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Attachment and Emotion Regulation in Middle Childhood: Changes in Affect and Vagal Tone during a Social Stress Task

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Abstract

In middle childhood, more securely attached children show better emotion regulation when assessed as general tendencies (e.g., coping style), but studies looking at emotion in response to specific stressors have revealed mixed results. This study examined how attachment security, avoidance, and ambivalence-- assessed with a story stem task (99 children, 9 – 11 years old)-- relates to dynamic indices of affective and autonomic responses (baseline, reactivity, recovery). Reports of positive and negative affect, and high frequency heart rate variability (HF-HRV), were assessed during a social stressor task. Securely attached children did not show reactivity effects, although they did show greater recovery of positive affect after the task ended. Avoidant children showed both less reactivity and recovery of negative affect, suggesting a dampened emotional response. Ambivalent children showed more reactivity and more recovery of negative affect. Autonomic response changes were only evident for ambivalent children, who showed less suppression of HF-HRV variability under stress.

Keywords

Attachment; Emotion Regulation; Stress; HF-HRV; RSA

Attachment is a long-lasting emotional bond between a child and a caregiver, and the attachment system evolves as an emotion regulation mechanism (i.e., children go to parents for comfort when upset; Ainsworth, 1989; Bowlby, 1969). Further, interactions with attachment figures are thought to facilitate the development of children's emotion regulation capacities (Cassidy, 1994), which become internalized and generalized to other contexts (Kerns, Abraham, Schlegelmilch, & Morgan, 2007; Sroufe, Schork, Motti, Lawroski, & LaFreniere, 1984). A growing body of evidence indicates that children who form secure attachments to caregivers are more advanced in their understanding of and ability to regulate emotion (Cassidy, 1994; Cooke, Stuart-Parrigon, & Kerns, in press; Brumariu, 2015; Parrigon, Kerns, Movahed-Abtahi, Koehn, & Koehn, 2015; Zimmer-Gembek et al, 2015). To date, most studies have examined how attachment is related to trait-like measures of emotion (e.g., emotion knowledge, mean affect, typical coping strategies), rather than examining how attachment is related to emotion as regulated in response to ongoing environmental demands. The current study examined how secure and insecure patterns of attachment in children are related to dynamic changes in children's emotions in response to a social challenge. We investigated this question in children 9 – 11 years of age as we were particularly interested in how attachment is related to the self-regulation of emotion (i.e., emotion regulation that takes place in the absence of the caregiver).

Attachment and the Development of Emotional Competence

Individual differences in attachment occur as a result of caregiving interactions in which emotion is a key to how the attachment system is organized. When a caregiver is responsive and sensitive to the child's emotion signals, the child develops a secure attachment and is confident that the caregiver is available when needed (Ainsworth, Blehar, Waters, & Wall, 1978; Bowlby, 1969). Therefore, when distressed, the child freely goes to the caregiver and shares feelings, and within these affective communications, the child learns effective ways to regulate emotions (Cassidy, 1994). In contrast, insecurity in attachment is hypothesized to be related to deficiencies in children's regulation of emotions. Avoidant children learn to minimize emotions because there is a history of rejection from the caregiver to the child's signals, and emotion suppression is developed as a strategy to avoid rejection, whereas ambivalent children maximize emotions because they have experienced an inconsistency in caregiver's responsiveness, and heightening of emotions increases the chance of getting attention from the caregiver (Cassidy, 1994). Patterns of affect regulation developed within the attachment relationship are hypothesized to generalize to other contexts (Kerns et al, 2007; Sroufe et al, 1984).

Middle childhood represents an important period of change for both attachment and emotion regulation. There are four defining characteristics of attachment in middle childhood (Kerns & Brumariu, 2016). As was true at younger ages, parents continue to be children's primary attachment figures. A change is that the set goal of the attachment shifts from maintaining proximity to the attachment figure to assured availability of the attachment figure. A third characteristic is that the attachment relationship evolves into a collaborative partnership, with children and parents engaging in greater coregulation of contact. As at younger ages, attachment figures function as both safe havens and secure bases, although their role as a secure base may become more important in middle childhood. Regarding emotion regulation, a change in middle childhood is that children are increasingly self-reliant in regulating emotion (Skinner & Zimmer-Gembeck, 2007). Norms for the expression of emotion also change, so that by middle childhood children are increasingly expected to modulate emotion (e.g., "be cool"; Saarni, 1999), and a failure to do so at this age is associated with difficulties such as rejection by peers (Eisenberg, Vaughn, & Hofer, 2009).

