INTERACTIONS BETWEEN HUMANS AND DOGS
Neurobiological factors relevant for the treatment of exhaustion-related disorders.

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Declaration of Authorship


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The above noted work is submitted to the School of Bioscience at the University of Skövde, as a final year Bachelor project toward the degree of Bachelor of Science in Cognitive Neuroscience. The project has been supervised by Stefan Berglund.

I, Johanna Sinisalo, hereby declare that:

1. The above noted work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any other degree.

2. The above noted work is the result of my own investigations, except where otherwise stated. Where corrections services have been used, the extent and nature of the corrections have been clearly marked.

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Abstract

Increasing evidence illustrates an involvement of stress in a large variety of physical and mental illness. Together with the evolutionary development of the social behavior in humans, the traditional interpretations of the attachment theory and the social support theory underscores the importance of affection, belonging and appreciation for human well-being. Not only can an imbalanced stress system be the cause of severe pathological consequences, insufficient social contact can also hamper recovery. Frequent usage of animals in various settings steadily illustrates both physiological and psychological benefits on both the young and the old, the healthy and the ill. Through the study of neurobiological factors, with oxytocin as a central mediator of social behavior and its impact in turn on the stress- and cortisol system, this paper examines the possibility of animals to function as social support. The potential of animals to reduce the suffering in patients with stress related psychiatric disorders, such as the highly frequent exhaustion disorder, human-animal interactions might offer a non-invasive complementary tool to current treatment methods.

Keywords: Cortisol, Oxytocin, Human-Animal Interactions (HAI), Animal-Assisted Therapy (AAT), Attachment Theory, Social Support Theory, Stress
THE BENEFICIAL RELATIONSHIP BETWEEN HUMANS AND DOGS

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Introduction: The Relationship Between Humans and Animals

This paper will start by presenting the historical aspects of the human-animal bond, illustrating a gradual progress of domestication. In relation to this, the social brain will be treated, investigating the attachment properties between human and animal. Next, a comprehensive overview over psychological and physiological benefits linked to human-animal interactions, will follow. The aim with this paper is to review previous research in the field of mutual neurobiological beneficial effects of interspecies relationships, with a particular focus on the attachment promoting properties of the neuropeptides oxytocin and arginine-vasopressin, as well as their involvement in stress regulation. The main question is if it is possible to practically apply this neurobiological knowledge as a complementary tool to current treatment methods of stress-related psychiatric disorders. The highly frequent exhaustion disorder, is of particular interest, as one of the most common causes for a growing number of sick leaves today. The most common used term for this symptomatology is burn out, referring to work related stress leading to disease. However, due to its narrow and dramatic (i.e. burnout is interpreted as something nonreversible) definition, exhaustion disorder has been proposed as an alternative definition with the wider scope of including also causes of disease outside the workplace. Exhaustion disorder will thus from here on be used as an umbrella term for the symptoms created by overpowering situations and prolonged stress reactions, including depression and inabilities to relax resulting in chronic fatigue.

Domestication, is described by Oltenacu (2004) as a “process by which a population of animals become adapted living in the environment controlled by humans” (p. 294). The history of domestication began during the hunter-gathering era, where humans and animals were brought together by their similar nomadic tendencies. For example wolves, the ancestors of dogs, discovered the benefits of staying in the vicinity of humans, while humans advanced their hunting strategies by using the wolf pack. A more settled existence (i.e. agriculture)
evolved where crops were produced and stored and where animals were used for food, clothing and transportation and reared as livestock (Oltenacu, 2004). Edney (1995) continues by adding tracking, vermin control and guarding to the list. In exchange the animals got nutrition, shelter and safety, which are scarce in nature. This shows the importance of mutual benefits for interspecies relationships to be formed (Oltenacu, 2004).

With time the relationship to animals gradually changed, from simply being a mere source of food and labor, to fulfilling companion purposes. Animals are described as having an important role of satisfying man’s religious and spiritual beliefs where some cultures regarded animals as possessing healing powers and providing humans with spiritual patronage (Walsh, 2009a). This mystical perception was further held by ancient Egyptians where pets were mummified, buried and mourned in extensive rituals (Walsh, 2009a). Evidence has been found in archaeological discoveries. For example a 12,000 year old tomb containing a man buried together with his dog (O’Haire, 2010), and cemeteries found in Peru where dogs were buried together with their owners, supplies and belongings, such as food and blankets (Walsh, 2009a). Together with evidence from the middle ages, showing human breastfeeding of pups, a phenomenon first believed to be related to class differences influencing pet ownership in western societies, but which later also was recognized in more primitive societies (Serpell, 1987), conclusions about a more affectionate relationship between humans and animals were drawn.

These are findings that have led to an increased interest and numerous attempts for explaining the possible social, emotional and recreational value of having animal companion. Even as anecdotal narratives, the knowledge of the beneficial effects of animals has been utilized in health care purposes as far back as the 9th century in Belgium, where the interaction with animals was found to improve the well-being in disabled (Brodie & Biley, 1999). As a precursor in the field of animal assisted interventions, Quaker philanthropist Samuel Tuke, in
the end of the 18th century integrated different species of animals in the environment at a mental institution (Berget & Ihlebæk, 2011). This he believed would facilitate feelings of benevolent and socializing in the hospitalized patients. During this experiment, it was recognized that self control and responsibility was encouraged (Edney, 1995). The contemporary understanding of animal assistance can be traced back to the findings of child psychologist Boris Levinson, who 1953 accidentally recognized the effects his dog had on one of his patients. This led to the later conclusion that pet facilitated therapies can benefit children suffering from, for instance personality traits of autism disorder, that is, withdrawal and inhibition (Mallon, 1994). However, these revolutionary ideas that Levinson proposed received a skeptical and reluctant response from academic colleagues (Mallon, 1994). A reluctance to accept this as an legitimate therapeutic alternative, is speculated to be based on suspicions of placebo effects interfering. It was not until the 80’s that the interest in the field flourished (Johnson, Odendaal, & Meadows, 2002), transforming the earlier self-reported thoughts of the pet owners themselves to an empirically well-studied phenomenon with various measurable physiological (Allen, 2003; Beetz, Uvnäs-Moberg, Julius & Kotrschal, 2012; Friedmann & Tsai, 2006; Handlin, Hydbring-Sandberg, Nilsson, Ejdebäck, Jansson, & Uvnäs-Moberg, 2011; Horowitz, 2008; Odendaal, 2000; Odendaal & Meintjes, 2003) and psychological effects (Beetz et al., 2012; Edney, 1995; Hart, 2006; Levinson, 1984; McNicholas & Collis, 2006; Nagasawa et al., 2015; O’Haire, 2010; Walsh, 2009a).

In the literature, the relationship between human and animal, is a phenomenon labeled in many terms, e.g. human-animal interactions (HAI), human-animal bond (HAB), or human-animal relationships (HAR). Also in therapy settings there seems to be disagreement of a unified conceptual definition, e.g. animal-facilitated therapy (AFP), pet-facilitated psychotherapy (PFP), human/companion-animal therapy (H/C-AT), and pets as therapy (PAT). As an aid in different mental and physiological disabilities, the terms service-animal
programs (SAP), animal-assisted interventions (AAI), and animal-assisted activities (AAA) can be used. As a interdisciplinary field of study, anthrozoology is defined by the International Society of Anthrozoology (2000-2015) as a collaboration between anthropologists, biologists, psychologists, sociologists, educators, historians and zoologists, all coming together on issues regarding animal welfare and attitudes, social and medical aspects of pet-keeping, vivisection and research. The most commonly used animals in anthrozoology studies and therapies are in descending order, dogs, cats and horses. This paper, however, will be restricted to dogs due to them being the most extensively investigated species.

In contemporary society pets are considered to be beloved family members (Allen, 2003; Berget & Ihlebæk, 2011; McNicholas, Gilbey, Rennie, Ahmedzai, Dono, & Ormerod, 2005; Walsh, 2009a, 2009b), with, as we will see, an increasing responsibility as co-workers in a variety of professions.

The Social Brain of Mammals

The closely related neuropeptides oxytocin and arginine-vasopressin, both produced by the supraoptic and periventricular nucleus of the hypothalamus (De Boer, Van Buel, & Ter Horst, 2012), are regarded to be the two most central components in the mechanisms behind the social brain of mammals (Churchland, 2011). Well preserved throughout evolution, with findings indicating on 700 million year old homologs of the two neuropeptides (Scantamburlo, Ansseau, Geenen, & Legros, 2009), illustrates the fundamental function of social behavior and attachment in our biology. However, the role for the two neuropeptides has been speculated to initially not serving any social functions. Churchland (2011) explain this as the primarily care for the survival and well-being of the self with time was extended to also involve caring in a similar manner for the own offspring’s survival and health. Further
down evolution this also came to include family, friends, and in some limited circumstances also strangers. This extended circle of care is assumed to have evolved gradually, because of the increased fitness purposes that cooperation could mean for the individual. Cooperation resulting in access to more resources, decreased vulnerability to predators, and increased overall well-being and prosperity in being part of a community (Churchland, 2011). Besides these practical benefits, the increased circle of care further illustrated psychological benefits; satisfying an innate need for affection and attachment. In the work by psychologist Harry Harlow (1958), cited in Levinson (1984), attachment in baby rhesus monkeys was investigated. The experiment illustrated a similar tendency as the human child to not only seek security and nutrition in the mother, but also warmth and comfort. This finding underscores the fundamental need for closeness, especially physical such, for normal development.

