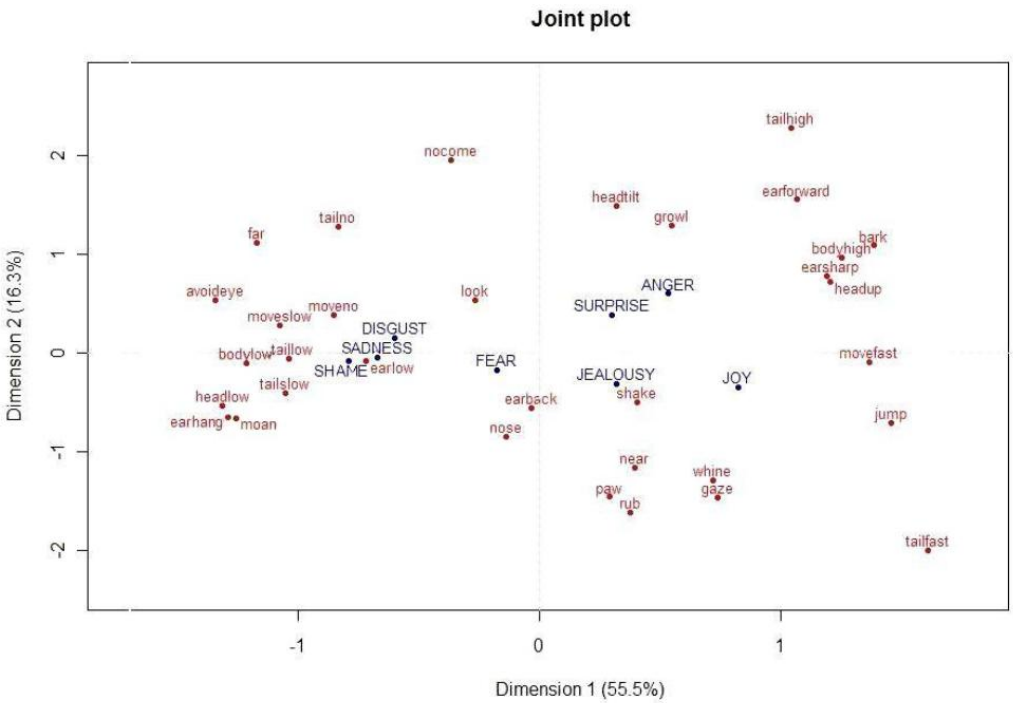


Figure 4. The asymmetric joint plot (where both emotions and behavior elements are visualized simultaneously) results of the Correspondence Analysis of the Emotional Behavior Questionnaire are shown. Dimension 1 was interpreted as 'activity', Dimension 2 as 'assertiveness'. Emotions with capital letter are referring to the emotions in Figure 3. Abbreviations of behavior elements with small letters are defined in Table 3.

| **Emotion** | **The most prominent behavior elements chosen for the given emotion (more than 40% of dog-owners selected it)** *(the abbreviations used in the graphical representation are written in italics)* |
|---|---|
| Shame | Hangs its head (*headlow*), Contracts itself (*bodylow*), Moves slowly (*moveslow*), Tries to be far from me (*far*). |
| Sadness | Hangs its head (*headlow*), Contracts itself (*bodylow*), Keeps glancing at me (*look*), The tail doesn't move (*tailno*), Hangs the ears (*earhang*), Touches me with nose (*nose*), Motionless (*moveno*), Moans (*moan*), Moves slowly (*moveslow*). |
| Disgust | Contracts itself (*bodylow*), Moves slowly (*moveslow*), Hangs its head (*headlow*), Keeps glancing at me (*look*) and The tail doesn't move (*tailno*) |
| Fear | Remains close to me (*near*), Pulls its tail between the legs (*taillow*), Keeps glancing at me (*look*), Hangs its head (*headlow*), Contracts itself (*bodylow*) |
| Surprise | Draws itself up (*bodyhigh*), Keeps glancing at me (*look*), Cocks the ears (*earsharp*), Lifts its head up (*headup*), Motionless (*moveno*) |
| Anger | Lifts its head up (*headup*), Moves actively (*movefast*), Barks (*bark*), Draws itself up (*bodyhigh*) and Keeps glancing at me (*look*) |
| Jealousy | Remains close to me (*near*), Touches me with nose (*nose*), Moves actively (*movefast*), Draws itself up (*bodyhigh*), Lifts its head up (*headup*), Rubs me (*rub*), Keeps staring at me (*gaze*) |
| Joy | Moves actively (*movefast*), Wags it quickly (*tailfast*), Lifts its head up (*headup*), Jumps on me (*jump*), Remains close to me (*near*), Keeps staring at me (*gaze*), Barks (*bark*), Draws itself up (*bodyhigh*), Rubs me (*rub*), Whines (*whine*), Cocks the ears (*earsharp*) |

Table 3. The most prominent behavior elements chosen for the specific emotion (more than 40% of dog-owners selected it)

On the first dimension of column plot joy and anger are on the very right side and shame and sadness are on the very left of this dimension. In the joint plot on the right side fast body-movements and fast tail-movements are located, while on the left side we can find elements such as no movement or slow movement and no tail-wagging or slow tail-wagging. Thus, Dimension 1 can be interpreted as 'activity'.

On Dimension 2 joy, jealousy and fear are in the lower part of the axis, and anger is positioned in the upper part. In parallel, high body posture, high head posture, high tail-posture and a forward posture of the ears are placed at the upper part on Figure 3. In contrast, low head and tail posture, and pulled-back ears are located at the lower section. In accordance with the location of the emotions and the signifying behaviors we interpret this dimension as 'assertiveness'.

The ellipsoids (which represent 95% confidence) of shame and sadness overlap which could be interpreted that these emotions share similar place in the human representation of dogs' affective space. Similarly, there is an overlap in the ellipsoids of sadness and disgust or surprise and anger, too.

## 3.4 Discussion

### 3.4.1 Emotion Reporting Questionnaire

The Emotion Reporting Questionnaire showed that according to the owners humans recognize a wide range of emotions in dogs. We think that subjects rely on their own concepts about dogs' emotions when they judge which emotions humans (in general) can recognize in dogs. So the results would be similar if we had asked which emotions they themselves would have attributed to dogs. Our results are in accordance with the results of Morris et al. (2008) who found that dog-owners attributed emotions to their dogs in a similar ratio as in or study. Similarly to Morris and his colleagues we also found that according to our subjects, humans recognize more primary emotions in dogs than secondary ones. Nevertheless, they thought that humans can perceive even the secondary emotions of dogs in a large percentage (58.4%). Based on the owners' responses the present findings suggest that the inter-specific emotion-recognition processes are not symmetrical: it suggests that humans recognize more emotions in dogs than in reverse. This is especially true for secondary emotions. Dogs are considered to perceive a large percent of primary human emotions (67.8%), but they are reported to

recognize secondary ones only in 27.7% of the cases. Experimental studies showed that human primary emotions are discriminated by dogs (Buttelmann & Tomasello, 2013; Deputte & Doll, 2011; Merola et al., 2012; Morisaki et al., 2009; Nagasawa et al., 2011; Racca et al., 2010; Ruffman & Morris-Trainor, 2011; Turcsán et al., 2014), but there are no data on such abilities of dogs in connection with secondary emotions. Secondary emotions are also called as complex emotions as they can be a mixture of two primary emotions (Plutchik, 2001) or can contain a self-conscious or self-evaluative element (Fischer & Tangney, 1995; Morris et al, 2008). Hence, it is not likely that dogs can recognize human secondary emotions. In contrast, humans may have the mental capacity to represent and attribute not only primary, but also secondary emotions to dogs (independently whether the emotion really exists or not; see Horowitz, 2009 or Hecht et al., 2012).

### 3.4.2 Emotional Behavior Questionnaire

By the means of the correspondence analysis we revealed how humans represent the emotions of dogs in the affective space. The dimensions of the Emotional Behavior Questionnaire had a good explanatory value. We have identified activity and assertiveness as the two main dimensions.

Activity refers to movement intensity. It is related to the concept ‘arousal’ (or ‘activation’) which is one of the most commonly found factors in human studies on emotion that use ordination techniques (e.g. Christie & Friedman, 2004; Pollick et al., 2001; Russell et al., 1989; Stephens, 2007). Arousal is a physiological and psychological state of activation, specifically, a reactivity to stimuli, sensory alertness and mobility. In contrast, activity reflects a behavioral activation rather than a physiological/ psychological arousal. Although arousal can be accompanied by behavioral activity, the two factors often diverge. For example, fear is characterized by high arousal but the behavioral manifestation depends on the context, ranging from escaping to freezing.

The position of the emotions in the affective space reported in the present study is in accordance with this: joy and anger (which are positioned at one side of the affective space, see Figure 3.) correspond with high behavioral activity, and shame and sadness (which are located on the opposite side) are characterized with slow or little movement. Fear is close to the middle section because this emotion can entail either active (escape) or passive (freezing) forms. In the human literature, one study that observed expressive body movements

(Wallbott, 1998), found also an activity-passivity dimension. This is not a physiological/ psychological activation, but a behavioral (movement) activity. Indeed, the emotions in their study are ordered on this dimension in a very similar way as in our study (except for shame): joy and anger entail the highest activity, sadness and disgust the lowest and fear is in between. Our second dimension is assertiveness, which is realized by erectness or expansion of the body. Erectness was linked to occupying a dominant position in stable social groups both in case of animals (e.g. dogs or wolves: Scott & Fuller, 1965; Fox, 1973; Kiley-Worthington, 1976) and in case of humans (Eibl-Eibesfeldt, 1984). Wallbott (1998) found that in humans, emotions such as shame and sadness are often associated with a collapsed body, while pride or anger is rarely associated with such a body state. Weisfeld and Beresford (1982) showed that students who were judged by peers to be dominant in agonistic interactions and successful in the school were observed to have more erected posture (e.g. as rated by blind observers).

Regarding the 'affective space' studies, assertiveness can be linked to potency, control or 'dominance' as described in the human literature. In line with this, the model by Osgood et al. (1971) suggests that the semantic space (which represents the semantics or the connotative meaning of words) consists of three dimensions: evaluation, activity and potency. According to Mehrabian and Russell's emotional model (1974) the main dimensions of the affective space are pleasure, arousal and dominance (PAD model). However, note that the reference to dominance in these cases is questionable because 'dominance' is not a feature of the individual (Drews, 1993) but describes a relationship between two group members. Thus, in order to avoid confusion one may want to retain the use of concept of dominance for social networks. The individual character that is typified by a tendency to control social partners should be labeled as assertiveness.

### 3.4.3 Similarities and differences between humans' representation of the canine and their own affective space

Our results show that there are marked similarities in the way humans represent their own affective space (as reflected in the literature, see earlier) and the emotions of dogs. Activity and assertiveness may underlie the affective space of humans and dogs too (although arousal was found more frequently in the human dimensional studies than activity). There are several non-exclusive explanations explaining these similarities.

First, humans may rely on cognitive mechanism to use their own existing affective space to represent dogs' emotions. This is generally referred to as anthropomorphism when people attributing spontaneously human mental features to animals (Wynne 2007). Accordingly, the features of the affective space we found in dogs may reflect humans' anthropomorphism. In general humans are prone to anthropomorphize about dogs, in Western societies the majority of dog owners regard dogs as family members (Berryman, 1985; Kubinyi at al., 2009), and, for example, Rasmussen and Rajecki (1995) report that people see only quantitative difference between the mental abilities of a 6-year-old boy and a dog. The finding of Morris et al. (2008) also support humans' tendency to attribute a wide range of specific emotions to dogs the existence of which is questionable (Horowitz, 2009; Hecht et al., 2012).

Second, humans and dogs also develop common communicative signals through ontogenetic ritualization and some of these signals refer emotional states as well. Thus, direct learning may also play a role in the recognition of dogs' emotion, although some data suggest that people are similarly capable of judging emotional behavior of dogs irrespectively of their experience with dogs (Molnár et al., 2009; Pongrácz et al., 2005; Tami & Gallagher, 2009).

Thirdly, similarity in the affective space of dogs and humans may have a common biological basis (Plutchik 2001), based on evolutionary (e.g. mammalian) homologies between the two species. This notion can be supported by correspondence in the brain structures underlying emotional behavior in mammals (Panskepp 2005), and that mammals (including humans) share some similar patterns in their emotion expression (e.g. van Hooff, 1972; Morton, 1977). In reference to dog barking, for example, the Morton's rule (i.e. that auditory signals of different species show some parallel physical features) can explain why people with different amount of experience with dogs can identify equally well the behavioral context and attribute motivational state of a dog bark after listening to from play backs of this vocalization (Pongrácz et al., 2005) (although we have no data on such skills of people who have absolutely no experience with dogs).

In addition, one cannot exclude that domestication might have favored convergent processes in emotional behavior of dogs and humans (Miklósi, 2007). For example, dogs show functionally analogue attachment behavior toward their owner as human infants do toward their parents which may be a result of a predisposition formed by domestication (Topál et al., 2005).

There are also differences in the way humans represent human affective space and the affective space of dogs (as reflected in our results). In the human studies arousal has been

found to be the most prominent dimension which is connected to but is not the same as activity. Besides, pleasantness or valence seems not so important in the construction of dog's affective space as it is in the representation of human emotions. (However, Faragó and colleagues (2014) showed that humans can rate the emotional intensity and valence of dog vocalization and they rate them according to the same acoustical parameters as in case of conspecific's vocalization. In addition, intensity and valence were predetermined rating dimensions and they were not derived from some ordination technique.) These differences can be attributed to the following.

First in spite of some similar emotional reactions, dogs and humans have obviously different means to express their emotions, because of the different composition of the body. For example, while facial expression plays a critical role in emotion recognition and social interaction in humans (Schmidt & Cohn, 2001), in the emotional or social behavior of canines behavior elements associated with other part of the body (e.g. tail, ear) or with whole body postures (Schenkel, 1947; van Hooff & Wensing, 1987; Tami & Gallagher, 2009) seem to have at least the same importance as facial expressions. Most of the human dimensional studies which deal with behavior as stimulus actually concentrate on facial expressions. The only study (Wallbott, 1998) in which whole body movements were measured found a more similar dimension to ours: activity-passivity (and not arousal).

Second, while in most of the human dimensional studies the data is somehow connected to conscious experience or the verbal construction of emotion and only a few deals with behavior, in the present study dogs' emotions were located in the space by the means of behavior elements. It is plausible that valence is not manifested in behavior, and especially, in body movements. In parallel with this, the only study that measured affective space by the means of whole body movements in humans neither found valence as a dimension, but approach-withdrawal instead (Wallbott, 1998).

Third, it is possible that our list of behavior elements was not detailed enough or elements that form part of the dogs' behavior repertoire were missing from the list which could influence the results. Applying more than eight emotions in the analysis may also affect the resulting dimensional solution of the affective space.

# 4 Study 2: The behavior of the domestic dog *(Canis familiaris)* during separation from and reunion with the owner: A questionnaire and an experimental study

## 4.1 Introduction

For social animals the group has a survival function because being alone could be dangerous. Pairs and larger groups are held together by social bonds (Carter, 1998). Attachment can be considered as a particular kind of affectionate bond which exists between monogamous mates (Remage-Healey et al., 2003) and most obviously between parent and its offspring (Ainsworth and Bell, 1970). According to Bowlby (1969) the ultimate function of parent-offspring attachment is to protect against predators and maintain the supply of resources for offspring if they remain in proximity to the parent(s). Attached individuals (e.g. offspring) tend to maintain proximity to and contact with the attachment figure (e.g. parent) and become distressed when separation occurs (Bowlby, 1969). Several studies showed that in many species a brief separation from the mother induced behavioral and/or physiological indicators of stress (e.g. human infants: Ainsworth and Bell, 1970; squirrel monkey (*Saimiri* sp): Coe et al., 1978; dog (*Canis familiaris*): Elliot and Scott, 1961).

The attachment is controlled through proximity-*seeking* and proximity-*maintaining* behaviors. These behaviors may modulate the reaction of the mother. In the case of human infants crying elicits approach in the mother, while smiling, babbling or eye-contact keep the mother close to the baby (Bowlby, 1969).

Dog-human relationship manifests a very special case because social ties develop among members of two different species. Nevertheless it has been argued that family dogs live in a mutual attachment relationship with their human companion(s) (e.g. Kurdek 2009; Serpell 1996). In addition, the application of the Strange Situation Test (Ainsworth, 1969) revealed that dogs show functionally analogue behaviors to human infants: they tend to maintain proximity and showing stress-related behaviors after brief separations from the owner (Topál et al., 1998; Prato-Previde et al., 2003). Dogs utilize the owner as a “secure base” for exploring the environment (Prato-Previde et al., 2003) and a “safe haven” in threatening situations (Gácsi et al., 2013) similarly to human infants. It has been supposed that the

domestication predisposed dogs to form attachment relationships with humans (Topál et al., 2005).

Humans also have a disposition to form an attachment relationship with their dogs (Archer and Ireland, 2011) which might be facilitated by dogs' paedomorphic morphological and behavioral features (Coppinger et al., 1987). Using the Repertory Grid (Kelly, 1955) technique Berryman (1985) found that pet owners (mostly dogs and cats) see their pets significantly more like „own child" than any other family member. In addition, owners use their dogs as a safe haven (to alleviate stress) (Archer and Ireland, 2011) more than any other family members or friends, except for romantic partners (Kurdek, 2009).

Although the stress-related behavior to separation is an adaptive response of the attached individual, normal maturation results in increased tolerance to both spatial and temporal separation from the attachment figure. However, both in humans and in dogs some in the course of development some individuals maintain a lower threshold for the activation of the attachment system which is often considered to be problematic (abnormal), due to its extreme degree, form and consequences.

Separation-related disorder (SRD) (Gaultier et al., 2005) is a common behavior problem in dogs, when the problematic behavior occurs exclusively in the owner's absence or virtual absence. Owners of dogs with SRD complain most frequently about destructive behavior displayed at home, excessive vocalization (often noticed by neighbors), or inappropriate elimination (urination/defecation) (Sherman, 2008). Further symptoms (which are less easily recognized) include autonomic signs such as hypersalivation or hyperventilation, increased and repetitive motor activity (e.g. pacing, circling), repetitive behavior (e.g. over-grooming or self-mutilation), behavioral signs of depression such as withdrawal, inactivity or inappetence, gastrointestinal symptoms (vomiting, diarrhea) or escape behavior that can result in self-trauma (Appleby and Pluijmakers, 2004; Overall et al., 2001; Sherman, 2008;). A recent study showed that dogs with SRD are characterized with a negative affective state which manifests in a cognitive bias in an ambiguous choice task (Mendl et al., 2010).

In the veterinary literature questionnaires are often used (e.g. Overall et al., 2001; McGreevy and Masters, 2008) to investigate separation behavior and separation-related disorder in dogs, but so far the questionnaires have not been validated by the means of behavior tests. Some studies have been carried out to observe separation behavior directly and to make standardized behavioral measurement (Lund and Jørgensen, 1999; Parthasarathy and Crowell-Davis, 2006; Palestrini et al., 2010, Rehn and Keeling, 2011), but there were no collations of

these behavioral observations and the reports of the owners. Owners report was used mostly for screening of dogs.

In some cases owners may infer the separation behavior of the dog indirectly only, for example by observing the intensity of the greeting behavior of the dog. One may assume that the amount of stressful experience influences directly the greeting behavior of the dog, or alternatively, it is possible that regardless of the separation some dogs greet their owners more or less enthusiastically. Previous studies on attachment (e.g. Topál et al., 1998; Prato-Previde et al., 2003; Gácsi et al., 2001, etc.) observed behavior both during separation and at greeting but they did not focus on the association between them. In line with this a recent study (Rehn and Keeling, 2011) reported that the longer the separation the more interaction the dog initiates with the owner and the more tail-wagging and owner-directed attentive behavior the dog displays in the post-separation period (10 minutes after owner's arrival).

It has been assumed that the behavior may change with increasing time of separation. Bowlby (1969) observed that children and young primates went through the same behavior sequence when separated from the attachment figure. The initial "protest" phase which consists of crying, screaming and burst of anger was followed by the "despair" phase which is characterized by the decrease of motor and vocal activity. If separation continues, the process eventuates in "detachment" from the attachment figure, and the young animal/child will be active and independent. Each phase can be considered as an adaptive strategy to survive. In accordance with this, and in case of dogs, Lund and Jørgensen (1999) found that activity and the frequency of some distress-related behavior elements decreased with time during a four-hour long period. (Although this time scale is different from the one that Bowlby referred to in case of hospiatized or institutionalized children, where days or weeks of separation occurred. However, he stated that protest phase may end after a few hours so the changes in the behavior of dogs in the experiment can be paralalled with this.) In contrast, in the study of Rehn and Keeling (2011) dogs' behavior did not change in parallel with different (half-, two- and four-hour long) separation durations. However, the comparability of the two studies is limited, because in the former only dogs with SRD, while in the latter only dogs without SRD were observed. However, Palestrini et al. (2010) found no significant change even in the separation behavior of dogs with SRD, during a 40-minute long separation at home.

Thus, the aim of the present study was threefold. First, we introduced a questionnaire (Separation Questionnaire) to estimate the prevalence of separation related disorder in a small sample of family dogs. Second, we designed a simple behavioral test (S&G) in order to

validate owner's report on their dogs' separation-related behavior. We assumed that owner's indication of SRD in their dog will be associated with certain behavior pattern displayed during separation and greeting. Third, we wanted to see whether the manipulation of separation duration affects the behavior of the dogs, predicting that the duration of separation affects the dog's separation and greeting behavior.

## 4.2 Method

### 4.2.1 Subjects

45 dogs and their owners participated in the test. One Separation Questionnaire was lost due to technical reasons. Dogs' median age was 4.2 years (ranging from 1.2 to 11.6 years); there were 18 males, 27 females, 16 mixed and 29 pure breeds. From the 45 dogs 15 had separation problem according to the Separation Questionnaire (see below). From the 15 dogs 12 were males, and only three were females, which is in contrast with the gender-proportion of the whole sample. The median age of the dogs with separation problem did not differ from the dogs without a problem (Mann-Whitney test; U=199.5; p=0.656).

### 4.2.2 Materials

The experiments took place in the Family Dog Project laboratory of Ethology Department, Eötvös Loránd University, Budapest, Hungary. The layout of the testing room is depicted on Figure 5. A ball, a paper box, a cupboard, and a chair were placed into the room before starting the experiment. The video-recording was made with four cameras. The view of the cameras was transferred to a computer in the adjacent room, where the experimenter could observe the events in the testing room. The experimenter gave instructions to the owner via a headset.

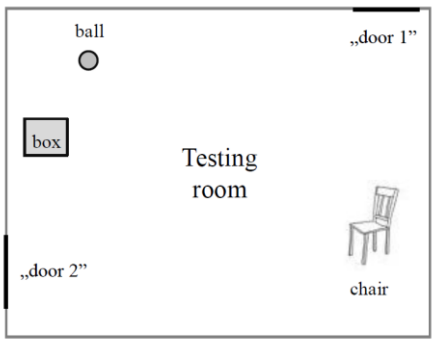


Figure 5. The layout of the testing room

Before the experiment the owners were asked to fill out the Separation Questionnaire regarding their habits and feelings in connection with leaving their dogs alone. The items of the questionnaire are listed in Appendix 3.