In line with theory, research findings point to advantages in emotional competence for more securely attached children (Brumariu, 2015; Parrigon et al., 2015; Zimmer-Gembek et al., 2015). In middle childhood, securely attached children adopt more adaptive emotion regulation strategies such as coping through seeking support or problem solving (Abraham & Kerns, 2013; Colle & Del Giudice, 2011; Contreras, Kerns, Weimer, Gentzler, & Tomich, 2000; Gaylord-Harden, Taylor, Campbell, Kesselring, & Grant, 2009; Kerns, Abraham, Schlegelmilch, & Morgan, 2007; Psouni & Apetroaia, 2014) and constructively regulating discrete emotions such as anger and sadness (Schwartz, Stutz, & Ledermann, 2012; Brenning & Braet, 2013). The relationship between regulatory competencies and insecure patterns of attachment in middle childhood has been investigated less extensively, and the existing studies include samples of adolescents. In a study of 12 and 14 year-olds who had completed the child version of the Experiences in Close Relationships questionnaire to assess attachment, Brenning, Soenens, Braet, and Bosmans (2012) found that ambivalent children primarily use dysregulation, while avoidant children strongly use suppression. In a second study of 11–16 year-olds that used the same attachment measure, Brenning and Braet (2013) showed that more avoidant children used anger dysregulation and sadness suppression, whereas more ambivalent (anxious) children rely on dysregulation for both sadness and anger. Brumariu, Kerns, and Seibert (2012), who studied 10 to 12 year-old children and assessed attachment with a story stem interview, found that attachment security was correlated with less difficulty in identifying emotions, and attachment disorganization was related to more catastrophizing interpretations and less active coping.

A Dynamic Perspective on Emotion Regulation

Emotion regulation has been defined in multiple ways. For example, Thompson (1994) defined emotion regulation as extrinsic and intrinsic processes that monitor, evaluate and modify emotional reactions to accomplish goals, and Cole, Martin and Dennis (2004) defined it as “changes associated with activated emotions”. The proposed definitions suggest that emotion regulation refers to the ability to adaptively regulate emotions over time and across contexts, and indicate the need to study how emotion varies in response to environmental demands such as the introduction of a challenge. Specifically, *emotional reactivity* refers to the magnitude of change from an emotional baseline state that is elicited in response to specific external events (Gross, Sutton, & Ketelaar, 1998; Thompson et al., 2012), and *emotional recovery* is defined as the magnitude of adjustment in emotional responsiveness from when the stimulus is presented to the subsequent period in which the stimulus has been removed (Gruber, Harvey, & Purcell, 2011).