From an evolutionary perspective, as pointed out by Archer (1997), animals benefited enormously from us providing them with nutrition and security, factors enhancing their reproductive success and survival, when the competition of limited resources rather should lead humans to favor the own species. With this in mind, one can’t help to wonder: where do animals fit in the human sphere of caring, and what is the purpose of this development?

The interspecies bonding between human and dog was recently investigated by Nagasawa et al. (2015), recognizing that the attachment promoting property of mutual eye-gaze between mother and child, also extended to the contact between dog-owner and pet. In comparison to our closest relatives, the chimpanzees, dogs have demonstrated greater skills in using the social communication behaviors of humans. Something that might be the result of humans selective breeding of some particularly desirable character traits in the dogs, for instance some breeds being better suited for guarding, hunting or company purposes. A recent
finding, illustrating these abilities in dogs, was done by Andics, Gácsi, Faragó, Kis and Miklósi (2014), while examining the brain mechanisms processing the information of vocalizations. Andics and colleagues hypothesized to find analogous brain regions for voice processing in both humans and dogs, responding to sounds with emotional valence. The hypothesis was confirmed. Twenty two humans and eleven dogs were presented with vocalizations (e.g. cry, laugh and barks), neutral environmental sounds and a silent baseline. The fMRI data illustrated similar processes in similarly located brain regions behind the auditory sensitivity to the emotional informational cues that these sounds revealed. Regarding the involved brain regions, increased activity could be found in auditory cortical and subcortical structures in both species. Especially the superior temporal sulcus (STS), the inferior frontal cortex (IFC) was activated in humans, and perisylvian regions in dogs. The temporal pole (TP) was activated in both species. Furthermore, dogs illustrated a dominant right-hemispheric activation following the emotionally charged stimuli, a lateralization that in earlier studies also has been recognized in humans (Andics et al., 2014). These experiments illustrate a complex element of social cognition, providing the recipient with important and informative social cues. What marvel researchers with these discoveries, are the similar alterations in brain mechanisms behind affection and attachment (Nagasawa et al., 2015), now found in both primates and non-primates. Parallel and convergent evolution in these two species are speculated to be the reason for these findings (Andics et al., 2014; Nagasawa et al., 2015).

There have been various attempts of finding an universal theory about the human-animal relationship. For example, Edward O. Wilson proposed the biophilia hypothesis, according to which there is a genetically instinctive predisposition towards relationships between humans and other organisms (Horowitz, 2008). This concerns an emotional need to have a connection to nature and other animals, which give us humans satisfaction at a, not
only physical, but also cognitive and spiritual level. The hypothesis is further described in O’Haire (2010) as evolutionary having a survival value, where attention to the animal behaviors could warn humans about hazards in the surroundings. A calm behavior of the animal indicated on safety and an anxious behavior was perceived as signs of threat. A function that in today’s society can be attributed to the sedative effect of observing animals.

Another theory receiving some attention in the field of human-animal interaction is the self-object theory, where animals contribute to the settlement of an individual’s identity (Horowitz, 2008). However, only the two most influential theories in the field, the attachment theory and the social support theory, will be treated more thoroughly below. Most literature in the field mention both of these theories as possible explanation models for the interspecies bond, something that might be interpreted either as disagreements for an universal assumption, alternatively both theories containing some elements that respectively are applicable on the phenomenon.

The Attachment Theory

John Bowlby, inspired by the earlier work of Konrad Lorenz and Harry Harlow, recognized that children were drawn to their mothers not only because of a need for nutrition and affection but also as secure base from which a healthy sense of self-esteem could later develop (Uvnäs-Moberg, 2009). Based on the differences seen in how early life experiences affected the attachment to parental figures, Bowlby created the attachment theory which divided the children’s responses to separation into to one of three groups: secure attachment, unsecure/ambivalent attachment and unsecure/avoidant attachment (Uvnäs-Moberg, 2009). According to Bowlby, attachment manifested itself through a motivational seeking of security and the organization of experiences into internal working models (i.e. cognitive representations), creating traits that in turn influence subsequent relationships in adulthood (Collis & McNicholas, 1998). Having an emotional motivational value, the human child
already in young age learn the positive reward and negative punishment following different types of social situations. Abilities to understand the mental states, intentions and emotions of others (i.e. mentalizing) are described as prerequisites for successive socializing (Churchland, 2011). In order to adequately predict the future behavior of our fellow creatures there are of great importance to understand the emotional state of those we are interacting with.

De Boer et al. (2012) differentiate between two types of attachment, the one between mother and child, and the other between adults. The attachment between mother and infant is by Collis and McNicholas (1998) described to involve an asymmetry regarding sophistication of cognitive abilities in the two parties involved. The same could be applicable on the attachment between pet-owner and pet; where language usage and intellectual abilities significantly differ. As elegantly described by Levinson (1984):

> Searching our memories for the time when we were at peace with ourselves and the world, we usually find that it was in our earliest childhood, when mother was providing touch comfort, love and acceptance. Reviewing what is known of the history of *Homo sapiens*, we find that it was animals who, from primeval times, provided our ancestors with the same priceless gifts (p. 141).

The adult attachment is in turn described to possess a more symmetrical conformation of cognitive abilities (Collis & McNicholas, 1998). The evolutionary role of attachment between adults in relation to child-rearing, is speculated to have developed in species where two parenting nurturance of offspring is needed. This can manifest itself either as a life-long commitment or as a cooperation only lasting the period where the offspring is most vulnerable (De Boer et al., 2012).

Investigations regarding differences in gender, age and styles of attachment, illustrate similar underlying mechanisms in the oxytocin, arginine-vasopressin and dopaminergic
reward system. Nevertheless, the effect of these chemical similarities results in many
differences in the regulating brain areas and, in turn, resulting behaviors. For instance, De
Boer et al. (2012) reports the hypothalamus to be involved in romantic attachment but not in
maternal attachment, which on the contrary is more sensitive for facial recognition (De Boer
et al., 2012). Regarding gender differences in parental attachment, women show increased
activity in brain regions involved in attention and emotion, while on the other hand, brain
activity associated with visual stimuli are increased in men. These differences are speculated
to have an evolutionary importance, where men need to recognize health in women and
mothers needed to primarily be aware of the face expressions of their children. Adult
attachment results in increased activity in brain regions associated with rewarding feelings
regulated through elevated concentrations of dopamine, such as the medial insula, anterior
cingulate cortex (ACC), hippocampus and the nucleus accumbens (De Boer et al., 2012). In
parallel there is a deactivation of several brain regions involved in cognitive functions such as
judgment and emotion regulation (frontal cortex and the amygdala) and mentalizing
(prefrontal cortex, temporal poles and parietotemporal junction) (De Boer et al., 2012).

According to Horowitz (2008) pets and children elicit the same type of innate
nurturing response in human adults, leading to the traditional attachment theory later being
broadened to also include the propensity of people to treat their pets as children (Archer,
1997). The phenomenon of anthropomorphism is by Archer (1997) described as the human
tendency to ascribe human physical and mental attributes to pets. Characteristics such as
affection and attention as well as childlike appearance, emotions and behavior is all features
we value and respond to in the relationships to human children and which we habitually,
without further reflection, also apply to our pets. McNicholas and Collis (2006) addresses this
in terms of counterfactual reasoning, according to which we humans show tendencies to
interact with our pets as if they were humans, as if they understood our language, mind and behavior as a human could.

Berget and Ihlebæk (2011) present the human-animal equivalents in relation to three fundamental concepts of traditional attachment theory. First, animals cater the needs of an emotional long-lasting bond, primarily met through tactile contact (e.g. caressing, brushing, playing). Second, they offer humans a emotionally and physically secure base. And finally, animals foster representational models affecting the way a subject handles stressful situations.

In order for an attachment between pet and owner to evolve, reciprocity and mutual satisfaction, are two factors that must be fulfilled (Archer, 1997). Berget and Ihlebæk (2011) further add voluntariness and persistence as critical elements for a relationship to evolve. Compatibility, which is assessed based on physical, psychological and behavioral factors, is described by Hart (2006) as decisive regarding whether the interaction will have beneficial or adverse outcomes. Earlier individual experiences that create certain attitudes to either animals in general or preference for specific species in particular, can be one determining mechanism. Interpretations of an animal as being friendly and non-threatening, is an important aspect that regulates the degree of positive effects following interaction (Friedmann & Tsai, 2006). Familiarity is another, where significant physiological effects have been found only for pet owners interacting with their own pet in comparison to subjects petting an unfamiliar dog (Friedmann & Tsai, 2006). Contradictory evidence for this hypothesis about familiarity however, illustrates that the presence of an unfamiliar dog also had a positive influence on the measurable stress (Odendaal, 2000; Odendaal & Meintjes, 2003), and oxytocin (Miller et al., 2009) levels. This is thus a continuous relationship, where the closer relationship between the animal and human, the more beneficial effects will follow.

The Social Support Theory
The second alternative describes the human need for love, appreciation and belonging (Wells, 2009). In relation to this theory, McNicholas and Collis (2006) further add the need to feel needed as an important element. The importance of social relationships is most clearly displayed in cases of social exclusion and isolation, affecting the physical and mental well-being of an organism. Distinguishing between social loneliness (i.e. an impoverished social network) and emotional loneliness (i.e. specific close relationships are absent), McNicholas and Collis (2006) present a study where emotional loneliness indicated a higher risk for depression and anxiety disorders as well as physical medical conditions. Social support has further illustrated to protect a subject against stress and impaired immune system functioning (Hart, 2006), and to accelerate recovery from medical conditions and procedures (Collis & McNicholas, 1998).

