ANTHROZOÖS VOLUME 24, ISSUE 4 PP. 349–368 REPRINTS AVAILABLE DIRECTLY FROM THE PUBLISHERS PHOTOCOPYING PERMITTED BY LICENSE ONLY


# The Effect of a Real Dog, Toy Dog and Friendly Person on Insecurely Attached Children During a Stressful Task: An Exploratory Study

**Andrea Beetz[*], Kurt Kotrschal[†], Dennis C. Turner[‡], Karin Hediger[*], Kerstin Uvnäs-Moberg[§] and Henri Julius[*]**

*[*]Department of Special Education, University of Rostock, Germany*
*[†]Konrad Lorenz Forschungsstelle Gruenau and University of Vienna, Department of Behavioural Biology, Austria*
*[‡]IEMT-Switzerland and Animal Behavior, University of Zurich-Irchel, Switzerland*
*[§]School of Life Science, University of Skövde, Sweden and Department of Animal Environment and Health, Swedish University of Agriculture, Skara, Sweden*

*Address for correspondence: Dr. Andrea Beetz, Department of Special Education, University of Rostock, August-Bebel-Str. 28, 18055 Rostock, Germany. E-mail: andrea.m.beetz@gmail.com*

**ABSTRACT** The regulation of stress by an attachment figure is a key feature of attachment relationships. Previous research suggests that in some cases animal companionship may be regarded as an attachment relationship. This may be particularly important for persons with an insecure or disorganized attachment pattern who may find it more difficult than securely attached individuals to accept social support from humans. In our study, we investigated whether 31 boys (aged 7–12 years) with insecure/disorganized attachment would profit more from the presence of a dog ($n$ = 11) than of a friendly human ($n$ = 11) or a toy dog ($n$ = 9) as support during a socially stressful situation (Trier Social Stress Test for Children, TSST-C). Stress levels were assessed via salivary cortisol recorded five times before, during, and after the TSST-C. The behavior of the children was coded from video recordings. Self-reported stress levels did not significantly differ between the groups before and after the TSST-C. Salivary cortisol, however, was significantly lower in the real dog condition than in the other two conditions (Kruskal-Wallis $H$ test on area under the curve increase (AUCi): $\chi^2$ =15.17, $df = 2$, $p = 0.001$). Also, the more the children stroked the dog, the less pronounced was their stress reaction ($r_s$ = –0.818, $p$ = 0.002). Our data suggest an important role of physical contact in the stress reducing effect. We

Anthrozoös DOI: 10.2752/175303711X13159027359746

conclude that the children investigated profited more from interacting with a friendly dog than with either a human or a toy dog in a stressful situation. We discuss the relevance of our findings for animal-assisted interventions.

**Keywords:** attachment, human–animal attachment, human–dog interaction, social support, stress regulation

Companion animals are known to facilitate social interactions and relationships among humans ("social catalyst" or "social lubricant effect:" Messent 1983; McNicholas et al. 1993). Hence, growing up with animals may benefit the social development of children (Melson, Peet and Sparks 1991; Bodmer 1998; Melson and Fine 2006) by promoting social interactions with other persons. While such effects on the psychosocial development are based on long-term relationships, the presence of animals may also favorably influence a range of short-term encounters, such as the case in some therapeutic settings. For example, therapists were perceived as more trustworthy in the presence of a dog (Schneider and Harley 2006) and practitioners of animal-assisted therapy have found it easier to establish a trustful relationship with a new client when assisted by an animal (e.g., Levinson 1962). Children, in particular, tend to develop trustful relationships with companion animals, and often communicate personal matters to pets rather than to other humans (Kurdek 2008, 2009a, 2009b). This is particularly true for children with impaired trust in their parents or peers. These children frequently report turning to their pets when feeling upset (Parish-Plass 2008).

We propose that attachment theory in connection with stress regulation provides a basis for understanding why many humans, in search of social support, may relate more easily and spontaneously to animals than to humans. This is also the theoretic background for our present study on stress regulation in children under different social support conditions.

### *Attachment Theory*

With their attachment theory, Bowlby (1969/1982) and Ainsworth (1963, 1972) provided a useful framework for the investigation of close and long-term relationships between humans. Previous research has employed this framework to explain and investigate human–animal relationships (Brown and Katcher 2001; Beck and Madresh 2008; Kurdek 2008, 2009a, 2009b). The transfer of this concept, which was developed around the mother–child bond, to human–animal relationships is not as far-fetched as it may first seem. Historically, attachment theory emerged from comparative bio-psychology (Harlow and Zimmerman 1959; Bowlby 1969/1982). Furthermore, it has become increasingly clear that at least within the mammals, brain mechanisms shared due to common ancestry are involved in attachment formation (Goodson 2005; Kotrschal, Scheiber and Hirschenhauser 2010).

Children develop an attachment to their primary caregiver(s) during their first year of life (Bowlby 1969/1982) via a "behavioral system" that includes brain mechanisms which also affect motivation. A behavioral system may be defined as "a biologically based motivational control system that governs the rules and behaviors associated with a specific […] goal" (George and Solomon 2008, p. 834; comp. Marvin and Britner 2008). Behavioral systems originate from the evolutionary history of a species and have a survival value (adaptedness; Baerends 1941, 1976).

Bowlby (1988, pp. 26–27) described attachment as "any form of behavior (e.g., crying, calling, seeking eye contact, reaching out for or following) that results in a person attaining or maintaining proximity to some other clearly identified individual who is conceived of as better able to cope with the world. It is most obvious whenever the person is frightened, fatigued, or sick and is assuaged by comforting and caregiving." The primary function of this system is to establish and maintain the proximity between child and mother, ensuring caregiving and protection for the child.

Another function of the attachment system mentioned by Bowlby (1969/1982) is the reduction and buffering of stress. An effective caregiver provides a safe haven in times of distress, such as illness, pain, hunger, or negative emotional states such as fear, anger, or sadness, which will also positively affect physiology. Furthermore, the caregiver serves as a secure base for exploration of the environment. Attachment-related behaviors are successfully terminated by closeness and direct physical contact (Hazan and Zeifmann 1999) as well as by the appropriate behavior of the caregiver, such as comforting and providing care.

An infant's attachment system is formed mainly via interacting with its primary caregivers. The adaptive flexibility of the attachment system may represent a selective advantage (Kermoian and Liederman 1986), adapting the child to the social environment it encounters. Under optimal conditions the primary strategy inherent in a behavioral system (Hinde and Stevenson-Hinde 1991) is followed, while conditional secondary strategies are developed under difficult environmental conditions. The primary attachment strategy is "secure." Secondary strategies are "insecure" (avoidant or ambivalent) or "disorganized" attachment. Behavioral systems are regulated by cognitive internal representations, called internal working models (IWM; Bretherton and Munholland 2008), which evaluate, emotionally assess, and organize the experiences made. The most important function of the IWM, according to Bowlby (1980), is to simulate social behaviors with others and thereby to allow the individual to develop anticipatory behaviors.

### *Secure Attachment*

In the IWM of children with a secure attachment, the parents are represented as sensitive, reliable, available, and supportive. Therefore, securely attached children actively seek closeness, consolation, and support in stressful situations (Ainsworth, Bell and Stayton 1971). Children with such an attachment representation generally have developed trust in the availability of their attachment figures and are free to explore their environment if there is no threat or stress activating the attachment system.

### *Insecure-Avoidant Attachment*

In contrast, children with an insecure-avoidant attachment perceive their caregivers as rejecting and unsupportive. These children rather avoid relating to them and do not seek closeness, consolation, and support from their caregivers. Instead, they emphasize exploratory behavior, for example, by attending to their toys or other objects (Ainsworth and Wittig 1969; Ainsworth, Bell and Stayton 1971). This behavior is interpreted as a shift of attention away from the emotionally stressful social situation. Insecure-avoidant children do not readily seek social support from others. Their cortisol levels during separation from the caregiver, however, are generally higher than in securely attached children (Spangler and Schieche 1998).

### *Insecure-Ambivalent Attachment*

These children have their parents represented as unpredictable with regards to responsiveness and availability (Cassidy and Berlin 1994) in emotionally stressful situations. Hence, to avoid stress, they constantly seek to maintain closeness to their parents, but also frequently display anger and aggression (overt or covert) towards them.

