HHS Public Access
Author manuscript
Soc Dev. Author manuscript; available in PMC 2019 February 01.

Published in final edited form as:
Soc Dev. 2018 February ; 27(1): 34–44. doi:10.1111/sode.12246.

Pet Dogs: Does their presence influence preadolescents' emotional responses to a social stressor?

Kathryn A. Kerns, **Kaela L. Stuart-Parrigon**, **Karin G. Coifman**, **Manfred H. M. van Dulmen**, and **Amanda Koehn**
Department of Psychological Sciences, Kent State University

Abstract

Despite interest in human-animal interaction, few studies have tested whether the presence of a dog facilitates children's emotional responding. Preadolescents ($n = 99$) were randomly assigned to complete the Trier Social Stress Test either with or without their pet dog. Children rated their positive and negative affect, and high frequency heart rate variability (HF-HRV) was assessed throughout the session. Children reported higher positive affect when they completed the task with their pet dog, although there were no differences for negative affect or HF-HRV. Children who had more physical contact with their dog at baseline reported higher positive affect. The findings suggest contact with pets is associated with enhanced positive affect.

Despite high levels of pet ownership in the United States (Melson, 2003; Walsh, 2009), especially for families with children (Harris poll, 2015), research regarding the impact of human-animal interaction on children's physical and mental health is still in the early stages (Griffin, McCune, Maholmes, & Hurley, 2011). There are a number of claims regarding ways in which pets can have a positive impact on children. For example, pets are credited with reducing children's stress (Covert, Whiren, Keith, & Nelson, 1985; Guerney, 1991) and enhancing their emotion regulation (Bryant & Donnelan, 2007). The evidence base for these conclusions is, however, still sparse, and based primarily on nonexperimental studies in which either pet ownership or children's reports of the quality of their relationship with pets has been loosely related to measures of children's social or emotional adjustment (Griffin et al, 2011). There are few experimental studies of the effects of human animal interaction that include children (Beetz, Uvnas-Moberg, Julius, & Kotrschal, 2012; Kertes, Liu, Hall, Hadad, Wynne, & Bhatt, 2016).

The goal of the present study was to conduct an experimental study to examine whether a pet dog can enhance children's real-time emotional responding during a socially stressful task. We focused on dogs, as pet dogs may be especially important providers of social support given that dogs seek social interaction, are loyal and nonjudgmental, and respond to human's emotions (Walsh, 2009). In addition, dogs are the most commonly owned pet (Harris Poll, 2015). We included preadolescents as children are likely to view pets as friends at this age (Davis & Juhasz, 1995; Melson, 2011), and ownership of pets is high for families with a preadolescent child (Davis & Juhasz, 1995). Moreover, we examined the influence of pet dog presence on *both* positive and negative emotional responses as well as an increasingly relevant indicator of regulatory resources and psychological health, high-frequency heart rate variability (HF-HRV; c.f. Beauchaine & Thayer, 2015)

Human Animal Interaction and Child Mental and Physical Health

A number of mechanisms have been proposed to account for why the physical presence of a pet dog might facilitate a child's adaptive emotion regulation. One possibility is that relaxation around the dog is a classically conditioned autonomic response due to past calming experiences with the pet (Virues-Ortega & Buela-Casal, 2006). A second possibility is that the presence of a pet reduces the perceived threat in a situation and makes the situation seem more benign (Wu, Niedra, Pendergast, & McCrindle, 2002). A pet may also enhance emotion regulation if the pet is perceived as providing nonjudgmental support (Polheber & Matchock, 2014; Walsh, 2009). Indeed, interacting positively with a loved pet might, much like interacting with supportive humans, enhance positive mood, which in turn could enhance regulatory responses through broadening attentional focus and creative thinking about coping responses (Fredrickson, 1998; Fredrickson & Levenson, 1998). Further, social interaction, especially when there is physical contact (e.g., petting a dog), might also have direct physiological effects such as reducing sympathetic arousal (Beetz, Kotrschal, Turner, Hediger, Uvnas-Moberg, & Julius, 2011) or cortisol stress responses (Kertes et al., 2016), and/or promoting the release of oxytocin (Beetz et al., 2012).

Although these proposed effects are plausible, experimental studies with children that manipulate the presence or absence of a dog provide mixed evidence regarding whether interactions with dogs do indeed enhance children's emotional responding when experiencing a stressor. One approach to indexing emotional responses focuses on children's positive and negative emotions. Some of these studies show that children display more positive emotion and less distress after completing stressor tasks in the presence of a dog (Hansen, Messinger, Baun, & Megel, 1999; Nagengast, Baun, Megel, & Leibowtz, 1997; Kaminski, Pellino, and Wish, 2002), whereas other studies have failed to replicate these effects (Beetz et al., 2011; Havener et al., 2001; Tsai, Friedmann, & Thomas, 2010).