The main effect hypothesis and the buffering hypothesis (McNicholas and Collis, 2006), are two mechanisms accounting for the stress reducing properties of social support. According to the first hypothesis, the mere knowledge of available support reduces anxiety for possible stressful situations ahead (Collis & McNicholas, 1998). The latter hypothesis in turn, proposes that social support can protect the subject from suffering pathological damage following stressful situations (Collis & McNicholas, 1998). The buffering hypothesis has further been divided into four sub-components: (1) emotional support refers to the social network providing a subject with comfort and care, (2) esteem support refers to the social network providing a subject self-worth through respect and appreciation, (3) practical support refers to concrete help with material resources and informational support refers to guidance, and finally (4) network support involves the human need for group affiliation (Collis & McNicholas, 1998). In relation to these four categories, the authors conclude that pets might be fulfilling the role of candidates for social support. The companionship with an animal is regularly described to contain emotional and esteem support. As the most promising sign of
mutualism, investigations repeatedly have shown that company animals and their owners provide each other with feelings of love and affection. Esteem support, in turn might be attributed to, for instance, the meaningful fulfilling aspect that animals contribute to the elderly. This aspect of the relationship also can be recognized in the dog’s countenance and behavior towards their owners. Where the happily wagging tail and attentive ears and eyes clearly illustrating feelings of appreciation and respect. The third category, practical support, can in turn be attributed to service animals providing their physically or mentally limited owners with assistance in every day life. For instance dogs escorting their blind owners. The final, network support is attributed by the authors to the indirect ways that animals facilitate person to person contact (i.e. as social lubricants). Finally, animals can be regarded as both friends and family members, where being part of a pack illustrates the important aspect of network support. All four factors, thus either directly or indirectly provides a subject with social support.

Reinterpretations of the social support theory has done it applicable also at an interspecies level, where the non-judgmental, non-critical and loyal characteristics of animals might be satisfying these human basic needs (Wells, 2009). Animals are said to provide humans with support in two ways, either directly in themselves or indirectly by facilitating social contact to other humans (McNicholas & Collis, 2006; O’Haire, 2010). O’Haire (2010) addresses one example of these indirect causes, where dogs are described to work as a social lubricants, promoting social interaction with other people through stimulating conversations by working as a topic, a phenomenon that in Wells (2009) is termed as the social catalysis effect.

The relationship to animals has been described to involve factors of unconditional love (Johnson et al., 2002) and acceptance (Beetz et al., 2012), continuous availability (Hart, 2006; Wells, 2009), and devotion (Walsh, 2009a). They provide us with uncomplicated
(Archer, 1997; Horowitz, 2008) and conflict free (Hart, 2006) support. Animals further have an entertainment value (Hart, 2006), this by functioning as a distractor offering a pleasant focus of attention (Odendaal, 2000). This possibly by reflecting a certain easy-going and encouraging their human companions to be in the present. Levinson (1984) also mentions the effects of animals as influencing self-understanding and acceptance of self and others, elements important for the structure of self-identity and personality in all individuals.

A final, interesting aspect of the social support in animals, is the finding done by Allen (2003), where animals to a higher extent than if a spouse was present could ease the physiological stress responses in subjects performing a stressful task, for example an oral presentation and a mentally demanding arithmetic tasks. A further study done by the same researcher, cited in Friedmann and Tsai (2006), illustrated that similar effects could be documented following the support of a person chosen by the subject herself. Similar decreasing responses in cortisol levels have been found in hospitalized children when a dog versus a human visits the facility (Beetz et al., 2012). This is speculated to be due to animals not expressing any expectations or direct requirements, with their attentive countenance providing the role of a dedicated and non-judgmental listener. Regardless of what you say, your appearance, social status, values, and so forth, the animal’s presence offer comfort and support without running the risk of humiliation or the shame of possible failures. Together these are all factors that in certain cases make them naturally preferred to the more complex contact with other people.

In relation to human-animal interactions we thus in one way or another find support for both the attachment theory and the social support theory. This due to their much like similar basis, where both involve the importance of social contact and belonging.
Physiological Effects Following Human-Animal Interactions

Wells (2009) begins her article by clarifying a distinction between short-term a long-term physiological health benefits, with the first one involving seconds to minutes, and the later reaching from weeks up to years. The short-term effects can in turn be divided and studied as either direct- or buffering effects (Friedmann & Tsai, 2006). In Brodie and Biley (1999) this is clarified as the buffering effects reflecting a protection against stressful situations in the future. On the contrary the direct effects illustrates, physiological changes here and now. The most studied physiological changes are the transient cardiovascular benefits, such as decreases in blood pressure and heart rate (Allen, 2003; McNicholas et al., 2005; Odendaal & Meintjes, 2003). This is also the most commonly reported evidence for the necessary mutualism, mentioned in the above section.

The physiological benefits are speculated to be due to dog-owners exercising more and in general having a more active life style (Horowitz, 2008). This is however something that has been questioned by McNicolas et al. (2005), proposing a third factor such as certain personal characteristics resulting in both a propensity to become pet owners and to have a lifestyle that promotes health. As correlation not automatically implies causation, a hen or the egg dispute seem to have evolved, where the occasionally occurring contradictory research results regarding associations between pet ownership and health, are especially thought to be created through difficulties in replication. Researchers have examined these possibilities, by investigating differences between pet owners and non-owners. Firstly, it has been shown that pet-owners on average utilizes medical care less frequently (Archer, 1997; Beetz et al., 2012; Friedmann & Tsai, 2006; Horowitz, 2008; McNicholas et al., 2005; O’Haire, 2010; Wells, 2009). Although cautiously, this has been interpreted as an indirect marker of better physical and psychological health. A frequently cited study (Archer, 1997; Friedmann & Tsai, 2006; Miller et al., 2009; O’Haire, 2010; Wells, 2009), performed by Friedmann, Katcher, Lynch
and Thomas (1980) illustrated a significant increase in chances of survival in patients of myocardial infarction that owned a pet. Besides these physical benefits of pet-ownership, McNicholas and Collis (2006) further mention senior pet-owners reporting to be more satisfied regarding their social and emotional lives.

Some final, well agreed physiological benefits are a reduced risk for asthma and allergies (McNicholas et al., 2005), faster healing and of a particular interest for this paper, interaction with a animal resulting in reduced cortisol levels in the stress system (Horowitz, 2008).

**Stress**

The unconscious regulation of the internal parts of the autonomic nervous system (a subdivision of the peripheral nervous system) is divided into the sympathetic and the parasympathetic system. With the former increasing and the latter decreasing bodily responses following a stressful stimuli, their functions are described by Engelmann, Landgraf, and Wotjak (2004) as a distinction between active and passive coping strategies.

In a stressful situation, the initially reflexive and non-specific behavioral response (for instance startle) is followed by so called *fight-or-flight* mechanisms. Classified as *defense reactions* by Lovallo (2004), fight-or-flight mechanisms are active coping strategies aimed to regain control and homeostasis (i.e. bodily balance) through enabling overt behavioral responses. Primarily mediated by the *sympatho-adrenal system* (SAS), immediate neuroendocrine and behavioral changes, such as increased heart rate, blood pressure, perspiration and respiratory rate (Lupien et al., 2007), are applied with the purpose of an acute regaining of homeostasis (Engelmann et al., 2004). The activation of SAS, thus mediates the acute responses to an aversive stimuli, through activity in the brainstem nuclei, the vagal nerve and the medulla of the adrenal gland (Engelmann et al., 2004).
The passive defeat reactions, are in turn, situations where the organism surrenders and withdraw due to feelings of lost control (Lovallo, 2004). These mechanisms are primarily mediated by the hypothalamic-pituitary-adrenocortical- (HPA) axis (Engelmann et al., 2004). Working to instead regain homeostasis in the long run, through delayed and prolonged neuroendocrine and behavioral changes (Engelmann et al., 2004), suppressing vegetative functions, such as nutrition ingestion and reproduction (Chrousos & Gold, 1992). In VanItallie (2002) the activity of the HPA-axis is described to consists of neurons in the hypothalamus releasing corticotropin-releasing hormone (CRH) and arginine-vasopressin (AVP). These in turn elicit the release of adrenocorticotropic hormone (ACTH) from the anterior parts of the pituitary glands. Transported by the blood, ACTH signals the adrenal gland to release the stress hormones glucocorticoids (cortisol) and catecholamine (epinephrine, norepinephrine) (Lupien, Maheu, Tu, Fiocco, & Schramek, 2007). When encountering a stressor, the acute function of stress hormones is to coordinate energy to targeted parts of the body. By mobilizing the energy supplies to for instance the muscles, conditions for an appropriate action in a demanding situations is made possible (Taylor, Klein, Lewis, Gruenewald, Gurung, & Updegraff, 2000). In other words, fight the encounter or flee the threatening situation.

The simultaneous activity of the SAS and HPA system, together with the rest-and-digest system (i.e. mechanisms of energy saving and damage repair) represents a bi-directional brain-body communication, making it possible for the organism to successfully adapt to potentially harmful and hostile situations.