### *Disorganized Attachment*

In contrast to the organized strategies described above, which are adaptive with regards to ensuring caregiving, the so-called disorganized representation of attachment is characterized by a breakdown of such adaptive strategies in attachment-relevant situations (Main and Solomon 1986, 1990; Main 1997). These children see themselves as vulnerable and helpless in anxiety-inducing situations. Their attachment figures are represented as persons who will not provide the needed security in such situations (Solomon and George 1999; Lyons-Ruth and Jacobvitz 2008). Disorganized attachment is characteristic of children who are neglected by their caregivers, whose caregivers leave them, frequently threaten to do so, or have a psychiatric disorder, and/or who are physically or sexually abused by their caregivers.

### *Insecure and Disorganized Attachment as Risk Factors*

In non-clinical samples, between 50% (Grossmann et al. 1981, German sample) and 70% of children (Ainsworth et al. 1978, American sample) are classified as securely attached and about 20% of children as disorganized (Gloger-Tippelt, Vetter and Rauh 2000; Julius 2001). However, in clinical samples and in children with special education needs, up to 90% of insecure and disorganized attachment may be found (van Ijzendoorn and Bakermans-Kranenburg 1996; Julius 2001; Buchheim and Strauss 2002). Insecure and disorganized attachment poses a risk factor for the socio-emotional development of children (Strauss, Buchheim and Kächele 2002), while a secure attachment is known as a potent protective factor (Werner and Smith 1982).

### *Transmission of Attachment Representations*

The IWM developed with the primary caregivers is normally transferred to all other close relationships. Achatz (2007), for example, found that the teacher–student relationship is, in essence, congruent with the parent–child relationship. Children with insecure or disorganized attachments indeed tend to re-establish their insecure attachment patterns in new relationships (Suess 1987; Sroufe and Fleeson 1988; Howes and Hamilton 1992; Dozier et al. 2001; Sroufe et al. 2005).

### *Stress and Social Support*

Modern societies suffer increasingly from stress and stress-related diseases (Wilkinson and Pickett 2009). Generally, the most important stressors originate from the social domain and at the same time, the most effective means to reduce such social stress is via social support in close and trusting interpersonal relationships. Maunder and Hunter (2001) summarize that insecure attachment leads to an increase of perceived stress, to a reduced efficacy of social support in buffering stress, and to a decline of adequate physiological stress reactions. Also, persons with an avoidant or an ambivalent attachment perceive a given stressful situation as significantly more stressful than securely attached participants (Mallinckrodt 2000; Mallinckrodt and Wei 2005; Ditzen et al. 2008; assessed via cortisol levels), indicating that they are unable to profit from social support to the same extent as securely attached individuals.

### *Attachment to Pets*

In accordance with the criteria for secure attachment, dogs may function as attachment figures for their owners (Kurdek 2008). An individual functions as an attachment figure whenever she or he: 1) is a reliable source of comfort and reassurance that allows for exploration (secure base); 2) is approached in cases of emotional stress (haven of safety), 3) the physical proximity to him/her is associated with positive emotions (maintenance of proximity) and

4) separations from the attachment figure are associated with separation pain (Ainsworth 1991). Many animal owners indeed report turning to their animals for social support in emotionally stressful situations (McNicholas and Collis 2006). More than 75% of children reported that they turn to their animals when emotionally stressed (Covert et al. 1985; Mallon 1994; Rost and Hartmann 1994).

### *No Generalized Transmission of Insecure/Disorganized Attachment to Animals*

Since it is reasonable to assume that in the above-mentioned studies also children with insecure/disorganized attachment were included, these children were obviously able to build trustful relationships with companion animals. This is consistent with clinical experience that children are open to relate to pets even if they would not approach human caregivers in stressful situations (Kurdek 2008, 2009a, 2009b). While an insecure or disorganized attachment with regards to parents is transferred to therapists, teachers, or partners, it seems that it is not transferred to the human–animal relationship. Hence, animal-assisted interventions hold great potential for therapy and education.

### *Pet Effects on Short-Term Stress Reactions*

Irrespective of attachment representations, there is evidence that talking to a pet is associated with lower cardiovascular responses than talking to people (Lynch 1985). For children who are asked to read aloud, the presence of a pet reduces blood pressure (Friedmann et al. 1983). People also have a greater increase in blood pressure in the presence of their friends or even spouses than in presence of their pets, when asked to perform an arithmetic task (Allen et al. 1991; Allen, Blascovich and Mendes 2002). Furthermore, Odendaal and Meintjes (2003) demonstrated that even subjects who were not exposed to a stressor, but asked to interact quietly with their own or an unfamiliar dog, experienced a decrease in cortisol and blood pressure.

### *Aims*

We hypothesized that dogs will have a greater stress-alleviating effect than humans in children with insecure/disorganized attachment exposed to a social stressor. These children were targeted because they are generally unable to use the presence of another unfamiliar person for social support and stress alleviation (see above). We suggest that such research in children with insecure and disorganized attachment is particularly relevant, because it is generally very difficult and time-consuming to establish a trustful relationship between them and a therapist or teacher. If these children would be able to accept social support from a friendly dog, this could be developed into a therapeutic tool for efficient re-establishment of trustful relationships of these children with other humans. Another aim of our study was to assess whether and how much the potential stress modulation would depend on the active interaction between the child and the social supporter. Towards these goals, stress levels were assessed during a standardized social stress test in children with insecure/disorganized attachment in the presence of a real dog, a friendly human, and a toy dog (control). Cortisol levels were determined from five saliva samples collected from the children before, during, and after the social stress test. The children's behavior was observed throughout the experiment.

## Methods

Participants were approached via schools for children with learning and behavior problems in Germany and Austria, and a regular school in Germany. Only male children in second to fourth grade were asked to participate on a voluntary basis. Due to the exploratory nature of the study at that time, female children were excluded to reduce variation in the sample and to obtain sufficient participants for each attachment and support group. Informed consent was obtained from the legal representatives of the children and from the school headmasters. Our study was approved by the Human Subjects Review Committee of the University of Rostock. Data were collected on two separate days of two consecutive weeks, but on the same weekdays, Tuesday to Thursday.

### *Day 1*

On the first day, the attachment representation and relationship with pets were assessed via the following instruments:

*The Separation Anxiety Test (SAT):* The SAT (Hansburg 1972; Klagsbrun and Bowlby 1976; Julius 2009) is a projective picture task for the assessment of the attachment representation in children (aged 6–12 years). In the current German version for male children (Julius 2009), eight pictures show a boy who is being separated from an attachment figure for a shorter or longer period of time (e.g., going to bed in the evening; parents go on trip for two weeks without the child). The participant is asked how the child in each picture would feel, what he would think, what he would do next, and how the story would end. Narratives are then transcribed and coded for elements of secure, avoidant, ambivalent, or disorganized attachment, according to Kaplan (1987). The SAT is a standard measure in attachment research and generally shows good inter-rater-reliability (93%, Wright et al.1995; 76%, Solomon and George 1999).

*The Questionnaire "My Pet and I":* This questionnaire was designed for this study in accordance with instruments such as the Inventory of Parent and Peer Attachment (IPPA, Armsden and Greenberg 1987). Although some scales that assess the quality of the relationship with a pet exist (e.g., Pet Attachment Questionnaire, PAQ, Stallones et al. 1990), a new scale was designed, since, to our knowledge, none of the existing scales met the following criteria: suitable for this age group; design based on attachment theory and existing instruments from human attachment research; assessment of the internal working model rather than a report of actual behavior; and applicable to a wide variety of pets (e.g., dogs, horses, guinea pigs, fish).

"My Pet and I" asks about pet ownership and about behavior towards the pet when feeling troubled, sad, or stressed. Fourteen items were designed according to the IPPA, trying to capture the internal working model of the relationship with the pet (e.g., "My pet likes me as I am," "When I am sad, angry or afraid, my pet is always there for me"). Two items are related to caregiving (feeding or taking care of the pet). All items can be answered with "not true," "a bit true," or "completely true," resulting in scores of 0 to 2. Based on the original IPPA subscales—trust, alienation, and communication—and an overall attachment scale, we summarized the scores of the items in an overall attachment score and extracted the subscales "communication" and "trust," with good scale reliabilities (see results).

As many of the children from the participating schools had problems with reading, the questions were read to them by the experimenter. The questionnaire was designed to assess children's attachment security towards their own pet. Only when children did not own a pet were questions asked related to another animal that was close to the child or that the child would like to have as a pet.