A second approach to understanding children's emotional reactions to stress relies on indexing indicators of the functioning of the Autonomic Nervous System (ANS). Although ANS activity is obviously influenced by many variables, it is in part affected by the activation of (and thereby reflects) emotion, and studying ANS activity provides a method to capture emotional responding that is largely outside of awareness and cannot be captured through the use of self-reports (Zisner & Beauchaine, in press). Prior psychophysiological studies of human animal interaction and emotional responses to stress have focused on the Sympathetic Nervous System (SNS; e.g., heart rate, blood pressure, cortisol). The SNS is typically conceptualized as the "flight or fight" system that is activated under conditions of stress to mobilize metabolic resources (Zisner & Beauchaine,in press). There is some evidence that the presence of dogs may modulate children's SNS reactivity (Friedmann, Katcher, Thomas, Lynch, & Messent, 1983; Negangast et al., 1997; Beetz et al., 2011). However, the evidence is mixed, in that other studies did not find similar benefits (Hansen et al, 1999) or provided mixed support (e.g., Krause-Porello & Friedmann, 2014; Tsai et al, 2010).

Although psychophysiological studies of human animal interaction and emotional responses to stress have focused on the SNS, the Parasympathetic Nervous System (PNS) also plays an important role in allowing humans to cope adaptively. Under conditions of high stress, PNS withdrawal may allow for an enhanced SNS response, but under conditions of lower stress, high levels of PNS activity are thought to reflect flexible and adaptive capacities to regulate emotion. Indeed, PNS activity is increasingly relevant in research to understand psychological resilience, as well as in contemporary models of psychiatric disease (Beauchaine & Thayer, 2015; Kashdan & Rottenberg, 2010). One common index of PNS activity, HF-HRV, refers to the variability in changes in the latency of the heart rate rhythm (Zisner & Beauchaine, in press). Conceptually, HF-HRV has been interpreted as "a transdiagnostic biomarker of self-regulation and cognitive control" (Beauchaine & Thayer, 2015, p. 338). Resting or baseline measures of HF-HRV, and moderate suppression of HF-HRV under conditions of challenge, are thought to reflect overall regulatory resources (i.e., capacity to regulate) and to be predictive of later adaptive responses (Zisner & Beauchaine, in press). For example, high resting HF-HRV predicts lower levels of internalizing and externalizing symptoms in children (Zisner & Beauchaine, in press) and higher levels of psychological and physical health in adults (Kok et al., 2013). Surprisingly, we found no studies with children that investigated whether the presence of a dog during a stressful event enhances emotional responding through impacting the PNS.

Finally, an important complication in this literature is a number of methodological limitations in prior studies: Previous studies have used small samples (15 – 20 children in a group; e.g., Beetz et al, 2011; Krause-Parello & Friedmann, 2014; Tsai et al, 2010) and thus had limited power, or used specialized samples (e.g., hospitalized children; Kaminski et al, 2002; Tsai et al, 2010) or settings (e.g., child visit to a doctor; e.g., Hansen et al, 1999; Havener et al, 2001; Nagengast et al., 1997) which limits their generalizability. Although it might be expected that the positive impact of human animal interaction might be greatest when children have an ongoing relationships with the animal (e.g., is a family pet), as has been found in studies with adults (Beetz et al, 2012), the prior studies we found with children that examined the impact of human animal interaction on emotional adaptation used trained unfamiliar animals rather than family pets (for a recent exception, see Kertes et al, 2016). Moreover, most studies have not controlled for whether children have prior experience with pets, a factor that might moderate the impact of human animal interaction. Finally, studies have manipulated the presence of a dog, but only three (Beetz et al, 2011; Kaminski et al, 2002; Kertes et al., 2016) provided information regarding how much children interacted with the dog during the investigation.

Our study was designed to address these methodological limitations as well as to examine potential mechanisms (social contact, affect, physiological stress responses) that might be linked to human animal interaction. We employed an experimental design to examine whether children's emotional responses during a standardized stress task are more adaptive if they complete the task in the presence of their family pet dog. In addition to measuring children's affect, we examined HF-HRV to test the idea that the presence of a pet dog may enhance children's regulatory resources. All children in the study owned pet dogs, and for those participating with their dog, we were able to code real-time contact with the pet to test if physical contact enhanced any salutatory effects of the dog's presence. Specifically, we:

1. Tested whether children who completed the task with their dog present reported more positive affect and less negative affect during the task than those who completed the task without their dog.
2. Tested whether children completing the task with their dog present exhibited greater HF-HRV at baseline, and evidenced expected HF-HRV responsivity to the task (moderate rather than high decreases during the stressor), compared to children who completed the task without their dog.
3. Evaluated, for those children who completed the task with their dog present, whether greater physical contact with their dog prior to the stressor (i.e., baseline) was associated with negative and positive emotional reports and HF-HRV during the baseline period.

Methods

Participants

We recruited families with children in fourth or fifth grade who owned at least one pet dog through local schools, newspaper announcements, and flyers posted at community locations. Families were invited to participate in a study of how parent, friends, and pet dogs influence children's everyday life, and they were asked to contact researchers to volunteer. The sample included 99 children (9 to 11 years old, 51 girls and 48 boys). Due to administration error and equipment malfunction, *N*s for the analyses for positive affect, negative affect, and heart rate variability are 98, 97, and 95 respectively. Most families resided in small towns, and 91% of the sample was European American (4% mixed race, 2% Hispanic, 2% American Indian, 1% African American). Approximately10% of children qualified for free or reduced school lunches. Mean education levels for mothers and fathers were 15.74 and 15.00 years, respectively. Families were compensated with $50 cash and a gift card to a local pet store.