A number of indices have been used to capture dynamic changes in emotion. *Experiential affect* refers to the valence of different types of affects that are experienced (Parrigon et al., 2015). Experiential affect is typically assessed with self-ratings of positive and negative affect. Physiological indices of emotion also have been used as a tool to represent emotion dynamics. Changes in vagal tone (See Zinser & Beauchaine, in press; Porges, 2007), cortisol level (See Dickerson & Kemeny, 2004 for a review), and skin conductance (Dawson, Schell, & Filion, 2007) are three well known methods utilized in psychophysiological studies of emotion. The Sympathetic Nervous System (SNS) plays a crucial role in challenging situations (fight and flight) by increasing blood flow and respiratory efficiency and mobilizing energy. The Parasympathetic Nervous System (PNS) also plays an important role in these situations by allowing the sympathetic system to exert excitatory effects unopposed, through acute withdrawal of its inhibitory effects (Zinser & Beauchaine, in press). Vagal tone is defined as the parasympathetic inputs from the brainstem to the heart (Porges, 1995). Vagal tone was chosen to capture dynamics of emotion in the present study because it has been conceptualized as an indicator of emotion regulation and thus was particularly relevant given our study focus (Gentzler, Santucci, Kovacs & Fox, 2009; Zinser & Beauchaine, in press). This construct, which is defined as the parasympathetic inputs from the brainstem to the heart (Porges, 1995), contributes to core regulatory functions in addition to slowing heart rate (Zinser & Beauchaine, in press). Literature supports the idea that suppression of vagal tone in response to environmental challenges is an indicator of skilled self-regulation under stress (Porges, 2007; Porges, 1995; Porges, Doussard-Roosevelt, Portales, & Suess, 1994; Zinser & Beauchaine, in press). For example, in the Strange Situation, infants typically show suppression of vagal tone during the separation episode compared to free play (Feldman, Singer, & Zagoory, 2010). Vagal tone is typically indexed with a measure of High-Frequency Heart Rate Variability (HF-HRV; also called Respiratory Sinus Arrhythmia-RSA; Zinser & Buchain, in press). Studies of normative samples indicate that high baseline HF-HRV and moderate HF-HRV reactivity (i.e., modest reductions in RSA in response to stress or to emotionally evocative stimuli) are associated with adaptive functioning, including social competence and resilience in contexts of stress and adversity (Zinser & Beauchaine, in press, Beauchaine 2001). By contrast, low baseline HF-HRV and either excessive HF-HRV reactivity or lack of suppression of HF-HRV are associated with emotion dysregulation (Beauchaine, 2001, Porges, 2007, Beauchaine & Thayer, 2015; Moore & Calkins, 2004).

Studies with infants that assess attachment and emotion often assess the two in the same context (e.g., Strange Situation; Hill-Soderlund et al, 2008; Oosterman, de Schipper, Fisher, Dozier,& Schuengel, 2010), which makes it difficult to disentangle emotion and attachment. Recent studies with older children have incorporated a dynamic emotion perspective to examine how attachment predicts emotion in the absence of the caregiver. These studies allow for testing whether attachment is related to internalized patterns of emotion regulation (i.e., self-regulation of emotion). Regarding attachment and emotion characteristics at baseline, Borelli et al. (2010) used affect reports and cortisol levels in a fear startle paradigm before and after the administration of an attachment autobiographical interview. In this sample of 8 – 12 year-olds, more securely attached children reported greater positive emotions and had lower cortisol levels before the attachment interview (baseline), which indicates lower stress responses (Borelli et al. 2010).

Emotional reactivity has been the focus of several studies of attachment and emotion dynamics, and existing data suggest three different patterns of findings. First, there is evidence that more securely attached children are more reactive to stress. In a study that used marital conflict videos to simulate parental conflict, more securely attached children felt more angry, sad and scared after watching the videos (Harold, Shelton, Goeke-Morey & Cummings, 2004). In another study (Spangler & Zimmerman, 2014), in which children who had been observed during the Strange Situation at 12 months of age played a computer game designed to elicit anger at age 12, more securely attached children reported more anger than insecurely attached children, which may reflect their greater awareness of their emotions. Borelli et al. (2010) found that during an attachment interview more securely attached children showed a steeper increase in positive affect and a faster decrease in negative affect. Also, Lutkenhaus, Grossman and Grossman (1985) found that children classified as securely attached at 12 months in the Ainsworth Strange Situation expressed more sadness than insecurely attached children after losing a game with an unfamiliar visitor at age 3 years. By contrast, another set of studies found no relationship between attachment security and emotional reactivity. A longitudinal study, which had assessed attachment at 12 months (Strange Situation) and at 16 years (Adult Attachment Interview), showed no difference between secure and insecure adolescents in feelings of joy in a stress inducing setting (Zimmermann, Maier, Winter & Grossmann, 2001). Borelli et al. (2010) and Spangler & Zimmerman (2014) found no association between attachment security and cortisol responses during stress. Also, Borelli et al. (2010) did not find a relationship between attachment security and changes in affect in response to fear-induced startle. In a study of 7 year-olds, Gilissen, Bakermans-Kranenburg, van Ijzendoorn, and van der Veer (2009) found that a story stem measure of attachment security did not predict heart rate variability in response to a fear inducing film clip.