### *Day 2*

*The Trier Social Stress Test for Children (TSST-C):* The Trier Social Stress Test (TSST) (Kirschbaum, Pirke and Hellhammer 1993) was designed to induce psychosocial stress in adults in a standardized manner. It is based on the combination of an uncontrollable situation with social evaluation by others (a social-evaluative threat; Dickerson and Kemeny 2004). The TSST-C ("C" for children) is an adaptation of this test for children and has been used in several studies with children from the age of seven years onwards (e.g., Buske-Kirschbaum et al. 1997; Buske-Kirschbaum et al. 2003; Dorn et al. 2003). It causes significant changes in endocrinological and cardiovascular parameters and of self-assessed stress levels (Kirschbaum, Wüst and Hellhammer 1992; Kirschbaum, Pirke and Hellhammer 1993; Schommer, Hellhammer and Kirschbaum 2003; Het et al. 2009; Foley and Kirschbaum 2010; Kudielka and Wüst 2010). In 70 to 80% of the participants in one study, salivary cortisol levels tripled in reaction to the procedure (Kudielka and Wüst 2010). However, whenever a child shows signs of strong distress (crying, fear), the experiment is aborted by the experimenter.

The TSST-C was conducted in an empty, unfamiliar classroom. Only one room was used instead of two separate rooms as in the original TSST-C, but locations for different tasks were located on different sides of the classroom. After arrival, the child was allowed to rest for 10 minutes, to prevent an activation of the hypothalamic-pituitary-adrenal (HPA) axis, and during the last two minutes of this period a short introduction to the procedure was provided. Then the participants had five minutes to interact freely with the social supporter. The child was then asked to stand in front of a large table, behind which two persons (the committee) were seated. The experimenter first greeted the child in a friendly manner and explained that he was expected to develop ideas of how a story, which was told by the committee, would continue. Then the committee left and the child was given five minutes to prepare his story. Afterwards he was asked to present his story in front of the committee for three minutes. Following this, a mathematical task appropriate to the child's age was given. If he made a mistake, he was asked to start all over again. At the end of the TSST-C, the committee gave positive feedback to the child, told him that the test was over, and gave a short debriefing. After this, the child was led back to the other side of the room for 30 minutes of relaxation. At the end of the entire procedure the experimenter thanked the child and handed over a small gift.

*Support Conditions:* Research has shown that the presence of a supportive friend or a friendly stranger can buffer responses (e.g., measured via blood pressure) to psychological stressors (for a review, see Uchino, Cacioppo and Kiecolt-Glaser 1996; Lepore 1998). In our study, participants were randomly assigned to one of three different support conditions: support by a real dog (the experimental group), a toy dog the size of a small dog, or a friendly female student (control groups). All three types of "social supporter" were introduced after the first 10 minutes of the experiment (during which the child rested) and then were present during and after the TSST-C. The children had the chance to interact for five minutes with the dog, toy dog, or student, to get comfortable and familiar with them. Only trained therapy dogs or certified school dogs were used. Participants were free to interact with the dog as they wished. The friendly student was allowed to talk to and support the child, but not to help with the preparation of the story. Only female students, aged 20–25 years, with practical experience and a calm and friendly manner with children of this age were selected. Social supporters accompanied the child in front of the committee and were present in the room for the entire time.

**Table 1.** Procedures during the Trier Stress Test for Children (TSST-C).

| Task | Duration |
|---|---|
| Settling down, instruction | 10 min |
| *Salivette 1 = t1* | 2 min |
| SAM | 2 min |
| Interaction with the social supporter | 5 min |
| *Salivette 2 = t2* | 2 min |
| TSST-C Introduction | 5 min |
| Preparation time | 5 min |
| TSST-C | 10 min |
| *Salivette 3 = t3* | 2 min |
| Debriefing | 3 min |
| Relaxation time 1—possible interaction with the social supporter | 10 min |
| *Salivette 4 = t4* | 2 min |
| SAM | 2 min |
| Relaxation time 2—possible interaction with the social supporter | 10 min |
| *Salivette 5 = t5* | 2 min |

A salivette is used for saliva sampling.
SAM = Self Assessment Manikin.

Since the focus of the study was on the specific effects of the dog in comparison to other social supporters, no "no-social support" condition was included. Therefore, it was not possible to investigate whether the friendly student and the toy dog had any support effect by themselves. Only differences between groups were explored.

*Instruments:* The following instruments were used to assess activation/stress and interaction between the child and the social supporter:

*1) Self-Assessment of Stress:* The Self Assessment Manikin (SAM): The Self Assessment Manikin (Lang 1980; Bradley and Lang 1994) is a non-verbal test for the assessment of emotional reactions to a situation. It contains three dimensions: cheerfulness, activation, and dominance (feeling of control). The test is applicable for children from the age of four years (Caprilli and Messeri 2006) and has been employed in combination with the TSST-C before (Gunnar et al. 2009). The dimension "dominance," however, was omitted, since early data showed that the children in our sample did not understand it. The dimensions are presented in the form of five different stick figures (manikins), reaching from one extreme (e.g., very sad) to the other (e.g., very cheerful). Children were asked to mark the picture that best expressed how they felt at the time. The test was given before the TSST-C and 15 minutes after the end of it.

*2) Salivary Cortisol:* The psychophysiological reaction to the TSST-C was assessed via repeated measurement of salivary cortisol, which has been shown to be an equivalent of the free, non-protein bound cortisol in plasma, with a delay of a few minutes (Vining and McGinley 1987; Woodside, Winter and Fisman 1991; Gallagher et al. 2006). Salivary cortisol was collected via standardized Salivettes® (Sarstedt), small cotton rolls that need to be chewed for one minute and then put back into their plastic tube. Saliva samples were frozen at –20 degrees Celsius until analysis of all the samples in the laboratory. Five saliva samples were taken during the TSST-C procedure on day 2 at regular intervals, or when it was indicated functionally (see Table 1).

Quantitative analysis was conducted via electro-chemical-luminescence immuno-assay (ECLIA, Cobas® Roche, with e 411 device). The assay can be used at concentrations between 0.5–1750 nmol/L, which includes the cortisol concentrations in human saliva of about 5–25 nmol/L. For saliva samples, the manufacturer found intra-assay variabilities of 1.5–6.1% (coefficient of variation) and inter-assay variabilities of 4.1–33.4%.

*3) Behavior:* All sessions were videotaped and behaviors of the child and the social supporter (dog/toy dog/friendly adult) and their interaction were coded from the tape. Frequencies (occurrence per minute observation time) and durations of the interaction (total percentage of observation time) of a total of 49 variables were estimated. These included physical contact, gaze direction, orientation of the body, vocalization, locomotor parameters, and emotional expressions. In this paper, we will only report on the variables "talking to" and "body contact" with the social supporter, including the variables "stroking/petting" and "holding," since seeking verbal and, in particular, physical contact is associated with secure attachment behavior and social support.

### Sample

Eighty-eight male children were tested with the SAT and asked to answer the "My Pet and I" questionnaire. From this sample, thirty-one male children, between seven and 12 years of age ($M$ = 9.6 years, $SD$ = 1.14) were selected based on their highly insecure or disorganized attachment representation in the SAT. Children who showed a secure or unclassifiable pattern or only weak indicators of disorganization or an insecure attachment were excluded. Randomly, nine of these children were assigned to the toy dog condition, and eleven children each to the real dog and friendly adult condition. There were no significant age differences between the children in the different social support conditions. In our sample of 31 children, 19 showed an avoidant attachment, five of them in combination with disorganization; 10 had a disorganized attachment; and two were classified as insecure-ambivalent without attachment disorganization. All participants were able to complete the TSST-C and displayed not more than the expected level of nervousness and stress.

### Data Analysis

Behavior codings were conducted using Noldus Observer version 5.0. Data were analyzed with SPSS 17.00, using parametric (ANOVA, repeated measures ANOVA) and nonparametric tests (Kruskal-Wallis $H$ test, Mann-Whitney $U$ test, Spearman's Rho).

Further analyses of the cortisol data included the calculation of the area under the curve with respect to increase (AUCi) for the entire sampling time, as an indicator of the increase and decrease of cortisol levels over the entire experimental period, taking into account the differences in the initial cortisol level of each participant (Pruessner et al. 2003). AUCi is a standard indicator in research using several saliva samples in combination with a stressor. Values indicate the area under the curve—in our study this was determined by the five samples taken, taking the level at time one (t1) as baseline (see Figure 1). When the cortisol level decreases below the baseline, this area is calculated as negative area under the curve with respect to the baseline. In case there is first an increase in the cortisol level and then a decrease below the baseline, the negative area is deducted from the positive area.