### 4.2.3 Procedure

From the 45 dogs 15 were tested with a 1-minute-long separation, 15 with a 3-minute-long separation, and 15 with a 5-minute-long separation (between-subject design). In the different conditions the proportion of dogs with and without separation problem did not differ (G-test, G=0.627; p=0.731). The test consisted of three phases.

*Introduction phase*: The dog and the owner entered the testing room, and dog was allowed to walk around off leash. The owner closed the door, put the leash on the back of the chair and sat down. The observation started one minute after the owner had taken the seat. During this period the owner was allowed to look at the dog and talk to it, but he/she was not allowed to touch it. If the dog brought the ball to the owner, he/she was not allowed to play with the dog. After one minute the experimenter told the owner via the headphone to say goodbye to the dog and to go out from the testing room through „door 1" (see Figure 5). Then the owner went out to the corridor, and came into the room, where the experimenter was sitting.

*Separation phase*: The phase started when the owner closed „door 1". Depending on the condition, the separation phase lasted 1, 3 or 5 minutes. At the end of the separation the owner was asked to go to „door 2" and call the dog loudly twice by its name separated by 5 seconds break. This was done in order to move the dog away from „door 1" before the owner returned to the testing room. This allowed us to observe how fast the dogs approach the owner.

*Greeting phase*: The owner entered through „door 1". After stepping in he/she closed the door and greeted the dog. Owners were free to interact with the dog, however, they were told that they should greet the dog intensely, pet it and talk to it. The greeting lasted for 15 seconds from the owner stepping in the testing room.

After the greeting the owner was told to put the leash back and leave the room with the dog.

### 4.2.4 Behavior coding

The videotapes of the experiments were coded with Solomon Coder beta 10.11.29 (Copyright © 2010 András Péter; http://solomoncoder.com/). The behavior of the dogs was coded during

the last minute of separation (which was the only minute in the case of the 1-minute-long separation) and during the greeting. Coded behavior elements, their definitions and the corresponding test phases are listed in Table 4. The relative percentage of the time spent with these behaviors was established.

| Category | Behavior element | Test phases in which the behavior unit was coded | Definition |
|---|---|---|---|
| Posture/ moving | Lying | S[1] & G[2] | The dog's elbows and sternum, or side touch the ground. |
| | Sitting | S & G | The dog's haunches are on the ground, whereas elbows are not. |
| | Standing | S & G | The dog is on all four feet, not moving. |
| | Walking | S & G | Dog moves from one point to another, three feet on the ground at any time. |
| | Running | S & G | Dog moves rapidly from one point to another. |
| | Rearing to the owner | G | The dog stands on its hind legs, and puts its forelegs on the owner's body. |
| | Rearing to the wall or door | S | The dog stands on its hind legs, and puts its forelegs on the wall or on the door. |
| Tail-wagging | Slow tail-wagging | S & G | The duration of one tail-amplitude is more than 0.2 seconds. |
| | Fast tail-wagging | S & G | The duration of one tail-amplitude is 0.2 seconds or less. |
| Vocalization | Whining | S & G | High-pitched vocalization. |
| Distance | Proximity to the chair | S | The dog's closest point is within one meter from the chair. |
| | Proximity to the owner | G | The dog's closest point is within one meter from the owner. |
| | Proximity to the doors | S | The dog's closest point is within one meter from any of the doors. |
| Looking | Looking at owner | G | The dog looks in the direction of the owner (at any body part) (close visual inspection, distant visual inspection). |
| Contact | Contact with the door (scratching) | S | The dog is in physical contact with the door, including scratching it, or touching it with paw or nose. |

Table 4. The label and description of behavior units coded in the Separation (S) and Greeting (G) phase

[1] Separation

[2] Greeting

Twenty percent of the videos (N=9, three per conditions) were coded also by a second observer. Inter-observer reliability was determined for each variable category by counting Cohen's Kappa coefficients between the coding of the two observers. The reliability can be considered as very good, the Cohen's Kappa ranged from 0.698 to 0.88.

### 4.2.5 Data analysis

Before analyzing the questionnaire and the S&G test, we formed scales to reduce data and to avoid multiple comparisons.

Internal consistencies of the questionnaire scales were high; Cronbach's alphas are presented in brackets. We formed a scale called "*Owner-worry*" (0.87) from the items reflecting the owners' worry about leaving the dog alone (items 7-9). In parallel, we constructed a scale named "*Dog-worry*" (0.837) from the items describing the dogs' worry when separated from owner (items 10-12). Similarly we merged items 13 to 15 in a scale called "*Need-for-calming*" (0.782), and items 16 to 17 were merged to a scale named "*Dog-joy*" (0.83). Neither of the scales was normally distributed.

We formed scales also from the correlating behavioral variables of the S&G test which seemed to refer to the same underlying construct. The *Separation Activity* scale was formed from standing, walking, running, and lying (inverse) (0.69). The *Separation Distress* scale consisted of whining, tail-wagging (fast and slow together), physical contact with the door (scratching), and rearing on the wall or the door (0.68). [There are several reports supporting this scale; vocalization can occur as a consequence of fear or anxiety (Landsberg et al., 2003; Overall, 1997). Tail-wagging may indicate stress (Beerda et al., 2000). Destruction is one of the main symptoms of separation-related disorder of dogs (Sherman, 2008)]. The *Greeting Affection* scale with moderate internal consistency (0.543) was formed based on proximity to owner, looking at owner, fast tail-wagging, rearing to the owner and walking (inverse). Additionally, we used "running" as a separate variable to indicate *Greeting Activity* (Running did not correlate with any other behavior).

From these four scales, three (*Separation Activity*, *Separation Distress* and *Greeting Activity*) were not normally distributed, because a large percent of the dogs had zero values (*Separation Activity*: 22.2%, N=10, *Separation Distress*: 40%, N=18 and *Greeting Activity*: 57.7%, N=26). The large number of tied values which would occur with standard non-parametric comparisons may lead to inappropriate results (Ruxton et al., 2010). Thus we chose to form

binary variables, that is, to recode the original variables, according to whether the behavior occurred or not. We applied this method to the *Separation Activity*, *Separation Distress* and *Greeting Activity* scales. The *Greeting Affection* scale was however normally distributed, so we left it unchanged, as a continuous variable (for the summary of the questionnaire and behavior scales, see Table 5).

| **Name of the scale** | **Relating test** | **Content of the scale** | **Cronbach's Alfa** | **Transformation of the scale for the statistical analysis** |
|---|---|---|---|---|
| Owner-worry | Separation Questionnaire | items 7-9 | 0.87 | no transformation |
| Dog-anxiety[3] | Separation Questionnaire | items 10-12 (Dog-worry) and items 13-15 (Need-for-calming) | 0.885 | no transformation |
| Dog-joy | Separation Questionnaire | items 16-17 | 0.83 | no transformation |
| Separation Activity | S&G test | standing, walking, running, lying (inverse) | 0.69 | into binary (categorical) variable |
| Separation Distress | S&G test | whining, tail-wagging (fast and slow together), physical contact with the door (scratching), rearing on the wall or the door | 0.68 | into binary (categorical) variable |
| Greeting Affection | S&G test | proximity to owner, looking at owner, fast tail-wagging, rearing to the owner walking (inverse) | 0.543 | no transformation |
| Greeting Activity | S&G test | running | | into binary (categorical) variable |

Table 5. Description of the questionnaire and behavior scales. Items of the questionnaire can be found in Appendix 3, behavior elements are presented in Table 4.

[3] This scale was formed later by merging „Dog-worry" and „Need-for-calming" scales- see later, in the results

### 4.2.6 Statistical analyses

We used SPSS 16.0 for the statistical analysis. Associations among questionnaire scales were analyzed by Spearman correlation because most of the items were not normally distributed. With the binary behavior variables Chi-square tests (or Fisher's exact tests, when cells had expected count less than 5) were applied when analyzing the association with the presence of SRD; Chi-square tests when analyzing the effect of separation duration (condition); and Mann-Whitney or T-tests when analyzing the associations between the binary variables and certain behavioral (e.g. *Greeting Affection*) or questionnaire (e.g. *Owner-worry*) scales. With the *Greeting Affection* scale ANOVA was used to analyze the effect of condition and Spearman correlations to analyze associations with questionnaire scales. We used 0.05 as the value of alpha.

## 4.3 Results

### 4.3.1 Descriptive analysis of the questionnaire (N=44)

Most of the owners (39 from the 44) leave their dog alone at least 3-6 times per week. Half of them (22) leave the dog alone for 4-8 hours, 11 owners for more than 8 hours, and 10 owners for 1-4 hours. Owners usually leave the dog alone at home (in the flat or in the garden).
From the 15 owners whose dog has separation problem, 11 owners complained about continuous vocalization (whining, howling and/or barking), seven about destructive behavior (scratching of the door/wall, chewing of objects), and only one about urination. There were four other responses, which referred to anxiousness, "hissy" or waiting for the owner at the gate.

### 4.3.2 Correlations between the questionnaire scales (N=44)

*Owner-worry* correlated positively with *Dog-worry* ($r_s$= 0.763, p<0.001) and with *Need-for-calming* ($r_s$=0.551, p<0.001) scales. *Dog-worry* correlated with *Dogjoy* ($r_s$=0.414, p=0.005), and with *Need-for-calming* ($r_s$=0.746, p<0,001). Because of these strong correlations and the possibly similar background construct (both scales describe dogs' anxiety), we merged the *Dog-worry* and the *Need-for-calming* scales into a new scale, that we called *Dog-anxiety* (Cronbach's Alpha=0.885, normally distributed). Thus for further analysis we used three scales (*Owner-worry*, *Dog-anxiety* and *Dog-joy*) (Table 5).

### 4.3.3 Analyses of the S&G test

4.3.3.1 Validation of behavioral observations with the Separation Questionnaire scales (N=44)
Dogs displaying more activity during separation (Separation Activity) got higher scores on both the Dog-anxiety scale and the Dog-joy scale. The more stressful a dog was during separation (Separation Distress), the higher scores it obtained on the Dog-anxiety, Owner-worry and Dog-joy scale (for the summary of the results, the test and p values, and the medians of the subgroups, see Table 6).
Dogs showing more affection toward the owner (*Greeting Affection*) got higher points on the *Dog-anxiety* and *Dog-joy* questionnaire scales, and dogs who were more active in greeting (*Greeting Activity*), obtained higher scores on *Owner-worry* scale (see also Table 6).

| **Behavioral variable in the S&G test** | **Questionnaire scales and the corresponding results of the Mann-Whitney and Spearman correlation tests** | **Medians of the questionnaire scales obtained by the groups of dogs who did not (0) and who did (1) show the specific behavior in the S&G test** |
|---|---|---|
| Separation Activity #[4] | Dog-anxiety (U=85, p=0.017) | Separation Activity (0): median=1.5<br>Separation Activity (1): median=2.33 |
| | Dog-joy (U=74, p=0.005) | Separation Activity (0): median=3.75<br>Separation Activity (1): median=4.5 |
| Separation Distress # | Dog-anxiety (U=48.5, p<0.001) | Separation Distress (0): median=1.33<br>Separation Distress (0): median=2.67 |
| | Dog-joy (U=113, p=0.004) | Separation Distress (0): median=4<br>Separation Distress (0): median=4.5 |
| | Owner-worry (U=82.5, p<0.001) | Separation Distress (0): median=1.33<br>Separation Distress (0): median=2.67 |
| Greeting Activity (Running) # | Owner-worry (U=141.5, p=0.022) | Greeting Activity (0): median=1.67<br>Greeting Activity (1): median=2.33 |
| Greeting Affection ##[5] | Dog-anxiety ($r_s$=0.338; p=0.025) | - |
| | Dog-joy ($r_s$=0.298; p=0.05) | - |

Table 6. Summary of the results regarding the associations between the behavioral and questionnaire variables. Mann-Whitney tests were applied in case of binary behavior variables (*Separation Activity*, *Separation Distress* and *Greeting Activity*) and Spearman correlation tests in case of the continuous behavior variable *Greeting Affection*.

[4] # indicates that the variable is categorical (binary)

[5] ## indicates that the variable is continuous (scale)

4.3.3.2 Comparison of the behavior of dogs with and without SRD (N=44)

Comparing *Separation Activity*, *Separation Distress*, *Greeting Activity* and *Greeting Affection* in dogs with and without an owner-reported separation problem (SRD) we found that in dogs with SRD the proportion of those who showed *Separation Distress* during separation and *Greeting Activity* at encountering the owner was significantly higher than in dogs without SRD (Fisher's exact test, p=0.003; p=0.03 respectively) (Figure 6). There was no significant difference between the two groups in *Separation Activity* and *Greeting Affection*.
In addition in dogs with SRD the proportion of those who stayed (for any duration) in proximity to the chair was lower than in dogs without SRD (Fisher's exact test, p=0.009) (Figure 6).

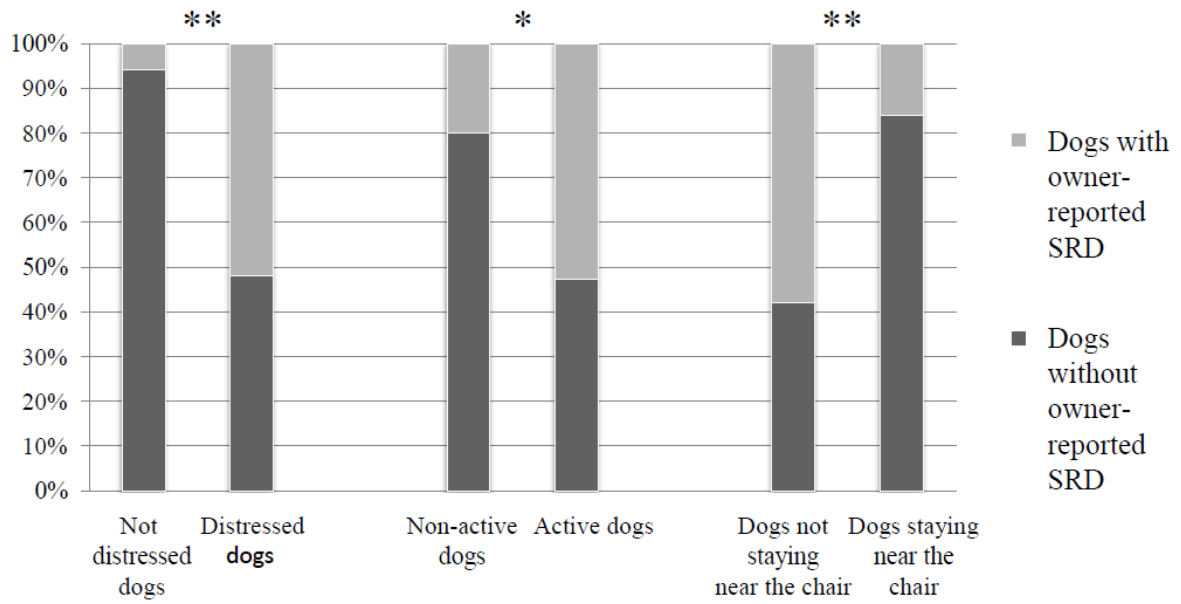


Figure 6. *Separation Distress* and staying at the owner's chair (*Proximity to Chair*) during separation, and activity (running) during greeting (*Greeting Activity*) in the Separation and Greeting test were more common in dogs with owner reported SRD (Separation-related disorder) (Chi-square test ,* p<0.05, ** p<0.01)

For further comparison we selected dogs from the non-SRD group that had higher "*Dog-anxiety*" score (N=13) than the group average. We compared these, highly anxious dogs with SRD dogs (N=15). The two groups did not differ in any of the questionnaire scales, however we found that in SRD dogs the proportion of those who stayed (for any duration) in proximity

to the chair was lower than in highly anxious dogs without SRD ($\chi^2$=12.253; p<0.001). In contrast, in SRD dogs the proportion of dogs who had physical contact with the doors ($\chi^2$=3.877; p=0.049) was higher than in highly anxious dogs without SRD.

#### 4.3.3.3 Effects of separation duration (N=45)

First we analyzed the effect of condition (separation duration) on the whole sample (N=45). From the 4 variables, separation time affected only *Separation Activity* (Chi-square test, $\chi^2$=7.2; p=0.027), dogs became less active with longer separation. We got similar results when we analyzed the effect of condition (separation duration) on the non-affected dogs solely (N=29): i.e. dogs became less active with longer duration of separation ($\chi^2$=6.913; p=0.032) (Figure 7), but separation time did not affect the other three variables. However, in dogs with SRD (N=15) separation duration had no influence on activity, either ($\chi^2$=2.143; p=0.34) (Figure 7). While in the non-affected group nine dogs were passive during separation (i.e. they had a zero value on the *Separation Activity* variable) independently from the condition, from the SRD group only one did not show *Separation Activity*, which can explain the lack of time-effect in this group.

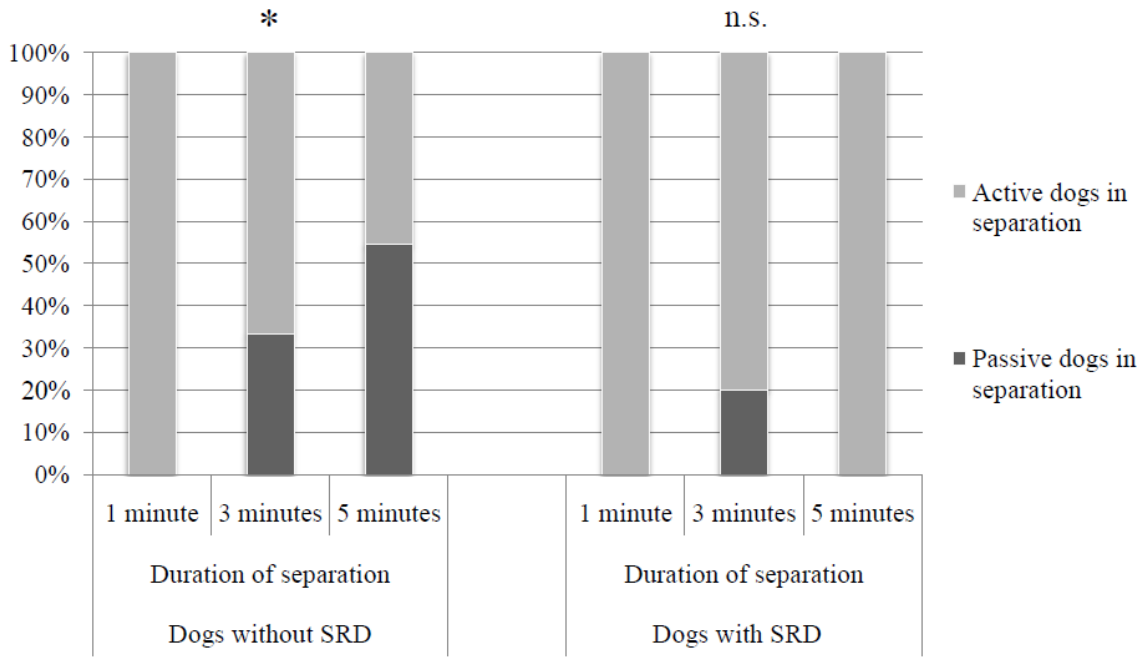


Figure 7. The number of dog categorized as passive or active which were tested under different durations of separation (1, 3 and 5-minutes). (G-test, ** p<0.01)

4.3.3.4 Association between separation and greeting behavior (N=45)

We found that dogs that were active during separation (*Separation Activity*) showed significantly more affection toward the owner during greeting (*Greeting Affection*) (T-test, t=2.454, p=0.018) (Figure 8). Additionally, there were significantly more active dogs during greeting (*Greeting Activity*) among dogs who showed *Separation Distress* than among dogs without any sign of *Separation Distress* (Chi-square test, $\chi^2$=4.919, p=0.027) (Figure 9).

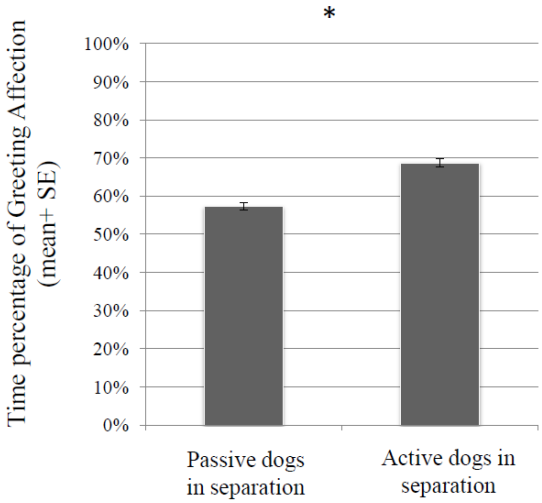


Figure 8. Effect of dogs' Separation Activity (whether they were active or passive in the separation phase of the Separation and Greeting test) on the time they spent with Greeting Affection (affectionate behaviors towards the owner). (T-test, * p<0.05)

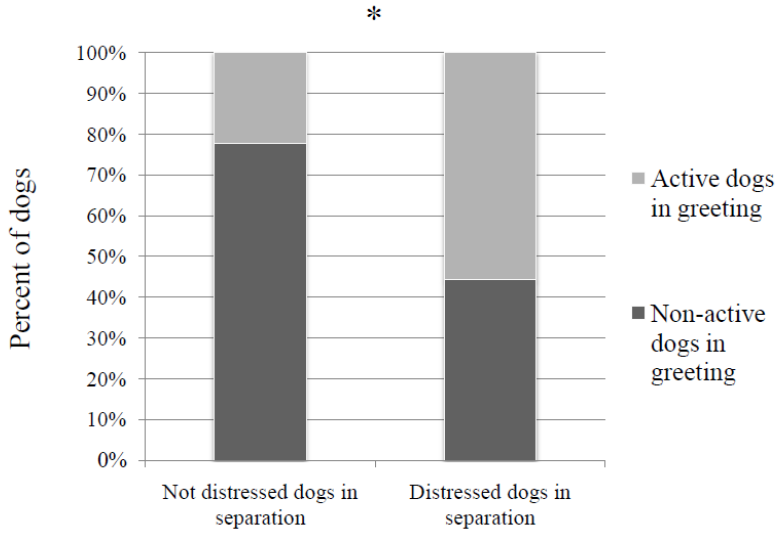


Figure 9. The percentages of active and non- active dogs' during greeting among dogs categorized as either showing distress or not showing distress during separation. (Chi-square test, * p<0.05)

## 4.4 Discussion

### 4.4.1 Validation of behavioral observation with the questionnaire

We assumed that owners are aware of the separation behavior of their dogs (McGreevy and Masters, 2008). Thus we aimed at validating our behavioral observations in the test situation by the means of the separation questionnaire. We found that dogs with higher *Separation Activity* and *Separation Distress* in the test are more anxious when alone according to their owners' report, and dogs showing higher affection toward their owner during greeting are perceived by the owner as the most "happy" on reunion. These associations provide strong convergent validity for our observations. Further, owners worry mostly about dogs with higher separation distress and greeting activity, which is in accordance with the finding that dogs with separation problem have higher scores on these behavior variables. This is the first demonstration that there is an association between dogs' separation behavior and owners' reports on its situation-related feelings.