Gender differences concerning how men and women handle a stressful encounter, has been proposed. Taylor et al. (2000) suggest that instead of the traditionally recognized fight-or-flight mechanisms, noteworthy primarily investigated in male rats, recent studies have illustrated females to rather employ a more affiliate approach, called tend-and-befriend.
From an evolutionary perspective, the fight-or-flight reaction of a female could mean that the offspring was left unprotected. Instead, by tending the offspring and befriending the social environment, the risk of threats could be reduced non-invasively and the belonging to a network offered security and increased chances of survival (Taylor et al., 2000). These functions are hypothesized to be mediated by the same neuroendocrine mechanisms facilitating attachment (Taylor et al., 2000), which will be attended to in more detail in forthcoming sections. Harari-Dahan and Bernstein (2014) comments studies through which these speculations have gained support, where intra nasal administration of oxytocin showed increases of the tend-and-befriend behavior in women and fight-or-flight response in men.

Chrousos and Gold (1992) point out that even though what human beings perceive as intimidating stimuli has changed much throughout evolution, the physiological reactions are fairly much the same. Lovallo (2004) differentiate between the physical and psychological aspect of both stress responses and stressors. The stressors regard either physical (i.e. physical threats and demands) or psychological (i.e. individual interpretations of situations as threatening) causes of stress. Physical stress is triggered by bottom-up brain processes, in which initial brainstem activity induces physiological stress responses in other related brain regions. Conversely, psychological stress are handled by top-down mechanisms, as areas in the brain related to higher-order functions signal to subcortical structures to activate stress responses. Besides performance of mentally demanding tasks (Lovallo, 2004), other sources for psychological stress might occur from interpretations of a situation as either novel, unpredictable or eliciting feelings of lost control (Lupien et al., 2007). As described by Chrousos and Gold (1992), an intimidating situation triggering psychological or physiological stress responses is a mechanism evolved to increase the chances for the survival and well-being of an organism. By successful adaption to the internal and external environment, the
organism counteracts the stressors and thereby balances its homeostasis. This is a process termed *allostasis* (Engelmann et al., 2004).

However, these responses are meant to be temporary, where an imbalanced stress-handling system can lead to severe pathological consequences. As emphasized by VanItallie (2002), from an evolutionary perspective there are no innate systems developed to handle the prolonged stress reactions humans are exposed to in today’s society. What differentiate physiological and psychological stress from one another is the lack of clear onset and offsets during the latter (Lovallo, 2004). The repeated and prolonged wear and tear of the body are in turn termed *allostatic load* (VanItallie, 2002). Three categories are discerned in Lundberg and Wentz (2004), which in one way or another can lead to physical or mental health problems. If a stressor result in (1) a repetitive stress reaction, (2) a protracted stress reaction with an inability to unwind, or (3) an inability to activate the stress-handling systems. VanItallie (2002) explains the acute reaction to a stressful stimuli to be shaped to mobilize the organism, physically and mentally preparing it for necessary behavioral adjustments in order for the immediate survival. These responses should then within a limited time period return to normal baseline (VanItallie, 2002).

Stress can both be the cause for illness onset and aggravating an existing disease. Regarding psychological deteriorations, stress can contribute to psychiatric conditions such as anxiety and depression (Chrousis & Gold, 1992; Engelmann et al., 2004), posttraumatic stress disorder (PTSD) and substance abuse (VanItallie, 2002). A hyper activated HPA and SAS system is regarded as contributing factors to the symptoms behind depression and anxiety disorders (Friedmann & Tsai, 2006). VanItallie (2002) presents studies where neuroendocrine abnormalities have been shown in maltreated children. Persistently elevated norepinephrine, epinephrine and dopamine concentrations together with decreased cortisol levels in urine samples years after the abuse, illustrates a chronically altered HPA system.
Both VanItallie (2002) and Åsberg et al. (2011) describe a genetic vulnerability in PTSD, whereas the stress sensitivity is set early in life, and might be the cause for permanent neuropsychological disabilities and abnormalities in the neuroendocrine system. Åsberg et al. (2010) further addresses a study where the decreased responsiveness in the HPA system of women suffering from exhaustion disorder, not returning to normal baseline in the one year later control. Physiological conditions such as obesity, cardiovascular disease, hypertension, stroke, dysfunction in immune system, type I and II diabetes mellitus and multiple sclerosis (VanItallie, 2002), are all conditions speculated to have stress as a contributing factor in the disease onset and exacerbation.

**Neuroendocrine Effects Following Human-Animal Interactions**

A complex interaction between various neurochemicals enables normal functioning and developments of an organism. An unbalanced cortisol system has been illustrated to have adverse effects on health. The fundamental functions of oxytocin and arginine-vasopressin in social behavior as well as their stress regulating properties on cortisol, will be addressed. Below, this will also be supplemented with some empirical studies illustrating how these systems has shown to be affected following interaction with an animal.

**Oxytocin and Arginine-Vasopressin**

Uvnäs-Moberg (2009) presents the history of oxytocin as first being discovered by Henry Dale in 1909, after studying cats giving birth. Initial studies hypothesized the neuropeptide to primarily be a hormone in the peripheral nervous system. By circulation in the bloodstream oxytocin was found to affect different bodily functions, primarily elicitation of muscle contractions during labor and lactation. This resulted in the name oxytocin, standing for quick birth in Greek. Peripheral oxytocin receptors are located in bodily organs responsible for cardio- and gut functions, namely the heart and vagus nerve (Zak, 2011).
Subsequent studies showed, however a role of oxytocin also in the central nervous system, where it as a neurotransmitter coordinates the network of a variety of different brain regions (Uvnäs-Moberg, 2009). Binding with receptors located in regions involved in emotion and social behavior, that is, hypothalamic regions, subgenual cortex and in the amygdala (Zak, 2011), oxytocin demonstrates to play a central role in social motivation, both pro- and anti-social such. However, because of the difficulties and invasive methods of measuring neurotransmitters in the brain, studies of the neuropeptide primarily disclosures its peripheral functions (Meyer-Lindenberg et al., 2011).

As a central mediator of the affiliated behavior in a variety of different species (McCall & Singer, 2012), oxytocin together with endogenous opiates create the rewarding feelings of maternalizing and nurturing in the female (Churchland, 2011). Besides promoting the attachment between mother and offspring, other pro-social behaviors have been added to the functional role of oxytocin, for example an involvement in sex and partner preference (Scantamburlo et al., 2009), social memory and recognition (McCall & Singer, 2012), trust (Churchland, 2009; Zak, 2011) and empathy (Horowitz, 2008; Meyer-Lindenberg, Domes, Kirsch, & Heinrichs 2011; Zak, 2011). Additional properties of oxytocin are sedative and analgesic effects (Uvnäs-Moberg, 2009), with studies for example illustrating suppressed responsiveness of the HPA-axis in nurturing mothers and raising the pain threshold in children following massage (Taylor et al., 2000).

Through manipulations by inserting synthetic oxytocin either in the form of nasal spray or intravenously (Zak, 2011), studies also have recognized an anti-social role to the neuropeptide. With the use of experiments such as the dictator game, the prisoners dilemma paradigm, the empathy for pain paradigm, the trust game and the ultimatum game, results repeatedly have illustrated a tend (i.e. in-group favorability) and defend (i.e. out-group discriminating) role of oxytocin in the test participants (De Dreu, 2012; Harari-Dahan &
Bernstein, 2014; McCall & Singer, 2012). Often mentioned in studies concerning psychological features of social behavior, these games for instance can reveal how oxytocin administration affects elements of social judgment regarding cooperation and trust by the monetary investment in a stranger. Another example is the brain images provided by the empathy for pain paradigm, revealing genuine compassion by the activation in similar brain circuits in experienced versus observed pain in oneself and a beloved one. The contribution of oxytocin in in-group favorability is driven through the complex regulation of brain areas such as inhibited amygdala activity and elevated inferior frontal gyrus, inferior temporal lobe and ventromedial prefrontal cortex activity (De Dreu, 2012). Which are circuits mediating trust, empathy, and other-concern. The need to make quick decisions regarding if an encounter is part of the in- or out group, the function of social categorization creates a memory signature facilitating familiarity (DeDreu, 2012). The role of oxytocin in out-group discrimination manifests itself through defensive aggression towards out-group members perceived as possible threats. In females this is most clearly observed in maternal aggression (Neumann & Landgraf, 2012), expressing itself when the offspring is perceived to be in danger.

These varying effects of oxytocin are speculated to be determined by contextual features of a situation together with individual differences in social proficiency (Bartz, Zaki, Bolger & Ochner, 2011). The authors (Bartz et al., 2011) propose three mechanisms to account for these differences: (1) anxiety reduction, whereas the fear modulating properties of oxytocin, can either increase or decrease pro-social behaviors, (2) affiliative motivation, where the pro-social and anti-social behavior might depend on the selective function of oxytocin on memory and emotion recognition, and (3) perceptual selectivity and social salience, where oxytocin regulates selective attention to information in different social context. Another explanation alternative proposed is the social approach/withdrawal hypothesis, presented by Harari-Dahan and Bernstein (2014). According to this hypothesis,
oxytocin mediates the motivational aspects of approach or avoidance in social interactions, through its function on rewarding contra fear related brain circuits. Both theories proposed above are depending on differences in the impact of oxytocin on amygdala activity. This is supported by the decreasing properties of oxytocin on the fear and vigilance promoting activity of the amygdala (De Dreu, 2012), as well as a decreased connectivity between the amygdala and the brainstem, a connection involved in autonomic fear responses (McCall & Singer, 2012).