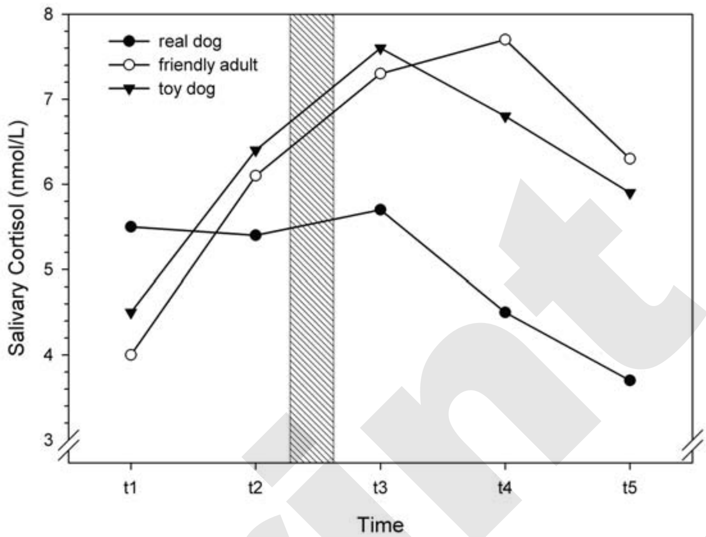


**Figure 1.** Salivary cortisol levels (nmol/L) before and after the Trier Social Stress Test for Children (TSST-C; grey shaded) in the three different support conditions at time 1 (t1) (before the TSST-C) to time 5 (t5) (end of investigation time, 30 minutes after the end of the TSST-C).

## Results

### *Attachment to Own Pet*

Analysis of the data of the complete original sample of 88 male children (age $M = 9.25$, $SD = 1.24$) showed good scale reliabilities for the overall scale *attachment security* (13 items, Cronbach's $\alpha = 0.845$, seeking closeness to pet when distressed, feeling accepted by the pet, trusting it) and the subscale *communication* (5 items, Cronbach's $\alpha = 0.806$; communication with the pet when child is distressed). The 31 children who were selected for their insecure/disorganized attachment representations all reported that they had, or recently had, a pet including dogs, cats, guinea pigs, rabbits, horses, farm animals, mice, rats, reptiles, and insects. On average, they indicated close relationships with their pet as shown by a mean of 18.97 ($SD = 5.35$) on the overall attachment security scale (My Pet and I: possible min = 0, possible max = 26; the *M* value indicating a medium quality of attachment would be 13.00; therefore our mean indicates a good quality of pet attachment in this sample). An ANOVA showed no significant differences with regard to attachment to own pet between the children assigned to the three different support conditions ($F = 0.743$, $p = 0.537$). Also, on the subscale "communication with own pet in times of stress," no difference between the three groups was found ($F = 0.756$, $p = 0.529$).

### *Self-Reported Activation and Mood*

On the SAM, no significant differences ($p < 0.05$) with regard to "cheerfulness" (valence) and "activation," neither before nor after the TSST-C were found between the children in the three different support conditions (using ANOVAs as well as post hoc tests for single comparisons of the three support conditions or repeated measures ANOVAs) (see Table 2).

### *Cortisol Levels*

Mean absolute cortisol levels (nmol/L) were significantly lower during and after the TSST-C in the presence of a real dog, in comparison with the presence of a toy dog or a friendly adult

**Table 2.** Results of Self Assessment Manikin (SAM) before (t1) and after (t2) the Trier Social Stress Test for Children (TSST-C).

| | Support Condition | | | | | |
|---|---|---|---|---|---|---|
| | Real Dog | | Toy Dog | | Friendly Adult | |
| SAM: | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| t1: Activation | 2.91 | 1.04 | 2.56 | 1.88 | 2.40 | 1.43 |
| t1: Cheerfulness | 4.45 | 0.69 | 3.89 | 1.76 | 4.36 | 1.21 |
| t2: Activation | 2.27 | 1.62 | 2.56 | 1.94 | 2.50 | 1.65 |
| t2: Cheerfulness | 4.64 | 0.67 | 3.78 | 1.72 | 4.55 | 1.04 |

**Table 3.** Absolute cortisol levels (nmol/L) in the three different support groups at t1–t5 and area under the curve increase (AUCi) over t1–t5 during the Trier Social Stress Test for Children (TSST-C).

| | t1 | | t2 | | t3 | | t4 | | t5 | | AUCi | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Support Condition | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Real Dog | 5.5 | 1.5 | 5.4 | 1.5 | 5.7 | 2.5 | 4.5 | 1.8 | 3.7 | 1.1 | –30.46 | 60.60 |
| Friendly Adult | 4.0 | 2.3 | 6.1 | 2.2 | 7.3 | 4.5 | 7.7 | 4.4 | 6.3 | 3.4 | 163.68 | 185.99 |
| Toy Dog | 4.5 | 2.3 | 6.4 | 4.3 | 7.6 | 3.4 | 6.8 | 3.1 | 5.9 | 2.4 | 132.15 | 105.64 |

(Table 3 and Figure 1). Area under the curve increase (AUCi) calculated for the entire sampling time differed significantly between the different support conditions (Kruskall-Wallis *H* test: $\chi^2 = 15.17$, $df = 2$, $p = 0.001$) (see Figure 2). AUCi from the real dog group was significantly smaller when compared with the AUCi of the friendly adult and toy dog groups (post hoc tests: Mann-Whitney *U*: real dog/friendly adult: $U = 10.0$, $p = 0.001$; real dog/toy dog: $U = 6.0$, $p = 0.001$). The friendly adult and the toy dog did not differ from each other ($U = 44.0$, $p = 0.676$).

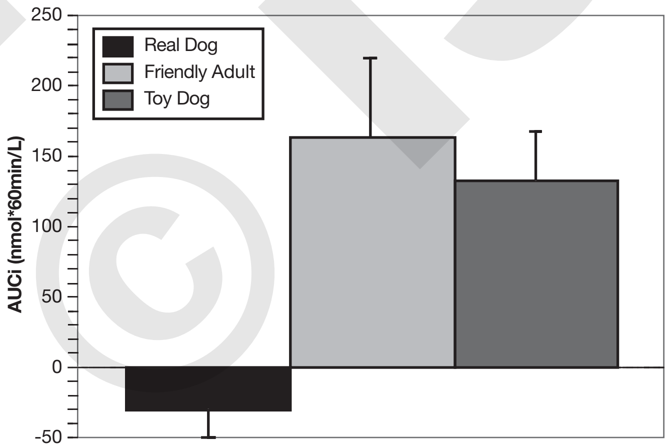


**Figure 2.** Salivary cortisol levels (nmol*60min/L): Area under the curve increase (AUCi, t1–t5) and standard error of mean (SEM) in the three different support conditions.

**Table 4.** Repeated measures ANOVA for cortisol levels at t1 and t2–t5; pairwise comparison of support conditions.

| Support Condition | Change from t1 to: | Wilks' Lambda: *F* | *p* |
|---|---|---|---|
| Real Dog–Friendly Adult | t2 | 6.624 | 0.018 |
| | t3 | 4.478 | 0.047 |
| | t4 | 8.952 | 0.007 |
| | t5 | 8.023 | 0.010 |
| Real Dog–Toy Dog | t2 | 4.071 | 0.059 |
| | t3 | 5.065 | 0.037 |
| | t4 | 6.583 | 0.019 |
| | t5 | 5.934 | 0.025 |
| Toy Dog–Friendly Adult | t2 | 0.010 | 0.922 |
| | t3 | 0.008 | 0.930 |
| | t4 | 0.748 | 0.399 |
| | t5 | 0.497 | 0.490 |

A Kruskal-Wallis *H* test revealed a significant influence of the factor "support condition" only at time 5 (t5) ($\chi^2 = 6.34$, $df = 2$, $p = 0.042$), with the real dog group showing the lowest cortisol levels, followed by the toy dog and the friendly adult. Only tendencies for differences at t1 and t4 were found for the factor "support condition" (Figure 1; t1: $\chi^2 = 5.31$, $df = 2$, $p = 0.070$; t4: $\chi^2 = 5.47$, $df = 2$, $p = 0.065$), while at t2 and t3 there was no significant influence of the factor "support condition" (t3: $\chi^2 = 0.69$, $df = 2$, $p = 0.708$; t3: $\chi^2 = 1.78$, $df = 2$, $p = 0.410$; Figure 1).