### 4.4.2 Effects of separation duration

We have also hypothesized that duration of separation affects the separation and greeting behavior of dog. In the present study we have found evidence only for the former, specifically, that during separation activity decreased with time (in accordance with Bowlby's observation on children, despite the fact that we applied very short durations of separation, see above). Similar finding was reported by Lund and Jørgensen (1999), although they observed the dogs during a four-hour long separation in their homes. Additionally, they observed only dogs with SRD, while our sample was a random family dog sample consisting of both healthy and SRD dogs. In a parallel study dogs without SRD did not change their behavior over long durations (half-, two- and four-hour long) of separation, when they were left alone at home (Rehn and Keeling, 2011). Dogs could be more or less habituated to the absence of the owner at home because this situation may occur frequently. Thus, separation at home may not activate strongly their attachment system. This may explain the lack of behavioral change in dogs without SRD (Rehn and Keeling, 2011). However, dogs with SRD may react strongly even to such common cases of separation (Lund and Jørgensen, 1999). Our findings show that at a strange place (which may activate to a larger degree the dog's attachment system; Topál et al., 1998) even normal dogs show these changes in the separation behavior, and even during a shorter period of separation. In contrast, dogs with SRD maintain

their activity also during the five-minute-long separation. This shows that these latter dogs show a mal-adaptive behavior with regard to the current situation (see also Bowlby, 1969), and keep on "protesting" against separation.

We found no effect of separation duration on the greeting behavior which is in contrast with a recent study (Rehn and Keeling, 2011). These authors reported that after longer separation dogs initiated more interaction with the owner and showed more tail-wagging and owner-directed attentive behavior in the post-separation period than after shorter separation. Importantly, in our case the separation time was much shorter.

### 4.4.3 Comparison of the behavior of dogs with and without SRD

Stress-related behaviors such as vocalization, scratching of the door, rearing to the wall or door and tail-wagging during separation were more common in affected dogs than in dogs without SRD. The former were also more active during greeting, that is, they preferred to run instead of being in proximity to and contact with the owner. Thus these dogs cannot be easily calmed down by the presence of the owner. In parallel, dogs with owner-reported SRD did not show more affection (e.g. proximity to, body contact (rearing) and eye-contact with the owner and fast tail-wagging) toward the owner at re-union. In line with this Parthasarathy and Crowell-Davis (2006) reported also that dogs with SRD spent equal time in proximity to or contact with the owner in the modified Strange Situation Test than non-affected dogs.

This result is relevant because some authors (e.g. Sherman, 2008) suggested that SRD is a result of the dog's "hyper-attachment" to the owner. According to Appleby and Pluijmakers (2004) hyper-attachment is characterized by staying constantly in proximity to, following and maintaining physical contact with the owner. Hyper-attached dogs express distress when constrained in a room/area detached from the owner, and react with distress behavior to departure cues of the owner. They also greet their owner excessively (Appleby and Pluijmakers, 2004). In a retrospective clinical case record study (Flannigan and Dodman, 2001) found that dogs with SRD were three-five times more likely to follow their owner around the house than dogs with other behavior problems and they also greet their owners excitedly for over 2 minutes. However, with regard to greeting behavior our result and the finding of Parthasarathy and Crowell-Davis (2006) do not support the view that SRD dogs are hyper-attached to the owner.

Most dogs characterized as having SRD did not spend any time near the owner's chair during separation. Instead, they wanted to escape and resume the contact/proximity with the owner by vocalizing and trying to open the doors or searching for other exits. Prato-Previde et al. (2003) suggest that owners' objects left with the dog may have a calming effect. In their study dogs contacted their owners' clothes more often and for longer durations compared to the stranger's clothes and spent more time near the owner's chair when the owner's objects were present. In our experiment the dog could see the leash and probably smell the owner's scent on the chair. Our observations show that dogs may utilize the owner's objects (and their scent) for reassurance (which is reminiscent to human children who use blankets or toys for reassurance in the absence of the mother). However, dogs with SRD were not attracted by the owners' objects. This may have contributed to the escalation of stress to a level which could not be reduced during the short reunion with the owner.

The above aspects of dogs' behaviors is reminiscent of the insecure-ambivalent ("C"-type) attachment style of human infants who do not use the parent as a secure base, who are very distressed during separation and cannot be easily calmed by the mother at reunion. Several studies (e.g. Warren et al., 1997; Muris et al., 2000) showed that infants with insecure attachment style are more liable to develop anxiety disorders (e.g. separation anxiety disorder). Studies with monkeys and infants suggest that a secure attachment to the parent figure helps the infants mediating the stress response (Kraemer, 1997).

This suggest that we may refer to this type of relationship as being ambivalent (or "insecure") using the terminology of developmental psychology and abandon the concept "hyper-attachment". This latter term does not exist in human developmental psychology and has not yet been defined in terms of behavior.

In the present study dogs with SRD were mostly males. Similar gender proportion was reported by Takeuchi et al. (2001) and Mcgreevy and Masters (2008). It may be that males and females are equally anxious but owners discover more easily the behavior problem in males because as a consequence of greater body size and strength their destructive behavior and vocalization is more conspicuous.

### 4.4.4 Generalizability and practical application

Our behavior test was carried out in a laboratory setting, in contrast with former studies in which dogs were filmed at home while alone. There are several reasons why we chose the

laboratory setting in addition to the practical reasons (saving time and cost). The laboratory tests can be more controllable and objective, and as we have found (see above) a strange place can provoke separation behavior more easily and intensely, so shorter testing duration is possible. We could use more cameras which may have increased the quality of the behavioral observations. The behavior of the owners is also more controllable. However, it should be investigated how much the behavior of the dog in a laboratory is generalizable to other settings and how relevant it is in connection to SRD. But dogs are often brought to strange places and the laboratory simulates this situation. In addition, we thought that our test can be applied in behavior counseling in the future to diagnose SRD and evaluate treatment efficacy.

# 5 Study 3: Influence of owners' attachment style and personality on their dogs' (*Canis familiaris*) separation-related disorder

## 5.1 Introduction

### 5.1.1 Separation stress and related disorders

As discussed earlier, stress response to separation is adaptive both in animals and humans, but typical maturation results in increased tolerance of separation. In infants, separation anxiety (Estes et al., 1956) is a developmentally appropriate distress reaction between the ages of 6 and 20 months, but it can become problematic in early childhood and later if it exceeds (in intensity and in age) normative reactions to separations from caregivers and cause troubles in social functioning. In humans this problematic behavior is called separation anxiety disorder, which is marked by recurrent excessive distress when separated from the home or important others, permanent and excessive worry about losing the attachment figures, refusal of going to school or reluctance to going to sleep alone (DSM-IV-TR, 2000; Kearney and Albano, 2004). A functionally analogue behavior problem in dogs is separation-related disorder (SRD) which was described in Study 1. Thus, it seems that both in humans and dogs there are individuals who have lower threshold for the activation of the attachment system (Bowlby, 1969), and who show a separation response that is developmentally inadequate, has extreme degree, form and consequences.

### 5.1.2 Attachment, caregiving behavior and separation anxiety

Attachment and separation anxiety are related concepts. Bowlby's theory of attachment provides a good theoretical framework for understanding the etiology of separation anxiety (Bowlby, 1969). Securely attached children have the confidence that the attachment figure will be available and accessible if needed, thus, they are less anxious during separation. In order for the child to feel accessibility and availability the mother (parent) has to be sensitive and responsive to the child's needs (e.g. responsive to the infants' cries, sensitive in initiating and terminating feeding, etc.). Sensitive and responsive parenting consists of synchrony, mutuality, emotional support, positive attitude, and stimulation (Wolff and Ijzendoorn, 1997).

In parallel with the theoretical assumptions, researchers found that insecurely attached children (both ambivalent and avoidant, but especially ambivalent) are more prone to show separation anxiety than securely attached children (Cassidy and Main, 1984; Dallaire and Weinraub, 2005). Children's attachment style is associated with parents' caregiving behavior (George and Solomon, 1996). Specifically, maternal responsiveness/sensitivity seems to be the primary predictor of a child's secure attachment (Ainsworth et al., 1971; Crockenberg, 1981; Gunnar et al., 1996; Meins et al., 2001; Leerkes, 2011). Thus it is not surprising that children's separation anxiety seems to be associated with parental behavior (Lynch and Cicchetti, 2002; Wolchik et al., 2002), and that mother's higher sensitivity predicted children's lower separation anxiety (Dallaire and Weinraub, 2005).

Parents' caregiving behavior is influenced by their own attachment style („adult attachment"; Hazan et al., 1987). Van Ijzendoorn (1995) hypothesized that the parents' representation of past and present attachment experiences (Bowlby's "inner working model"; Bowlby, 1969) influences the degree of sensitivity and responsiveness with which the parent reacts to the child's attachment signals. Accordingly, insecure adults may tend to restrict or distort their perception of the child's signals. These hypotheses were supported by investigations showing that insecurely attached adults show less consistent responsiveness to their children's needs (for a meta-analysis, see IJzendoorn, 1995). More precisely, mothers with an avoidant/ dismissing adult attachment style are less sensitive/ responsive with their children than secure mothers, and this is especially true in stressful situations or with mothers experiencing more psychological distress (Adam et al., 2004; Mills-Koonce et al., 2011). It seems that preoccupied (anxious) mothers have deficiency not in sensitivity but rather in autonomy support/non-intrusiveness (Adam et al., 2004; Whipple et al., 2011).

As attachment styles are associated with different personality traits (Carver, 1997; Shaver and Brennan, 1992), and personality affects parenting (Metsäpelto and Pulkkinen, 2003), mothers' personality can also affect the child's attachment style and behavior problems. For example, it was shown that mothers high in neuroticism and low in agreeableness have children who are more likely to have insecure attachment style and behavior problems (Kochanska et al., 2004). In summary, higher extraversion, agreeableness, conscientiousness and lower neuroticism seem to be associated with more secure adult attachment (Carver, 1997; Shaver and Brennan, 1992; or for a meta-analytic review see Noftle and Shaver, 2006) and a warmer and more sensitive parenting (e.g. Metsäpelto and Pulkkinen, 2003; Kochanska et al., 2004; or a meta-analysis: Prinzie et al., 2009). Thus these traits are plausible candidates for influencing children's attachment style and behavior problem including separation anxiety. However, as far as we know, no study has been carried out on the association between parental personality and the child's separation anxiety.

### 5.1.3 The etiology of separation-related disorder in dogs: owners' attitude, dogs' attachment

As separation-related disorder is much less studied in family dogs, we have only few data on the etiology of the disorder. The potential causes mentioned in the literature include negative early experiences such as too early separation from the bitch, other traumatic experience while alone, change in family circumstances (for details see Flannigan and Dodman, 2001) or heritable factors (King et al., 2000). McCrave (1991) reported an increased prevalence of SRD in mixed breed dogs. However, mixed breed dogs are represented in a large percentage among shelter dogs (New et al., 2000) and staying in a shelter can contribute to the development of SRD (McCrave, 1991; Voith and Borchelt, 1985). SRD is reported more often in male dogs than in females (see Study 2 or Konok et al., 2011; Mcgreevy and Masters, 2008; Takeuchi et al., 2001). Mendl et al. (2010) reported that dogs from the shelter with SRD show more „pessimistic" choice behavior in a food search test.

As discussed earlier, based on the results of Study 2, we assume that SRD dogs have an insecure attachment style, analogue to human C type (insecure, ambivalent/anxious) (Ainsworth et al., 1978). Based on the functional analogy in attachment between dogs and children we assume that owners' responsiveness and sensitivity to the dog's needs influences the dog's attachment style and separation-related disorder as in the case of human mother-

child dyads. Experts in behavioral disorders agree that owners' attitude to the dog may contribute to a variety of behavior problems (O'Farrell, 1997). For example, time spent with the dog and shared activities with the owner correlates negatively with dogs' behavior problems (e.g. disobedience, aggression, nervousness, overexcitement, etc.) (Kobelt et al., 2003; Bennett and Rohlf, 2007). Degree of owners' anthropomorphic emotional involvement correlates positively with the degree of dog's aggression toward people (O'Farrell, 1997). Owners' personality was also found to be associated with dogs' behavior problems: Owners of aggressive dogs were reported to be emotionally less stable, more disciplined and tense than owners of non-aggressive dogs (Podberscek and Serpell, 1997). Owners' neuroticism was found to correlate with the degree of the dog's displacement activities (O'Farrell, 1997) and with dogs' neuroticism (Turcsán et al., 2012). However, only one study issued whether the dog's SRD is associated with certain behavioral or attitude characteristics of the owner: they found that the prevalence of separation-related elimination is lower if the dog has been subjected to obedience training and if it does not sleep in the bedroom of the owner (Jagoe and Serpell, 1996).

### 5.1.4 Aims of the study

Our aim was to reveal characteristics of owners that may increase the occurrence of SRD in their dogs, with special focus on owners' attachment and personality. We were also interested in associations of dogs' personality and SRD as it can contribute to the better understanding of this behavior problem. This is an exploratory study because the data about the dogs' personality and SRD stems from the owners and not from independent experimental observations. However, Study 2 demonstrated that owners can judge appropriately the separation-related behavior of their dog (Konok et al., 2011). In addition, in order to increase the validity of the results two separate parallel studies were performed in Hungary and Germany –in cooperation with Wohlfarth Rainer[6], Bettina Mutschler[7]and Ulrike Halsband[8]– using the same methodology.

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We assumed that people with insecure-avoidant attachment style (in the two-dimensional model of attachment it is called “attachment avoidance”) were less responsive to their dogs’ needs. This can lead to insecure attachment on the part of the dog, and – as a consequence – increase the chance for the development of separation-related disorder.

We predicted that with owner’s higher attachment avoidance the prevalence of SRD in the dog would increase; however, degree of owners’ attachment anxiety would have no effect on dogs’ SRD.

We predicted that owners’ higher neuroticism will also contribute to higher occurrence of SRD (i) because higher neuroticism is associated with less warm and sensitive parenting and less secure adult attachment in case of human parents, and (ii) because higher neuroticism of the owner was found to be associated with their dogs’ behavior problem and neuroticism. Finally, we hypothesized also that more neurotic dogs (given their increased proneness to stress reaction) would have more often SRD.

## 5.2 Method

### 5.2.1 Subjects

323 Hungarian and 1185 German owners (Hungarians: 96 men, 227 women; median age= 31, range: from 18 to 70; Germans: 105 men, 1080 women; median age = 42, range: from 18 to 76) of family dogs (various pure and mixed breeds; Hungarian dogs: 154 males, 169 females; median age = 3.2, range: from 1 to 14, n = 227, dog age is missing in 96 cases; German dogs: 542 males and 617 females, n = 1159, dog gender is missing in 26 cases; median age = 4.65, range: from 1 to 17, n = 1116, dog age is missing in 69 cases) filled out the questionnaires. The sample of the dogs was random and non-clinical. Dogs were not screened for the presence of SRD in advance.

Owners (aged at least 18 years) were recruited from the dog-owner database of the Department of Ethology (Hungary) / the Freiburg Institute of Animal-Assisted Therapy (Germany) via email, via Facebook (dog owner pages), internet forums and advertisement on our homepages. The criteria of inclusion were that the dog had to be at least 1 year old and had to live together with the owner for at least half a year. By filling out the questionnaires owners became entitled to participate in a lottery in which they could win two dog-toys (Hungary) / twenty shopping coupons (20 Euros) for a pet food shop (Germany).

Due to practical reasons (communication problem with the owners) not all questionnaires were filled out by all Hungarian owners: 323 owners filled out the Adult Attachment Scale, 201 owners filled out the Big Five Inventory, and 201 owners filled out the Dog Big Five Inventory. All three questionnaires were filled out by 200 Hungarian owners. All of the German owners filled out all questionnaires.

### 5.2.2 Materials and procedure

The Hungarian data collection began in December 2011 and ended in February 2012. The German data collection lasted from November 2012 until January 2013. Subjects filled out the questionnaires on an online interface and it took approximately half an hour. They were allowed to fill in the questionnaires at any place with internet access. The questionnaires had to be filled in at once as subjects could not save them for subsequent editing.

5.2.2.1 Set of questionnaires:

*Demographic questions and SRD* (see Appendix 4)*:* We asked owners about their gender and age, and about the breed, sex and age of the dog, and about how long they have been living together. We asked also whether the owner thinks that his/her dog has a separation-related disorder (Yes/No question).

*Adult Attachment Scale* (AAS; Collins and Read, 1990; the Hungarian translation can be found in '75 papír-ceruza teszt', n.d.; the German translation in Schmidt et al., 2003; see Appendix 5): the questionnaire contains 18 items in the original English and in the Hungarian versions, and 15 items in the German version. It is based on a dimensional view of attachment and it originally contains three subscales: *closeness* (the degree to which a person is comfortable with closeness and intimacy), *dependence* (the extent to which a person feels he/she can depend on others to be available when needed) and *anxiety* (the extent to which a person is worried about being abandoned or unloved).

From these three subscales Collins (1996) derived two main scales: *anxiety* and *avoidance*. *Avoidance* means attachment avoidance, and it is the reverse of the original *dependence* and *closeness* scales. The advantage of using these two dimensions is that they fit to other

attachment models (e.g. Griffin and Bartholomew, 1994; Brennan et al., 1998). Items are rated by the subjects on a 5-point Likert scale from 1 (not at all characteristic) to 5 (very characteristic).

*Big Five Inventory* (BFI; John and Srivastava, 1999; Hungarian translation: Rózsa et al., 2006; German translation: Lang et al., 2001; Borkenau and Ostendorf, 2008; see Appendix 6): the 44-item questionnaire is based on a framework of human personality, namely the Five Factor Model or the Big Five Theory (Norman, 1963; Goldberg, 1993; John et al., 1990; Costa and McCrae, 1988) which holds that the personality can be described along five adjective factors or dimensions. For each item, the owners had to score themselves using a 5-point scale (from disagree strongly to agree strongly). The questionnaire contains 5 factors: *extraversion* (e.g. assertive, unreserved, sociable), *neuroticism* (e.g. anxious, nervous, depressed), *agreeableness* (e.g. kind, warm, trusting, cooperative), *conscientiousness* (e.g. persistent, self-disciplined, diligent, efficient,) and *openness* (e.g. original, inventive, curious).

*Dog Big Five Inventory* (DBFI; Gosling et al., 2003; Hungarian translation: Turcsán et al., 2012; German translation: translation by Wohlfarth Rainer, Bettina Mutschler and Ulrike Halsband for this study, according to the human questionnaire; see Appendix 7): The Inventory was adapted to dogs utilizing the human Five Factor Model (FFM) by Gosling et al. (2003). DBFI consists of five scales which are similar or the same as in the human BFI: *energy* (analogue to human *extraversion*), *neuroticism*, *affection* (analogue to *agreeableness*), *conscientiousness* and *intelligence* (analogue to *openness*). The owners had to score their dogs along 43 items on a 5-point scale ranging from 1 (disagree strongly) to 5 (agree strongly).

### 5.2.3 Statistical analysis

Scores on the attachment and personality sub-scales were calculated. The internal consistencies of questionnaires were acceptable/high: Cronbach's alphas were between 0.59 and 0.88 (calculated separately for each sub-scale for the German and Hungarian data in SPSS 16.0).

Sample sizes were highly different between the two populations, and all human personality, human attachment and dog personality differed between the two groups (MANOVAs, Table 7). Furthermore some of the Cohens's d effect sizes for the differences between the two

populations were medium (d=0.5) or almost large (d=0.8). Therefore we analysed the data separately for Germany and Hungary.

| | **Germany** | **Hungary** | ***d* (95% CI)** | **Wilks' λ** | ***p*** |
|---|---|---|---|---|---|
| **Owner personality** | *n*=1185 | *n*=201 | | | |
| Extraversion | 3.56 ± 0.672 | 3.47 ± 0.713 | 0.13 (0.02 – 0.23) | 0.945 | < 0.001 |
| Agreeableness | 3.56 ± 0.504 | 3.65 ± 0.578 | 0.17 (0.06 – 0.27) | | |
| Conscientiousness | 3.66 ± 0.552 | 3.65 ± 0.650 | 0.02 (-0.08 – 0.13) | | |
| Neuroticism | 2.79 ± 0.715 | 2.74 ± 0.767 | 0.07 (-0.04 – 0.17) | | |
| Openness | 3.53 ± 0.579 | 3.87 ± 0.627 | 0.59 (0.49 – 0.70) | | |
| **Owner AAS** | *n*=1185 | *n*=323 | | | |
| Avoidance | 2.29 ± 0.800 | 2.82 ± 0.545 | 0.70 (0.60 – 0.81) | 0.915 | < 0.001 |
| Anxiety | 2.07 ± 0.830 | 2.15 ± 0.771 | 0.09 (-0.01 – 0.19) | | |
| **Dog personality** | *n*=1185 | *n*=201 | | | |
| Energy | 3.86 ± 0.601 | 3.86 ± 0.595 | 0.01 (-0.09 – 0.12) | 0.942 | < 0.001 |
| Affection | 3.71 ± 0.510 | 4.02 ± 0.563 | 0.60 (0.49 – 0.71) | | |
| Conscientiousness | 3.48 ± 0.552 | 3.56 ± 0.553 | 0.14 (0.04 – 0.25) | | |
| Neuroticism | 2.70 ± 0.740 | 2.38 ± 0.802 | 0.42 (0.32 – 0.53) | | |
| Intelligence | 3.85 ± 0.488 | 3.80 ± 0.433 | 0.10 (0.00 – 0.21) | | |

Table 7. Owner personality and adult attachment (AAS) and dog personality from German and Hungarian questionnaire data (mean ± sd). For each personality scale the Cohen's *d* effect size and 95% confidence interval (CI) are given. The three personality measures between the two populations were compared by MANOVAs for which Wilks' λs and *p*s are given.

Binomial generalized linear models (GLMs) with separation-related disorder (SRD: 0 or 1) as response variable were used. Four sets of models were built. First, the effect of potential confounding variables (age and gender of dog, and age and gender of owner) were investigated in one model set. As the age of dog and the time the dog and the owner were living together were highly correlated in both datasets (Spearman correlations, Germany:

$r_s$=0.882, n=1075, p<0.001, Hungary: $r_s$=0.915, n=205, p<0.001), only the effect of age of dog on SRD was investigated as confounding variable. All four potential confounding variables were included in the initial model and non-significant terms were removed by backward model selection based on likelihood-ratio tests. In Hungary none of the confounding variables had a significant effect on SRD, whereas in Germany the dogs of female and older owners had less often SRD (likelihood-ratio tests, age of owner: $b$=–0.02±0.007, $\chi^2$=6.480, $df$=1, $p$=0.011, gender of owner: $b$=–0.79±0.244, $\chi^2$=9.591, $df$=1, $p$=0.002).