A third pattern is studies that suggest securely attached children are less reactive to stress. Gilissen, Bakermans-Kranenburg, van Ijzendoorn, and Linting, (2008) found that 7 year olds who were shown to be securely attached using a story stem task experienced lower levels of skin conductance during a social stress task. Gilissen et al. (2009), using a fear inducing film clip, found that greater attachment security predicted less skin conductance, and Spangler and Zimmerman (2014) found that more securely attached children showed less fear in response to a talk show fear elicitation task. In addition, 15 month old securely attached infants showed markedly lower levels of cortisol than insecurely attached infants after separation from mothers during the Strange Situation (Ahnert, Gunnar, Lamb, & Barthel, 2004).

To our knowledge, *Emotional recovery* was investigated in only one study. Borelli et al. (2010) found that more securely attached children (8 – 12 year-olds) showed a steeper decline in negative affect after removal of the fear-induced startle, while avoidant (dismissing) children had a slower decrease in their cortisol levels.

Collectively, current findings do not show a consistent pattern of association between emotional reactivity and attachment, and only one study looked at baseline emotion characteristics and recovery of emotion in relation to attachment. In addition, data regarding how different insecure patterns of attachment are related to emotional change in real time is sparse, such that even studies assessing insecure patterns have reported results as comparisons between securely and insecurely attached children. Although sympathetic activation as a component of stress response has been studied frequently in relation to attachment in older children, parasympathetic influences as the other known party in the stress response system has not. Given that parasympathetic activation is thought to be an indicator of emotion regulation (Zinser & Beauchaine, in press), indexing parasympathetic activation is similarly important in understanding the physiological aspects of responding to stress.

Goals and Hypotheses: Attachment and Emotion Dynamics

The present study was designed with two main goals. The first goal was to conceptually replicate the studies that have examined the relationship between attachment security and changes of affect during a dynamic task, and extend these studies by examining associations between secure attachment and HF-HRV, which is an index of vagal tone (Zinser & Beauchaine, in press). The second goal was to look at insecure patterns of attachment in relation to emotional change. To pursue these goals, successive reports of affect and constant measures of vagal tone were used to look at emotion responses to a social stressor, preparing and giving a speech to an audience.

Attachment and Baseline Emotion

It was hypothesized that children who are more securely attached would report more positive affect at baseline, based on findings of Borelli et al. (2010) and studies of trait-like emotion that show securely attached children generally experience higher levels of positive affect and lower levels of negative affect (Abraham & Kerns, 2013; Kerns et al., 2007; Kim, Sharp & Carbone, 2014; Hershenberg, Davila, Yoneda, Starr, Miller, Stroud & Feinstein, 2011; Becker-Stoll, Delius & Scheitenberger, 2001). Based on evidence that higher levels of HF-HRV at baseline reflect a greater capacity for emotion regulation, and evidence that securely attached children show better emotion regulation on trait-like measures, it was hypothesized that more securely attached children would have higher baseline HF-HRV. In regards to the associations with insecure patterns of attachment, it was hypothesized that children who were more ambivalent or avoidant would report less positive and more negative affect, and also show lower HF-HRV at baseline.

Attachment and Emotional Reactivity

Based on the inconsistences in the literature, we could not make clear hypotheses regarding how securely attached children react to stress in terms of experiential affect and HF-HRV. Securely attached children could be more reactive since they are capable of more appropriately responding to contextual cues and thus show less positive affect and more negative affect, as well as greater suppression of HF-HRV following the stressor. Alternatively, more securely attached children could be less emotionally reactive to stress because they are expected to be more emotionally stable, and consequently would show less decline in positive affect and less increase in negative affect, as well as less suppression of HF-HRV, following the stressor.