Pairwise post hoc comparisons of the support conditions show that the children who had a real dog present during the stress test had higher cortisol levels before the stress test (t1), possibly due to their being expectant and excited about the study, but had lower levels after the stress test (i.e. in samples at t4 and t5), when compared with the children supported by a friendly adult (Mann-Whitney *U*: t1: $U = 22.0$, $p = 0.011$; t4: $U = 29.5$, $p = 0.042$; and t5: $U = 26.0$, $p = 0.023$). At t2 and t3, no significant differences ($p > 0.10$) were found between the children supported by a real dog and the children supported by a friendly adult. In comparison with the toy dog group, the real dog group had significantly lower cortisol levels at t5 ($U = 23.0$, $p = 0.044$) and a tendency for lower levels at t4 ($U = 24.0$, $p = 0.053$), while there were no statistically relevant differences at t1 and t3. There was no significant difference in cortisol levels between the friendly adult and the toy dog conditions at t1 through t5.

Repeated measures ANOVAs were computed for the differences between the real dog and friendly adult groups for t1 in relation to t2–t5. All repeated measures ANOVAs revealed a significant ($p < 0.05$) influence of the support condition on changes in salivary cortisol (Table 4). Likewise, assessment of changes between the real dog and toy dog groups showed significant differences in changes between t1 and t3–t5, but not for the change between t1 and t2. At t1 and t2–t5, no repeated measures ANOVAs reached significance when comparing the toy dog and friendly adult groups.

### *Behavior*

Kruskal-Wallis *H* tests revealed a significant effect ($p < 0.01$) of support condition on the duration and frequency of talking to the social supporter, overall body contact, stroking/petting, and holding (Table 5). Pairwise comparisons between groups (Mann-Whitney *U* test,

**Table 5.** Mean (*M*) and standard deviation (*SD*) of frequency (f) and duration (d) of observed behavior towards the social supporter in the three support conditions.

| | Real Dog | | Toy Dog | | Friendly Adult | |
|---|---|---|---|---|---|---|
| **Behavior** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** |
| Talk to (f) | 0.04 | 0.05 | 0.00 | 0.00 | 0.30 | 0.15 |
| Talk to (d) | 2.05 | 3.99 | 0.00 | 0.00 | 23.92 | 15.53 |
| Body Contact (f) | 0.24 | 0.19 | 0.10 | 0.10 | 0.00 | 0.00 |
| Body Contact (d) | 24.78 | 18.43 | 26.56 | 9.26 | 0.01 | 0.03 |
| Stroke/Pet (f) | 0.23 | 0.18 | 0.03 | 0.04 | 0.00 | 0.00 |
| Stroke/Pet (d) | 15.45 | 12.21 | 8.17 | 16.02 | 0.00 | 0.00 |
| Hold (f) | 0.00 | 0.01 | 0.09 | 0.10 | 0.00 | 0.00 |
| Hold (d) | 0.05 | 0.18 | 11.42 | 11.83 | 0.00 | 0.00 |

$p < 0.05$) showed that the children more frequently had body contact with the real dog in comparison with the toy dog, and stroked the real dog more frequently and for longer periods of time. Children petted the real dog for 16% of the total observation time, but held the toy dog for a longer time (11% of the time) than the real dog (0.05%). Body contact occurred significantly more often and for a longer period of time with the toy dog (27% of the time) than with the real dog or the friendly adult. Body contact with the social supporter and stroking was for longer and was more frequent in the real dog group compared with the friendly adult group.

Children talked more frequently and for longer periods of time to the friendly adult than with the real dog, and in both conditions more frequently and longer than with the toy dog, with which most participants did not talk at all. The more often the children talked to the real dog, the more often they also had body contact ($r_s = 0.712$, $p = 0.014$), while there was no significant relation between talking to the friendly adult and physical contact.

### *Behavior and Cortisol Levels*

As systemic cortisol is represented in salivary cortisol with a delay of 10 to 15 minutes, significant associations (Spearman's Rho) with physical contact and talking to the supporter were only found for t4 and t5, while all correlations with cortisol at t1–t3 did not reach statistical significance. In the toy dog group, no significant correlations ($p < 0.05$) between behavior and cortisol were found, despite the fact that some children held the toy dog for some time during the experiment. In the friendly adult group, the only significant correlation was found between talking to the social supporter (frequency) and cortisol level at t5 ($r_s = –0.609$, $p = 0.047$). In the real dog group, the frequency of talking to the dog was negatively correlated with cortisol at t4 ($r_s = –0.693$, $p = 0.018$) and t5 ($r_s = –0.609$, $p = 0.030$). Also, the frequency of body contact with the dog scaled negatively with cortisol levels at t4 ($r_s = –0.682$, $p = 0.021$) and t5 ($r_s = –0.673$, $p = 0.023$). Further, the more often the children stroked the dog during the experiment, the lower their cortisol level at t5 ($r_s = –0.818$, $p = 0.002$).

## Discussion

In our sample of male children with insecure/disorganized attachment, the interaction with a real dog rather than with a toy dog or with a friendly female student lowered salivary cortisol levels during a social challenge situation (Figure 1). Due to the lack of a control group without any supporter, however, we cannot be sure from our data whether the friendly adult and toy dog can be socially supportive at all, or whether their effect on the salivary cortisol levels of the children is just significantly less than that of the real dog.

It was unexpected that the real dog group started out with significantly higher cortisol levels in comparison with the friendly adult group, given that the children had similar amounts of pre-exposure time to the dog, human, and toy dog. We suggest that this was due to the greater expectation and arousal caused by the dog than by any of the other conditions. Also, data collection in the school setting did not allow keeping children from knowing that on the day of their participation a dog would be present.

In self-reported activation and mood (SAM), however, no differences were found between our different support conditions. The children in our sample indicated only a minor arousal and a good mood before and after the TSST-C, suggesting that they did not perceive the TSST-C as very stressful. In fact, our sample of children with insecure and/or disorganized attachment may provide an explanation for this discrepancy between objective stress levels (cortisol) and self-perceived stress. Persons with an insecure-avoidant attachment representation (> 60% of our sample) often use the defense mechanism of deactivation (George and West 2001) and generally tend to minimize, suppress, or dismiss negative emotions, also when confronted with laboratory-induced stressors (Fraley and Shaver 1997; Allen et al. 1998; Mikulincer 1998; Rholes, Simpson and Orina 1999). These emotion-minimizing strategies of avoidant individuals will affect self-reported mood, but not their physiological reactivity (Mikulincer 1998; Roisman, Tsai and Chiang 2004; Diamond, Hicks and Otter-Henderson 2006).

The more children stroked, and had body contact with, the dog, the lower were their cortisol levels after the TSST-C. This implies that the stress-dampening effect of the dog is not due to its mere presence, but actually depends on the readiness of the child to relate to the dog via talking and sensory contact such as petting and body contact. Our findings correspond with the work of Odenaal and Meintjes (2003), who report a significant decrease in cortisol levels in owners after a positive interaction with their dog. We propose that the more children were interested in contact with the dog, the more they were able to turn this contact into social support (as judged by the stress-dampening effect).

Obviously, in the stressful situation of the TSST-C, children found an “acceptable and trustworthy” provider of support in the dog to differing degrees, but not so much in the friendly student or toy dog. This further indicates that whether and to what extent a child can profit from animal-assisted interventions on a short-term basis depends on how willing and able the child is to make contact with an animal, which in turn, is related to individual and social factors (Wedl and Kotrschal 2009).

However, such openness to relate spontaneously to someone, in particular under stress, is not to be mistaken for attachment. The general attachment representation was used to select a sample that in general has difficulties in spontaneously relating to other humans, due to the transmission of an insecure/disorganized attachment representation. And it was shown that the children in our sample had trusting attachment relationships with their pets, irrespective of their human attachment (Covert et al. 1985; Mallon 1994; Rost and Hartmann 1994; Kurdek 2009b). We conclude that even male children with highly insecure/disorganized attachment are open to relate to a dog, and therefore are able to utilize the presence of a dog more efficiently for social support and stress reduction than when in the presence of a friendly adult.

Our data may also be interpreted from a more basic physiological point of view.

When a child meets a dog who they perceive as friendly, oxytocin may be released in their brain, facilitating social approach (Carter 1998; Uvnäs-Moberg 1998). In addition, tactile interaction by children may release even more oxytocin (Stock and Uvnäs-Moberg 1998), in response to activation of non-noxious sensory nerves (the "deep" system of free nerve endings) by physical contact (Petersson, Hulting and Uvnäs-Moberg 1999; Matthiesen et al. 2001; Lund et al. 2002; Handlin et al. 2009). As a consequence, cortisol would decrease. In fact, the oxytocin-mediated decrease of cortisol levels may explain the negative correlations between the amount of stroking and physical contact and lower cortisol levels in the real dog condition. Our data suggest that positive physical contact was a key factor in the stress reduction observed in our sample. Although children established physical contact with the real dog and the toy dog, significant associations with their cortisol levels were only found with the real dog.