Second, the effect of human personality, human attachment (AAS) and dog personality on SRD was investigated in three binomial GLMs. In case of Germany, also the confounding variables having a significant effect in the first model set were included in all models.

Sample sizes were relatively large in both datasets, and this can cause significant results even at small differences. Therefore, we report not only the parameter estimates and their significance from the GLMs, but also the appropriate standardized effect sizes ($r$) and their 95% confidence intervals (CIs) following Nakagawa and Cuthill (2007). Statistical analyses were performed in R (version: 3.1.0, R Core Team, 2014).

## 5.3 Results

### 5.3.1 Ratio of dogs with SRD in the two samples

In the German sample 218 dogs (18.4%, $n$ = 1185) were reported to have SRD. In the Hungarian sample this number is 107 dogs (33.1%, n = 323) with SRD which ratio is significantly higher than the ratio of dogs with SRD in the German sample ($\chi^2$ = 31.7, $df$ =1, $p$ < 0.001).

### 5.3.2 Effect of owners' attachment scales (AAS) on SRD in dogs

With increasing *avoidance* score of owners the occurrence of SRD in dogs increased significantly with similar estimated slope (Figure 10) in the two populations, whereas *anxiety* score of owners had no effect on SRD (Table 8).

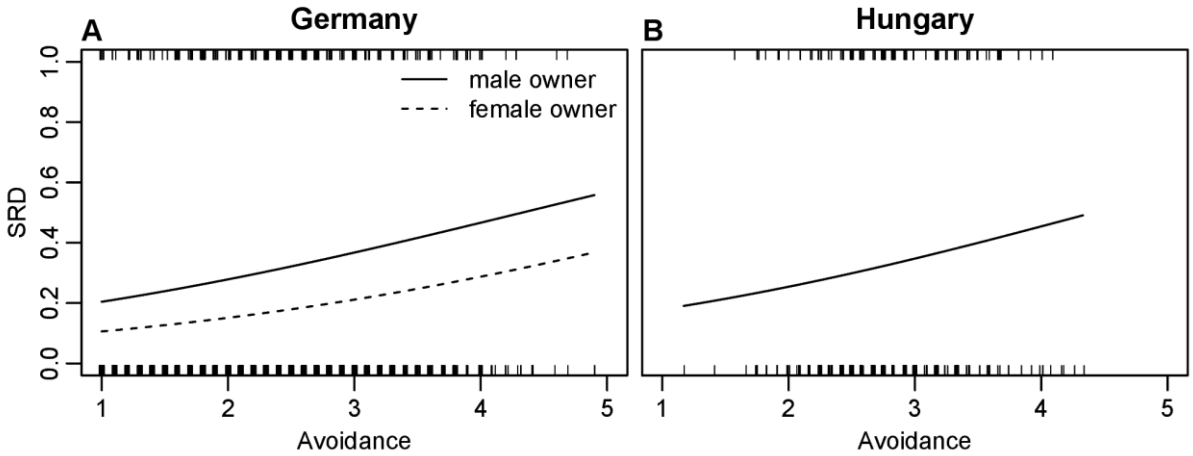


Figure 10. The effect of human avoidance on dog separation disorder (SRD) in German and Hungarian questionnaire data. Lines represent fitted values from binomial GLMs in Table 8. Fitted values were calculated at the mean value of independent variables not shown on the plots. Rugs on the top and bottom of the plots represent the data points with SRD and without SRD, respectively. In case of ties, small amount of random noise were added to visualize the spread of data. 'A' panel represents German, 'B' panel represents Hungarian data.

| | **Germany** | | | | **Hungary** | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **estimate** | ***z*** | ***p*** | ***r* (95% CI)** | **estimate** | ***z*** | ***p*** | ***r* (95% CI)** |
| **Avoidance** | 0.41 ± 0.106 | 3.850 | < 0.001 | 0.11 (0.08 – 0.14) | 0.45 ± 0.223 | 1.999 | 0.046 | 0.11 (0.06 – 0.17) |
| **Anxiety** | -0.08 ± 0.104 | -0.797 | 0.425 | -0.02 (-0.05 – 0.01) | 0.01 ± 0.156 | 0.062 | 0.951 | 0.00 (-0.05 – 0.06) |

Table 8. Parameter estimates (± se) from binomial GLMs for the Adult Attachment Scale. Wald tests, standardized effect sizes (*r*) and their 95% CI are given. Note that in case of German data gender ($b$=–0.774±0.237, $p$=0.001) and age of owner ($b$=–0.015±0.007, $p$=0.031) were also in the model.

### 5.3.3 Effect of human personality (BFI) scales on SRD in dogs

None of the human personality scales influenced SRD in dogs significantly in either datasets. There was a marginally significant effect of owner's neuroticism in Germany: the occurrence of SRD in dogs of more neurotic owners was higher, however, the calculated effect size was negligible (r<0.1, Table 9). In Hungary, the slope of this effect was similar (Figure 11) and had a similar effect size, but was far from significant.

Furthermore, openness had a marginally significant effect in Germany, but with very low effect size. Conscientiousness had a just marginally (p=0.098) significant effect in Hungary, and had different slope in the two populations. Agreeableness had a just marginally (p=0.091) significant effect in Germany, and with very low effect size, and the slopes were different in the two populations.

| | **Germany** | | | | **Hungary** | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **estimate** | ***z*** | ***p*** | ***r* (95% CI)** | **estimate** | ***z*** | ***p*** | ***r* (95% CI)** |
| **Extraversion** | -0.01 ± 0.126 | -0.109 | 0.913 | 0.00 (-0.03 – 0.03) | -0.17 ± 0.237 | -0.737 | 0.461 | -0.05 (-0.12 – 0.02) |
| **Agreeableness** | -0.28 ± 0.166 | -1.693 | 0.091 | -0.05 (-0.08 – -0.02) | 0.25 ± 0.305 | 0.826 | 0.409 | 0.06 (-0.01 – 0.13) |
| **Conscientious-ness** | 0.02 ± 0.144 | 0.161 | 0.872 | 0.00 (-0.02 – 0.03) | -0.43 ± 0.262 | -1.655 | 0.098 | -0.12 (-0.19 – -0.05) |
| **Neuroticism** | 0.24 ± 0.124 | 1.923 | 0.054 | 0.06 (0.03 – 0.08) | 0.25 ± 0.241 | 1.023 | 0.306 | 0.07 (0.00 – 0.14) |
| **Openness** | 0.26 ± 0.139 | 1.831 | 0.067 | 0.05 (0.02 – 0.08) | 0.04 ± 0.271 | 0.165 | 0.869 | 0.01 (-0.06 – 0.08) |

Table 9. Parameter estimates (± se) from binomial GLMs for the human personality (BFI). Wald tests, standardized effect sizes (*r*) and their 95% CI are given. Note that in case of German data gender ($b$=–0.75±0.240, $p$=0.002) and age of owner ($b$=–0.01±0.007, $p$=0.074) were also in the model.

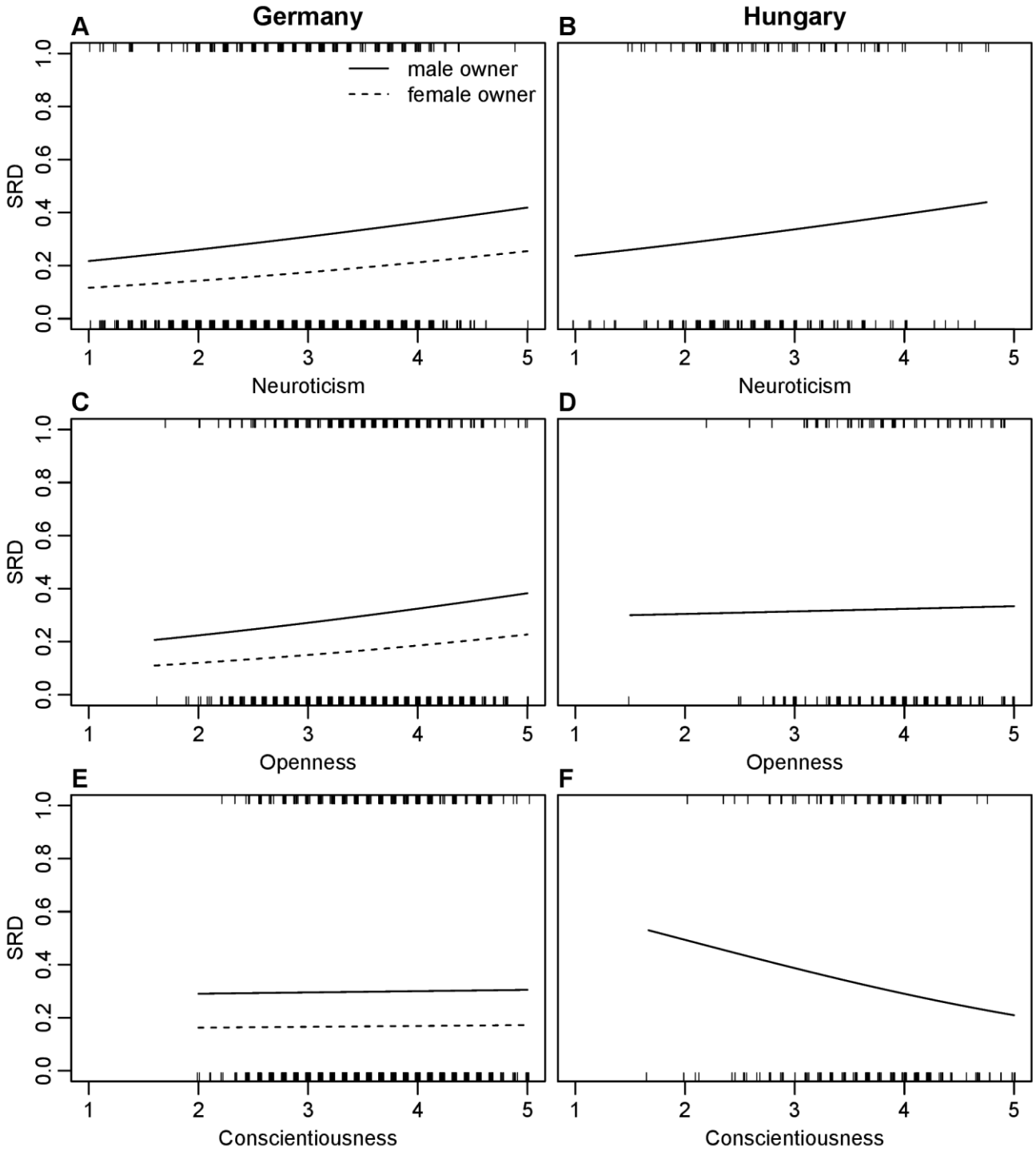


Figure 11. The effects of human neuroticism, openness and conscientiousness on dog separation disorder (SRD) in German and Hungarian questionnaire data. Lines represent fitted values from binomial GLMs in Table 9. For further details see legend of Figure 10. The panels represent German (A, C and E) and Hungarian (B, D and F) data regarding the effect of human *neuroticism*, *openness* and *conscientiousness*, respectively on dog's SRD.

### 5.3.4 Relationship between dog personality (DBFI) scales and SRD in dogs

In both populations, the more *neurotic* dogs had more often SRD (Table 10). More *affectionate* dogs had more often SRD in Germany, but the effect size was negligible. Furthermore the non-significant slope of this relationship was different in Hungary (Figure 12). In case of *conscientiousness* there was a marginally significant effect with negligible effect size in Germany, but the slopes were different in the two populations (Table 10, Figure 12).

| | **Germany** | | | | **Hungary** | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **estimate** | ***z*** | ***p*** | ***r* (95% CI)** | **estimate** | ***z*** | ***p*** | ***r* (95% CI)** |
| **Energy** | 0.07 ± 0.156 | 0.453 | 0.650 | 0.01 (-0.02 – 0.04) | 0.42 ± 0.328 | 1.296 | 0.195 | 0.09 (0.02 – 0.16) |
| **Affection** | 0.38 ± 0.177 | 2.167 | 0.030 | 0.06 (0.03 – 0.09) | -0.03 ± 0.353 | -0.079 | 0.937 | -0.01 (-0.08 – 0.07) |
| **Conscien-tiousness** | -0.31 ± 0.165 | -1.847 | 0.065 | -0.05 (-0.08 – -0.02) | 0.19 ± 0.352 | 0.529 | 0.597 | 0.04 (-0.03 – 0.11) |
| **Neuroticism** | 0.98 ± 0.129 | 7.551 | < 0.001 | 0.21 (0.19 – 0.24) | 1.28 ± 0.279 | 4.579 | < 0.001 | 0.31 (0.25 – 0.37) |
| **Intelligence** | 0.19 ± 0.213 | 0.891 | 0.373 | 0.03 (0.00 – 0.06) | 0.31 ± 0.432 | 0.726 | 0.468 | 0.05 (-0.02 – 0.12) |

Table 10. Parameter estimates (± se) from binomial GLMs for the dog personality (DBFI). Wald tests, standardized effect sizes (*r*) and their 95% CI are given. Note that in case of German data gender ($b$=–0.869±0.247, $p$<0.001) and age of owner ($b$=–0.007±0.007, $p$=0.303) were also in the model.

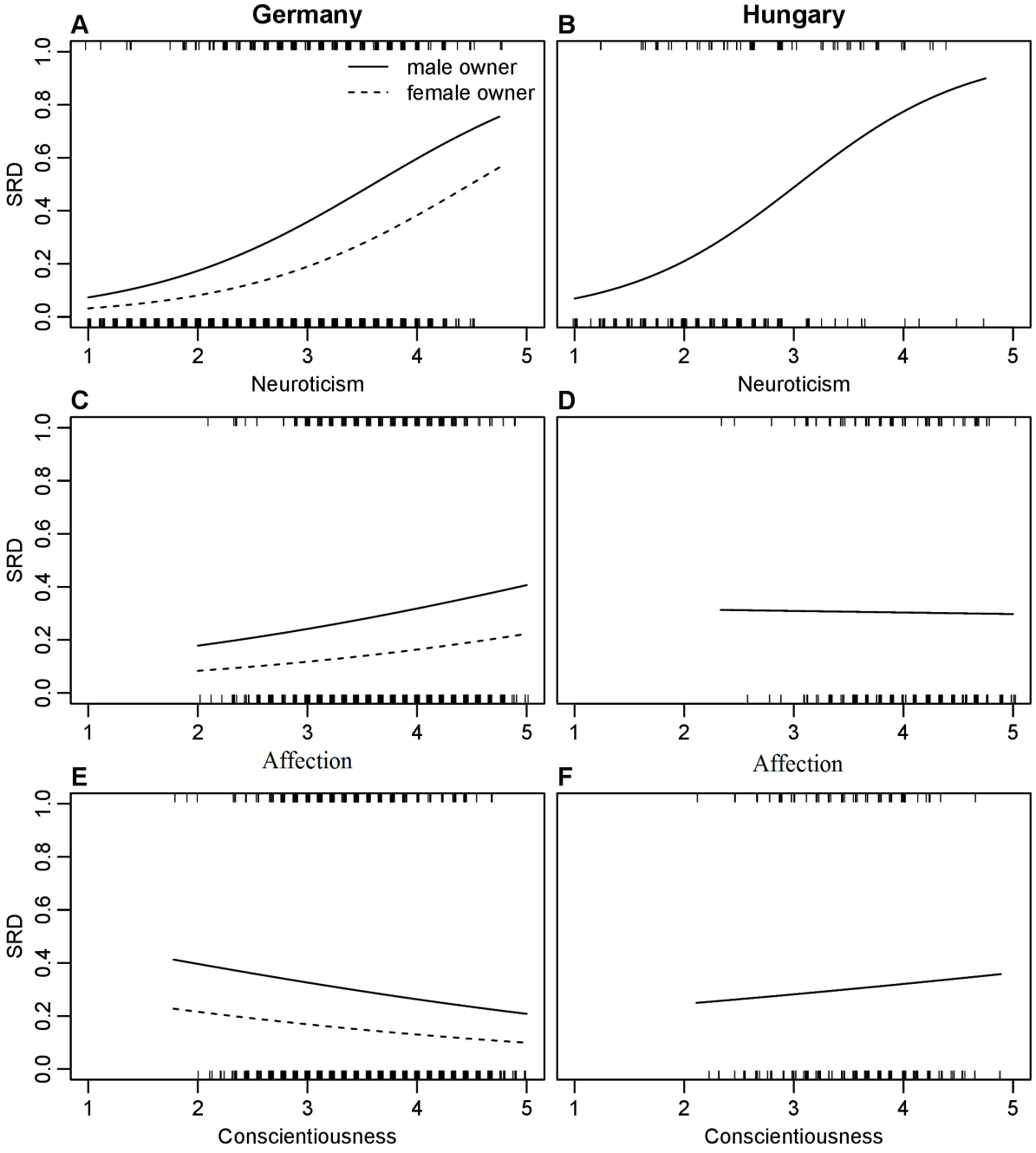


Figure 12. The effect of dog neuroticism, affection and conscientiousness on dog separation disorder (SRD) in German and Hungarian questionnaire data. Lines represent fitted values from binomial GLMs in Table 4. For further details see legend of Figure 1. The panels represent German (A, C and E) and Hungarian (B, D and F) data regarding the effect of dogs' *neuroticism, affection* and *conscientiousness*, respectively on dog's SRD.

## 5.4 Discussion

### 5.4.1 Effect of human attachment on dogs' SRD

In accordance with our hypothesis we found that owners scoring higher on self-reported attachment *avoidance* are more likely to have dogs with separation-related disorder. Although we cannot be sure about the direction and causality of this relationship, there are reasons to assume that the owners' avoidant attachment contributes (at least in part) to the behavior problem of the dog. This assumption is strengthened by the analogy between child-parent and dog-owner relationship (Topál et al., 1998; Prato-Previde et al., 2003) and by the results of the human studies on parent-child attachment and parenting (see Introduction).

We suppose that owners' attachment style influences their caregiving behavior toward the dog: they may show a less consistent responsiveness to the dog's needs. Owners with insecure-avoidant attachment style avoid intimate contacts, closeness and affection (Hazan and Shaver, 1987) and it is possible that they behave in this way not only in their interpersonal relationships but also toward their dogs. Dogs who meet refusal or ignorance of their needs (e.g. need for contact) can learn that they cannot be sure about the availability of the owner. We should note, however, that a recent study did not find a correlation between people's interpersonal attachment avoidance and avoidance toward their pet, although their attachment anxiety toward people was correlated with attachment anxiety toward pets (Zilcha-Mano et al., 2011).

Additionally, avoidant owners may refuse the attachment behavior of their dog especially in stressful situations. This assumption is also based on the human literature: mothers displaying high levels of avoidance are less responsive when their child is highly distressed, while this pattern is reversed among parents scoring low on avoidance (Edelstein et al., 2004). According to Van Ijzendoorn's (1995), dismissing parents may often refuse the attachment behavior of their child in stressful situations because such behaviors trigger negative attachment-related memories in them.

As a consequence, avoidant mothers' children experience higher distress during the stressful event (Edelstein et al., 2004). Similarly, avoidant dog-owners' refusal of the dog's attachment behavior may contribute to the dogs' stress response to separation escalates. Thus, the owner constitutes neither a secure base (see also Study 2 or Konok et al., 2011) nor a safe haven for them. An insecure attachment develops in the dog that can contribute to SRD.

We found no effect of owners' attachment *anxiety* on the dog's SRD, which is in accordance with the findings of the human mother-child attachment studies. Namely, that parental anxious attachment does not lead to deficiency in parental sensitivity/responsiveness, but rather in autonomy support/non-intrusiveness (Adam et al., 2004; Whipple et al., 2011). As parental sensitivity seems to play the primary role in developing secure attachment (e.g. Ainsworth et al., 1971) and separation anxiety (Dallaire and Weinraub, 2005) in the child, it is a logical consequence that *avoidance* in the parent contributes to separation anxiety in the child, but attachment *anxiety* does not. The same may be true for owners and dogs.

### 5.4.2 Effect of human personality on dogs' SRD

Owners' *extraversion* had no effect on their dogs' SRD in either sample, *neuroticism, conscientiousness, agreeableness* and *openness* had only a marginal ($0.1>p>0.05$) effect in one of the samples.

Thus, the results do not support our hypothesis that owners with higher *neuroticism* are more likely to have dogs with SRD. It is surprising because in the human literature association was found between mothers' (or parents') *neuroticism* and anxiety disorder and children's less secure attachment, behavior problems and separation anxiety disorder (Kochanska et al., 2004; Biederman et al., 2001; Manassis et al., 1994). In case of dogs, owners' *neuroticism* correlated with dogs' *neuroticism* (Turcsán et al., 2012) (which was found also to predict dogs' SRD in the present study, see later) and with the degree of the dog's displacement activities (O'Farrell, 1997). In the light of these results one can assume that owners' *neuroticism* can also contribute to separation-related disorder in the dog. Although the effect was almost significant ($p=0.054$) in the German sample, we cannot verify our hypothesis. Maybe other factors should be investigated in future studies that can account for the weakness of the relationship.

### 5.4.3 Relationship between dogs' personality and SRD

In accordance with our hypothesis, we found in both samples that more *neurotic* dogs had more often SRD. *Neurotic* dogs are prone to stress (and to other negative emotions) in any situation including separation situations. This is in accordance with Mendl et al.'s (2010) study which suggests that SRD dogs are generally in a negative affective state. This proneness to negative emotions and distress can be the result (at least partly) of the attachment problem

as it is supported by some evidence in the case of humans (e.g. Warren et al., 1997). According to Bowlby (1969) the attachment relationship directly influences the infant's capacity to cope with stress by impacting the maturation of the „control system" of the infant's mind. Fischer-Mamblona (2000) argues also that the lack of a primary attachment object may cause an immense escape motivation both in humans and in animals.

In Study 2 we found that SRD dogs did not show more affection toward the owner and the same was found by Parthasarathy and Crowell-Davis (2006). We interpreted these results as an argument against the commonly hold belief that SRD dogs are "hyper-attached" to the owner (Konok et al., 2011). In the present study our results are mixed: although in the Hungarian sample we did not find any effect of *affection* on dogs' SRD , in the German sample more *affectionate* dogs had more often SRD (although the effect size was negligible). Interestingly, the non-significant slope of this relationship was different in Hungary. The reason of this difference is unclear and needs to be investigated in future research.

*Energy*, *conscientiousness* and *intelligence* had no significant effect on SRD in either sample.

### 5.4.4 Ratio of dogs with SRD in the two samples

Hungarian owners reported SRD in their dog in a significantly higher ratio than German owners. According to a recent survey which screened 1201 dog owners with 1960 dogs across the United States 13% of the dogs had separation anxiety (Thundershirt, 2011). Thus, the ratio seen in the German sample is similar to the American one. In our previous, experimental study in Hungary (Study 2) we experienced the same high ratio of SRD in a rather limited sample (15 out of 44 dogs, 34%) as in the present Hungarian sample. The reason of this difference in the prevalence of SRD between nations is still unclear and needs to be investigated in future research.