Procedure

As part of a larger study (Kerns, Koehn, van Dulmen, Stuart-Parrigon, & Coifman, 2017), children were visited at their home after school or in the evenings, and parents provided consent for the child's participation. After completing assent forms, children completed several questionnaires (not part of the present report). Children were then randomly assigned to complete a social stressor task either with ($n = 52$) or without ($n = 47$) the presence of their pet dog. Children were informed via the assent form that they would be asked to complete the stress task, but they were not told that some children would do so with their dog present to avoid creating disappointment for those assigned to the control condition. Children rated their affect at several points during the task, and HF-HRV was assessed in real-time throughout the procedure. Children completed all materials in a private location in their own home (e.g., child's bedroom, recreation room in basement) that also allowed for controlling whether or not the child was with the dog during the stressor task (i.e., the dog could be either enclosed within or excluded from the room, depending on the experimental condition).

Measures

Trier Social Stress Test (TSST)—This task, which requires children to prepare and give a videotaped autobiographical speech, has been used with preadolescents (e.g., Buske-Kirschbaum et al, 1997; Gunnar, Frenn, Wewerka & Ryzin, 2009). Children completed the task in the presence of two adult experimenters trained to be as nonresponsive as possible during the task, and children were also told they were being videotaped so that their performance could later be evaluated by their peers. Children were debriefed after they completed the task, which included explaining the deception (i.e., their session would not be shown to other children, the experimenters were acting and their performance was fine).

The task began with an initial 5 min resting period to collect baseline affect ratings and HF-HRV. During this time, children listened to soothing music and were asked to sit quietly. Next, children were told they would be asked to deliver a 5 min speech about themselves, and were given 5 min to prepare the autobiographical speech. This was followed by a 5 min period during which the child actually gave the speech in front of two adults. The final segment was a 3 min resting period where participants were asked to sit quietly and again listened to music.

Ratings of Positive and Negative Affect—After each of the 4 segments, children rated their positive and negative affect on 5 point scales, using 6 positive emotion words (excited, happy, calm, comfortable, proud, cheerful) and 6 negative emotion words (mad, nervous, upset, sad, lonely, guilty) taken from the child version of the PANAS (Laurent et al., 1999). We averaged ratings to create scores for positive affect and negative affect for each segment. Alphas for positive and negative affect across the 4 segments were: baseline, positive affect (α=.80) and negative affect (α=.22); post-speech preparation, positive affect (α=.90), negative affect (α=.56); post-speech delivery, positive affect (α=.87) and negative affect (α=.74); and after resting period, positive affect (α=.88), negative affect (α=.71). The low alphas for negative affect at the first 2 time points were due to floor effects (few children with scores greater than 1.0 on negative affect).

Assessment of HF-HRV—HF-HRV was measured throughout the TSST using the *Polar* RS800CXsd Heart Rate Monitor (HRM, sampling frequency: 1000 Hz), a valid and reliable index of heart rate (Gamelin, Berthoin, & Bosquet, 2006). Parents were instructed how to assist children with putting the respiration monitoring band around their child's upper chest and the signal was monitored by the experimenter throughout the task. The HRM data were extracted using *Polar* software and exported to a CSV file. Kubios software (Version 2.0, Kuopio, Finland) was used to quantify HF-HRV from R-R intervals (Fast Fourier Transform, HF Absolute). The cutoff for defining the high frequency domain (HF:0.23–1.0Hz) was set using age adjusted ranges for defining high frequency ranges (Adinda Judardin, personal communication; Tarvainen, Niskanen, Lipponen, Ranta-Aho & Karjalain, 2014). Artifacts were detected and removed using visual methods and the Kubios standard medium-level of artifact correction. One participant was missing HF-HRV data from all segments, and 5 more were missing data from one of the segments. Data loss was primarily due to movement. These 6 cases did not differ from the others on measures of affect or HF-HRV (for those sessions available).

Observation of Social Interaction with the Dog—For children who completed the task with their dog, we coded the child's social contact with the dog. A preliminary viewing of a few sessions revealed that children had little contact with the dog after the baseline period, as they tended to focus on completing the assigned task. We therefore only coded child-dog interaction during the 5 minute baseline period.

To develop the coding system, we began by reviewing a list of child behaviors directed to dogs that had been identified in prior research of home observations of young children (ages 2 to 6 years; Filiatre, Millot, Montagner, Eckerlin & Gagnon, 1998). The list included several indicators of "antagonistic" behaviors that we did not see in our sample of older children (e.g., hitting, pushing, or riding on the dog). Given our focus on social support, we started with Filatre et al.'s list of "appeasing and linking behaviors", which included verbal communication as well as several forms of physical contact (e.g., touching dog, stroking dog, leaning on dog). We then reviewed a small set of tapes to see which behaviors occurred, and based on our preliminary viewing we decided to code three child behaviors that occurred with some frequency: child physically touched the dog (e.g., petted, hugged), child looked at dog, and child talked to the dog. For ease of coding and to avoid having a large number of categories with low frequencies, we included any form of touching the dog in the code, "physically touched the dog", rather than making the distinctions among types of touching identified by Fillatre et al.

To code the baseline session, we divided the 5 min period into ten 30 sec blocks. We then coded separately, for each 30 sec interval, whether the child physically touched, looked at, or talked to the dog during the interval. Scores for each behavior were calculated by summing the number of intervals during which the given behavior was observed. A primary coder coded all tapes. A second coder coded 20% of the sessions to check observer agreement. Coders were blind to other information about the child. Agreement, which was calculated as the percent of intervals in which coders agreed on the presence or absence of the target behavior, was high for all categories: physical contact, 99%; looking at the dog, 93%; and talking to the dog 91%. We subsequently dropped the "looking" coding as it was highly correlated with physical contact with the dog (r=.91, p<.01), which was of special interest given that physical contact has been hypothesized to be especially important for emotion regulation effects. The correlation between physical contact with the dog and talking to the dog was 0.37 (p<.01).