The generalization of our findings is obviously limited due to the present exclusion of female children. Clearly, further, more comprehensive research is needed. However, since the general physiological mechanisms of stress reactivity, social support, and attachment-based behavior should be relatively independent of gender, we are confident that similar results can be expected for female children with insecure and disorganized attachment representations. Also, instead of a toy dog condition a no-support condition would allow for an investigation of whether children with insecure or disorganized attachment can profit from social support from a friendly adult at all or just significantly less so than by a dog.

Overall, our findings suggest that children with insecure/disorganized attachment, whose ability to profit from a supportive adult human is impaired, may readily accept and profit from the availability of a friendly dog during a stressful situation. Thereby animals, in particular therapy dogs, may act as door-openers for human caregivers and therapists. They may take away some of the stress of dealing with a new person, of establishing a new relationship, or to focus on a specific task, in particular at the beginning of intervention programs. By activating the oxytocin system of these children, such animals may act as facilitators for making friendly and trustful contacts with humans, too.

Our findings support and substantiate the practice of animal-assisted interventions, to employ dogs to buffer or reduce stress in children with different problems. The probability that children in intervention programs have an insecure or disorganized attachment is high (Julius 2001). Hence, the majority of such children will not be able to fully benefit from social support by a friendly teacher or therapist, at least at the beginning. A friendly dog may significantly improve and accelerate the building of trust with other humans in these children.

Overall, we conclude that dogs may have a specific stress buffering and stress reducing effect, particularly on children with an insecure or disorganized attachment, creating a supportive environment for most children in socially stressful situations.

## Acknowledgements

We thank MARS Inc. for the financial support of this study. Further, we thank the headmasters, teachers, and children of the schools involved: Schule am Wasserturm, Grundschule Rostock-Dierkow, Werner-Lindemann-Grundschule in Rostock; Volksschule Oberhaid, Germany, Peter-Petersen-Landesschule Leonding, Austria. Also, we thank our doctoral students, Marlen Eisfeld and Manuela Wedl, and our students involved in the study: Denise Hebesberger, Daniel Österle, Gabi Sandler (Austria), Christian Berntsen, Sara Burmeister, Maria Föste, Franziska Hanisch, Jacqueline Henke, Janet Langer, Elaine Lemke, Natascha Nuding, Steffen Oettel, Brit Pietsch, Claudia Schlösser, Nicole Seeberger, Sarah Stahl, Tanja Stovpjaga, Anne Szigat, Franziska Tausch, and Julia Volk (Germany).

## References


Achatz, A. 2007. *Bindung von Kindern zu ihren Eltern und Lehrern* (Published dissertation at the University of Vienna, Austria). Saarbrücken: Südwestdeutscher Verlag für Hochschulschriften.

Ainsworth, M. D. S. 1963. The development of infant–mother interaction among the Ganda. In *Determinants of Infant Behavior*, 67–104, ed. B. M. Foss. New York: Wiley.

Ainsworth, M. D. S. 1972. Attachment and dependency: A comparison. In *Attachment and Dependency*, 97–137, ed. J. L. Gerwitz. Washington: Winston.

Ainsworth, M. D. S. 1991. Attachment and other affectionals bonds across the life cycle. In *Attachment across the Life Cycle*, 33–51, ed. C. M. Parkes, J. Stevenson-Hinde and P. Marris. New York: Routledge.

Ainsworth, M. D. S., Bell, S. M. and Stayton, D. J. 1971. Individual differences in Strange-Situation behavior of one-year-olds. In *The Origins of Human Social Relations,* 17–52, ed. H. R. Schaffer. New York: Academic Press.

Ainsworth, M. D. S., Blehar, M. C., Waters, E. and Wall, S. 1978. *Patterns of Attachment: A Psychological Study of the Strange Situation*. Hillsdale, NJ: Erlbaum.

Ainsworth, M. D. S. and Wittig, B. A. 1969. Attachment and the exploratory behavior of one-year-olds in a strange situation. In *Determinants of Infant Behavior*, 111–136, ed. B. M. Foss. London: Methuen.

Allen, K., Blascovich, J. and Mendes, W. B. 2002. Cardiovascular reactivity and the presence of pets, friends, and spouses: The truth about cats and dogs. *Psychosomatic Medicine* 64: 727–739.

Allen, K., Blascovich, J., Tomaka, J. and Kelsey, R. M. 1991. Presence of human friends and pet dogs as moderators of autonimic responses to stress in women. *Journal of Personality and Social Psychology* 61: 582–589.

Allen, J. P., Moore, C., Kuperminc, G. and Bell, K. 1998. Attachment and adolescent psychosocial functioning. *Child Development* 69: 1406–1419.

Armsden, G. C. and Greenberg, M. T. 1987. The Inventory of Parent and Peer Attachment: Relationships to well-being in adolescence. *Journal of Youth and Adolescence* 16: 427–454.

Baerends, G. P. 1941. Fortpflanzungsverhalten und Orientierung der Grabwespe Ammophila campestris. *Zeitschrift für Entomologie* 84: 68–275.

Baerends, G. P. 1976. The functional organization of behavior. *Animal Behaviour* 24: 726–738.

Beck, L. and Madresh, E. A. 2008. Romantic and four-legged friends: An extension of attachment theory to relationships with pets. *Anthrozoös* 21: 43–56.

Bodmer, N. M. 1998. Impact of pet ownership on the well-being of adolescents with few familial resources. In *Companion Animals in Human Health*, 237–248, ed. C. C. Wilson and D. C. Turner. Thousand Oaks, CA: Sage Publications.

Bowlby, J. 1969/1982. *Attachmend and Loss. Vol. 1: Attachment.* New York: Basic Books.

Bowlby, J. 1980. *Attachment and Loss. Vol. 3: Loss, Sadness and Depression.* New York: Basic Books.

Bowlby, J. 1988. *A Secure Base: Parent–Child Attachment and Healthy Human Development.* New York: Basic Books.

Bradley, M. M. and Lang, P. J. 1994. Measuring emotion: The Self-Assessment Manikin and the Semantic Differential. *Journal of Behavior Therapy and Experimental Psychiatry* 25: 49–59.

Bretherton, I. and Munholland K. A. 2008. Internal working models in attachment relationships: Elaborating a central construct in attachment theory. In *Handbook of Attachment: Theory, Research and Clinical Applications,* 2nd edn, 134–152, ed. J. Cassidy and P. R. Shaver. New York: The Guilford Press.

Brown, S. E. and Katcher, A. H. 2001. Pet attachment and dissociation. *Society & Animals* 9: 25–41.

Buchheim, A. and Strauss, B. 2002. Interviewmethoden der klinischen Bindungsforschung. In *Klinische Bindungsforschung: Methoden und Konzepte*, 27–53, ed. B. Strauss, A. Buchheim and H. Kächele. Stuttgart: Schattauer Verlag.

Buske-Kirschbaum, A., Jobst, S., Wustmans, A., Kirschbaum, C., Rauh, W. and Hellhammer, D. H. 1997. Attenuated free cortisol response to psychosocial stress in children with atopic dermatitis. *Psychosomatic Medicine* 59: 419–426.

Buske-Kirschbaum, A., von Auer, K., Krieger, S., Weis, S., Rauh, W. and Hellhammer, D. H. 2003. Blunted cortisol responses to psychosocial stress in asthmatic children: A general feature of atopic disease? *Psychosomatic Medicine* 65: 806–810.

Caprilli, S. and Messeri, A. 2006. Animal-assisted activity at A. Meyer Children's Hospital: A pilot study. *Evidence-based Complementary and Alternative Medicine* 3: 379–383.

Carter, C. S. 1998. Neuroendocrine perspectives on social attachment and love. *Psychoneuroendocrinology* 23: 779–818.

Cassidy, J. and Berlin, L. J. 1994. The insecure/ambivalent pattern of attachment: Theory and research. *Child Development* 65: 971–991.

Covert, A. M., Whiren, A. P., Keith, J. and Nelson, C. 1985. Pets, early adolescents and families. *Marriage and Family Review* 8: 63–78.