# 6 Study 4: Emotion attribution to a non-humanoid robot in a social situation

## 6.1 Introduction

As discussed in the General Introduction, a general requirement for social robots is that they should be able to participate in different interactions with humans. In order to interact in a meaningful way a robot has to convey intentionality and emotions of some sort in order to increase believability.

The importance of the representation of emotions in artificial agents (or virtual characters) has been recognized long ago in art. According to Thomas and Johnston (1981), two of the core animators of the Disney's productions, "it has been the portrayal of emotions that has given the Disney characters the illusion of life". Bates et al. (1994) claimed that emotional behavior makes social robots more believable and attractive for humans. Although many robots and virtual agents have been supplied with affective expressions so far (see General Introduction), analyzing humans' (behavioral) reactions to the emotional expressions of these artificial agents in direct human-robot interaction tests are relatively rare. For example, one of these few studies showed that subjects tended to feel less lonely and found the agent (Max) more life-like if it expressed empathy toward them compared to situations, in which the robot did not show emotions or tended to be self-centered (Becker-Asano, 2008). Additionally, the electromyography showed that subjects had higher activity of the masseter muscle (which is one of the muscles of mastication and an indicator of negative valence) when the agent expressed negative empathy ("Schadenfreude") compared to positive empathy (Becker-Asano, 2008).

Bruce and colleagues (2002) found that if they supplied their robot with a face that expressed adequate emotions, people were more willing to interact with it, that is, they more frequently stopped in their way to answer some questions the robot asked from them. Leite and colleagues (2008) reported that users understood better the actual state of a chess game (whether they were losing or winning) if the iCat robot opponent produced adequate emotional expressions. Thus, it seems that the robot's expression of emotions facilitates the human-robot interaction (Fong et al., 2003) and may contribute to the long-term engagement of humans towards artificial companions.

Many of the present-day social robots are built to have humanoid embodiments and their behavior is designed on the basis of human psychological models. However, human-human interactions are very complex, are generally symmetric, develop since birth and are based on the use of language. Hereby, it is extremely hard for robot designers to mimic human behavior successfully and the robots mimicking human behavior will never be perfect "humans". This leads to the well-known phenomenon of the „uncanny valley" (Mori, 1970), that is, agents which are very but not totally similar to humans, induce aversion in people.

Other companion robots are designed to have rather pet-like appearance (e.g. PLEO, AIBO, PARO; Pitsch and Koch, 2010; Fujita, 2004; Shibata and Wada, 2011) and have also been used as alternatives to animal assisted therapy (Shibata and Wada, 2011; Melson et al., 2009). However, the behavioral repertoire of these pet-like social robots is very limited and for this reason, compared to animal pets they proved to be less successful in maintaining humans' interest in long term (Kaplan, 2001; Donath, 2004).

The application of animal models for the behavioral design could provide an important alternative in the development of future social robots (Miklósi and Gácsi, 2012). Human-animal interaction can provide a useful alternative since similarly to human-robot interactions human-animal interactions are asymmetric, they are much simpler than human-human interactions, they may start at any age and importantly, human-animal social interactions develop without using language via non-verbal communicational behavior. We argue (Lakatos et al., 2014) that social robots should not necessarily be human-like - nor pet-like in appearance - but rather functional with regard to their roles in the human community, and their social behavior could be based on the abstractions of the behavior observed in companion animals when they interact with humans.

Accordingly, human-robot interaction could be regarded as a specific form of inter-specific social interaction. This situation has its natural analogies in human-animal interaction, including humans' specific relationship with domesticated animals (such as dogs, cats, etc., see below) or wild living species, like dolphins (Trone et al., 2005). The analysis of these behavioral analogies (human-animal interactions) enables us to build behavior models on inter-specific interactions based on naturalistic evidence.

Domestic animals seem to be the best candidates for providing the inspiration to design robot behavior because they are able to develop effective social interaction with humans (Miklósi and Gácsi, 2012). Human-dog interaction has already been suggested as a framework to model human-robot interactions before (Miklósi and Gácsi, 2012; Dautenhahn, 2004). Dogs

engage successfully in complex social interactions (e.g. cooperation) with humans despite their less complex cognitive capacities. We also know that owners can recognize the behavior of dogs, which corresponds to its emotional states (see General Introduction). There is much to be learnt from dogs about how they achieve a relatively complex level of social interaction with humans (Miklósi and Gácsi, 2012), hence we (Lakatos et al., in press) assume that dogs provide an appropriate animal model for building social robots.

Note, however, that when we propose to design emotionally expressive behavior of robots using the behavior of dogs as inspiration, we do not want to copy dog behavior in any direct sense. Our goal is to observe the behavioral organization of various behavior systems in dogs and build a functional analogue into our robots. Then these dog-inspired robots can be tested during direct interactions with humans to see how they manage social interactions in an inter-specific context.

The present study constituted part of a European funded research project named LIREC (Living with Robots and Interactive Companions). LIREC was a collaboration of 10 European partners specialized in psychology, ethology, human-computer interaction, human-robot interaction, robotics and graphical characters. It explored how to design digital and interactive companions who can develop and read emotions and act cross-platform. The LIREC network aimed to create a new generation of interactive, emotionally intelligent companions that is capable of forming long-term, meaningful relationships with humans (http://lirec.eu/project). Our research group added ethological aspects for the development of these interactive companions, offering dogs as a model species for designing human-robot interactions.

As part of this project we investigated the effects of the emotionally expressive behaviors of a robot that were inspired by functionally analogous behaviors observed in dogs. By the means of both direct (behavioral observations) and indirect ('Robot Anthropomorphizing Questionnaire': see below) measures we wanted to study whether the non-human ways of emotion expression influenced human-robot interactions. We provided our companion robot with two kinds of emotional behavior (joy and fear) designed on the basis of dogs' expressive behavior (canine 'happy' and 'fearful' behavior), and studied whether people recognized and attributed the appropriate emotion to the robot, and interacted with it accordingly.

Recognition of joy and fear has been examined in many different robotic platforms so far (Saldien et al., 2010; Sosnowski et al., 2006; Kühnlenz et al., 2010; Canamero, 2002), showing that fear is generally more difficult to recognize for people (Saldien et al., 2010) and that animal-like features have a positive effect on robotic emotion recognition (Kühnlenz et

al., 2010). However, previous studies used mostly facial expressions to express emotions and no direct behavioral observations were taken to analyse humans' reactions. In this regard the present experiment provides two important novelties.

We hypothesized that the dog-inspired expressive behavior will be readable for humans and they will attribute the appropriate emotions to the robot. In addition, in line with the results of earlier studies we expected a lower emotion recognition rate in case of the 'fearful' emotional behavior.

Here we present the results of an experiment (Emotion Attribution Test) in which we examined humans' ability to recognize two primary emotions expressed by a robot. Apart from getting a subjective feedback from the subjects, we were interested in the behavior of the participants during the interactions with the robot. We also examined whether interacting with the robot can change the subjects' attitude towards robots in general.

## 6.2 Method

### 6.2.1 Subjects

71 individuals (37 men, 34 women, age: median=24, range=19-34) participated in the Emotion Attribution Test, of which the data of 48 individuals was analyzed (26 men and 22 women, age: median=24, range=19-34 years. The remaining 23 individuals were excluded from the further analysis due to technical problems (some parts of the robot did not function properly) or due to mistakes in the procedure. The questionnaire data of these 48 individuals is analyzed here.

### 6.2.2 The robot

The robot (Mogi Robi) (Figure 13) used in this study was built by Balázs Varga, Bence Kovács, and Géza Szayer from the Department of Mechatronics, Optics, and Mechanical Engineering Informatics at the Budapest University of Technology and Economics in collaboration with the Department of Ethology at Eötvös Loránd University (Vincze et al., 2012). This robot was controlled by the means of a remote controller via bluetooth connection. It could travel freely around in the room and move its head, rear-antenna and ear-like appendices independently from the body. The two 'ear-like appendices' could be rotated either upward or backward, and a rear antenna could also be positioned upward or downward,

and moved sideways (3 degree of freedom (DOF) head, 2 DOF neck, 1 DOF ear-like appendix, 2 DOF rear antenna).

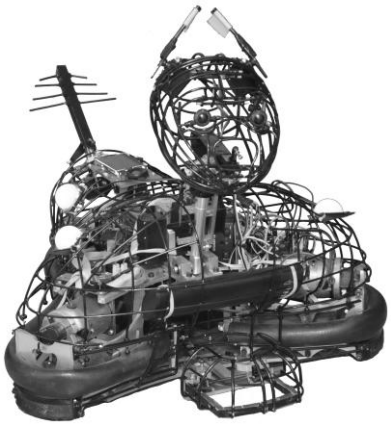

Figure 13. Photo of the robot, called "Mogi Robi" used in Study 4. Its size relative to a human person can be seen in Figure 15.

### 6.2.3 Procedure

The whole procedure consisted of 3 subsquent experiments, however, as the experiments were conducted in collaboration, only the results of Experiment 1 (Emotion Attribution Test) I was personally involved in will be dealt with in detail.

Human subjects filled out three pre-test questionnaires at their computer at home or at the department before they met the robot. It took approximately 15 minutes to complete the questionnaires. I will discuss here only the results of the third questionnaire (Negative Attitudes towards Robots Scale, see Appendix 8) as only this is relevant from the perspective of this thesis. After filling out of the questionnaires subjects participated in three experiments, which followed each other in a fixed order: (1) Emotion Attribution, (2) Guilt Attribution and (3) Personality Attribution. The results of the second and the third experiment will not be discussed here further. The experiment took place at the Family Dog Project laboratory, Eötvös Loránd University (Budapest, Hungary). The Emotion Attribution Test lasted approximately 5 minutes (the three experiments together lasted approximately 20 minutes). After the tests the subjects filled out two post-test questionnaires what took about 10-15 minutes to complete. In one of the post-test questionnaires (Robot Anthropomorphizing Questionnaire, Appendix 9) we asked questions specifically about the Emotion Attribution Test, whereas the other one was a repetition of the Negative Attitudes towards Robots Scale (see later).

### 6.2.4 Emotion Attribution Test

During the test the robot was always controlled from an adjoining room by an experimenter (who could follow the actions of the robot on a computer monitor), but the participants were unaware of this condition.

Before the experiment, the subjects were informed that they were supposed to interact with a robot and we explained them what to do during the test. Before the test the participants did not know anything about how the robot looks like and what it is able to do. We only answered participants' questions about the procedure of the behavior tests but did not answer questions regarding the robot's skills or behavior. In case of such questions we asked the participants to wait for the answers until the end of the behavior tests.

The experiment was conducted in a wizard-of-oz scenario. For the testing we used two different-colored balls with which Mogi Robi and the subject interacted. Mogi Robi's reaction toward the ball was one of two different kinds: preference or non-preference (see detailed description below).

#### 6.2.4.1 Experimental design of the Emotion Attribution Test

There were two independent variables: the robots' reaction to the ball, that is, preference or non-preference, and the color of the ball, that is, yellow vs. black-and-white (see below). We used a within-subject design: each subject participated in both conditions (preference and non-preference), but the order of these two conditions and the color of the preferred ball were counterbalanced among subjects. Twenty-four subjects participated in the 'preferred ball' condition first, and in the 'non-preferred ball' condition second; out of the 24 participants in case of 12 participants the preferred ball was the yellow one, while in the case of the other 12 participants the preferred ball was the black-and-white one. Another 24 subjects participated in the 'non-preferred ball' condition first, and in the 'preferred ball' condition second; again, for 12 of these participants the preferred ball was the yellow one, while for the other 12 participants the preferred ball was the black-and-white one.

#### 6.2.4.2 Procedure of the Emotion Attribution Test

The two balls (a yellow tennis ball and a black-and-white ball of the same size) balls were placed in a bag at the beginning of the test. The bag (30x40 cm), in which the balls could be

placed during the testing, was fixed on the handle of one of the doors. Mogi Robi was placed in the testing room at the predetermined position (see Figure 14).

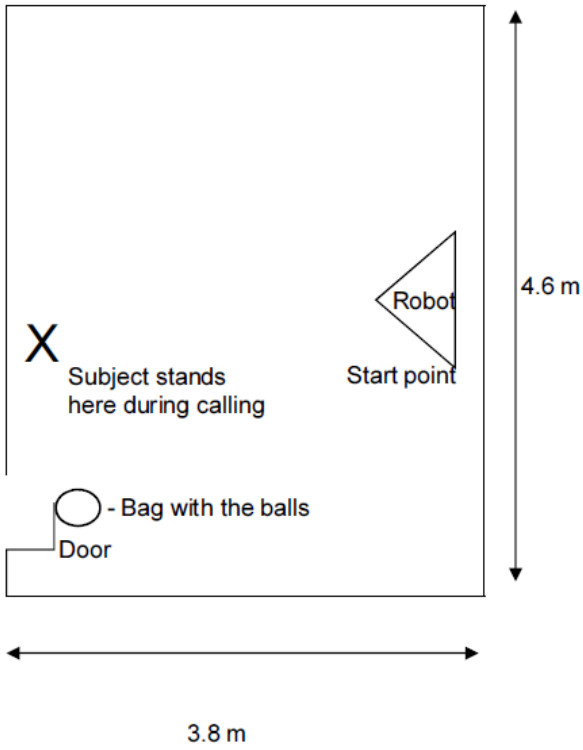


Figure 14. Experimental layout of the Emotion Attribution Test.

The experiment consisted of four episodes.

*Episode 1: 'Greeting'* (15-20 s): The robot's starting position was in the back of the room, it stood with the tufts upward, holding his steady antenna in upright position. The behavior of Mogi Robi was modeled on the greeting behavior displayed by companion dogs. We asked the subjects to enter the room and call Mogi Robi. The robot was turning its head toward the entering person, moved its antenna sideway mimicking the tail wagging of a happy dog and started to move its antenna. When called by the subject, the robot approached her/him wagging its antenna (see Figure 15.). Arriving at the subject, Mogi Robi lowered its antenna and tufts.

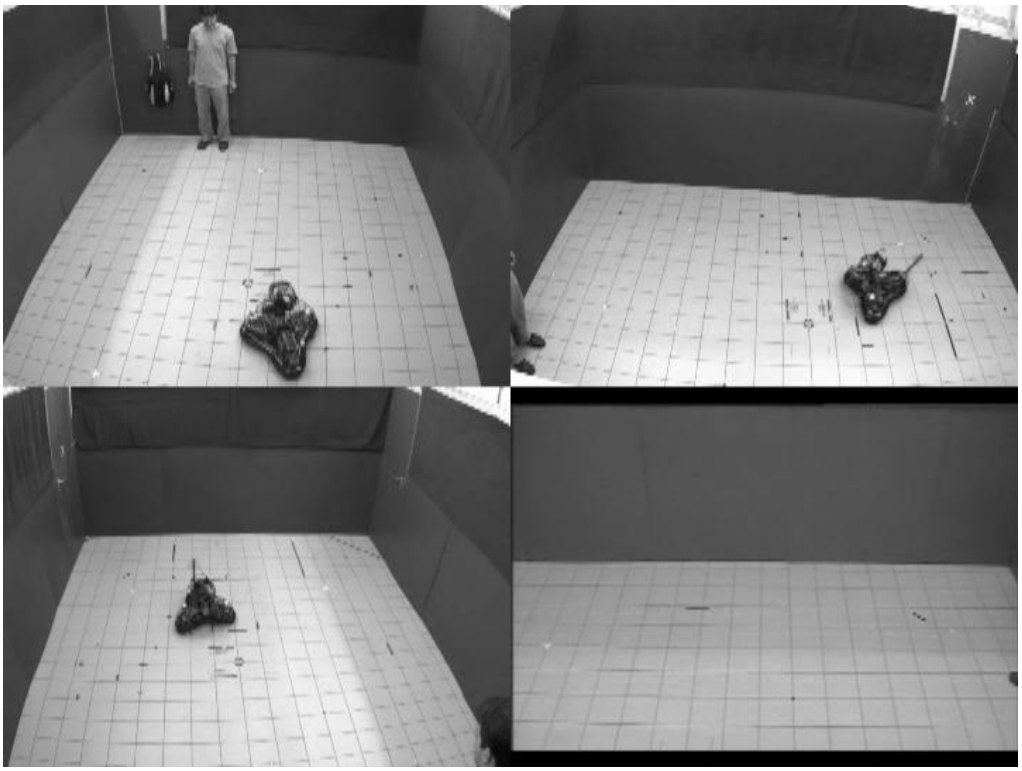

Figure 15. Still picture from the start of the ‘Greeting’ episode. Mogi Robi is approaching the entering subject who is standing still at the door. The four pictures are the synchronized views of the four cameras.

*Episodes 2 and 3: ‘Directed play 1, 2’* (2x1 minute): The subject was told to play with Mogi Robi for 1 minute with each ball. There were two conditions. In one condition the robot was attracted to one of balls (‘preferred ball’ condition), while in the other condition it showed avoidance toward the other ball (‘non-preferred ball’) (see below the details of the expressed behavior). The order of these two conditions and the color of the preferred ball were counterbalanced among subjects. The ball which was not used was always put away in the bag. Subjects had no a priori knowledge about the preferences of the robot.

*Episode 4: ‘Free play’* (1 minute): The two ‘directed play’ episodes were followed by a ‘free play’ episode without break. The subject could play again with Mogi Robi, but now he/she was free to play with either of the balls. He/she was allowed also to switch the balls, but only one ball could be used at a time, the other ball had to be kept in the bag. During the ‘free play’ Mogi Robi expressed the corresponding emotions related to the specific ball.
The experimenter indicated the end of each episode by knocking on the door.

#### 6.2.4.3 Emotional behavior of the robot

When the subject played with the preferred ball (in the ‘preferred ball’ condition, and during the ‘free play’ episode) the robot expressed behavioral features that resembled the canine „happy” behavior: upward tail and ear-posture, tail-wagging, approaching the targeted object (Melson et al., 2009; Kubinyi et al., 2007). When the subject played with the non-preferred ball (in the ‘non-preferred ball’ condition, and during the ‘free play’ episode) the canine behaviors typical in frightening situations (pulled-back tail and ears, holding maximum distance from the object of fear) were applied. Note, however, that the robot’s tufts and antenna, showed relatively little physical resemblance to the ears and tail of dogs (see Figure 13). Based on the above characteristics the robot’s expressive behavior was designed as follows:

‘Preferred ball’ condition: When the subject took out the ball, the robot lifted its antenna and tufts, and wagged its antenna. When the subject threw/rolled the ball, the robot always approached it and brought it back to the subject (Figure 16, left side).

‘Non-preferred ball’ condition: When the human took out the ball from the bag, the robot stopped moving the antenna, went closer to the ball, oriented its head towards it and suddenly lowered down its antenna and tufts, and backed. It tried to maintain as large distance from the ball as possible. When the human subject threw/rolled the ball toward the robot, it moved to the other side of the room (Figure 16, right side).

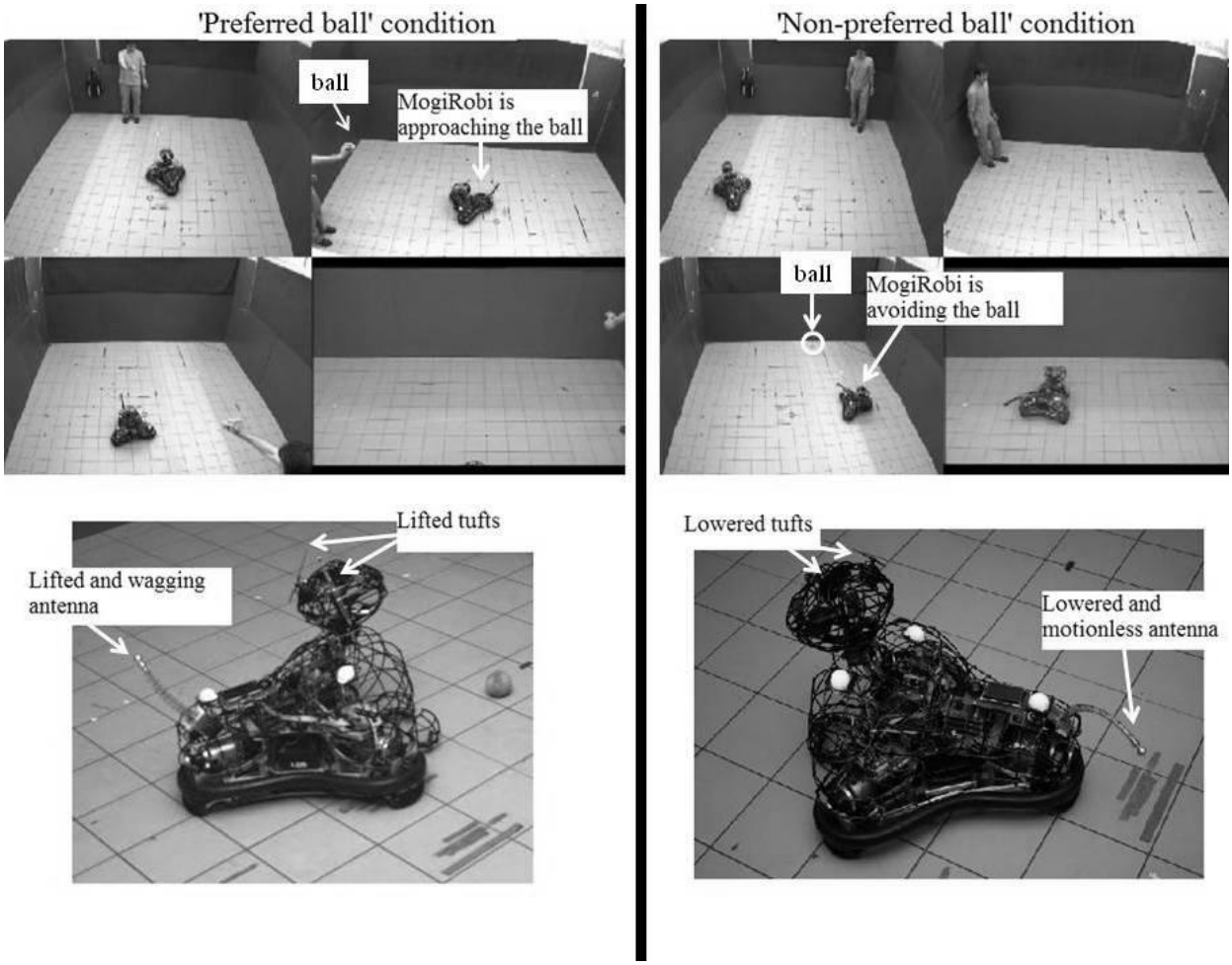


Figure 16. Photos of the ‘preferred ball’ (left side) and ‘non-preferred ball’ (right side) conditions.