For children with insecure patterns of attachment, it was hypothesized that more avoidant children would show less emotional reactivity during stress, reflected in little change in positive or negative affect, as younger avoidant children have been found to be affectively neutral (Ainsworth et al., 1978). Also, we expected that avoidant children would show little suppression of HF-HRV, indicating less physiological reactivity. By contrast, more ambivalent children were expected to show more reactivity as reflected in declines in positive affect and increases in negative affect, as well as more suppression of HF-HRV, in transition from baseline to stressful stages of the experiment. These predictions are consistent with evidence that ambivalent children show heightened negative emotionality in relation to stress (Cassidy, 1994).

Attachment and Emotional Recovery

Securely attached children were hypothesized to more efficiently recover from the stressor, and thus we predicted that more securely attached children would show more positive affect and less negative affect after the stressor ended. In addition, we expected more securely attached children to have increased HF-HRV when stress is removed.

For insecure patterns of attachment, it was hypothesized that more avoidant children would show less recovery (i.e., changes in affect or HF-HRV) because they are not expected to experience substantial emotional change (Cassidy, 1994). Ambivalent children were expected to show less recovery, reflected in less of an increase in positive affect and less of a drop in negative affect and continued suppression in HF-HRV after removal of the stress, because these children have been shown to have more difficulty calming after stressful situations (Cassidy, 1994).

Method

Participants

As part of a larger study that included examining benefits of human-animal interaction, we recruited families with children in fourth or fifth grade (age range: 9–12, mean age= 10.63 years) who owned at least one pet dog. Information about the study was distributed through local schools, newspaper announcements, and information sheets posted at community locations (e.g., libraries). Families who were interested in participating in the study were asked to contact researchers to volunteer. The sample included 99 children (9 to 11 years old, 51 girls and 48 boys). Most families resided in small towns. About 90% of the sample was Caucasian. Both mothers and fathers had at least a high school diploma, and about 40% of each group had a college degree; 4% of the sample were eligible for food stamps and 11% were eligible for free or reduced school lunches.

Procedure

Children were visited at their home. After both parents and children provided consent, children completed several questionnaires and other tasks that are not part of the present report. All children competed a story stem attachment interview, and participated in the Trier Social Stress Task, which they were randomly assigned to complete with (n = 52) or without (n= 47) the presence of their pet dog. The effect of pet dog presence was controlled in all analyses as it was not of interest in this study. Children rated their affect at several points during this task, and HF-HRV was assessed throughout the procedure. Missing affect and HF-HRV scores resulted from distractions or disruptions by pet dogs during procedures that led to corrupted reports of affect or unreliable heart rate values. All study procedures were approved by the university ethics committee.

Measures

Assessment of Children's Representations of Attachment—To assess representations of attachment, children completed a story stem task in which the experimenter begins a story with an attachment theme, and the child continues and finishes the story using dolls and props. The child and his/her mother are the characters in the story. Two stories, which were developed by Kerns, Brumariu, and Seibert (2011) to reflect secure base behavior in middle childhood in American children, were used. In the first story, a child is working on a homework assignment that is due tomorrow, and he or she is worried about finishing it before bedtime. The second story presents the child with the situation of playing with a friend at the friend's house. The child and friend get into a big fight and the friend asks the child to leave. The child gets home and slams the door. The mother, who does not see who enters the house, calls the child's name and asks, "is that you (child's name)?". These story themes were chosen because some themes used with younger children did not work as well with older children (See Kerns et al, 2011), and interviews with children suggest that performance failures and social conflict are salient concerns that lead children in middle childhood to seek out the attachment figure (Kerns & Seibert, in press; Vandevivere, Braet, & Bosmans, 2015). After telling each story stem, the experimenter prompts the child to tell and show what happens next. The procedure was videotaped for later coding.