Diamond, L. M., Hicks, A. M. and Otter-Henderson, K. 2006. Physiological evidence for repressive coping among avoidantly attached adults. *Journal of Social and Personal Relationships* 2: 205–229.

Dickerson, S. S. and Kemeny, M. E. 2004. Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin* 130: 355–391.

Ditzen, B., Schmidt, S., Strauss, B., Nater, U. M., Ehlert, U. and Heinrichs, M. 2008. Adult attachment and social support interact to reduce psychological but not cortisol responses to stress. *Journal of Psychosomatic Research* 64: 479–486.

Dorn, L. D., Campo, J. C., Thato, S., Dahl, R. E., Lewin, D., Chandra, R. and Di Lorenzo, C. 2003. Psychological comorbidity and stress reactivity in children and adolescents with recurrent abdominal pain and anxiety disorders. *Journal of the American Academy of Child and Adolescent Psychiatry* 42: 66–75.

Dozier, M., Stovall, K. C., Albus, K. E. and Bates, B. 2001. Attachment for infants in foster care: The role of caregiver state of mind. *Child Development* 72: 1467–1477.

Foley, P. and Kirschbaum, C. 2010. Human hypothalamus-pituitary-adrenal axis responses to acute psychosocial stress in laboratory settings. *Neuroscience and Biobehavioral Reviews* 35: 91–96.

Fraley, R. C. and Shaver, P. R. 1997. Adult attachment and the suppression of unwanted thoughts. *Journal of Personality and Social Psychology* 73: 1080–1091.

Friedmann, E., Katcher, A. H., Thomas, S. A., Lynch, J. J. and Messent, P. R. 1983. Social interaction and blood pressure: Influence of companion animals. *Journal of Nervous and Mental Disease* 171: 461–463.

Gallagher, P., Leitch, M. M., Massey, A. E., McAllister-Williams, R. H. and Young, A. H. 2006. Assessing cortisol and dehydroepiandrosterone (DHEA) in saliva: Effects of collection method. *Journal of Psychopharmacology* 20: 643–649.

George, C. and Solomon, J. 2008. The Caregiving System: A behavioral systems approach to parenting. In *Handbook of Attachment: Theory, Research and Clinical Applications.* 2nd edn, 833–856, ed. J. Cassidy and P. R. Shaver. New York: The Guilford Press.

George, C. and West, M. 2001. The development and preliminary validation of a new measure of adult attachment: The adult attachment projective. *Attachment and Human Development* 3: 30–61.

Glogger-Tippelt, G., Vetter, J. and Rauh, H. 2000. Untersuchungen mit der "Fremden Situation" in deutschsprachigen Ländern: Ein Überblick. *Psychologie in Erziehung und Unterricht* 27: 87–98.

Goodson, J. L. 2005. The vertebrate social behavior network: Evolutionary themes and variations. *Hormones and Behavior* 48: 11–22.

Grossman, K. E., Grossman, K., Huber, F. and Wartner, U. 1981. German children's behavior towards their mothers at 12 months and their fathers at 18 months in Ainsworth's Strange Situation. *International Journal of Behavioral Development* 4: 157–181.

Gunnar, M. R., Frenn, K., Wewerka, S. S. and Van Ryzin, M. J. 2009. Moderate versus severe early life stress: Associations with stress reactivity and regulation in 10-12-year-old children. *Psychoneuroendocrinology* 34: 62–75.

Handlin, L., Jonas, W., Petersson, M., Ejdebäck, M., Ransjö-Arvidson, A. B., Nissen, E. and Uvnäs-Moberg, K. 2009. Effects of sucking and skin-to-skin contact on maternal ACTH and cortisol levels during the second day postpartum-influence of epidural analgesia and oxytocin in the perinatal period. *Breastfeeding Medicine* 4: 207–220.

Hansburg, H. G. 1972. *Adolescent Separation Anxiety: A Method for the Study of Adolescent Separation Problems:* Springfiled, IL: Charles C. Thomas.

Harlow, H. F. and Zimmermann, R. R. 1959. Affectional responses in the infant monkey: Orphaned baby monkeys develop a strong and persistent attachment to inanimate surrogate mothers. *Science* 130: 421–432.

Hazan, C. and Zeifman, D. 1999. Pair bonds as attachments: Evaluating the evidence. In *Handbook of Attachment: Theory, Research and Clinical Applications,* 436–455, ed. J. Cassidy and P. R. Shaver. New York: The Guilford Press.

Het, S., Rohleder, N., Schoofs, D., Kirschbaum, C. and Wolf, O. T. 2009. Neuroendocrine and psychometric evaluation of a placebo version of the "Trier Social Stress Test." *Psychoneuroendocrinology* 34: 1075–1086.

Hinde, R. A. and Stevenson-Hinde, J. 1991. Perspectives on attachment. In *Attachment across the Life Cycle*, 52–65, ed. C. M. Parkes, J. Stevenson-Hinde and P. Marris. New York: Routledge.

Howes, C. and Hamilton, C. E. 1992. Children's relationships with child care teachers: stability and concordance with parental attachments. *Child Development* 63: 867–878.

Julius, H. 2001. Die Bindungsorganisation von Kindern, die an Erziehungshilfeschulen unterrichtet werden. *Sonderpädagogik* 31: 74–93.

Julius, H. 2009. Diagnostik der Bindungsqualität im Grundschulalter—Der Separation Anxiety Test (SAT). In *Bindung im Kindesalter,* 121–137, ed. H. Julius, B. Gasteiger-Klicpera and R. Kissgen. Göttingen: Hogrefe.

Kaplan, N. 1987. Individual differences in six-year-olds' thoughts about separation: Predicted from attachment to mother at age one. Unpublished doctoral dissertation, University of California, Berkeley.

Kermoian, R. and Liederman, P. H. 1986. Infant attachment to mother and child caretaker in an east African community. *International Journal of Behavioral Development* 9: 455–469.

Kirschbaum, C., Pirke, K. M. and Hellhammer, D. H. 1993. The "Trier Social Stress Test"—a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology* 28: 76–81.

Kirschbaum, C., Wüst, S. and Hellhammer, D. H. 1992. Consistent sex differences in cortisol responses to psychological stress. *Psychosomatic Medicine* 54: 648–657.

Klagsbrun, M. and Bowlby, J. 1976. Responses to separation from parents: A clinical test for young children. *British Journal of Projective Psychology* 21: 7–21.

Kotrschal, K., Scheiber, I. B. R. and Hirschenhauser, K. 2010. Individual performance in complex social systems: The Greylag Goose example. In *Animal Behavior: Evolution and Mechanisms*, 121–148, ed. P. Kappeler. Berlin: Springer Verlag.

Kudielka, B. M. and Wüst, S. 2010. Human models in acute and chronic stress: Assessing determinants of individual hypothalamus-pituitary-adrenal axis activity and reactivity. *Stress* 13: 1–14.

Kurdek, L. A. 2008. Pet dogs as attachment figures. *Journal of Social and Personal Relationships* 25: 247–266.

Kurdek, L. A. 2009a. Pet dogs as attachment figures for adult owners. *Journal of Family Psychology* 23: 439–446.

Kurdek, L. A. 2009b. Young adults' attachment to pet dogs: Findings from open-ended methods. *Anthrozoös* 22: 359–369.

Lang, P. J. 1980. Behavioral treatment and bio-behavioral assessment: Computer applications. In *Technology in Mental Health Care Delivery Systems,* 119–137, ed. J. B. Sidowski, J. H. Johnson and T. A. Williams. Norwood, NJ: Ablex Publishing Corporation.

Lepore, S. J. 1998. Problems and prospects for the social support reactivity hypothesis. *Annals of Behavioral Medicine* 20: 257–269.

Levinson, B. M. 1962. The dog as a "co-therapist." *Mental Hygiene* 46: 59–65.

Lund, I., Ge, Y., Yu, L. C., Uvnäs-Moberg, K., Wang, J., Yu, C., Kurosawa, M., Agren, G., Rosén, A., Lekman, M. and Lundberg, T. 2002. Repeated massage-like simulaion induces long-term effects on nociception: Contribution of oxytocinergic mechanisms. *European Journal of Neuroscience* 16: 330–338.

Lynch, J. J. 1985. *The Language of the Heart*. New York: Basic Books.

Lyons-Ruth, K. and Jacobvitz, D. 2008. Attachment disorganization: Genetic factors, parenting contexts, and developmental transformation from infancy to adulthood. In *Handbook of Attachment: Theory, Research, and Clinical Applications*. 2nd edn, 666–697, ed. J. Cassidy and P. R. Shaver. New York: The Guilford Press.