#### 6.2.4.4 Behavior coding

The experiment was video-recorded for later analysis. Solomon Coder beta 10.11.29 (Copyright © 2010 András Péter; http://solomoncoder.com) was used for behavioral coding.

We recorded the time percentage the subjects played with each of the balls in the ‘free play’ episode and coded the subjects’ verbal and nonverbal behaviors (similarly to Fox, 1978; Topál et al., 1998; Gácsi et al., 2013, Prato-Previde et al., 2013) during the whole behavioral test (in all four episodes). The specific behavior elements coded are presented in Table 11. We counted the frequencies of the coded behavior elements, and formed scales from those elements that had similar function or indicated similar inner state of the subject (we had no pre-conceptual categories, the scales were formed inductively). Values of the scales are the

sum of the corresponding variables (e.g. total frequency of any positive emotional display). These scales are the following (the composition of the scales can be seen in Table 11):

Positive emotional behaviors (PosEmo): Sum of behavior frequencies indicating positive emotion

Negative emotional behaviors (NegEmo): Sum of behavior frequencies indicating negative emotion

Confusion related behaviors (Confuse): Sum of behavior frequencies indicating confusion, embarrassment or indecisiveness

Commands and attention-calling behaviors (CommandAtt): Sum of behavior frequencies functioning as commands, instructions or attention getters.

Twenty percent (N=10) of the videos were coded also by a second observer. Inter-observer reliability was determined for each variable category by counting Cohen's Kappa coefficients between the coding of the two observers. The reliability can be considered excellent, Cohen's Kappa coefficients ranged from 0.93 to 1.

| Variables | Definition | Commu-nicative channel | Name of the scale |
|---|---|---|---|
| Calling by name | Naming the robot, like "Mogi", "Robi", "Mogi Robi" or using nicknames like "buddy". | verbal | CommandAtt |
| Calling in | Encouraging the robot to go to the subjects, like "Come!", "Come here!", "Would you come here?". | verbal | CommandAtt |
| Attention getting | Calling the attention of the robot verbally, like "Look!", "Listen!", "Hey!", or with voices, e.g. by whistling. | verbal/ acoustic | CommandAtt |
| Command („fetch!”) | Giving verbal commands to the robot concerning the fetching of the ball, like "Fetch it!", "Go for it!", "Cath it!". | verbal | CommandAtt |
| Pointing | Stretching one arm with extended index finger in the direction of the target (usually, the ball). | non-verbal | CommandAtt |
| Showing of the ball | Holding the ball in hand and bringing it closer to the robot, holding it in front of the robot (in the scope of the robot). | non-verbal | CommandAtt |
| Asking about the rules | Asking information from the experimenter about rules or permitted/ forbidden/expected behavior of the subject, e.g. "How should I throw the ball?", "May I move?", "Can I touch him?". | verbal | Confuse |
| Asking about the robot | Asking information from the experimenter about the skills, abilities or features of the robot, e.g. "Does he recognize the ball?", "What kind of commands does he know?". | verbal | Confuse |
| Expressing incomprehension | Expressing incomprehension, embarrassment or confusion, like "What's up?", "What's now?", "What's the problem?". | verbal | Confuse |
| Sad voice (without word) | Expressing sad, disappointed feelings with voice only, without words ("Ohh" with a descending intonation). | acoustic | NegEmo |
| Discouraging the robot | Discouraging, frowning or disapproving the robot's behavior or expressing dissatisfaction, resentment, displease, e.g. "Tut!", "Hey, you know this!", "Be a little bit more interactive!", etc. | verbal | NegEmo |
| Hand on hip | Putting the hands (or at least one hand) on the subject's hip. | non-verbal | NegEmo |
| Arms outspread | Spreading out the arms (or at least one arm), that is, lifting them sidelong and straight. | non-verbal | NegEmo |
| Any other gesture/ motion that expresses negative emotion | Any other gesture/ motion that expresses negative emotion (e.g. shrug, scratching of the chin, waving with the hands resignedly) | non-verbal | NegEmo |
| Praising | Praising the robot, like "Well done!", "You are clever!", "Good!". | verbal | PosEmo |
| Saying thanks | Saying thanks to the robot, e.g. "Thank you", "Thanks". | verbal | PosEmo |
| Expressing liking | Expressing general liking, satisfaction or positive feelings with the robot or with the experiment, e.g. "Cool!", "This is great!", "It's cute!", "It's funny!". | verbal | PosEmo |

Table 11. The coded behavioural variables in the Emotion Attribution Test, and the association with the four scales used in the analysis.

### 6.2.5 Questionnaires

1. Negative Attitudes towards Robots Scale (NARS) (Nomura et al., 2004) (Before and after the behavioral observation)(Appendix 8)

The NARS measures pre-existing biases and attitudes towards robots. The scale was developed using a lexical method, based on free-form responses from participants regarding anxieties towards robots. The questionnaire was validated by the means of behavioral observations: subjects with more negative attitudes toward robots behaved differently (e.g. started to talk to the robot later, uttered less, etc.) in live Human-Robot Interaction (HRI) studies (Nomura et al., 2004; Nomura et al., 2006).

The questionnaire has three sub-scales which are the following: (1) Negative Attitudes toward Situations and Interactions with Robots; (2) Negative Attitudes toward Social Influence of Robots; (3) Negative Attitudes toward Emotions in Interaction with Robots.

Subjects have to evaluate the statements on a 5-point Likert-scale. High scores indicate more negative attitudes towards robots. Subjects filled this questionnaire before and after the behavioral observation in order to see whether their attitude changes after the interaction with the robot.

2. Robot Anthropomorphizing Questionnaire (RAQ) (after the behavioral observation)

The RAQ (Appendix 9) was specifically constructed for the Emotion Attribution Test. It contained open ended and forced choice questions about the subjects' view about the robot's behavior and inner states. We were interested whether they recognized the difference in the robot's behavior toward the two balls, how they interpreted the different behaviors, and whether they used spontaneous emotion (or inner state) attribution for the interpretation. Besides, we wanted to find out which of Ekman's six primary emotions (anger, fear, happiness, surprise, disgust, sadness; Ekman, 1992) the subjects felt they had experienced during the interaction with the robot. It was also our aim to reveal on what behavior elements of the robot the subjects based their emotion attributions.

6.2.5.1 Coding of the open-ended questions of the RAQ

The answers to the open-ended questions of the RAQ (e.g. “Why did you play more with that ball?” or “What was the difference?”) were categorized after content-analysis. We assigned the answers to one or more of the following five categories: emotions, behavior, cognition, expressiveness, and other. These categories and their definitions are provided in Table 12. One answer could be assigned to more categories (e.g. if it contained reference to both emotion and cognition), but the category “behavior” was exclusive to any other category.

| **Category** | **Definition** | **Example** |
|---|---|---|
| Emotions | The subject explicitly refers to some emotion of the robot. | “The robot was afraid of the ball.” |
| Behavior | The subject refers only to the observable behavior of the robot. | “The robot did not retrieve the ball.” |
| Cognition | The subject refers to the cognition or perception of the robot. | “The robot did not recognize the ball.” |
| Expressiveness | The subject refers to some emotional expressive behavior of the robot (without mentioning specific emotion). | “The robot escaped from the ball.” |
| Other | The subject refers to something else. | “I did not like that ball.” |

Table 12. Questionnaire categories used in the RAQ (Robot Anthropomorphizing Questionnaire)

### 6.2.6 Data analysis

SPSS for Windows was used for all statistical analyses. Using the Shapiro-Wilk test, we found that most of the behavioral variables and questionnaire scales were not normally distributed, so we used non-parametric tests.

We used Wilcoxon matched pairs test to compare repeated measures and order effects. Binomial tests were used to analyze whether subjects’ choices differed from chance level, and Chi-square tests were used to observe whether ratios differ among groups.

## 6.3 Results

### 6.3.1 Emotion Attribution Test and RAQ

First, we checked whether the subjects (N=48) reacted differently to the appearance of the balls independently from the condition, in which they were used. By analyzing behavior data, we found that there was no significant difference in the time spent with playing with the two balls in the 'free play' episode (W=354; p=0.61). When we analyzed the answers of the questionnaire (RAQ) item „Which ball did you play more with?" 23 subjects reported that they played more with the black-and-white ball and 25 with the yellow. Thus for further analysis we merged the data concerning the two balls.

Next, we found that participants spent more time with playing with the 'preferred' ball compared to the 'non-preferred' one in the 'free play' episode (W=828; p<0.001, Figure 17; see also Table 13) and this was also supported by questionnaire data (RAQ): participants reported that they played more with the ball, which in that condition was the 'preferred' ball compared to the 'non-preferred' ball ($\chi^2$=24.125; p<0.001).

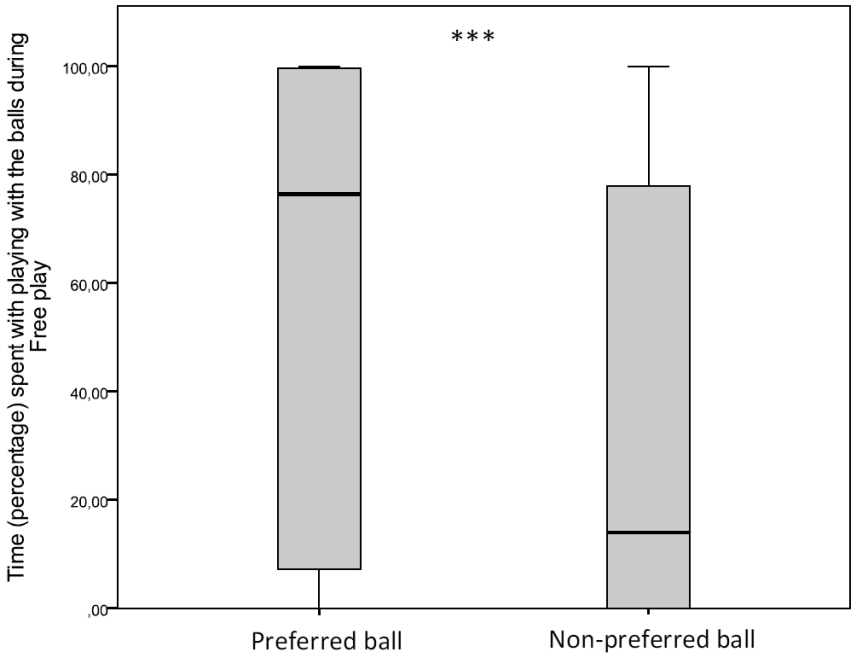


Figure 17. Time percentage spent playing with the 'preferred' and the 'non-preferred' ball during the 'free play' episode.

| Behavior variable | Median | Interquartile range | W | p |
|---|---|---|---|---|
| Time spent with playing with the yellow ball in the Free Play episode (in time percent) | 76,42 | 96,105 | 354 | 0.61 |
| Time spent with playing with the black-and-white ball in the Free Play episode (in time percent) | 13,935 | 79,0575 | | |
| Time spent with playing with the "preferred" ball in the Free Play episode (in time percent) | 97,24 | 28,775 | 828 | <0.001 |
| Time spent with playing with the "non-preferred" ball in the Free Play episode (in time percent) | 0 | 25,14 | | |
| Sum of behaviour frequencies indicating positive emotion ("PosEmo" scale) in Directed Play 1. | 0 | 0 | -105 | 0.09 |
| Sum of behaviour frequencies indicating positive emotion ("PosEmo" scale) in Directed Play 2. | 0 | 0,75 | | |
| Sum of behaviour frequencies indicating negative emotion ("NegEmo" scale) in Directed Play 1. | 0 | 1 | -6 | 0.92 |
| Sum of behaviour frequencies indicating negative emotion ("NegEmo" scale) in Directed Play 2. | 0 | 1 | | |
| Sum of behaviour frequencies indicating confusion ("Confuse" scale) in Directed Play 1. | 0 | 1 | 167 | 0.03 |
| Sum of behaviour frequencies indicating confusion ("Confuse" scale) in Directed Play 2. | 0 | 0 | | |
| Sum of behaviour frequencies functioning as commands or attention getters ("CommandAtt" scale) in Directed Play 1. | 3 | 4 | 164 | 0.19 |
| Sum of behaviour frequencies functioning as commands or attention getters ("CommandAtt" scale) in Directed Play 2. | 2 | 3,75 | | |
| Sum of behaviour frequencies indicating positive emotion ("PosEmo" scale) in the "preferred ball" condition | 0 | 1 | 240 | <0.001 |
| Sum of behaviour frequencies indicating positive emotion ("PosEmo" scale) in the "non-preferred ball" condition | 0 | 0 | | |
| Sum of behaviour frequencies indicating negative emotion ("NegEmo" scale) in the "preferred ball" condition | 0 | 0 | -198 | <0.001 |
| Sum of behaviour frequencies indicating negative emotion ("NegEmo" scale) in the "non-preferred ball" condition | 0,5 | 2 | | |
| Sum of behaviour frequencies indicating confusion ("Confuse" scale) in the "preferred ball" condition | 0 | 0 | -179 | 0.022 |
| Sum of behaviour frequencies indicating confusion ("Confuse" scale) in the "non-preferred ball" condition | 0 | 1 | | |
| Sum of behaviour frequencies functioning as commands or attention getters ("CommandAtt" scale) in the "preferred ball" condition | 2 | 3 | -452 | <0.001 |
| Sum of behaviour frequencies functioning as commands or attention getters ("CommandAtt" scale) in the "non-preferred ball" condition | 3 | 7,5 | | |

Table 13. Descriptives (medians and interquartile ranges) for the behavior variables in the Emotion Attribution Test and results of the Wilcoxon matched pairs tests (W and p values).

When subjects had to explain why they played more with one of the balls, they referred to the above-mentioned categories in the following ratios: emotions (35.4%), behavior (25%), cognition (20.8%), expressiveness (16.7%), and other (18.8%).

An overwhelming majority (95.8 %) of the subjects said that the robot reacted differently to the two balls. When we asked what the difference was in the robot's reaction, 43.8% of them referred to emotions, 29.2% to cognitions, 22.9% to expressive behavior, 16.7% to general behavior, and 2.1% to other.

The median response was 4 (from the maximum 5) to the question „How much did it seem in this test that Mogi Robi possessed emotions?". Happiness, fear and interest were the main emotions subjects reported spontaneously to open-ended questions (Table 14). Happiness and interest were the most frequently mentioned emotions with regard to the 'preferred ball', and fear in the case of the 'non-preferred ball'.

| | Emotions reported in general (not specifically to one of the ball) | Emotions toward the "preferred" ball | Emotions toward the "non-preferred" ball |
|---|---|---|---|
| Happiness | **59.2** | **47.9** | 4.2 |
| Fear | **26.5** | 0 | **33.3** |
| Interest | **24.5** | **33.3** | 2.1 |
| Playfulness | **14.3** | **18.8** | 0 |
| Excitement | **10.2** | **12.5** | 2.1 |
| Enthusiasm | 4.1 | 4.2 | 0 |
| Sadness | 8.2 | 0 | 4.2 |
| Indifference/ neutral | 6.1 | 2.1 | **35.4** |
| Attention | 6.1 | 8.3 | 6.3 |
| Dislike/ Rejection | 6.1 | 4.2 | **12.5** |
| Affection/ Love | 0 | **12.5** | 0 |
| Other | 6.1 | 6.1 | **14.6** |
| Doesn't know/ Irrelevant answer | 8.2 | 0 | 6.3 |

Table 14. Ratio of subjects (in percent) who reported the given emotions and expressions spontaneously (open ended), regarding overall emotional expressions of Mogi Robi (question 7) and the robot's emotions specifically toward the two balls (questions 8 and 9). For better comprehension, percentages over 10 are indicated in bold. Note that one subject could indicate more than one emotion.

Corresponding results were obtained in response to the forced-choice questions (see Appendix 9). Binomial tests were carried out to compare subjects' choices to the chance level (as there were 8 options - 6 emotions, 1 "no emotion" and 1 "other", the chance level was determined as 0.125). In case of the 'preferred ball', the choices differed significantly from chance level except for the choice of "no emotion" and "other". Subjects chose happiness and surprise more frequently than chance ($p<0.001$ and $p<0.01$, respectively), and chose all the other emotions less frequently than chance ($p<0.01$ in all cases). In case of the 'non-preferred ball', percentage of choices of happiness, sadness, disgust and "other" did not differ from chance, but subjects chose fear and "no emotion" more frequently than chance ($p<0.001$) and anger and surprise less frequently than chance ($p<0.05$) (Figure 18).

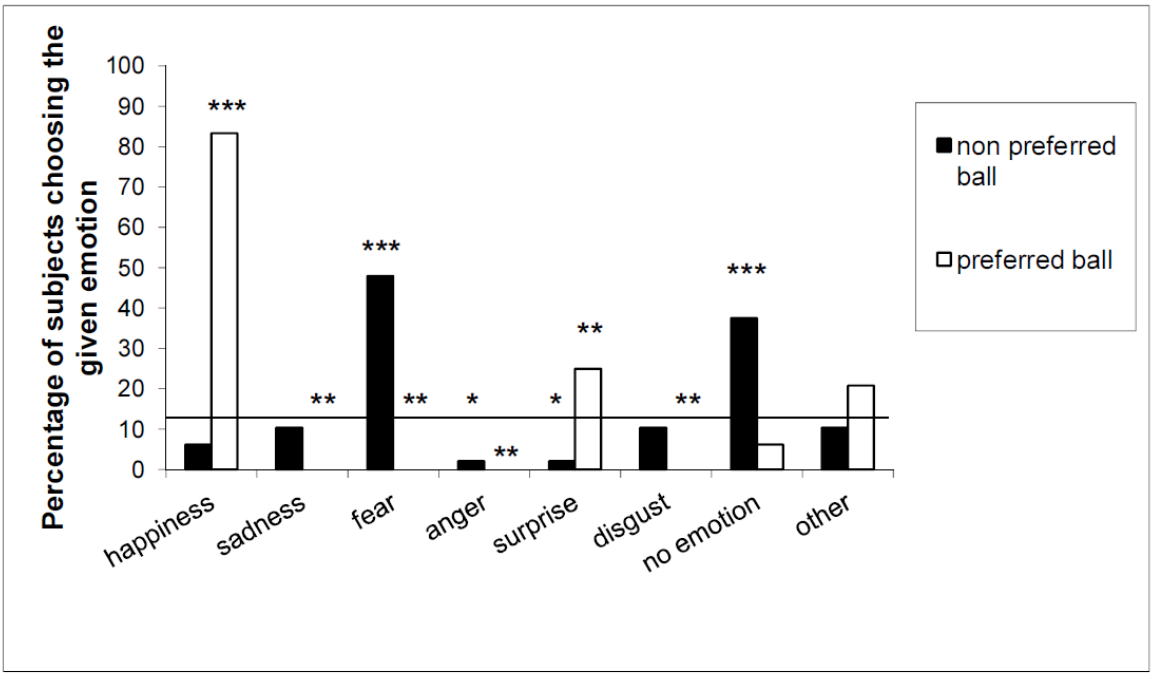


Figure 18. Percentage of subjects choosing the given emotions in the forced-choice questionnaire in case of both the 'preferred' ball and the 'non-preferred' ball (* $p<0.05$, ** $p<0.01$, *** $p<0.001$).

Subjects reported that they based their emotion-attributions on specific behaviors of the robot both in the case of the 'preferred' and the 'non-preferred' ball. They referred to specific actions, e.g. following and retrieving the ball, lifting its ear-like appendices and antenna or being passive (see Figure 19 for a more detailed description).

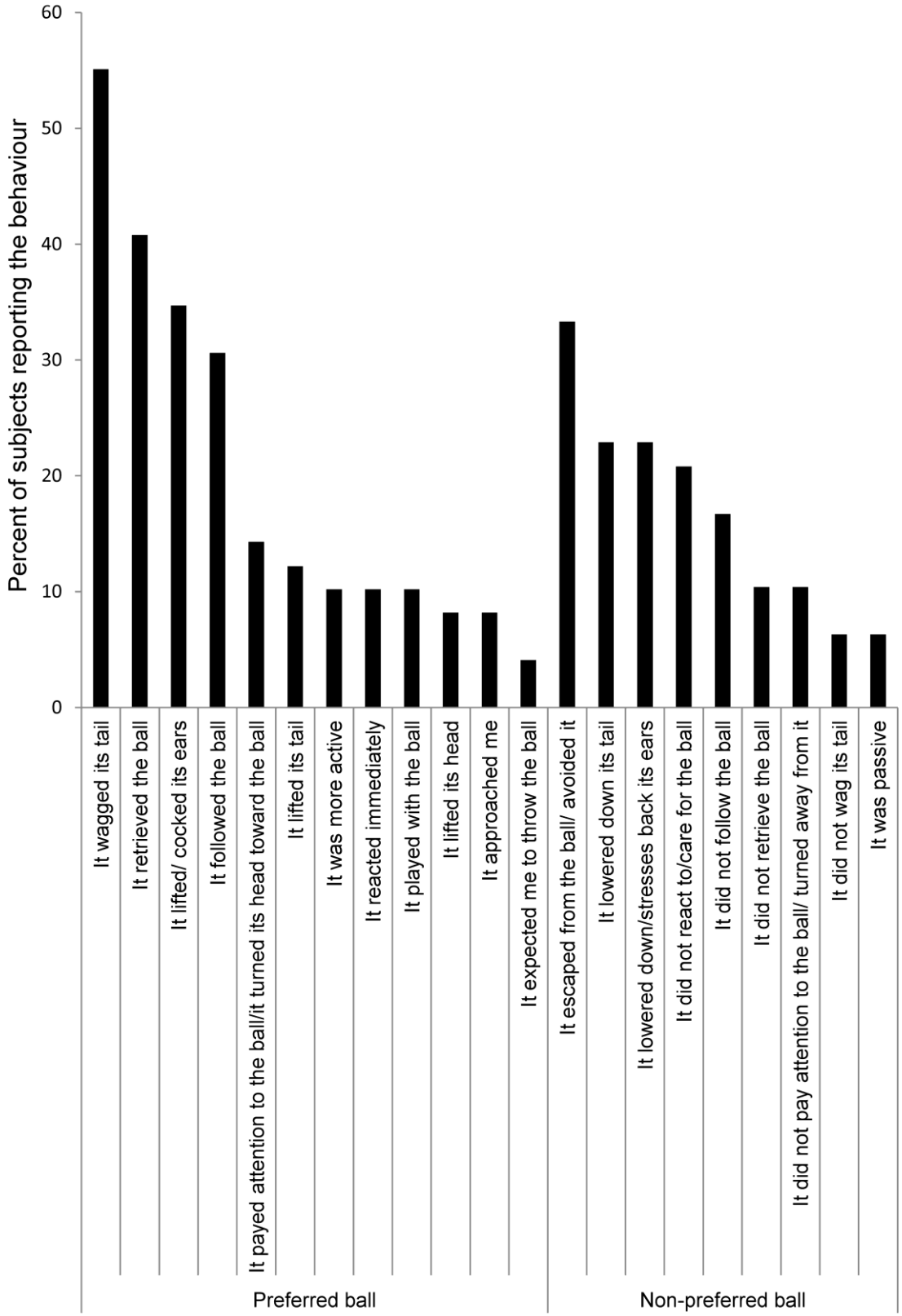


Figure 19. Percentage of subjects reporting the given behaviors when describing on what behaviors they based their emotion-attribution in case of the ‘preferred’ and the ‘non-preferred’ ball.