Results

We conducted three repeated measures ANOVAs to examine whether children's positive affect, negative affect, and heart rate variability differed for children who completed the task either with or without their dog. These analyses included time (baseline, preparation, speech delivery, recovery) as a within subjects factor and condition (dog present, dog absent) as a between subjects factor. We report below main effects for time and condition; none of the time by condition tests of interaction effects was significant.

Changes in Affect and HF-HRV Across Task Segments

As expected, there were main effects for time segment for positive affect, negative affect, and HF-HRV, which showed the TSST did indeed affect emotional responding. We conducted additional descriptive analyses to identify when changes occurred (see Table 1). There was a significant effect for positive affect, $F(2.77, 265.65) = 23.75$, $p < .001$, $d = .47$. Within-subject contrast effects for ratings of the individual segments showed that positive affect scores significantly declined from baseline to preparation, $F(1, 96) = 27.12$, $p < .001$, $d = .39$ and preparation to the speech, $F(1, 96) = 4.47$, $p = .04$, $d = .15$, and significantly increased following the recovery segment, $F(1, 96) = 29.00$, $p < .001$, $d = .29$. There was also a significant effect of time for negative affect, $F(2.18, 206.64) = 29.98$, $p < .001$, $d = .48$. Comparisons for ratings of individual segments demonstrated that negative affect increased significantly from baseline to speech preparation $F(1, 95) = 27.79$, $p <.001$, $d = .62$, speech preparation to the speech task $F(1, 95) = 16.15$, $p <.001$, $d = .40$, and then decreased from the speech task to the recovery period $F(1, 95) = 67.41$, $p <.001$, $d = .66$. There was also a significant time effect for HF-HRV, $F(2.76, 251.45) = 17.52$, $p < .001$, $d = .42$. There were significant decreases in HF-HRV levels from baseline to speech preparation $F(1, 91) = 29.87$, $p < .001$, $d = .49$, but no change from speech preparation to speech $F(1, 91) = 0.37$, $p = .55$, suggesting as expected suppression of HF-HRV during the two challenging segments of the task. There also was a significant increase in HF-HRV from the speech to recovery period ($F(1, 91) = 15.99$, $p < .001$, $d = .36$), as would be expected following removal of a stressor.[1]

Presence of Pet: Associations with Reported Affect and Heart Rate

Our primary interest was in testing condition effects (dog present vs. absent). In this study with family pets, there were some dogs who became disruptive for major portions of the session ($n = 7$), usually after baseline when the child became involved with the assigned stress task. For example, these dogs repeatedly attempted to leave the room, barked excessively at the experimenters, or were otherwise generally distracting. We excluded these seven cases from analysis. The condition effect for positive affect was significant, with children who completed the TSST with their dog present reporting greater positive affect during the task than children who completed the task without their pet dog, $F(1, 89) = 4.46$, $p < .038$ (see Figure 1). [2] The effect size for this condition effect, based on comparison of means, was in the medium range, $d = .46$. Follow-up tests at each time point using a false discovery rate correction (Benjamini & Hochberg, 1995) revealed that effect sizes for individual segments were in the medium range, with differences significant at the following time points: at baseline, $t(90) = -2.33$, $p < .022$, $d = .49$, and at speech preparation, $t(90) = -2.16$, $p < .001$, $d = .45$.

---

[1]In the present study, we utilized HRV absolute values. There were two cases which had outlier values of HRV absolute as well as some skew in the data. We tested HRV without the outliers and results were the same. We additionally tested HRV with log transformed data and results still did not change.

[2]Findings were similar albeit slightly weaker when the sessions with disruptive dogs were not excluded. Specifically, when we included these children in the analyses, we again found a condition effect only for positive affect, ($F(1, 96) = 3.69$, $p = .058$). Follow-up t-test comparisons using a false discovery rate correction for ratings of the individual segments showed that these differences were significant at baseline ($p = .029$, $d = .45$), and marginally significant at speech preparation ($p = .052$, $d = .40$).

There were no significant effects of condition for either negative affect, $F(1, 88) = .07$, $p = .794$, or HF-HRV, $F(1, 84) = .043$, $p = .837$.

Social Interaction with Pet: Associations with Individual Differences in Affect and Heart Responding During Baseline

For those children in the dog present condition, we examined whether amount of contact with the dog during baseline (physically touching or talking to the dog) predicted individual differences in children's positive affect, negative affect, or heart rate variability for the baseline period. As shown in Table 2, children who had more physical contact with the dog during baseline reported more positive affect at the end of baseline (effect size in the medium to high range.) Physical contact was not related to negative affect, although it must be kept in mind that there was very little variability in children's negative affect at baseline. In addition, physical contact was not related to HF-HRV. Talking to the dog showed only one marginally significant trend: children who talked more to their dogs tended to report greater positive affect.