Furthermore oxytocin has an impact on the dopaminergic reward system, something supported by Zak (2011) presenting the Human-Oxytocin-Mediated-Empathy (HOME), a model concretizing the brain circuits that mediate social behavior. Following a social stimuli, oxytocin together with the calming and comforting effects of serotonin and the rewarding and motivating function of dopamine, handle the production and sustainment of social contact (Zak, 2011). The role of oxytocin, enhancing the caudate nucleus activity and thereby creating the rewarding feelings of reciprocated cooperation (De Dreu, 2012), is findings one could speculate to be support for the HOME model.

Overall, and especially in contrast to oxytocin, studies of the effects on the arginine-vasopressin system up to date are scarce. Even more rare are investigations regarding the neuropeptides role in human-animal interactions. Because of this, it will not receive any greater focus in this paper, except to give a fundamental understanding that it too has a specific role in social behavior and stress regulation.

Although arginine-vasopressin is closely related to oxytocin with similar molecular structure (Churchland, 2011; Zak, 2011), the two neuropeptides are considered to have opposite roles in an organism’s functioning (Meyer-Lindenberg et al., 2011). Where oxytocin has stress reducing properties, arginine-vasopressin instead are believed to possess stress
promoting functions, for instance increasing cortisol release as well as amygdala activity (Meyer-Lindenberg et al., 2011). Besides the peripheral functions of blood pressure and water homeostasis regulation (Churchland, 2011), arginine-vasopressin has also shown enhancement of certain cognitive functions. For instance intranasal administration of the neuropeptide has illustrated changes in the amplitudes of event-related potentials, a pattern considered to be part of higher order brain processes (Meyer-Lindenberg et al., 2011). With a so far demonstrated, stronger impact on the behavior in males, arginine-vasopressin is associated with externalized aggression (Zak, 2011). The neuropeptide regulates parental aggression both in males and females. However, the most cited functions are demonstrated in males, mediating a protecting and guarding role in the parental aspect (Zak, 2011), as well as male-rivaling and post-mating aggression (McCall & Singer, 2012). In relation to stress, arginine-vasopressin, with more medial involvement of the central nucleus of the amygdala, has showed to increase cortisol levels in men, increasing their stress responses (De Boer et al., 2012; Meyer-Lindenberg, et al., 2011). This in turn, involves cognitive elevations of selective attention, memory and mood (VanItallie, 2002), as well as physiological stress responses such as suppressed urine production (VanItallie, 2002) and elevated blood pressure (Uvnäs-Moberg, 2009).

The contributing role of the two neuropeptides in different psychiatric disorders has been investigated. Recent studies have found a correlation between a malfunctioning oxytocin and arginine-vasopressin regulation and various types of malfunctioning emotions and behaviors (Neumann & Landgraf, 2012), especially psychiatric disorders characterized by impairments in social functioning (Meyer-Lindenberg et al., 2011). A pathological avoidance to social contact can be regarded as the first signs of autism spectrum disorder (Levinson, 1984), a neurodevelopmental condition recognized in subsequent studies to be linked to attenuated oxytocin levels (Meyer-Lindenberg et al., 2011). Regarding depression, oxytocin is
said to have anti-depressive effects where arginine-vasopressin on the contrary has a more promoting quality to depression (Neumann & Landgraf, 2012). This is supported by Meyer-Lindenberg et al. (2011), in which elevated plasma oxytocin levels are associated with decreased anxiety in depressive patients and reduced oxytocin levels are associated with the depression diagnosis in general. Arginine-vasopressin is called to be anxiogenic (i.e. promoting anxiety) where oxytocin on the other hand is regarded as anxiolytic (i.e. inhibiting anxiety), in Neumann and Landgraf (2012). Beetz et al. (2012) did a literature review, finding indications of reduced self-reported anxiety in a variety of study settings, age groups and mental conditions. For instance, anxiety levels decreased following the interaction with a friendly animal, both in short-term experiments and clinical long-term studies.

Sensitive to early life experiences, the oxytocin system can be chronically impaired by early life traumas or maltreatment (McCall & Singer, 2012). For instance the suppressing function of oxytocin on cortisol can be impaired by early life separations (Meyer-Lindenberg et al., 2011). Which could be interpreted as a possible genetic mechanism for an increased vulnerability for stress later on in life. Other support is presented by Zak (2011), where an unmet HOME system in early childhood can result in a reduced amount of receptors in otherwise oxytocin dense brain regions. Resulting in a condition he himself has termed the oxytocin deficit disorder (Zak, 2011). Promising results from recent preclinical investigations have shown indications of possible treatment with intranasal administered oxytocin.

Mitigating effects have been observed on symptoms, such as improved social interaction and understanding in autism-patients, lowering amygdala activity in patients with social anxiety disorder, and stress buffering effects on the emotionally unstable individuals suffering from borderline-personality disorder (Meyer-Lindenberg et al., 2011).

**Empirical findings in relation to human-animal interactions:** Measured either through plasma (i.e. blood), urine or cerebral spinal fluid (Zak, 2011), oxytocin has shown to
be released not only following direct physical interaction. Nagasawa et al. (2015) also found evidence of alterations in the oxytocin system during both eye contact and verbalizations directed towards a companion animal. However, it does not stop there. Even the mere presence of an animal has illustrated beneficial changes (Wells, 2009). The strength of the neurochemicals effect, furthermore depends on properties of the relationship between the two parties interacting. That is, the closer and more trusting relationship, the larger amount of oxytocin will be released (Beetz et al., 2012).

Odendaal and Meintjes (2003) investigated the neurophysiological changes following the interaction with an animal, with results indicating on an doubled concentration of oxytocin in both species. In the same experiment the authors also found significant increases of β-endorphins, β-phenylethylamine, prolactin and dopamine, in both species. This is neurochemicals related to affiliate, pleasurable and bonding behavior, reward, stress relief and analgesia (Odendaal & Meintjes, 2003). Furthermore, the attachment facilitating properties of oxytocin are not restricted to humans only. Nagasawa et al. (2015) reported a prolonged period of eye-gaze towards the owner in female dogs following oxytocin administration. However, no such change could be recognized in male dogs. These are differences speculated to be due to the interacting role of arginine-vasopressin in males creating vigilance towards strangers. In another study, Miller et al. (2009) investigated gender differences in the stress reducing properties of oxytocin. Men and women, instructed to read (control condition) or interact with their companion dog (experimental condition) after a day at work. The results indicated on a significant increase of oxytocin in women approaching their dog, where on the contrary a decrease in the oxytocin levels of men were recognized. These findings are hypothesized, by the authors, to partly be due to the reinforcing function of estrogen on oxytocin production, secretion and function in women. Male sex hormones, has on the other hand illustrated inhibiting role on oxytocin (Miller et al., 2009).
A problem however, as addressed by Zak (2011): “high levels of stress have been shown to inhibit OT [oxytocin] release” (p.62). Other authors (McCall & Singer, 2012; Meyer-Lindenberg et al., 2011; Zak, 2011) support this, illustrating alterations in the oxytocin system in children traumatized in early age. Thus introducing the risk of a vicious circle, whereas the isolated exhaustion disorder suffering patient won’t benefit from therapy assisted by an animal.

**Cortisol**

The hormone known as cortisol in humans, and corticosterone in animals (Lupien et al., 2007), can be measured and studied either through blood or saliva sampling (Åsberg et al., 2011). The normal circadian rhythm of cortisol circulation levels illustrates a peak in the morning, a slow decrease during the day, and an elevation again during the middle phases of sleep, pre awakening (Lupien et al., 2007). Altering factors increasing the cortisol levels can be seen during novel, unpredictable, or challenging situations (Lupien et al., 2007). Also alcohol, tobacco and physical exercise affect cortisol levels (VanItallie, 2002), as well as some research finding indications of a positive correlation between the emotional interpretation of a aversive situation and cortisol response (Lovallo, 2004).

Described by Lupien et al.(2007), cortisol is binding to two types of receptors. The mineralocorticoid receptors are exclusively located in the limbic system, and the glucocorticoid receptors essentially located in the prefrontal cortex but also subcortical structures. The proficiency range of the cortisol binding receptors varies during the day. Where the majority of the mineralocorticoid receptors are activated both in the morning and the evening. Regarding the glucocorticoid receptors in turn, about half is activated in the morning, and a tenth activated in the evening (Lupien et al., 2007).
With a high concentration of glucocorticoid neurons in the amygdala and hippocampus (VanItallie, 2002), cortisol has an important impact on the activity of the limbic system. In Lupien et al. (2002) the glucocorticoids function on memory is conceptualized in the form of a bell-curve. An optimal impact on cognitive functions such as declarative memory, is achieved when stress- and glucocorticoids levels are moderate. When these levels instead are either in the low or high range of the curve, impaired memory functions might follow (Lupien et al., 2007). The involvement of the hippocampus in memory formation and the amygdala’s role in memory consolidation and behavioral coordination, illustrates an important function of learning (VanItallie, 2002). Evolutionary, learning is a necessity for survival. Information of an earlier stressful stimulus is stored enabling successful adaptive behavioral responses in subsequent threatening situations.