The comparison of the subjects' behavior in the two conditions revealed that when the robot displayed 'happy' behavior, subjects also expressed more positive emotions ('PosEmo' scale) (W=240; p<0.001), less negative emotions ('NegEmo' scale) (W=-198; p<0.001), less confusion/embarrassment ('Confuse' scale) (W=-179.0; p=0.022) and their commanding and attention-getting behavior was also less frequent ('CommandAtt' scale) (W=-452; p<0.001) than when the robot behaved in a 'fearful' way (see also Table 13).

We checked also whether the order of the two conditions had an effect on the subjects' behavior. We found a significant effect of order only in the case of the confusion related behaviors, showing that subjects showed more confusion in the first 'directed play' episode (independently from whether it was a 'preferred ball' or a 'non-preferred ball' condition) than in the second 'directed play' episode ('PosEmo': W=-105, p=0.09; 'NegEmo': W=-6, p=0.92; 'Confuse': W=167, p=0.03; 'CommandAtt': W=164, p=0.19) (see also Table 13).

### 6.3.2 Change in negative attitudes towards robots (NARS)

Subjects expressed less negative attitude towards robots after the test than before the test (Wilcoxon signed-rank test, W=821, p<0.001, Figure 20). This decrease in negative attitude manifested in two of the three subscales: subjects' aversion declined toward situations and interactions with robots (Subscale 1) (W=465, p<0.001) and towards social influence of robots (Subscale 2) (W=815, p<0.001), but remained the same toward emotions in interactions with robots (Subscale 3) (W=97, p=0.4).

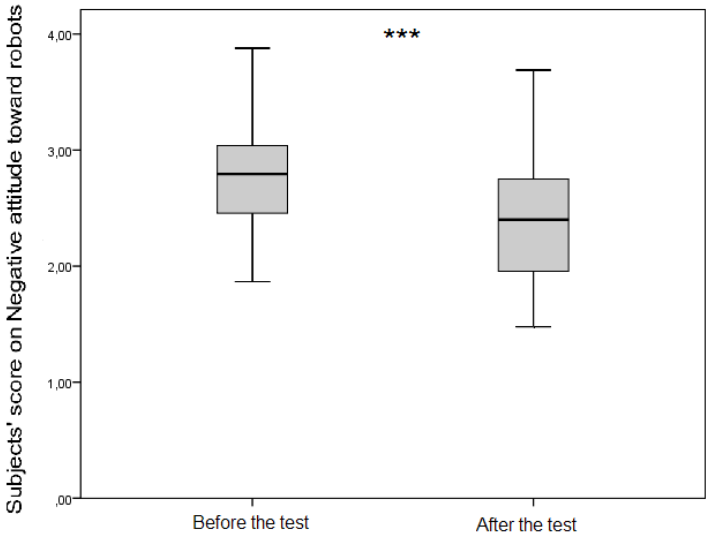


Figure 20. Change in negative attitude towards robots after the behavior tests (NARS, total score).

## 6.4 Discussion

In the present study we aimed to investigate whether people can recognize a robot's emotional behavior if it is designed on the basis of dogs' emotional behavior instead of using facial expressions. Our findings showed that dog-inspired behavior of the robot was a suitable medium for making people attribute emotional states to the robot. Subjects could generally recognize two primary ("happiness" and "fear") emotions.

Results of the Emotion Attribution Test showed that people readily attribute emotions to a social robot and interact with it in accordance with the expressed emotional behavior. They played more (or exclusively) with the ball toward which Mogi Robi had previously expressed "happiness". When we asked the subjects about an explanation of why they played more with that ball, they referred to inner states (emotion, cognition, and expressiveness) overwhelmingly. This tendency was even more explicit when we asked directly about what the difference was between Mogi Robi's reactions toward the two balls. These findings suggest that participants found the emotional behavior of Mogi Robi quite convincing. When they had to name the emotions they experienced in Mogi Robi, the two most frequently reported emotions were the expected ones ("happiness" and "fear"). Subjects recognized "happiness" very well, especially in the forced-choice task (83.3%), but they were less successful in recognizing "fear" (47.9% in the forced-choice task), when approximately the same amount of people thought that the robot was indifferent or showed no emotion as those who said that it was fearful. Our results are in accordance with earlier findings. A number of recent studies have demonstrated that the recognition of fear tends to be the most difficult, although again we have to note that these previous studies were mostly based on facial expressions (Kismet, Probo, EDDIE, Feelix; Breazeal, 2003; Saldien et al., 2010; Sosnowski et al., 2006; Kühnlenz et al., 2010; Canamero, 2002), while in our study we rather used body position and movements of certain body-parts (e.g. the antenna). For example, Breazeal (2003) has found a similar success rate in recognizing the emotional expressions of the anthropomorphic robot called "Kismet". In their study the authors analyzed how people recognized the humanoid robot's facial expressions, which were designed on the basis of human emotion expression. The findings showed that while participants could recognize joy in 82.4% in a forced-choice questionnaire, they could recognize fear only in 47.1% (although still above the 10% chance level). Emotion recognition rate was slightly higher in case of the facial expressions of the animal-like robot 'Probo' (joy: 100%; fear: 65%) (Saldien et al.,

2010). Kuhnlenz et al. (2010) also found that animal-like features helped to improve the emotion expression of the robot head ‘EDDIE’. The similar success rate in recognizing these primary emotions in robots having such different embodiments (animal-like vs. humanoid) suggests that simpler embodiment and expressive behavior can also successfully transmit emotions and the sensation of livingness without the need of applying complicated and expensive technical solutions.

Our finding regarding fear recognition, namely that many subjects did not interpret the robot’s behavior as escape or avoidance but only as passivity or ignorance, fits recent findings on human-dog relationship too. A recent video survey of Wan et al. (2012) demonstrated that dog owners are not good at recognizing fear in dogs either, when only visual signals are available, but they have no difficulty with recognizing happiness.

Although, the fact that people played more with the ‘preferred’ ball suggests that people took into account the robot’s expressive behaviors and they preferred to interact with the robot when it expressed positive emotions. The participants’ preference toward the ‘preferred ball’ could be explained also simply by the robot’s inactivity with the non-preferred ball, regardless of the emotions shown by the robot towards the two balls.

This latter possibility is supported also by the results that while subjects reacted with positive emotions to the robot’s positive “emotions”, they reacted with negative emotions such as anger or embarrassment (they discouraged the robot, made negative comments, placed their hands on their hip etc.) to the robot’s negative “emotions”. This may be attributed to subjects’ interpretation of the robot’s behavior as indifferent or resistant (reluctant to do the task) rather than fearful. They also gave more commands and/or attention-getting cues, and expressed more confusion/ embarrassment/ indecisiveness in the fearful condition.

So, the ‘fearful’ behavior of our robot was not as successful in making people attribute fear to the robot as the ‘happy’ behavior. Maybe fear is a less recognizable emotion for humans (e.g. Rapcsak et al., 2000; Coulson, 2004) compared to happiness. It might also be that the ‘fearful’ behavior of our robot was less appropriately designed than the ‘happy’ behavior.

The results of the experiment showed that subjects communicated actively with the robot (gave commands, called its attention, expressed feelings etc.), that is, they interacted with the robot as if it had perceptual and cognitive skills. It is already well known that humans tend to interpret even lifeless objects as social beings, and tend to attribute emotions, inner states and personality to them (Koppensteiner, 2011; Reeves and Nass, 1996). In the present study

subjects behaved with Mogi Robi as if it was a living and social being (e.g. communicated with it, petted and praised it) and attributed emotions, cognition and perceptions to it. Saerbeck and Bartneck (2010) also found recently that humans tend to treat robotic pets as living beings and to attribute emotions to them. These are considered as some of the most important factors of robots' believability (Rose et al., 2010).

We can assume that the behavior of the robot differed from the one that the participants had imagined or expected from robots, since subjects decreased their negative attitudes toward robots after the interaction with Mogi Robi. This means that the interaction provided some positive experience for the participants. This is supported also by our general observations that participants often petted the robot, praised it, and when they left the room after the test, they often looked back at the robot and waved/said goodbye to it. Based on these observations we have a good reason to believe that robots built on these principles of emotional behavior (after the necessary technical improvement and becoming autonomous) could have the potential to become a long term social companion for humans.

In summary, subjects in general understood the emotional expressions of the robot despite that its behavior was inspired by non-human behavior. One main advantage of implanting animal behavior into companion robots is that it is simple enough to be easily realized technically. Given that realized developments of human-like social skills in robots are far away from psychological models, this advantage should not be neglected. The successful interaction between Mogi Robi and the participants provides additional evidence for the general effectiveness of human-robot interspecific relations.

# 7 General discussion

In this thesis we investigated dogs' emotions 1) indirectly by reports of human responders, 2) in a social situation with the owner which induces attachment-related feelings, 3) we examined some possible contributing factors to an emotion-related disorder in the dog and 4) we used dogs' emotions as a model to construct the affective expressions of a social companion robot.

## 7.1 Similar mental mechanism in the recognition of human and dog emotion

Our study (Study 1) is the first that utilizes the dimensional approach of emotion in connection with non-human animals. The study revealed that humans represent the affective space of dogs similarly to their own. Activity and assertiveness may underlie the affective space of humans and dogs too (although arousal was found more frequently in the human dimensional studies than activity). In line with this, Faragó et al. (2014) suggest that humans may utilize similar mental mechanisms for recognizing human and heterospecific (dog) emotion. For example, similar basic rules were applied in the recognition of emotional content of human and canine vocal expressions (Faragó et al., 2014). Those with shorter call lengths were rated as more positive, whereas those with a higher pitch were rated as more intense. It would be an interesting research question whether humans also rate the assertiveness of dog and human vocalization along the same acoustic parameters (in humans the degree of perceived ‘power’ or ‘dominance’ of speakers was found to be correlated with some acoustic parameters, but the results are contradictory, e.g. Schröder et al., 2001; Pereira, 2000).

The existence of similar mental mechanisms for recognizing human and dog emotion is strengthened also by the finding that humans’ conspecific emotion recognition capability can be enhanced by observing emotional expressions of dogs (Stetina et al, 2011). Subjects who received an animal-assisted intervention focusing on emotional expressions of dogs performed better in an emotion recognition test (where human facial expressions have to be recognized) than the control group.

Thus, interacting with dogs can improve the emotion recognition abilities of humans. Generally, growing up with pets has a beneficial effect on children's non-verbal communication (Guttmann et al., 1983). Dogs' ability to develop a complex communication system with humans makes these animals particularly suitable to facilitate social interactions and communication in humans (Cirulli et al., 2011). This may explain the popularity of dogs in animal-assisted therapies.

## 7.2 Is the report of owners on their dogs’ behavior correct?

In Study 1, 2 and 3 questionnaires were used to investigate people’s view about dogs’ emotions, separation and greeting behavior, SRD and personality. The usage of human reports on animal emotions and personality may have the risk that such insights are influenced by

anthropomorphism. However, as discussed earlier, (critical) anthropomorphism (Burghardt, 1991) can provide useful hypotheses for looking at animal behavior and these types of studies represent only the first step in this direction, which should be followed by more experiment-oriented approaches. Additionally, Study 2 gives some support that humans judge the emotional behavior of their dog correctly- at least in case of some certain emotional behavior (separation stress or anxiety and joy at reunion with the owner). This is in accordance with other studies (Bloom and Friedman, 2013; Pongrácz et al., 2005, 2006; Tami & Gallagher, 2009; Walker et al., 2010) which showed that humans can recognize the emotional behavior of dogs. As we argued, evolutionary (e.g. mammalian) homologies can provide the biological basis (Plutchik 2001) for some of the emotional similarities between dogs and humans or their inter-specific emotion-recognition abilities.

In addition, in Study 2 we demonstrated that humans can also judge correctly whether their dog has a separation-related disorder (in dogs with owner-reported SRD the proportion of those who showed separation distress was higher than in dogs without SRD). This is especially important from the applied perspective (see later).

In Study 3 we found associations between owners' characteristics and the dogs' SRD. However, the causality behind this association could be the opposite. Insecure owners might see their dogs differently than secure ones: it is possible that they consider them to be more problematic than securely attached owners, thus the „diagnosis" of SRD might mirror a subjective view of the owners. This would be in accordance with the finding that neurotic owners regard their dog's phobic behavior more as a problem although the degree of the phobic behavior did not correlate with owner's neuroticism (O'Farrell, 1997). However, our previous finding in Study 2 suggests the opposite: dogs which were reported by the owner to have SRD showed indeed more distress during separation (Konok et al., 2011).

## 7.3 What we have got to know about dogs with SRD- analogies between dogs and humans in development and psychopathology

With our behavioral test we gained important knowledge about the behavior of dogs with SRD: we demonstrated that they show a different attachment stlye than non-affected dogs, analogue to the human "C" type (insecure, ambivalent). This is the first study that reveals a human-analogue attachment type in dogs. More study is needed to investigate whether other

types of attachment found in humans exist also in dogs. Topál et al. (1998) found five clusters of dogs based on their behavior during the Strange Situation Test, which differs from the number of attachment types found in humans (3, or 4 with disorganized attachment being the fourth one, e.g. Main, 1995). So it is possible that dogs' attachment types differ from human ones or additional attachment types exist in dogs. As insecure (both ambivalent and avoidant) attachment in humans is associated with a higher susceptibility to psychological disorders both in children and adults (e.g. Brennan and Shaver, 1998; Muris et al., 2000; Rosenstein and Horowitz, 1996; Warren et al., 1997), studying the effect of dog's attachment types on several behavior problems is also a promising research area which can contribute to the better treatment of these behavior problems.
In addition, we showed (Study 3) that (at least partly) similar ethiology may exist in the development of separation-related disorder (or separation anxiety disorder) in dogs and children: the caregivers' (owners/parents) attachment style (presumabely through the responsiveness of their caregiving behavior) may influence the attachment style of the child/dog and in this way the development of their separation- related/ separation anxiety disorder. We found that owners of SRD dogs tend to have an insecure, avoidant attachment style. Consequently, their dogs may frequently meet refusal or ignorance of their need for contact, so they learn that they cannot be sure about the availability of the owner. Avoidant owners may refuse the attachment behavior of their dog especially in stressful situations which contributes to that the dogs' stress response to separation escalates.

However, in humans a concordance was found between adult attachment types of the mother and their infants' attachment type (for a review, see van Ijzendoorn, 1995). Thus, avoidant (dismissing) mother usually have avoidant children, and not ambivalent. However, in case of humans, a genetic transmission of basic temperamental characteristics (Goldsmith, 1983) can contribute to the concordance of attachment types between mothers and children. Demographical variables such as maternal education or paternal support also contribute to the observed transmission of attachment types between mothers and children (Tarabulsy et al., 2005). When the contribution of demographical variables was statistically controlled for, maternal adult attachment no longer contributed to infant security, but maternal sensitivity remained a significant mediator (Tarabulsy et al., 2005). We also hypothesize that owners' lower sensitivity/responsiveness (supposed in avoidant owners) contributes to the ambivalent

attachment of their dogs, and not a direct transmission of attachment exist between owners and dogs.

The similarity between the ethiology of separation-related disorder (or separation anxiety disorder) in dogs and children is interesting also from the perspective of developmental psychology and psychopathology (Overall, 2000). Our results shed light on similarities even in developmental and pathological processes between parent-child and owner-dog relationship. Hence, owner-dog attachment may be used as a model of parent-child attachment which additionally has the advantage that there is no underlying genetic factor which can be confounding in human studies. For example, the genetic contribution can be ruled out when investigating the possible correspondences between attachment types of owners and dogs (see earlier).

The human-analogue attachment behavior of dogs and the tendency of humans to attach to dogs can be exploited in psychotherapeutic interventions. There are findings that attachment security in humans can be enhanced by undergoing animal-assisted therapy (AAT) (Balluerka et al., 2014), and interactions with dogs seem to improve many social, emotional, communicational and cognitive skills in humans (e.g. Cipriani et al., 2013). These influences are attributed to the beneficial effect of the emotional bond developing between dogs (or other animals) and humans (Balluerka et al., 2014).

We hypothesized that owners' attachment avoidance may facilitate the development of SRD in dogs as these owners do not constitute a secure base, nor a safe haven for the dog and thus the dogs' stress response to separation escalates. We should admit, however, that several other factors such as genetic predisposition to stress (Wilsson and Sundgren, 1997) can contribute also to SRD.

It is also possible that owners' insecure attachment is not a triggering factor of the dogs' SRD but it influences the selection of a puppy/ adult dog and/or a dog breed. This would be in accordance also with the psychological „similarity-attraction hypothesis" which suggests that the more similar two individuals are, the higher the attraction between them (Byrne, 1971; Byrne et al., 1967). Turcsán et al. (2012) found positive correlations in all the five personality traits using the Big Five Inventory between owners and dogs living in single-dog households (similarly to those found in close human social relationships, e.g. Luo and Klohnen, 2005). This would mean that owners select dogs that are similar to themselves, either at the

individual or at the breed level. People with higher avoidance may have a different personality than less avoidant people (Noftle and Shaver, 2006), so avoidant owners may chose puppies (or breed) with different personality (temperament) than secure owners; and the personality of the dog can contribute to the later attachment security and SRD. Based on the results of the present study we cannot exclude this possibility. Comparison of personality of puppies chosen by owners with different attachment style could clarify this issue.

## 7.4 The illusion of emotion

Humans are willing to interpret even lifeless objects as social beings, attributing aims, desires, inner states and even personality to them (e.g. Heider and Simmel, 1944; Koppensteiner, 2011; Reeves and Nass, 1996). In Study 4 we exploited humans' anthropomorphizing tendency, which manifests itself also in connection with animals. Designers of artificial agents supply social robots with social cues that induce the concepts of intentions in people. Our findings showed that dog-inspired behavior of the robot was a suitable medium for making people attribute emotional states to the robot.

Communicative skills (Gácsi et al., 2013, Koay et al., 2013), attachment behavior (Vincze et al., 2012) and affective expressions (Syrdal et al., 2010) of dogs have already been used in earlier studies as a model for designing robots' or artificial agents' corresponding behavior. Similarly to our study, Syrdal et al. (2010) found that the robot's dog-inspired affective cues were effective in inducing the concept of intention and affection in human observers. The results are interesting because they show that emotion-attribution to a robot can be provoked from humans even when its appearance is very constrained and it has limited modalities for non-verbal expression. The behavior repertoire of their mechanical-looking Pioneer robot consisted of proxemic behavior, gross body movements and camera orientation and movement. Even with these very simple behaviors (e.g. approaching the user, looking at the user) the illusion of emotions can be induced. Importantly, in their study no live human-robot interactions were observed, but they showed a video from the human-robot interaction to the experimental subjects for evaluation.

Emotional expressions (along with other features) of pet animals have been found to be especially important in forming a close relationship with their owner (Hart, 1995). Similarly, it seems that robot's expression of emotions facilitates the human-robot interaction (Fong et

al., 2003) and may contribute to the long-term engagement of humans towards artificial companions. In Study 4 we showed that people's attitudes toward robots have improved due to the interaction with an emotionally expressive robot. These phenomena draw our attention to the function of emotion in forming or maintaining social bonds, both in human-human, human-animal and human-robot interactions.

## 7.5 Contribution of our results to applied fields of science

We believe that our results are not only important from a theoretical point of view but they give important contributions to applied fields of science as well.

### 7.5.1 Veterinary practice

We provided support that our questionnaire reliably indicates dogs' separation-related problem and behaviors associated with separation. Thus it can be a useful device to diagnose SRD in the veterinary practice. For getting a more subtle picture we propose the inclusion of our short behavior test by the means of which the veterinary clinician can get further insights on the dog's specific behavior during separation, e.g. whether their activity during separation endures after minutes, or whether they use owners' objects for self-reassurance, which may assist the process of correcting such behavioral problems.

Our results contribute also to the better understanding of the etiology of separation-related disorder in dogs which can help the treatment of this behavior problem. Because of its financial and emotional cost, unresolved separation anxiety is a common cause of relinquishment to animal shelters (Sherman, 2008) or can ultimately lead to the sale, abandonment or euthanasia of the dog (McGreavy, 2008). However, it is one of the most common canine behavior problems and for example in North America it is diagnosed in 20 to 40% of dogs referred to animal behavior practices (Voith and Borchelt, 1996; Simpson, 2000). Hence, finding more effective treatment or prevention methods of this behavior disorder would be very important. So far the management of the problem consists of environmental control, behavior modification, and medication (Sherman, 2008). Environmental control strategies include e.g. the establishment of a safe place for the dog that reduces self-injury and damage to the home. The presence of a conspecific at home may be

also helpful in some cases but does not necessarily alleviate separation distress (Sherman, 2008). Behavior modification refers to techniques such as the owner ignore the clingy and attention-seeking behavior of the dog, or the dog is taught to lie down on a comfortable resting place and stay calm as the owner practices departure cues but does not depart (Sherman, 2008). These techniques are similar to behavior therapeutic or behavior modification techniques in humans (Wolpe, 1973), which involve also e.g. the usage of desensitization, operant conditioning, etc. Based on our results new therapeutic approaches of SRD in dogs can be developed which can be paralleled with psychodynamic therapies in humans. Owners of dogs that may be prone to develop SRD could develop their self-knowledge regarding their caregiving behavior and how responsive they are. They should be made aware about the need of consistent and reliable responsiveness toward the dog. Treatments may include even the modification of the owners' inner working models of attachment (Bowlby, 1988; Dozier and Tyrrell, 1998), hereby integrating psychotherapy and dog behavior therapy.

### 7.5.2 Animal welfare

The results of Study 1 suggest that humans represent dogs' emotions in a similar way to their own emotions. From the viewpoint of animal welfare it is a crucial question whether animals have similar emotional states as humans. But it is also crucial what humans think of it. As animal welfare is a socially constructed idea, assessing "folk animal psychology" is important in order to establish a consensus about animal welfare (Watanabe, 2007). The fact that humans represent animal emotions similarly to their own help understanding why the human public may be sensitive to welfare issues that affect the emotional behavior of animals. And if our study is a step in the direction of more experiment-oriented observations of animal emotions, the contribution to animal welfare will be even more.

The better understanding of SRD in dogs contributes also to animal welfare as dogs with this disorder obviously suffer in the owner's absence. Besides medication, improvement of therapeutic interventions may reduce the distress or anxiety that these dogs experience. Focusing on behavior therapies instead of medication would have a beneficial effect as in this way we could minimize the side effects of the treatment (King et al., 2000).

### 7.5.3 Robotics

Our results support that dogs can provide an appropriate animal model for building social robots. Results of the Emotion Attribution Test showed that people readily attribute emotions to a social robot and interact with it in accordance with the expressed emotional behavior. These findings suggest that participants found the emotional behavior of Mogi Robi quite convincing. As emotional behavior makes social robots more believable and attractive for humans (Bates et al., 1994), it is important for building a long-term engagement.