Discussion

The field of human animal interaction has begun to establish how and when the presence of animals can influence children's emotional adaptation. The present study is one of the first to test whether the presence of a pet dog facilitates children's adaptive emotion responses when coping with a social stressor. We found that children who completed a social stress task in the presence of their pet dog reported greater positive affect compared to children who completed the stressor task without their dog present. The differences in positive affect were found at baseline, and continued (but did not magnify) across the stress conditions of the task, with the differences significant for the comparisons at baseline and the speech preparation segments. Interestingly, the presence of the pet did not mitigate negative affect nor influence HF-HRV during the stress task. For those who completed the stress task with their dog, we also examined whether interaction with the pet influenced emotional responding at baseline (note there was too little child-pet interaction to examine this question for other segments of the task). We found that greater contact with the pet dog was associated with greater positive affect.

Our primary finding was that the presence of a pet enhances reported positive emotion. The experience of positive emotion has been broadly linked to enhanced problem solving, cognitive flexibility, emotion regulation, and physical health, and decreased lifetime risk for affective disorders (Fredrickson, 1998, 2013; Kendall et al, 2015). Thus, pets may indirectly promote resilience through providing more experiences of positive emotion. The differences we found could be a classically conditioned response to the presence of the pet that increased feelings of positive emotions (Virues-Ortega & Buela-Casal, 2006), or children may have framed the stress task as less threatening when the pet dog was present (Wu et al., 2002). Alternatively, it could be that the pet's presence offered social support and feelings of social connection. This interpretation is consistent with our finding that children who spent more time in physical contact with the dog during baseline reported more positive affect, and is also in line with dominant theories that link positive emotions to social connections

(Fredrickson, 1998). If social interaction is a key factor, then similar results may be found only when children complete tasks in the presence of pets that allow for social interaction such as cats or horses, but not in the presence of pets that do not allow for social interaction (e.g., scorpions, fish). If similar benefits of enhanced positive affect were found regardless of the type of pet, this would suggest support for other mechanisms that do not require social interaction (e.g., classically conditioned relaxation responses).

There were several strengths to the study. We employed an experimental design to provide a rigorous test of the impact of human animal interaction on children's emotional responses in a standardized stress situation. The sample size was relatively large for this type of research. The study, like Kertes et al. (2016), is also unique in the child literature in focusing on the potential benefits of pets rather than service animals. We included multiple measures of emotional responding, as well as examining interaction between the child and his or her pet dog. The findings for social interaction suggested that physical contact may be one mechanism that explains why the presence of the pet was associated with more positive emotion.

The finding that the presence of pet dogs enhances positive affect also has practical implications. If positive affect enhances coping resources and creativity, then children may also show performance improvements when engaging in tasks with their pet present. For example, in a problem solving task, they might be able to generate a wider variety of solutions. Further, physical contact with a pet may also provide initial resiliency preceding stressful circumstances which may also allow a child to stay calmer in stressful situations and thereby enhance their coping in the situation. One study found that children undergoing a forensic interview regarding child abuse evaluations showed lower heart rate when interviewed with a therapy dog present (Krause-Parello & Gulick, 2015). The dog's presence may not only be calming but could potentially enhance children's ability to provide a fuller account of their experiences. Our findings also have implications for work on the therapeutic benefits of human animal interaction. If the presence of a pet increased positive affect then it may also help children transitioning to new situations (e.g. foster care) or may increase children's receptivity to treatment.

Prior studies of the potential regulatory benefits of the presence of dogs have tended to examine sympathetic rather than parasympathetic responses. We focused on HF-HRV, given that this metric has been interpreted as a broad biological indicator of regulatory resources (Beauchaine & Thayer, 2015). Contrary to expectation, we did not find that the presence of a pet was associated with lower HR-HRV throughout the task, although for the total sample we did find the expected pattern that HF-HRV declined during the stressful segments of the task and showed an increase after the stress task ended. An important direction for future research will be to further investigate additional biological mechanisms that might account for the positive impact of contact with pets. Physical contact is associated with increased release of oxytocin, in samples of children and pet dogs (Beetz et al., 2012), suggesting that oxytocin may be another underlying biological mechanism deserving of greater attention.

There were some limitations to the study. Although we found that children who interacted with their dogs during baseline reported greater positive affect, given the non-experimental nature of this finding it is possible that an unmeasured child characteristic (e.g., child extraversion) might affect interest in the dog and thus account for these findings. Additional experimental conditions that allow for other types of social interaction or other types of activities also could be included to rule out alternative interpretations (e.g., higher positive affect for children in the dog condition occurred because the dog functioned as a distraction from the stress task). Another limitation was reliance solely on self-report measures of affect, and the study could be extended by using observational ratings of emotion. Although the changes in affect and HF-HRV suggest the TSST had an impact, the amount of change was relatively small. It may be that participating in the TSST in their homes dampened emotional responding. To more fully evaluate the impact of the stressor task, our measures could have been augmented with more direct assessments of perceived stress or more extensive assessment of specific emotions (e.g., anxiety). Finally, the modest sample size of the study precluded examining factors, such as closeness of the child's relationship with the dog or length of pet ownership, that might moderate the impact of the presence of the pet dog.