Based on responses to the two stories, trained coders rated the degree to which a child's stories reflected the secure, ambivalent, avoidant and disorganized attachment patterns. Ratings were based on four criteria adapted from Granot and Mayseless (2001): The coordination of actions, expression and regulation of emotions within the dyad, the coherence of narrative, and constructive resolutions to the problems (see Kerns et al., 2011). For example, a narrative would be rated high on security if a child and parent coordinated their actions, emotion was expressed appropriately, the story was coherent, and the problem was constructively resolved. First, 20 videotaped interviews were coded by two raters (one an experienced coder), and used as training tapes for the second coder. The ratings of the experienced coder were used in analyses. Then, the remaining 79 interviews were double coded by both raters. The raters were blind to other information about mother-child dyads, and independently scored the interviews. Each child was assigned a 5-point rating (5: a prototypical pattern, 1: no sign of a pattern) for each of the four attachment patterns (security, avoidance, ambivalence, and disorganization) based on the four criteria. Inter-rater agreement (intra-class correlations) were: .77 for security, .69 for avoidance, and .60 for ambivalence. Although disorganization was coded, it proved difficult to score in this community sample, and was dropped due to low agreement (.30). In cases where the difference in coders' scores for a pattern were higher than 1.5 points, coders conferenced to reach agreement. The correlation between ratings of security with ratings of avoidance and ambivalence were $r = -.71$, $p < .001$, and $r = -.24$, $p < .05$, respectively. The correlation between ratings of avoidance and ambivalence was $r = -.29$, $p < .01$.

Trier Social Stress Task—All children completed a version of the Trier Social Stress Task (TSST), which is a standard protocol for the induction of moderate psychosocial stress in laboratory settings, and has been used with preadolescents (Gunnar, Wewerka, Frenn, Long, & Griggs, 2009; Kirschbaum, Pirke, & Hellhammer, 1993). The task, which is videotaped, required children to prepare and give an autobiographical speech in the presence of two adult experimenters. An initial 5 minutes resting period prior to introducing the task allowed for collecting baseline affect ratings and heart rate data. During this time, children were asked to sit quietly. Children were then told they would be asked to deliver a 5 minute speech about themselves, and were given 5 minutes to prepare the autobiographical speech. This was followed by a 5 minute period during which the child gave the speech in front of 2 adults. The fourth segment was a 3 minute resting period that allowed for examining emotional recovery.

Children were also told they were being videotaped so that their performance could later be evaluated by their peers, and the experimenters were instructed to be as nonresponsive as possible during the task. After the task was finished, debriefing was done by the experimenters, assuring the children that the videos of their speech would not be shown to their peers, everything would be kept confidential, and the experimenters were just pretending to be serious during the task.

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 (happy, cheerful, excited, proud, calm, comfortable) and 6 negative emotion words (sad, mad, guilty, nervous, upset, lonely), taken from the child version of the PANAS (Laurent et al., 1999). We averaged ratings to create a single score for positive affect and a single score for negative affect for each segment. Cronbach's alpha for positive affect at each stage of the experiment were: .80 at baseline, .90 at preparation, .87 at speech and .88 at rest. For negative affect alphas respectively were .21 at baseline, .43 at preparation, .74 at speech and .71 at rest. Lower alphas for negative affect for the first two segments were due to floor effects (i.e., generally low levels of negative affect prior to the speech task).

Assessment of Heart Rate Variability—High Frequency Heart Rate Variability (HF-HRV) was used to measure vagal tone. HF-HRV (also called RSA) was measured throughout using a Polar RS800CXsd Heart Rate Monitor (HRM, sampling frequency: 1000 Hz), which was designed to be used as a watch to be less intrusive for children. The polar watch receives signals from a band that the child puts on around the waist. For baseline, recording started when the experimenter had the child sit and told him/her to relax and listen to music for a few minutes, and recording was ended after five minutes. In the preparation period, recording started once the instructions were read for the child and the child understood the task, and it was finished after 5 minutes. At the speech period, recording started once the child started giving the speech, and it ended after five minutes. At the resting period, recording started when the child was told to relax and listen to music, and it ended after three minutes. The data were extracted using Polar software, and artifacts were detected and removed using visual methods and the Kubios standard medium-level of artifact correction. Kubios software (Version 2.0, Kuopio, Finland) was used to quantify HF-HRV (Fast Fourier Transform) in the frequency domains (HF: 0.15–0.4Hz; and LF: 0.04–0.15Hz) from R-R intervals, using Hz ranges selected to be age appropriate (Tarvainen, Niskanen, Lipponen, Ranta-Aho & Karjalain, 2014).