As a next step it could be investigated whether these simple behavioral cues can be successfully accommodated with other embodiments as well. Furthermore, the recognizability of secondary emotions could also be tested. Additionally, integrating what we know about dogs' emotional expressions and their attachment behavior, human-robot interaction tests with robots showing some sort of attachment behavior toward the human subject could be conducted.

Of course, other animal species can also be considered as a model species for designing robots. Pets are especially good candidates for this given the long-term engagement people show toward them. However, no other pet behavior was used for modeling so far, neither the behavior of animals besides pets, only in the sense of their appearance (e.g. PARO, AIBO; Shibata and Wada, 2011; Fujita, 2004).

In Study 4 we provided our companion robot with the expressional behavior of two primary emotions (joy and fear). However, on the basis of the results of Study 1 we could also design the robot's expressional behavior by using a dimensional model of emotion (like e.g. Tsapatsoulis et al., 2002; Albrecht et al., 2005; Becker-Asano and Wachsmuth, 2010). Unlike others who applied the dimensions "arousal" and "pleasure" in modeling of facial expression of emotion in human-like artificial agents, we propose to design the emotional expressions of robots or agents with non-human appearance by means of the dimensions "activity" and "assertiveness" which is better suited for overall expressions with the whole body. This approach would be also useful because it would make roboticists to design the behavior and not the emotion. For example, the attribution of 'fear' to robots may be more effectively induced if in the expression of 'fear' a low degree of assertiveness and a medium degree of activity would be reflected (instead of a high arousal and low pleasure, which can be assigned also to e.g. anger, see for example Russel et al., 1989). Regarding our study (Study 4) we can infer that if we had a possibility to decrease the apparent size of the robot in a higher degree,

indicating a submissive stance in a larger extent (see Darwin, 1872; Scott & Fuller, 1965; Eibl-Eibesfeldt, 1984;Wallbott, 1998) then in case of the robot's expression of 'fear' (non-preferred ball' condition), subjects would have attributed 'fear' to it more frequently. Similarly, it is possible that the robot was not active enough in this condition, making the subjects confuse its expression of fear with indifference/neutrality/dejection.

## 8 Acknowledgement

This work was supported by the EU FP7 ICT-215554 LIREC and the grant of the Hungarian Academy of Science (MTA 01-031) to the MTA-ELTE Comparative Ethology Group, and the ESF Research Networking Programme - CompCog: The Evolution of Social Cognition.
I would like to thank my supervisor, Ádám Miklósi for his help during the whole study. I am grateful to András Kosztolányi and Krisztina Nagy for their help in the statistical analysis. I thank Csillag Csepreghy for helping in data collection, Anna Bálint for reviewing the translation of the questionnaires, and András Péter for the behavioural coding software. I am grateful to Wohlfarth Rainer, Bettina Mutschler and Ulrike Halsband for their cooperation in Study 3, and to Gabriella Lakatos, Ildikó Brúder, Boróka Bereczky, Márta Gácsi and Barbara Gáspár for their cooperation in Study 4. I would like to thank the builders of Mogi Robi (Balázs Varga, Bence Kovács, and Géza Szayer) and Péter Korondi and Szilveszter Kovács for putting the robot for our disposal. We are grateful to all people who participated in the studies.

# 9 Appendixes

## 9.1 Appendix 1- Emotion Reporting Questionnaire

In the following we kindly ask you to indicate which emotions do you think dogs can recognize in humans, and humans can recognize in dogs.

| What do you think which emotions humans can recognize in dogs? (sign it with an „X”) | |
|---|---|
| Sadness | |
| Anxiety | |
| Surprise | |
| Anger | |
| Curiosity | |
| Interest | |
| Love | |
| Joy | |
| Fear | |
| Embarrassment | |
| Shame | |
| Disgust | |
| Guilt | |
| Empathy | |
| Pride | |
| Grief | |
| Jealousy | |

| What do you think which emotions dogs can recognize in humans? (sign it with an „X”) | |
|---|---|
| Sadness | |
| Anxiety | |
| Surprise | |
| Anger | |
| Curiosity | |
| Interest | |
| Love | |
| Joy | |
| Fear | |
| Embarrassment | |
| Shame | |
| Disgust | |
| Guilt | |
| Empathy | |
| Pride | |
| Grief | |
| Jealousy | |

## 9.2 Appendix 2- Emotional Behavior Questionnaire

Please, indicate with an „X" which behaviors you have observed on your dog when he/she was in the given emotional state (you can sign more than one behavior element). If you don't remember what your dog does, write an X in the corresponding square („Not sure"). If the dog does other things besides the given behaviors, you can write it on the dotted line.
When my dog is ***HAPPY***, he/she …

***Distance:***

Tries to be far from me ☐

Doesn't come when I call ☐

Remains close to me ☐

…….

*Not sure* ☐

***Body posture:***

Contracts itself ☐

Its body shakes ☐

Draws itself up ☐

…….

*Not sure* ☐

***Head posture:***

Lifts its head up ☐

Hangs its head ☐

Tilts its head ☐

…….

*Not sure* ☐

***Contact:***

Jumps on me ☐

Touches me with paw ☐

Touches me with nose ☐

Rubs me ☐

…….

*Not sure* ☐

***Tail:***

Pulls its tail between the legs ☐

Holds its tail high ☐

Wags it quickly ☐

Wags it slowly ☐

The tail doesn't move ☐

…….

*Not sure* ☐

***Vocalization:***

Barks ☐

Whines ☐

Growls ☐

Moans ☐

…….

*Not sure* ☐

***Looking:***

Avoids eye-contact ☐

Keeps glancing at me ☐

Keeps staring at me ☐

…….

*Not sure* ☐

***Intensity:***

Motionless ☐

Moves slowly ☐

Moves actively ☐

…….

*Not sure* ☐

***Ears:***

Hangs the ears ☐

Cocks the ears ☐

Holds the ears ahead ☐

Flattens the ears ☐

Stresses the ears backward ☐

…….

*Not sure* ☐

## 9.3 Appendix 3- Separation Questionnaire

Your name: ……

Dog's name: ……

Dog's breed: ……

Dog's gender: male/ female

Dog's date of birth: ……

1. How often do you leave your dog alone (without human company)?
   - every day
   - 3-6 times per week
   - 1-2 times per week
   - more rarely
   - never

2. When you leave your dog alone, for how much time?
   - for the whole day (at least for 8 hours)
   - for 4-8 hours per day
   - for 1-4 hours per day
   - for less than 1 hour per day
   - only for some minutes

3. Where do you leave your dog alone? (you can choose more than one answer as well)
   - at home, in the flat
   - at home, in the garden
   - at the dog school
   - on the street, on leash
   - at other familiar place
   - at other strange place

4. Have you got another dog or a cat at home with which the dog inhabits the same area when you leave him/her alone?

- No, there is no other dog or cat
- Yes, a dog
- Yes, a cat
- Yes, a dog and a cat

5. Does your dog have separation anxiety, any behavior problem in relation with leaving him/her alone? (Yes/No)

6. If he/she has, what kind of problem are these? (you can mark more than one answer)

- Continuous whining, barking or howling
- Chewing of objects, scratching of the door/wall, or other destructive behavior
- Urinating/ defecating in the flat
- Other, such as: .....

7. What do you feel, if you have to leave your dog alone **at home**?

1----2----3----4----5

I am absolutely calm. I am very nervous.

8. What do you feel, if you have to leave your dog alone **at a familiar place** (but not at home)?

1----2----3----4----5

I am absolutely calm. I am very nervous.

9. What do you feel, if you have to leave your dog alone **at a strange place**?

1----2----3----4----5

I am absolutely calm. I am very nervous.

10. What does your dog feel (in your opinion), if you leave her/him alone **at home**?

1----2----3----4----5

She is absolutely calm. She is very nervous, stressful.

11. What does your dog feel (in your opinion), if you leave her/him alone **at a familiar place** (but not at home)?

1----2----3----4----5

She is absolutely calm. She is very nervous, stressful.

12. What does your dog feel (in your opinion), if you leave her/him alone **at a strange place**?

1----2----3----4----5

She is absolutely calm. She is very nervous, stressful.

13. Who is the person with whom your dog is calm when he/she is alone **at home**? (mark only **one** answer!)

1. My dog is calm even alone, without human company.
2. My dog is calm when a stranger is with her/him.
3. My dog is calm only when a familiar person is with her/him.
4. My dog is calm only when I am with her/him.

14. Who is the person with whom your dog is calm when he/she is alone **at a familiar place** (but not at home)? (mark only **one** answer!)

1. My dog is calm even alone, without human company.
2. My dog is calm when a stranger is with her/him.
3. My dog is calm only when a familiar person is with her/him.
4. My dog is calm only when I am with her/him.

15. Who is the person with whom your dog is calm when he/she is alone **at a strange place**? (mark only **one** answer!)

1. My dog is calm even alone, without human company.
2. My dog is calm when a stranger is with her/him.
3. My dog is calm only when a familiar person is with her/him.
4. My dog is calm only when I am with her/him.

16. How much joy do you think your dog feels, when you meet again after **some minutes** of separation?

1----2----3----4----5

He/she doesn't seem to feel joy. He/she shows very intensive joy.

17. How much joy do you think your dog feels, when you meet again after **some hours** of separation?

1----2----3----4----5

He/she doesn't seem to feel joy. He/she shows very intensive joy.

## 9.4 Appendix 4- Demographic questions and SRD

Dog's name:

Dog's breed:

Dog’s age (in years):

Dog's sex:

How long have you been living with your dog? (in years)

Your sex:

Your age (in years):

Does your dog have separation anxiety, that is, any behaviour problem related to leaving it alone? Yes/ No

## 9.5 Appendix 5- Adult Attachment Scale

Please read each of the following statements and rate the extent to which it describes your feelings about romantic relationships. Please think about all your relationships (past and present) and respond in terms of how you generally feel in these relationships. If you have never been involved in a romantic relationship, answer in terms of how you think you would feel.

Please use the scale below by placing a number between 1 and 5 in the space provided to the right of each statement.

**1----------2----------3----------4----------5**

| **Not at all characteristic of me** | **Very characteristic of me** |
|---|---|

| | | |
|---|---|---|
| (1) | I find it relatively easy to get close to others. | _____ |
| (2) | I do not worry about being abandoned. | _____ |
| (3) | I find it difficult to allow myself to depend on others. | _____ |
| (4) | In relationships, I often worry that my partner does not really love me. | _____ |
| (5) | I find that others are reluctant to get as close as I would like. | _____ |
| (6) | I am comfortable depending on others. | _____ |
| (7) | I do not worry about someone getting too close to me. | _____ |
| (8) | I find that people are never there when you need them. | _____ |
| (9) | I am somewhat uncomfortable being close to others. | _____ |
| (10) | In relationships, I often worry that my partner will not want to stay with me. | _____ |
| (11) | I want to merge completely with another person. | _____ |
| (12) | My desire to merge sometimes scares people away. | _____ |
| (13) | I am comfortable having others depend on me. | _____ |
| (14) | I know that people will be there when I need them. | _____ |
| (15) | I am nervous when anyone gets too close. | _____ |
| (16) | I find it difficult to trust others completely. | _____ |
| (17) | Often, partners want me to be closer than I feel comfortable being. | _____ |
| (18) | I am not sure that I can always depend on others to be there when I need them. | _____ |

## 9.6 Appendix 6- Big Five Inventory

*Here are a number of characteristics that may or may not apply to you. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement.*

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| **disagree strongly** | **disagree a little** | **neither agree nor disagree** | **agree a little** | **agree strongly** |

*I see myself as someone who...*

| | | | |
|---|---|---|---|
| 1 | ..... is talkative | 23 | ..... tends to be lazy |
| 2 | ..... tends to find fault with others | 24 | ..... is emotionally stable, not easily upset |
| 3 | ..... does a thorough job | 25 | ..... is inventive |
| 4 | ..... is depressed, blue | 26 | ..... has an assertive personality |
| 5 | ..... is original, comes up with new ideas | 27 | ..... can be cold and aloof |
| 6 | ..... is reserved | 28 | ..... perseveres until the task is finished |
| 7 | ..... is helpful and unselfish with others | 29 | ..... can be moody |
| 8 | ..... can be somewhat careless | 30 | ..... values artistic, aesthetic experiences |
| 9 | ..... is relaxed, handles stress well | 31 | ..... is sometimes shy, inhibited |
| 10 | ..... is curious about many different things | 32 | ..... is considerate and kind to almost everyone |
| 11 | ..... is full of energy | 33 | ..... does things efficiently |
| 12 | ..... starts quarrels with others | 34 | ..... remains calm in tense situations |
| 13 | ..... is a reliable worker | 35 | ..... prefers work that is routine |
| 14 | ..... can be tense | 36 | ..... is outgoing, sociable |
| 15 | ..... is ingenious, a deep thinker | 37 | ..... is sometimes rude to others |
| 16 | ..... generates a lot of enthusiasm | 38 | ..... makes plans and follows through with them |
| 17 | ..... has a forgiving nature | 39 | ..... gets nervous easily |
| 18 | ..... tends to be disorganized | 40 | ..... likes to reflect, play with ideas |
| 19 | ..... worries a lot | 41 | ..... has few artistic interests |
| 20 | ..... has an active imagination | 42 | ..... likes to cooperate with others |
| 21 | ..... tends to be quiet | 43 | ..... is easily distracted |
| 22 | ..... is generally trusting | 44 | ..... is sophisticated in art, music, or literature |

## 9.7 Appendix 7-Dog Big Five Inventory

*Here are a number of characteristics that may or may not apply to your dog. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement.*

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| **disagree strongly** | **disagree a little** | **neither agree nor disagree** | **agree a little** | **agree strongly** |

*I see my dog as an individual who...*

| | | | |
|---|---|---|---|
| 1 | .... is talkative, vocal | 23 | .....tends to be lazy |
| 2 | .... is disagreeable, difficult to please | 24 | .....is emotionally stable, not easily upset |
| 3 | .... does things thoroughly | 25 | .... is inventive, finds new ways to get his/her way |
| 4 | .... is down, depressed, blue | 26 | .... has an assertive personality |
| 5 | .....is original, comes up with new ways of doing things | 27 | .... can be cold and aloof |
| 6 | .... is reserved | 28 | .... perseveres until the task is finished |
| 7 | .... is helpful and unselfish | 29 | .... can be moody |
| 8 | .... can be somewhat careless | 30 | .... appreciates sensory experiences |
| 9 | .... is relaxed, handles stress well | 31 | .... is sometimes shy, inhibited |
| 10 | .... is curious about many different things | 32 | .... is considerate and kind |
| 11 | .... is full of energy | 33 | .... does things efficiently |
| 12 | .... starts quarrels with others | 34 | .... remains calm in tense situations |
| 13 | .... is a reliable dog | 35 | .... enjoys learning and doing new things |
| 14 | .... can be tense | 36 | .... is outgoing, sociable |
| 15 | .... appears contemplative, thoughtful | 37 | .... is sensitive to the needs and feelings of others |
| 16 | .... shows a lot of enthusiasm | 38 | .... is planful, determined |
| 17 | .... has a forgiving nature | 39 | .... gets nervous easily |
| 18 | .... tends to be disorganized | 40 | .... appears to “reflect,” mull things over |
| 19 | .... worries a lot | 41 | .... is cooperative |
| 20 | .... is unimaginative, dull | 42 | .... is easily distracted |
| 21 | .... tends to be quiet | 43 | .... is sophisticated |
| 22 | .... is generally trusting | | |

## 9.8 Appendix 8- Negative Attitudes towards Robots Scale

Rate the following statements on a five-point scale according to how much you think they are correct. The number of grades for each item is five (1: I strongly disagree, 2: I disagree, 3: Undecided, 4: I agree, 5: I strongly agree).

1. I would feel uneasy if robots really had emotions.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

2. Something bad might happen if robots developed into living beings.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

3. I would feel relaxed talking with robots.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

4. I would feel uneasy if I was given a job where I had to use robots.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

5. If robots had emotions, I would be able to make friends with them.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

6. I feel comforted being with robots that have emotions.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

7. The word “robot” means nothing to me.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

8. I would feel nervous operating a robot in front of other people.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

9. I would hate the idea that robots or artificial intelligences were making judgments about things.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

10. I would feel very nervous just standing in front of a robot.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

11. I feel that if I depend on robots too much, something bad might happen.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

12. I would feel paranoid talking with a robot.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

13. I am concerned that robots would be a bad influence on children.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

14. I feel that in the future society will be dominated by robots.
(I strongly disagree) 1---2---3---4---5 (I strongly agree)

## 9.9 Appendix 9- Robot Anthropomorphizing Questionnaire

1. Which ball did you play more with Mogi Robi in the "free play" phase? (underline it)
*Black-and-white one / Yellow one*

2. Why did you play more with *that* ball? .....

3. Did you experience that Mogi Robi reacted differently to the two different balls? *Y/ N*

4. What was the difference? .....

5. How much do you think Mogi Robi resembles to a living creature?
(not at all) 1---2---3---4---5 (totally)

6. How much do you think Mogi Robi possesses (or seems to possess) emotions?
(not at all) 1---2---3---4---5 (totally)

7. What kind of emotions have you experienced in Mogi Robi? .....

8. What kind of emotion did Mogi Robi show toward the *yellow* ball?
…….....……

9. What kind of emotion did Mogi Robi show toward the *black-and-white* ball?
……

10. What kind of emotions did Mogi Robi show toward the *yellow* ball from the following? (forced choice)
    - joy
    - sadness
    - fear
    - anger
    - surprise
    - disgust
    - no emotion
    - other: _____

11. What kind of behavior elements of the robot do you base your response on? (What did the robot do that made you think that it had the given emotion?)
……

12. What kind of emotions did Mogi Robi show toward the *black-and-white* ball from the following? (forced choice)
    - joy
    - sadness
    - fear
    - anger
    - surprise
    - disgust
    - no emotion
    - other: _____

13. What kind of behavior elements of the robot do you base your response on? (What did the robot do that made you think that it had the given emotion?)

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## 11 Summary

The present studies aimed to take different perspectives on how we can conceptualize emotional behavior in the domestic dogs (*Canis familiaris*), using different methodological approaches.

In Study 1 our aim was to obtain a detailed picture about dogs' emotions (the whole spectrum if possible) relying on the receiver's (humans) perspective by using questionnaire data. We revealed that according to the subjects humans recognize a wide range of emotions in dogs and we found a similarity between the 'affective space' of dogs (as represented by humans) and the human affective space (as reflected in earlier studies). We found two dimensions which were interpreted as 'activity' and 'assertiveness'. So far, the dimensional approach of emotion (the "affective space") has not been applied to animal emotions, so our study is the first in this field.

In Study 2 we combined the humans' perspective with experimental validation of the dogs' expressive behavior. Our aim was to observe dogs' emotional behavior related to their attachment to the owner: we observed separation and greeting behavior in a behavior test and by the means of a questionnaire. Our results show that owners' have a realistic view on their dogs' separation and greeting behavior. We found differences in the behavior of dogs with owner-reported separation-related disorder (SRD) compared to dogs without SRD, and based on these results we suggest that SRD dogs have an insecure, ambivalent attachment style.

In Study 3 we found that dogs' SRD is associated with their owners' own attachment style: with owners' higher score on attachment avoidance the occurrence of SRD in the dog increases. Such associations were found also between human infants' separation anxiety and parents' insecure attachment. Dogs could serve as a behavioral model for infant-parent attachment, and these results also help in managing separation-related disorder in dogs.

In Study 4 we investigated in a human-robot interaction test and in a questionnaire whether emotional behavior of dogs can provide a model for expressive behavior of social robots. The results show that dog-inspired behavior of the robot was a suitable medium for making people attribute emotional states to the robot. Additionally, subjects' attitudes toward robots became more positive after the interaction with the robot. Robots built on these principles of emotional behavior could have the potential to become a long term social companion for humans.

## 12 Összefoglalás

A jelen kutatások célja az volt, hogy különböző nézőpontokból és különböző metodológiai megközelítésekkel tanulmányozzuk a kutya (*Canis familiaris*) érzelmi viselkedését.
Az első kutatásban egy részletes képet szerettünk volna kapni a kutyák érzelmeiről (lehetőleg az egész spektrumról) a kommunikációs jelvevő (az ember) nézőpontjára támaszkodva, kérdőíves módszerrel. Azt találtuk, hogy az alanyok szerint az emberek számos érzelmet felismernek a kutyákon, és hasonlóságot találtunk a között, ahogy az emberek a humán (korábbi kutatások alapján) és a kutya „affektív terét" (affective space) leképezik. Az eredmények szerint két dimenzió alkotja a kutya érzelmi terét: az aktivitás és az asszertivitás. Az érzelmek dimenzionális megközelítését (affektív tér) eddig nem alkalmazták az állati érzelmekkel kapcsolatban, így kutatásunk az első ezen a területen.
A második kutatásban az emberi nézőpontot a kutya érzelem-kifejező viselkedésének kísérleti validálásával ötvöztük. A célunk az volt, hogy a kutyának a gazdához való kötődésével kapcsolatos érzelmi viselkedését vizsgáljuk: a kutya szeparációs és üdvözlési viselkedéséről egy viselkedés tesztben és egy kérdőíves vizsgálatban gyűjtöttünk adatokat. Eredményeink szerint a gazdák reálisan tudják felmérni a kutya szeparációs és üdvözlési viselkedését. Különbségeket találtunk a gazdák által „szeparációs zavar"-ral (v. szeparációs szorongással) jellemzett kutyák és a tipikus kutyák között, mely különbségekre alapozva azt feltételezzük, hogy ezek a kutyák bizonytalan, ambivalens kötődéssel rendelkeznek.
A harmadik kutatásban azt találtuk, hogy a kutyák szeparációs zavara összefügg a gazda saját kötődési stílusával: a bizonytalan, elkerülő kötődési skálán magasabb pontszámot elért gazdák kutyái nagyobb eséllyel mutatnak szeparációs zavart. Hasonló kapcsolatot találtak gyerekek szeparációs szorongása és a szülők bizonytalan kötődése között. A kutya viselkedési modellként szolgálhat a szülő-gyerek kötődés vizsgálatához, az eredményeink ezen kívül hozzájárulhatnak a kutyák szeparációs zavarának hatékonyabb kezeléséhez.
A negyedik kutatásban azt vizsgáltuk, hogy a kutya érzelmi viselkedése felhasználható-e modellként a társrobotok érzelemkifejező viselkedésének tervezéséhez. A humán-robot interakciós tesztünk eredményei szerint a kutya által inspirált robot-viselkedés megfelelő eszközként szolgált ahhoz, hogy elérjük, hogy az emberek érzelmi állapotokat tulajdonítsanak a robotnak. Továbbá, az alanyok robotok iránti attitűdje javult az interakció hatására, így a mienkhez hasonló elvek alapján épített robotok feltételezhetőn hosszú távú társat jelenthetnek az emberek számára.