An additional issue to consider in future research is whether dog ownership might have different impacts for children of different ages. We explored our questions in a preadolescent sample as it has been suggested that children are especially likely to view pets as friends at this age (Davis & Juhasz, 1995; Melson, 2011). Yet evidence that pets are especially important for children at this age is sparse. It is possible that in early childhood other figures such as parents or older siblings, who can function as attachment figures for young children, would have greater salience. Indeed, children may view dogs more as play objects than as relationship partners at that stage. In middle childhood, as friendship becomes a more prominent concern, children may increasingly turn to pets as another nonparental support figure and form deeper relationships with pets. McNicholas and Collis (2001) reported that 7 – 8 year-old children were especially likely to turn to their dogs (as well as parents) when they felt ill, scared, or wanted to share a secret. It is possible that the salience of pets as support figures declines somewhat in adolescence as children may increasingly turn to peers rather than to pets for support. In addition, adolescents may be better able to self-regulate emotion, and may even see themselves as the providers of support to pets rather than seeking pets as comfort figures (e.g., calming a frightened pet or providing daily care for a pet). Nevertheless, given that even adults can receive comfort and support from pets (Walsh, 2009), pets may not completely relinquish the role of support provider in adolescence. It is also important to bear in mind that seeking comfort from a pet may be even more beneficial than support from a friend because the pet may be perceived as less judgmental than a friend (Allen, Blascovich, Tomaka, & Kelsey, 1991; Polheber & Matchock, 2014). Cross-sectional and longitudinal studies that examine pets as sources of support at different ages are needed to address questions regarding when pets may be most significant as support providers.

In summary, in this multi-method experimental study we found that children reported elevated positive emotion during a stress task when they completed the task in the presence of their pet dog, although the presence of the pet dog did not influence negative affect or HF-HRV. Children's positive affect was highest at baseline when children had more contact with their dog, suggesting that physical contact might further enhance the effects of the presence of the dog. The specific effects for positive affect support the interpretation that the presence of a pet dog may enhance adaptive emotional responses to stress.

Acknowledgments

This project was funded by a grant from the National Institute of Nursing Research (NR013872) and the Waltham Centre for Pet Nutrition. We thank the families who participated in this project.

References

Allen KM, Blascovich J, Tomaka J, Kelsey RM. Presence of human friends and pet dogs as moderators of autonomic responses to stress in women. Journal of Personality and Social Psychology. 1991; 61:582– 589. [PubMed: 1960650]

Beauchaine TP, Thayer JF. Heart rate variability as a transdiagnostic biomarker of psychopathology. International Journal of Psychophysiology. 2015; 98:338–350. [PubMed: 26272488]

Beetz A, Kotrschal K, Turner DC, Hediger K, Uvnas-Moberg K, Julius H. The effect of real dog, toy dog, and friendly person in insecurely attached children during a stressful task. An exploratory study. Anthrozoos. 2011; 24:349– 368.

Beetz A, Uvnas-Moberg K, Julius H, Kotrschal K. Psychosocial and psychophysiological effects of human-animal interactions: The possible role of oxytocin. Froniters in Psychology. 2012:3.

Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. Journal of the Royal Statistical Society B. 1995; 57:289–300.

Bryant BK, Donnellan BM. The relation between socio-economic status concerns and angry peer conflict resolution is moderated by pet provisions of support. Anthrozoos. 2007; 20:213–223.

Buske-Kirschbaum A, Jobst S, Wustmans A, Kirschbaum C, Rauh W, Hellhammer D. Attenuated free cortisol response to psychosocial stress in children with atopic dermatitis. Psychosomatic Medicine. 1997; 59:419– 426. [PubMed: 9251162]

Covert AM, Whiren AP, Keith J, Nelson C. Pets, early adolescents, and families. Marriage and Family Review. 1985; 8:95–108.

Davis JH, Juhasz AM. The preadolescent/pet friendship bond. Anthrozoos. 1995; 8:78–82.

Fillatre JC, Millot JL, Montagner H, Eckerlin A, Gagnon AC. Advances in the study of the relationship between children and their pet dogs. Anthrozoos. 1998; 2:22–32.

Fredrickson BL. What good are positive emotions? Review of General Psychology. 1998; 2:300–319. [PubMed: 21850154]

Fredrickson BL, Levenson RW. Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. Cognition and Emotion. 1998; 12:191–220. [PubMed: 21852890]

Friedmann E, Katcher AH, Thomas SA, Lynch J, Messent PR. Social interaction and blood pressure: Influence of animal companions. Journal of Nervous and Mental Disease. 1983; 171:461– 465. [PubMed: 6875529]

Gamelin FX, Berthoin S, Bosquet L. Validity of the polar S810 heart rate monitor to measure R-R intervals at rest. Medicine and science in sports. 2006; 38:887–893.

Griffin, JA., McCune, S., Maholmes, V., Hurley, K. Human-animal interaction research: An introduction to issues and topics. In: McCardle, P.McCune, S.Griffin, JA., Maholmes, V., editors. How Animals Affect Us Examining the Influence of Human-Animal Interaction on Child Development and Human Health. Washington, DC: American Psychological Association; 2011. p. 3-9.

Guerney LF. A Survey of Self-Supports and Social Supports of Self-Care Children. Elementary School Guidance and Counseling. 1991; 25:243–254.

Gunnar MR, Wewerka S, Frenn K, Long JD, Griggs C. Developmental change in the hypothalamus-pituitary-adrenal activity over the transition to adolescence: Normative changes and associations with puberty. Development and Psychopathology. 2009; 21:69–85. [PubMed: 19144223]

Hansen KM, Messinger CJ, Baun MM, Megel M. Companion animals alleviating distress in children. Anthrozoos. 1999; 12:142– 148.