Correlations of positive affect and negative affect ratings, for specific segments, ranged from −.29 to −.35, $p<.01$, although the correlation between the two was not significant at baseline. HF-HRV positive affect were correlated significantly only at preparation, $r = .34$, $p<.01$, and HF-HRV and negative affect were correlated significantly only at baseline, $r = -.20$, $p<.05$.

Results

Preliminary Analyses

As reported in (omitted for blind review), there were predictable changes in affect and HF-HRV across the task. Positive affect after preparation was significantly lower in comparison to baseline, and declined further after the speech period, then increased after the rest period. Negative affect after the preparation period was significantly higher than the baseline, and significantly higher after the speech compared to after preparation, then significantly declined after the rest stage. HF-HRV at preparation was not significantly lower than baseline, but HF-HRV was significantly suppressed during the speech period compared to preparation, which is the expected response to a stressor. After the rest period, however, HF-HRV did not show a significant increase, suggesting that recovery was not evident for HF-HRV at the end of the experiment.

We also examined gender differences for all measures. There were no significant difference between boys and girls in scores of positive and negative affect, however, HF-HRV after the rest stage following the speech was significantly higher for boys (M=47.28, SD=17.05) than for girls (M=35.61, SD=16.09), t (90)=3.38, p<.01, suggesting greater recovery for boys. Also, there was a significant difference between boys (M=2.49, SD=1.18) and girls (M=1.72, SD=1.06) in ratings of avoidance t(90)=3.25, p<.01, and ambivalence, boys (M=1.23, SD=.49) and girls (M=1.76, SD=1.00), t(90)=−3.57, p<.01. Thus, in subsequent analyses we controlled for experimental condition (presence of pet during stressor) and gender, although it should be noted that controlling for these variables did not substantially changes in results.

Main analyses: Associations of Attachment Patterns with Baseline Emotion, Emotion Reactivity, and Emotion Recovery

Associations between Attachment Ratings and Reports of Experiential Affect at each Segment—We calculated partial correlations between attachment and affect ratings for each segment, controlling for gender and experimental condition (presence of dog during stressor task). As shown in table 1, consistent with our hypotheses, at baseline children who were more securely attached experienced less negative affect and showed a trend toward reporting higher positive affect (p=.09) and higher HF-HRV variability (p=.08). Children who were more securely attached also experienced more positive affect after preparation and after the rest following the speech task. For avoidance, the only significant effect was that children who were more avoidant experienced less positive affect at preparation. Contrary to expectation, ratings of ambivalence were not significantly correlated with either positive or negative affect at any stages of the experiment, although ambivalent children showed higher HF-HRV (i.e., lack of suppression) when giving the speech.

Hierarchical regression analyses to predict Reactivity and Recovery (changes in affect and vagal tone)—Hierarchical regression analyses were performed to predict changes in positive affect, negative affect, and vagal tone across the sessions. Child gender and experimental condition (presence of pet) were entered in the first step. For *reactivity*, we then examined whether attachment predicted changes in affect or HF-HRV from after preparation to after the speech task. Specifically, we conducted a series of regression analyses, separately for positive affect, negative affect, and HF-HRV reactivity. At the second step, we entered the relevant emotion variable assessed after preparation and one of the attachment pattern ratings (security, avoidance or ambivalence). To predict *recovery*, we conducted an analogous set of regressions, in which at the second step we entered the relevant emotion variable (positive affect, negative affect, or HF-HRV) from the speech session and attachment pattern (security, avoidance or ambivalence) to predict affect or HF-HRV after the rest following the speech. All effects were significant at $p<.05$, 2-tailed tests, unless otherwise noted.

Reactivity: As shown in Table 2, attachment security did not significantly predict positive affect, negative affect or HF-HRV after speech, after controlling for the corresponding variable after the speech preparation period.

Ratings of the avoidant pattern of attachment did not predict positive affect or variability of HF-HRV after speech. As expected, more avoidant children experienced less of a rise in negative affect after the stressor (i.e., showed less reactivity of negative affect).