Main, M. 1997. Desorganisation im Bindungsverhalten. In *Die Bindungstheorie. Grundlagen, Forschung und Anwendung.* 2nd edn, 120–139, ed. G. Spangler and P. Zimmermann. Stuttgart: Klett-Cotta.

Main, M. and Solomon, J. 1986. Discovery of an insecure disorganized/disoriented attachment pattern: Procedures, findings and implications for the classification of behavior. In *Affective Development in Infancy,* 95–124, ed. T. Braxelton and M. Yogman. Norwood, NJ: Ablex Publishing Corporation.

Main, M. and Solomon, J. 1990. Procedures for identifying infants as disorganized/disoriented during the Ainsworth Strange Situation. In *Attachment in Preschool Years,* 121–160, ed. M. T. Greenberg, D. Cicchetti and E. M. Cummings. Chicago: University of Chicago Press.

Mallinckrodt, B. 2000. Attachment, social competencies, social support, and interpersonal process in psychotherapy. *Psychotherapy Research* 10: 239–66.

Mallinckrodt, B. and Wei, M. 2005. Attachment, social competencies, social support, and psychological distress. *Journal of Counseling Psychology* 52: 358–67.

Mallon, G. 1994. Some of our best therapists are dogs. *Child and Youth Care Forum* 23: 89–101.

Marvin, R. S. and Britner, P. A. 2008. Normative development: The ontogeny of attachment. In *Handbook of Attachment: Theory, Research and Clinical Applications.* 2nd edn, 269–294, ed. J. Cassidy and P. R. Shaver. New York: The Guilford Press.

Matthiesen, A. S., Ransjö-Arvidson, A. B., Nissen, E. and Uvnäs-Moberg, K. 2001. Postpartum maternal oxytocin release by newborns: effects of infant hand massage and suckling. *Birth* 28: 13–19.

Maunder, R. G. and Hunter, J. J. 2001. Attachment and psychosomatic medicine: Developmental contributions to stress and disease. *Psychosomatic Medicine* 63: 556–567.

McNicholas, J. and Collis, G. M. 2006. Animals as social supports: Insights for understanding animal-assisted therapy. In *Handbook on Animal-Assisted Therapy*. 2nd edn, 49–71, ed. A. H. Fine. San Diego: Elsevier.

McNicholas, J., Collis, G. M., Morley, I. E. and Lane, D. R. 1993. Social communication through a companion animal: The dog as a social catalyst. In *Proceedings of the International Congress on Applied Ethology*, 368–370, ed. M. Nichelmann, H. K. Wierenga and S. Braun. Berlin: Humboldt University.

Melson, G. F. and Fine, A. H. 2006. Animals in the lives of children. In *Handbook on Animal-Assisted Therapy.* 2nd edn, 207–226, ed. A. H. Fine. Sand Diego: Elsevier.

Melson, G. F., Peet, S. and Sparks, C. 1991. Children's attachment to their pets: Links to socio-emotional development. *Children's Environment Quarterly* 8: 55–65.

Messent, P. R. 1983. Social facilitation of contact with other people by pet dogs. In *New Perspectives on Our Lives with Companion Animals*, 45–67, ed. A. H. Katcher and A. M. Beck. Philadelphia: University of Philadelphia Press.

Mikulincer, M. 1998. Adult attachment style and affect regulation: Strategic variations in self-appraisals. *Journal of Personality and Social Psychology* 75: 420–435.

Odendaal, J. S. and Meintjes, R. A. 2003. Neurophysiological correlates of affiliative behavior between humans and dogs. *Veterinary Journal* 165: 296–301.

Parish-Plass, N. 2008. Animal-assisted therapy with children suffering from insecure attachment due to abuse and neglect: A method to lower the risk of intergenerational transmission of abuse? *Clinical Child Psychology and Psychiatry* 13: 7–30.

Petersson, M., Hulting, A. L. and Uvnäs-Moberg, K. 1999. Oxytocin causes a sustained decrease in plasma levels of corticosterone in rats. *Neuroscience Letters* 264: 41–44.

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G. and Hellhammer, D. H. 2003. Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology* 28: 916–931.

Rholes, W. S., Simpson, J. A. and Orina, M. M. 1999. Attachment and anger in an anxiety-provoking situation. *Journal of Personality and Social Psychology* 76: 940–957.

Roisman, G. I., Tsai, J. L. and Chiang, K. H. 2004. The emotional integration of childhood experience: Physiological, facial expressive, and self-reported emotional response during the adult attachment interview. *Developmental Psychology* 40: 776–789.

Rost, D. H. and Hartmann, A. 1994. Children and their pets. *Anthrozoös* 7: 242–245.

Schneider, M. and Harley, L. 2006. How dogs influence perceptions of psychotherapists. *Anthrozoös* 19: 128–142.

Schommer, N. C., Hellhammer, D. H. and Kirschbaum, C. 2003. Dissociation between reactivity of the hypothalamus-pituitary-adrenal axis and the sympathetic-adrenal-medullary system to repeated psychosocial stress. *Psychosomatic Medicine* 65: 450–460.

Solomon, J. and George, C. C. eds. 1999. *Attachment Disorganization.* New York: The Guilford Press.

Spangler, G. and Schieche, M. 1998. Emotional and adrenocortical responses of infants to the Strange Situation: The differential function of emotional expression. *International Journal of Behavioral Development* 22: 681–706.

Sroufe, L. A., Egeland, B., Carlson, E. A. and Collins, W. A. eds. 2005. *The Development of the Person. The Minnesota Study of Risk and Adaptation from Birth to Adulthood.* New York: The Guilford Press.

Sroufe, L. A. and Fleeson, J. 1988. The coherence of family relationships. In *Relationships within Families: Mutual Influences,* 27–47, ed. R. A. Hinde and J. Stevenson-Hinde. Oxford: Oxford University Press.

Stallones, L., Johnson, T. P., Garrity, T. F. and Marx, M. B. 1990. Quality of attachment to companion animals among US adults 21 to 64 years of age. *Anthrozoös* 3: 171–176.

Stock, S. and Uvnäs-Moberg, K. 1998. Increased plasma levels of oxytocin in response to afferent electrical stimulation of the sciatic and vagal nerves and in response to touch and pinch in anaesthetized rats. *Acta Physiologica Scandinavica* 132: 29–34.

Strauss, B., Buchheim, A. and Kächele, H. eds. 2002. *Klinische Bindungsforschung: Theorien—Methoden—Ergebnisse.* Stuttgart: Schattauer Verlag.

Suess, G. J. 1987. Auswirkungen frühkindlicher Bindungserfahrungen auf die Kompetenz im Kindergarten. Unveröffentlichte Dissertation, Universität Regensburg.

Uchino, B., Cacioppo, J. T. and Kiecolt-Glaser, J. K. 1996. The relationship between social support and physiological processes: A review with emphasis on underlying mechanisms and implications for health. *Psychological Bulltin* 119: 488–531.

Uvnäs-Moberg, K. 1998. Oxytocin may mediate the benefits of positive social interaction and emotions. *Psychoneuroendocrinology* 23: 819–835.

van Ijzendoorn, M. H. and Bakermans-Kranenburg, M. J. 1996. Attachment representations in mothers, fathers, adolescents, and clinical groups: A meta-analytic search for normative data. *Journal of Consulting and Clinical Psychology* 64: 8–21.

Vining, R. F. and McGinley, R. A. 1987. The measurement of hormones in saliva: Possibilities and pitfalls. *Journal of Steroid Biochemistry* 27: 81–94.

Wedl, M. and Kotrschal, K. 2009. Social and individual components of animal contact in preschool children. *Anthrozoös* 22: 383–396.

Werner, E. E. and Smith, R. S. eds. 1982. *Vulnerable but Invincible: A Longitudinal Study of Resilient Children and Youth.* New York: McGraw-Hill.

Wilkinson, R. and Pickett, K. eds. 2009. *The Spirit Level. Why More Equal Societies Almost Always Do Better*. London: Allen Lane.

Woodside, D. B., Winter, K. and Fisman, S. 1991. Salivary cortisol in children: Correlations with serum values and effect of psychotropic drug administration. *Canadian Journal of Psychiatry* 36: 746–748.

Wright, J. C., Binney, V. and Smith, P. K. 1995. Security of attachment in 8–12 year-olds: A revised version of the separation anxiety test, its psychometric properties and clinical interpretation. *Journal of Child Psychology and Psychiatry* 36: 757–774.