Poll, Harris. 2015. http://www.theharrispoll.com/health-and-life/Pets-are-Members-of-the-Family.html

Havener L, Gentes L, Thaler B, Megel ME, Baun MM, Driscoll FA, Beiraghi S, Agrawal S. The effects of a companion animal on distress in children undergoing dental procedures. Issues in Comprehensive Pediatric Nursing. 2001; 24:137– 152. [PubMed: 11817428]

Kaminski M, Pellino T, Wish J. Play and pets: The physical and emotional impact of child-life and pet therapy on hospitalized children. Children's Health Care. 2002; 31:321– 335.

Kashdan TB, Rottenberg J. Psychological flexibility as a fundamental aspect of health. Clinical Psychology Review. 2010; 30:865– 878. [PubMed: 21151705]

Kendall AD, Zinbarg RE, Mineka S, Bobova L, Prenoveau JM, Revelle W, Craske MG. Prospective Associations of Low Positive Emotionality With First Onsets of Depressive and Anxiety Disorders: Results From a 10-Wave Latent Trait-State Modeling Study. Journal of Abnormal Psychology. 2015; 124:933– 943. [PubMed: 26372005]

Kerns KA, Koehn AJ, van Dulmen MHM, Stuart-Parrigon KL, Coifman KG. Preadolescents' relationships with pet dogs: Relationship continuity and associations with adjustment. Applied Developmental Science. 2017; 21:67– 80.

Kertes DA, Liu J, Hall NJ, Hadad NA, Wynne CDL, Bhatt SS. Effect of pet dogs on children's perceived stress and cortisol stress response. Social Development. 2016; doi: 10.1111/sode.12203

Krause-Parello CA, Friedmann E. The effects of an animal-assisted intervention on salivary alpha-amylase, salivary immunoglobulin A, and heart rate during forensic interviews in child sexual abuse cases. Anthrozoos. 2014; 27:581– 590.

Krause-Parello CA, Gulick EE. Forensic interviews for child sexual abuse allegations: An investigation into the effects of animal-assisted intervention on stress biomarkers. Journal of Child Sexual Abuse: Research, Treatment, & Program Innovations for Victims, Survivors, & Offenders. 2015; 24:873– 886.

Laurent J, Catanzaro SJ, Joiner TJ, Rudolph KD, Potter KI, Lambert S, Gaithright T. A measure of positive and negative affect for children: Scale development and preliminary validation. Psychological Assessment. 1999; 11:326– 338.

McNicholas J, Collis GM. Children's representations of pets in their social networks. Child: Care, Health, and Development. 2001; 27:279– 294.

Melson GF. Child development and the human-companion animal bond. American Behavioral Scientists. 2003; 47:31–39.

Melson, G. Principles for human-animal interaction research. In: McCardle, P.McCune, S.Griffin, JA., Maholmes, V., editors. How Animals Affect Us Examining the Influence of Human-Animal Interaction on Child Development and Human Health. Washinton, DC: American Psychological Association; 2011. p. 13-33.

Nagengast SL, Baun MM, Megel M, Leibowtz M. The effects of the presence of a companion animal on physiological arousal and behavioral distress during a physical examination. Journal of Pediatric Nursing. 1997; 12:323– 330. [PubMed: 9420370]

Polheber JP, Matchock RL. The presence of a dog attenuates cortisol and heart rate in the Trier Social Stress Test compared to human friends. Journal of Behavioral Medicine. 2014; 37:860– 867. [PubMed: 24170391]

Tarvainen MP, Niskanen JP, Lipponen JA, Ranta-Aho PO, Karjalain PA. Kubios HRV – Heart rate variability analysis software. Computer Methods and Programs in Biomedicine. 2014; 113:210– 220. [PubMed: 24054542]

Tsai C, Friedmann E, Thomas SA. The effect of animal-assisted therapy on stress responses in hospitalized children. Anthrozoos. 2010; 23:245– 258.

Virues-Ortega J, Buela-Casal G. Psychophysiological effects of human-animal interaction: Theretical issues and long-term interaction effects. Journal of Mervous and Mental Disease. 2006; 194:52– 57.

Walsh F. Human-animal bonds I: The relational significance of companion animals. Family Process. 2009; 48:462–480. [PubMed: 19930433]

Wu AS, Niedra R, Pendergast L, McCrindle BW. Acceptability and impact of pet visitation on a pediatric cardiology inpatient unit. Journal of Pediatric Nursing. 2002; 17:354– 362. [PubMed: 12395303]

Zisner, AR., Beauchaine, TP. Psychophysiological methods and developmental psychopathology. In: Cicchetti, D., editor. Handbook of Developmental Psychopathology. 3. Hoboken, NJ: Wiley; in press