An imbalanced cortisol system can lead to either reversible short-term memory impairments or, in more severe and prolonged stress reactions, hippocampal neuronal cell death (VanItallie, 2002). In this regard, the stress sensitivity of the hippocampus can have grave consequences. Elevated cortisol levels have shown a connection to chronic disease, diabetes, depression and abdominal obesity. High levels of cortisol also has been ascribed to impaired immune system functioning, however, social support has illustrated to have opposing effects on these deteriorative processes (Lovallo, 2004). Low cortisol levels are on the other hand connected to chronic fatigue syndrome, struma, rheumatism and nicotine withdrawal syndrome (Lundberg & Wentz, 2004). An imbalance in the cortisol system can thus have adverse effects on an organism’s functioning, stress mechanisms switching from a protecting to a harmful mode.

**Empirical findings in relation to human-animal interactions:** Friedmann and Tsai (2006) present studies where not only the direct interaction, but also the mere presence and observation of an animal has demonstrated stress reducing effects on physiological arousal.
Following interaction with an animal, studies (Odendaal & Meintjes, 2003) showing a significant decrease of cortisol concentration in humans when on the other hand no such change could be recorded in the investigated dogs. A subsequent study presented in McNicholas and Collis (2006) neither identified any increases in the cortisol levels of dogs undergoing therapy training. An experiment performed by Handlin et al. (2011) however, recorded significant increases of cortisol in dogs following interaction with their owners. Results speculated by the authors (Handlin et al., 2011) to be due to the effect of physical activity on the circadian rhythm of the cortisol system.

A study presented in Beetz et al. (2012) investigated the influences of a dog in families containing a child with autism disorder. This study, interestingly, found a clear correlation of decreases in cortisol levels when having a dog present following morning awakening. When the dog was present a decrease from 58% to 10% in the children’s cortisol levels were recognized contra a increase back to 48% when it later was removed.

Levels of other stress related hormones, such as epinephrine (also known as adrenaline) and norepinephrine (also known as noradrenaline) has also been recognized to significantly decrease following human-animal interactions (Beetz et al., 2012; Berget & Ihlebæk, 2011). Thus the stress reducing properties of animal contact on the cortisol system not solely being responsible for the reported beneficial effects.

**Psychological Effects Following Human-Animal Interactions**

This section will shortly deal with the psychological effects of companion animals from a non-pathological perspective. Beginning with young children, pet ownership has been proven to assist normal development. For instance the mere presence of pets in the home environment have shown to improve psychological factors such as non-verbal communication, social competence, self-esteem (Edney, 1995), and empathy (Beetz et al.,
2012; Walsh, 2009a). These are all skills trained through the encouragement of responsibility and nurturing, where an inappropriate behavior towards the animal is directly noticed, corrected and forgiven (Edney, 1995). The child is furthermore, introduced to the natural way of life, including reproduction, birth, illness and death (Edney, 1995). Further, Beetz et al. (2012) addresses learning promoting properties in dogs, mentioning studies where both motor-, imitation- and memory skills could be improved when a dog was present. These, the authors speculate, might be due to dogs increasing motivation and attention in children. These are behavioral improvements that can be used both in future interactions with other animals but also in the contact with humans (McNicholas & Collis, 2006).

The practice of communication is not limited only to the younger parts of the society. The presence of a companion animal has in studies illustrated to facilitate more constructive ways to communicate between arguing couples (Meyer-Lindenberg et al., 2011). Dogs also have shown to facilitate cohesion within a family, where every day challenges encourages practicing in problem-solving, rules and communication (Walsh, 2009b), as well as motivating the family members to spend time together (Beetz et al., 2012).

**Stress-related Psychiatric Disorders**

Depending on symptomatology and disease progression, ICD-10 differentiates between four kinds of stress related psychiatric disorders. These four are presented in Åsberg, Wahlberg, Wiklander and Nygren (2011) as (1) **adjustment disorder**, where a life crisis results in an prolonged and deepened stress reaction that the subject has difficulties adjusting to. Next, there are the (2) **acute stress disorder**, involving a life-threatening trauma, which in some circumstances can be a precursor to (3) **post-traumatic stress disorder**, with invalidating flashbacks of a trauma. Finally (4) **the burnout syndrome [exhaustion disorder]**, which is characterized by a prolonged stress reaction, resulting in physiological and/or psychological
exhaustion. A more detailed distinction between the symptomology of these different stress-related disorder can be found in Table 1, below. The focus of this section will remain on the exhaustion disorder.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Type of stress</th>
<th>Clinical symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjustment disorder</strong></td>
<td>Life crisis, normal psychological distress.</td>
<td>Depression, anxiety, agitation, sleep disturbance, suicidal thoughts.</td>
</tr>
<tr>
<td></td>
<td>E.g. separation, unemployment, grief reactions.</td>
<td></td>
</tr>
<tr>
<td><strong>Acute stress disorder</strong></td>
<td>Life threatening trauma (the acute phase)</td>
<td>Strong and alternating affects, dissociation, inadequate behavior, confusion, vegetative symptoms.</td>
</tr>
<tr>
<td><strong>Post-traumatic stress disorder</strong></td>
<td>Life threatening trauma (the after phase).</td>
<td>Intrusive, unwelcome and anxiety-provoking memories (flashbacks), anxiety, tension symptoms, phobic avoidance.</td>
</tr>
<tr>
<td><strong>Burnout syndrome</strong></td>
<td>Non-life threatening chronic stress without recovery.</td>
<td>Extreme mental and physical fatigue, cognitive disorders (such as memory and concentration difficulties), disturbed sleep, affective symptoms.</td>
</tr>
<tr>
<td></td>
<td>E.g. psychosocial stress.</td>
<td></td>
</tr>
</tbody>
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*Table 1. Stress-Related Psychiatric Disorders.* The table contains the four distinct stress-related psychiatric disorders, each clarified with what type of stress causing illness as well as clinical symptoms. Adopted from Åsberg et al. (2010), translated from Swedish by the author.

**Exhaustion disorder**

Neurasthenia (Greek for nerve weakness), described by White (1989), was introduced already in the middle of the 19th century by neurologist George Miller Beard. Beard recognized a new type of patient group, characterized by symptoms such as headache, general malaise, low appetite and insomnia. This he believed was due to the rapidly advancement of modern civilization resulting in exhaustion of the nerves in the central nervous system. Involving a similar clinical picture of today’s term of burnout syndrome, the condition later was supplemented with symptoms of irritability, lack of interest, concentration impairments and chronic fatigue. *Rest cure* was prescribed, which consisted of rest, diet and massage (White,
1989). Noteworthy, these symptoms furthermore are similar to the somatic condition of chronic fatigue syndrome. However, due to the limited scope of this paper, these classification speculations won’t be further addressed to. The term neurasthenia was used with some caution by medical practitioners until the 1970’s. Subsequent work by psychologist Herbert J. Freudenberger and social psychologist Christina Maslach recognized an emotional exhaustion in devoted workers in social service professions (Schaufeli, Leiter & Maslach, 2009).

The term burnout was coined. Based on unrealistic performance goals and work overload, the burnout syndrome was divided into three sub dimensions: (1) physical and emotional exhaustion, (2) cynicism, and (3) inefficiencies (Åsberg et al., 2011). This in turn resulted in symptoms, in addition to those of neurasthenia, such as a weakened immune system and impairments in cognitive functions (e.g. memory and attention) (Lundberg & Wentz, 2004; Åsberg et al, 2011).

However, definitional disagreements exists concerning the non-reversible meaning of burnout, and the more non-dramatic and reversible implications of exhaustion. As presented by Schaufeli et al. (2008), some argue that there is no difference between the two terms and that all self-rating scales lead to similar conclusions, namely some sort of physical, mental or emotional exhaustion. The authors however claim that health professions and researchers in Sweden and Netherlands, to the opposite argue that it is important not to confuse the two possible overlapping but not identical conditions. The burnout syndrome was in 1997 included in the World Health Organization (WHO) diagnostic manual International Statistical Classification of Diseases and Related Health Problems (ICD). In ICD the burnout syndrome is defined with a Z-code, standing for significant factors influencing the health status, even if not directly characterizing the disease diagnoses (Schaufeli et al, 2009). According to Åsberg et al. (2011), the most obvious difference between the two terms is the subject’s attitude to his/her work. The exhaustion disorder is, in opposition to the burnout syndrome, classified as
a disorder, and patients in this condition still have a passionate, and far from cynical, commitment to their professional occupations, despite exhaustion. In 2005 exhaustion disorder became an accepted distinct psychiatric diagnosis in the ICD-10, however, DSM-5 still only include it as a subcategory under different depressive conditions.

The exhaustion disorder is divided into three phases. The first indications of the syndrome, which with varying impact can last for years, is known as the prodromal phase. This phase consists in episodic symptoms of psychological and physiological overload, including for instance signs of gastrointestinal problems and pain conditions caused by tensions in back and neck. Next is the acute phase with a pronounced physical and mental fatigue that cannot be lifted with rest. These symptoms are episodic and sudden, and last most commonly a maximum of a couple of weeks. Lastly, the recovery phase is a long process consisting in a increased sensitivity to stress and risk of relapse (Åsberg et al., 2010).

According to the diagnostic criteria presented by Socialstyrelsen (2003) the patient has been experiencing physical and psychological exhaustion for at least two weeks as the result of one or more identifiable stressors persisting over at least a six months period. Further, symptoms such as energy and interest loss, cognitive impairments, emotional irritability and sleep disturbances significantly causes the patient suffering. Other potential medical conditions must also be excluded.

Differential diagnostics are problematic as depressive symptoms both can be a secondary symptom and an occasionally fundamental part of the exhaustion disorder (Åsberg et al., 2010; Åsberg et al., 2011). In general, comorbidity is a common aspect of depression and anxiety disorders (Neumann & Landgraf, 2012). With similarities in symptom manifestation as well as underlying mechanisms, misdiagnosis are common, something complicating the diagnostic assessment (Socialstyrelsen, 2003). One factor differing between the two conditions of exhaustion disorder and major depression, is treatment efficiency.
Indications of ordinary antidepressants not being an effective alternative for the exhaustion disorder, instead has shown positive results following occupational rehabilitation with progressive reintegration to the work (Åsberg et al., 2011). Patients of exhaustion disorder are advised to lifestyle changes, which includes establishment of a balance between rest and activity, stress reduction as well as healthy sleep habits (Åsberg et al., 2011).

Further, there are also biological differences important to take into consideration in the process of diagnosing, with differences in stress regulation. In major depressive disorder an increased reactivity of the HPA-axis has been shown, where on the contrary a reduced susceptibility in this system is recognized in exhaustion disorder (Åsberg et al., 2011).

Although evidence still is uncertain, Socialstyrelsen (2003) treat possible mechanisms believed to influence the risk of illness onset. These are described to partly consist of genetic causes resulting in a deteriorated resilience, and partly the upbringing environment, where the basis of an individual’s self-esteem is grounded.

Regarding the involved brain regions in the exhaustion disorder, empirical studies still are lacking. However, signs of disturbances in the amygdala and hippocampus have been found, as well as a decreased serotonin receptor binding in these two regions (Åsberg et al., 2011).

**Practical Applications of Human-Animal Interactions in Psychiatric Care**

Besides the today most common pet assistance, using guide dogs for the blind or deaf and horse riding for the physically and mentally disabled (Edney, 1995), a relatively new finding is the ability in dogs to predict the early warning signs of epileptic seizures and diabetic episodes (Horowitz, 2008; Walsh, 2009a; Wells, 2009). However, animals have also been assigned an increasingly important role in psychiatric therapy.
There are various alternatives in how the use of animals in a therapy session can be designed. Levinson (1984) lists up four methods that he states, in one way or another satisfy the need for tactile contact. These are: (1) as an aid and assistant, (2) as the therapist itself, (3) to facilitate personal change, or (4) as an instrument to a contact with nature. The perception of the therapist as an authority figure, the author continues, can sometimes discourage the patient to open and confide. For instance, college students perceived a psychiatrist accompanied with a dog as more trustworthy (Beetz et al., 2012). This is knowledge frequently utilized in advertisement, where the physiological stress reducing properties of watching images containing a person accompanied by an animal inspires feelings of trustworthiness and safety (Friedmann & Tsai, 2006). Levinson (1984) compare these trust enhancing properties in animals that increase trust between individuals, to the tendency in children to confide their inner feelings and thoughts to a doll when direct vocalizations to a therapist might be perceived as too difficult.

Psychosocial stress is defined as an imbalance between society’s requirements and expectations and the own abilities and resources (Lundberg & Wentz, 2004; Socialstyrelsen, 2003). It is thus not the burden itself that causes morbidity but rather our interpretation of the situations as overpowering. Hart (2006) distinguishes between four categories regarding the psychosocial benefits of human-animal interactions. First of all animals offer companionship, especially to the elderly and people with physical or mental illnesses and disabilities. Second, animals facilitate socializing, with studies finding evidence for the social support theory, which are addressed above. The third category concerns the motivational aspects of animals, promoting feelings of meaningfulness and encouraging engagement in constructive and productive activities. Finally, Hart (2006) points to the calming effects of animals, with empirical studies in different samples and settings have shown to reduce the anxiety level.
According to Odendaal (2000) the use of animals in therapeutic settings has proven to be particularly useful in the work with the weaker and more vulnerable parts of the population. Odendaal (2000) continues with that people who due to their position can not compete for attention egens, a Latin word standing for: “the need for attention on a normal, basic emotional level as the prerequisite for successful social interaction” (p. 276) to the same degree as the economically active mainstream community. According to Hart (2006) animals facilitate socializing, as well as motivate. Promoting feelings of meaningfulness and encouraging engagement in constructive and productive activities. Besides having calming effects on the subjects receiving treatments, the presence of an animal also eases the workload in caregivers and close family (Berget & Ihlebæk, 2011).

Pet facilitated therapies have been proven useful in a variety of medical conditions, easing the suffering in patients in different ages. Beginning in the pediatric care setting, particularly disabled children suffering from social stigma have shown to profit from the anti-isolating effects of a companion animal (Horowitz, 2008). According to Hart (2006) the company of animals might normalize an individuals social environment. Likewise, using dogs in therapy has shown to facilitate adaption by reducing the psychological distress in children exposed to treatment in hospitalized settings. The soft fur of animals can act comforting for distressed children, a phenomenon called the security blanket effect, also known as the transitional object effect (Edney, 1995; Levinson, 1984). Furthermore, maladaptive behaviors can be remedied in neglected and abused children, with psychological effects of reduced anxiety and restored trust.

Regarding school aged children, the company of a dog during classroom lectures increased attention (Beetz, et al., 2012) and lessened the disturbance of distractions (Hart, 2006), promoting a more homogenous learning environment. Anti-social behavior could be eased in emotionally disturbed youths (McNicholas & Collis, 2006), and other issues such as
aggression and hyperactivity in children suffering from attention deficit and hyperactivity disorder or conduct disorders became less problematic (Hart, 2006). Children with autism is a further condition largely benefiting from the company of an animal. A dog can, for instance, promotes language usage, increases social interaction and facilitates play in these children (Beetz et al., 2012). The authors continue with an example where children suffering from different psychiatric disorders, show improvements in emotional balance following one single intervention with an animal.

Wells (2009) and Beetz et al. (2012) describe the ability in animals to reduce feelings of loneliness in humans. For instance, there are many studies indicating on the improved socializing skills and reduced violence in the rehabilitation of prisoners (Edney, 1995), as well as overcoming their feelings of isolation (Wells, 2009).

Most studies made in the subject involve the senior parts of the population. Loneliness is an natural process and a not unusual downside with aging. You retire, partner and friends pass away, bodily changes leading to a less active leisure time, all causes leading to a systematic culling of the social network (Hart, 2006). In moments of sorrow the presence of animals can give effective consolation (McNicholas et al., 2005). Studies mostly performed on the residents of institutional facilities, exemplify increased happiness and responsiveness in the patients at a nursing home. They can create improvements in mood (Horowitz, 2008), and decreasing depression symptoms (Beetz et al., 2012; Walsh, 2009a). The company of an animal can ease the anxiety level in palliative care patients (Walsh, 2009a), as well as patients suffering of dementia (Horowitz, 2008; Johnson et al., 2002). Other psychological benefits, such as increased social interest and interaction as well as general life-satisfaction has been observed (Johnson et al., 2002). To this list McNicholas and Collis (2006) add improved and independent personal hygiene, self-care and living. Horowitz (2008) addresses studies where analgesic medications could be reduced when a therapy dog visited a long-term care facility.
Speculated contributory effects to these above mentioned findings are that animals compels to the establishment of stability and routines (McNicholas et al., 2005), as well as creating a protective responsibility (Walsh, 2009a). This might give rise to the salutary feelings of meaningfulness, a important element in well-being that can be insufficient in the lives of the elderly.

Regarding efficiency in psychiatric treatment, various mental disorders, especially those involving affective problems, has proven benefit from human-animal interactions (Berget & Ihlebæk, 2011). Also individuals struggling with substance abuse benefited from an animal assisted treatment program (Beetz et al., 2012). Horowitz (2008) further addresses studies that have shown emotional support in times of life-threatening illnesses, such as in cancer- or AIDS patients. This can be supported by Levinson (1984), whom emphasizes the importance of emotional healing in order for a therapeutic treatment to be effective. Several components need to be fulfilled, with touch comfort and social attachment/companionship, being two conditions that are absolutely necessary. These, Levinson (1984) continues, are fundamental principles of animal-assisted therapies, leading to successfulness as a complementary treatment method. There is an innate and biological need for social contact; a silent communication manifesting itself already in the neonates contact to the mother that later is satisfied by other individuals. This need, being satisfied by both humans and animals, is something the next section will address.

**Discussion**

According to Levinson, pets are needed to re-humanize our society, which through our sparse spiritual life has ended up astray (Mallon, 1994). The steady statistical increase of stress-related sick leaves, is a serious problem the society of today is facing. One may speculate that a possible causing mechanisms behind these numbers, consists partly in speculations
regarding changes in the societal structure, evolving from collectivistic to rather individualistic cultures. Beginning already in young school children, competition and rivalry is encouraged, dimming the compassion and empathy towards our fellow men and creatures. Thus, the interspecies relationship should not only be restricted to the healing of the already damaged. With empirical evidence of the positive influence of animals in promoting normal, healthy development in children (Beetz et al., 2012; Edney, 1995), one could propose that the usage of animals should be more frequent in the school environment. Due to emotional, intellectual and behavioral problems created and improperly treated earlier in life, animal assisted interventions could work as prevention against stress related suffering in adulthood, sparing children from pharmaceutical interventions.

With the effects of cortisol as the most extensively investigated in the anthrozoology field, studies repeatedly have illustrated a suppressing function on the stress system following human-animal interactions. With this in mind, we now continue to the heart of the matter. Is there reason to believe that the neurobiological effects that human-animal interactions result in can be used as a complementary tool in the treatment of exhaustion disorder?