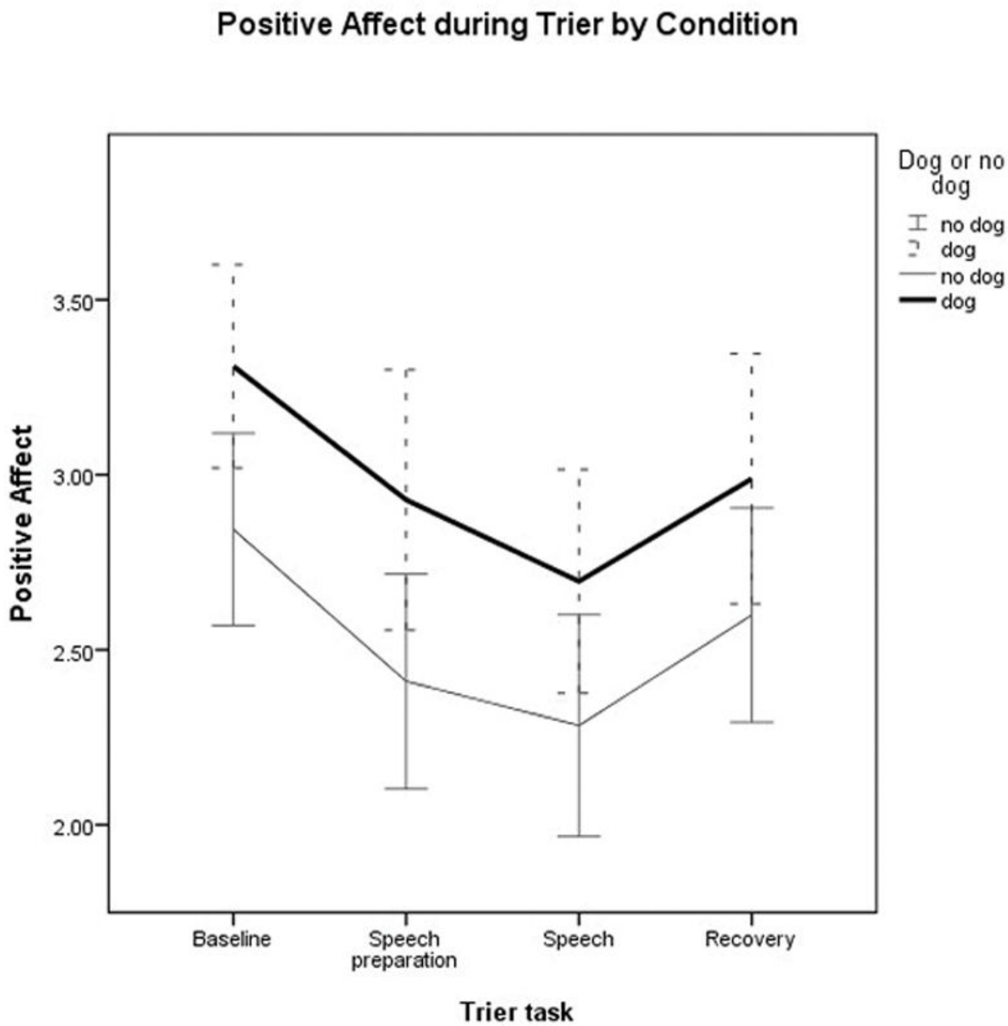

Figure 1.
Positive Affect During Trier by Condition

Table 1

Means, Standard Deviation, and Effect Sizes for Key Study Variables

Variables	Full Sample Means *(SD)*	Dog Condition Mean *(SD)*	No Dog Condition Means *(SD)*	Effect sizes (*d* s)
Positive Affect				
Baseline	3.07 *(.98)*	3.31 *(.97)*	2.84 *(.94)*	.49
Speech Preparation Task	2.66 *(1.17)*	2.93 *(1.24)*	2.41 *(1.05)*	.45
Post-Speech	2.49 *(1.09)*	2.70 *(1.07)*	2.28 *(1.09)*	.39
Recovery	2.79 *(1.13)*	2.99 *(1.18)*	2.60 *(1.05)*	.35
Negative Affect				
Baseline	1.13 *(.18)*	1.10 *(.15)*	1.15 *(.21)*	.27
Speech Preparation Task	1.29 *(.34)*	1.30 *(.38)*	1.29 *(.30)*	.03
Post-Speech	1.45 *(.51)*	1.48 *(.62)*	1.42 *(.38)*	.12
Recovery	1.15 *(.29)*	1.17 *(.37)*	1.13 *(.18)*	.14
HF-HRV				
Baseline	1360.38 *(1180.19)*	1306.38 *(1059.74)*	1413.22 *(1296.85)*	.09
Speech Preparation Task	841.41 *(863.26)*	860.80 *(923.59)*	822.46 *(809.71)*	.04
Post-Speech	855.25 *(973.11)*	908.34 *(1126.63)*	803.33 *(804.90)*	.11
Recovery	1201.78 *(1292.54)*	1288.83 *(1504.13)*	1122.30 *(1074.77)*	.13

Note: Ns for Positive Affect ranged from 91 to 92 for the total sample, 44 to 45 for the dog condition, and 47 for the no dog condition; for Negative Affect, 91 to 92 for the total sample, 44 to 45 for the dog condition, and 47 for the no dog condition; and for HF-HRV, 88 to 91 for the total sample, 42 to 45 for the dog condition, and 45 to 46 for the no dog condition. Scores for positive affect and negative affect could range between 1.0 and 5.0.

Table 2

Correlations of Social Interaction with Dog with Affect and Autonomic Responding at Baseline (for those completing task with dog)

	Physical Contact with Dog	**Talking to Dog**
Positive Affect	.417**	.263
Negative Affect	−.060	.059
HF- HRV	.075	.016

Note: + = $p < .10$,

*$p < .05$,

**$p < .01$.

$N = 45$ for Positive Affect and HF-HRV and N= 44 for Negative Affect.