With a rather comprehensive understanding about the involved mechanisms behind stress regulation, reflection is needed regarding it’s influence in the particular case of exhaustion disorder. As presented by Lovallo (2004) fight-or-flight often involve strong and unpleasant emotions such as fear, anger and anxiety. Endocrine effects behind these mechanisms are cortisol and epinephrine, both primarily associated with stress regulation and stress responses. β-endorphin is a further neurochemical involved in these reactions, but is on the contrary more associated with positive and rewarding feelings, for instance the feelings of flow experienced during physical exercise termed runner’s high (Lovallo, 2004). Noteworthy, human-animal interaction studies have reported decreases in both cortisol (Beetz et al., 2012; Friedmann & Tsai, 2006; Horowitz, 2008; Johnson et al., 2002; Odendaal & Meintjes, 2003),
and epinephrine (Beetz et al., 2012; McNicholas & Collis, 2006), as well as increases in β-
endorphines (Beetz et al., 2012; Horowitz, 2008; Johnson et al., 2002; Odendaal & Meintjes, 2003). However, Socialstyrelsen (2003) speculates about the symptom picture behind the particular case of exhaustion disorder, where the symptoms rather manifest themselves in mechanisms of a play-dead program. That is, the opposite of the fight-or flight responses. Furthermore, the features of this program are reminiscent to the so called defeat reactions mentioned by Lovallo (2004) above. This Socialstyrelsen (2003) base on both the exhaustion disorder and the play-dead program consisting in features of avoidance and isolation, fatigue, and depression. In order to apply appropriate methods in the treatment of exhaustion disorder, further investigations regarding the precise involved stress-regulating mechanisms, are needed.

As a further central parameter in decreases of stress related chemicals, oxytocin secreted through positive social contact, also has received much interest in the field. Evidence of increases in oxytocin levels during interaction with a companion animal, has repeatedly been cited in the anthrozoology literature (Allen, 2003; Beetz et al., 2012; Berget & Ihlebæk, 2011; Handlin et al., 2011; Horowitz, 2008; Johnson et al., 2002; Miller et al., 2009; Nagasawa et al., 2015; Odendaal, 2000; Odendaal & Meintjes, 2003; Wells, 2009). The disturbances found in brain regions related to exhaustion disorder has as mentioned primarily been recognized in the limbic system structures (Åsberg et al., 2011). Interestingly, oxytocin has a strong impact on the neurons of the amygdala (Bartz et al., 2011; De Boer et al., 2012; De Dreu, 2012; Harari-Dahan & Bernstein, 2014; McCall & Singer, 2012; Meyer-Lindenberg et al., 2011; Neumann & Landgraf, 2012; Scantamburlo et al., 2009; Zak, 2011). Further, as pointed out by Meyer-Lindenberg et al. (2011) the stress buffering effects of oxytocin has been observed in several studies applying intranasal doses of oxytocin. This together with social support showed to reduce cortisol levels, stress responses and self-reported anxiety.
This is a finding that Meyer-Lindenberg et al. (2011) assume to be due to the decrease in activity of the amygdala. With this in mind, the natural trust given by animals thus could be speculated to constitute a non-invasive opposing effect on the fear and anxiety responsiveness of the amygdala in exhaustion disorder suffering patients.

With numerous psychiatric disorders characterized by the lacking of a social network, prolonged isolation can lead to severe psychological and physical suffering. With the four factors of social support (Collis & McNicholas, 1998) in mind, the contact with both humans and animals could be assumed to satisfy these needs. The experiment performed by Allen (2003) showed that the mere task of reading aloud to a human, even though familiar, resulted in elevated stress responses. On the contrary the presence of a dog had opposite effects on the stress responses. This could be suggested to be due to animals not only providing some of the elements valuable in human-human relationships (such as affection, belonging and encouragement), but also animals might add a non-judgmental aspect to the interspecies relationship. This is something that might be a short coming in the human-human relationships due to the human ego. This together with other important characteristics such as a positive and easygoing attitude, animals could be speculated to affect the patient’s susceptibility, and by this in turn promote the treatment progress.

However, as argued by Archer (1997), strong interspecies relationships could be interpreted as mere signs of human abnormality and inadequacy. By this he means that pets merely might work as substitutes for an individual’s insufficient ability to form relationships with other humans. This, however, conflicts with statistics presenting 6 million dogs in the households in England (Wells, 2009) and 68 million pet dogs in the United States (Allen, 2003). If pet ownership were signs of psychological abnormalities, we would probably have serious social problems as a consequence. Also somewhat contradictory is the fact that a faltering social life, both self-chosen or involuntary, is regarded as signs of morbidity. Pet
ownership thus rather should be interpreted as an energetic effort to sustain a normal and healthy social life.

In my eyes, there is some shortcomings in the contemporary knowledge base of the field. There is a seemingly unilateral focus on the effects of oxytocin in anthrozoology studies, where the on the other hand, a modest amount of research on arginine-vasopressin is creating a large gap in our knowledge base regarding social interaction. For instance, it is hard to find any research investigating the contributing role of arginine-vasopressin in human-animal interactions. This although the neuropeptide, for a long time already, has been recognized as an important element in social interaction. With its involvement in aggression, a more thoroughly study of arginine-vasopressin maybe could reveal important information about pathological propensities in relation to social behavior.

The ethical aspects in a subject of this kind, is no less important. The utilization of animals in care settings should under no circumstances compromise the animal’s welfare at the expense for the human well-being. More longitudinal studies need to be done, investigating the exact effects of cortisol on the animal after interaction with a human. With animals being in an inferior position to humans, we are responsible for the animals to not suffer harm in our attempts to integrate them in our care settings. This can be controlled by careful education of those making use of animals as a complementary tool in treatment, something organizations such as the Delta Society and the Society for Companion Animal Studies can offer. A furthermore important thing to keep in mind is the aspekts making not everybody either capable or suitable of owning either pets in general or specific species in particular. In these cases, other complementary alternatives are needed to be considered.

Given the beneficial effects of social contact on many aspects of an individuals well-being, other alternatives should be possible to utilize. For instance experiments have illustrated that recreational and community-based activities improve the psychological well-being in elderly
(Sviden, Tham, & Borell, 2004). For instance Nakanishi and Tatara (2000), cited in Onishi, Masuda, Suzuki, Gotoh, Kawamura, and Iguchi (2006), found a correlation between decreased mortality and socializing in elderly. The creation of opportunities to participate in socializing activities, could thus potentially be used as a specific mean to promote the wellbeing in individuals that otherwise runs the risk of pathological isolation. In the cases where allergies, infection risks or attitudes towards animals prevents the usage of animals as social lubricants, other alternatives that could be utilized are video gaming, physical exercise, gardening or group activities such as choir singing or painting.

Regarding the two theories proposed earlier, the question remains if one could be regarded as a better explanatory model than the other for the interspecies relationships? Firstly, animals might fulfill the psychological need for affection and belonging, that is, needs proposed both by the attachment theory and the social support theory. The question is why oxytocin is promoting attachment between interspecies relationships. Security and trust are considered to be prerequisites for attachment, and as proposed by Levinson (1984) attachment in turn foregoes companionship. With animals, especially dogs, regularly being regarded as dear and beloved family members and companions, it could be assumed that the trust promoting properties of oxytocin creates attachments to certain individuals rather than certain species. Furthermore, talking about the asymmetry of relationships (Collis & McNicholas, 1998; De Boer et al., 2012) it could be assumed that there are similar underlying mechanisms behind the attachment style between mother and child respectively human and animal. With the use of brain imaging, it could be possible to find the neural correlates of the attachment style between the pet owner and pet, respectively the mother and the child. On account of this, it could be expected to find activation in brain areas associated with the nurturing and maternalizing features of women encountering their child, as well as an individual approaching their pet. Experiments of this kind could potentially reveal information weighting
in favor of either the social support theory or the attachment theory, where the first could be speculated to illustrate a more symmetrical relationship and the latter a more asymmetrical relationship between humans and animals.

In conclusion, both an imbalanced stress system (Chrousis & Gold, 1992; Engelmann et al., 2004; Friedmann & Tsai, 2006; Lovallo, 2004; Lundberg & Wentz, 2004; VanItallie, 2002) and an imbalanced oxytocin system (Levinson, 1984; McCall & Singer, 2012; Meyer-Lindenberg et al., 2011; Neumann & Landgraf, 2012; Zak, 2011) play a critical role in various physical and mental pathologies. The same goes for the importance of social contact for an individual’s well-being. Evidence from anthrozoology studies, so far, indicates a positive impact on all these factors. With the property of decreasing cortisol levels and increasing oxytocin levels, interaction with animals could thus be seen as potentially working as a complementary tool in the treatment of stress-related disorders. Where exhaustion disorder generally is treated by lifestyle changes and rest (Åsberg et al., 2011), the presence of a companion animal could promote recovery by adding meaningfulness, unconditional affection and attention as well as mild physical activity in the form of dog walks or play, to the life of the exhausted individual. This paper will thus finish with the insightful words written by Levinson himself:

Our estrangement of life is compounded by the fact that we have alienated ourselves not only from our inner beings, but also from nature and our natural allies, the animals. In desperation, we look to the various therapies that have sprung around us like weeds, hoping for an answer to our soul’s malaise (Levinson, 1984, p. 141).
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The beneficial relationship between humans and dogs

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