Ambivalence did not significantly predict changes in positive affect, however, it significantly predicted more negative affect after the speech, consistent with our hypothesis that ambivalent children would heighten the expression of emotion. Ambivalent children also showed less suppression of HF-HRV in response to stress, which was contrary to our hypothesis that more ambivalent children would display excessive suppression of HF-HRV.

Recovery: As shown in Table 3, more securely attached children experienced more of a rise (greater recovery) in positive affect from after the speech to after the rest period. Attachment security did not, however, predict changes in negative affect or HF-HRV after the stress ended.

Avoidance did not predict changes in positive affect after the rest following the speech, but marginally predicted less of a drop in negative affect (p=.08), consistent with our hypothesis. Avoidance did not predict changes in HF-HRV.

Ambivalence did not significantly predict changes in positive affect after rest, however, it significantly predicted more of a decline in negative affect after rest, which reflects more recovery of negative affect. This finding was not consistent with our hypothesis. As expected, Ambivalence also marginally predicted less of a rise in HF-HRV (p=.06) during the rest period, which indicates that ambivalent children showed less recovery of HF-HRV after the stress ended.

Discussion

The present study contributes to our understanding of how mother-child attachment in middle childhood is related to children’s emotional responses to environmental demands. We had children participate in a social stressor task to study emotional change, as reflected in both psychological and physiological components, which allowed us to examine emotional reactivity and recovery. This study is one of the first to examine attachment in relation to emotional recovery. Few studies beyond infancy have examined how insecure attachment patterns are related to children’s emotional responding, and thus we also extended prior studies by testing how variation in avoidant and ambivalent attachment, as well as secure attachment patterns, predicted dynamics of children’s emotional responses to a stressor. Interestingly, we found that some effects were specific to particular attachment patterns. Finally, assessing attachment and emotion regulation with different tasks allowed us to examine how attachment predicts children's self-regulation of emotion.

Securely attached children showed less negative affect, and a trend toward more positive affect, at baseline. This finding is consistent with Borelli et al. (2010) who found securely attached children reported greater positive emotions before an attachment interview, and with evidence that the typical mood in securely attached children tends to be more positive and less negative (Abraham & Kerns, 2013). Securely attached children also showed more positive affect after preparation, indicating they are able to maintain their positive affect after realizing a stressful task is ahead, which could be the result of their higher self-esteem (Cassidy, Ziv, Mehta, & Feeney, 2003; Doyle, Markiewicz, Brengden, Lieberman, & Voss, 2000). Positive affect could help them manage the task more readily, given that positive affect has been shown to be an important correlate of successful task accomplishment (Fredrickson & Branigan, 2005) and to expand physical, intellectual, social and psychological resources that results in flourishing (Fredrickson, 2001). Securely attached children also showed higher HF-HRV at baseline, which reflects adaptive function and resilience under stress (Beauchaine, 2001; Porges, 2007; Zinser & Beauchaine, in press). Although some findings were marginally significant, the overall pattern was consistent in showing small to medium effect sizes in associations between secure attachment and emotional responding at baseline.

Regression analyses for reactivity revealed that children who were rated as more securely attached did not show a significant change in positive affect, negative affect, or HF-HRV in response to challenge. Finding no association between attachment and emotional reactivity is one of the three patterns of findings in prior studies. Of course null findings are difficult to interpret, and future studies are needed to uncover why the associations between attachment security and emotional reactivity have varied substantially across studies. It is possible that features of the task are important to consider, such as the nature of the stressor task (social, nonsocial) as well as the specific types of emotions elicited by a task (e.g., anger vs. sadness). For example, it may be that social interaction tasks are the most salient contexts for eliciting attachment effects. Alternatively, it could be that situations that induce empathy (e.g., seeing another in distress) might provoke emotion in securely attached children, but in stress tasks that require problem solving skills (e.g., solving a difficult puzzle) securely attached children may seek to suppress emotion to allow for responding to the challenge at hand. As a whole, the current literature does not support a broad conclusion that more securely attached children are prone to higher or lower emotional reactivity. Instead, aspects of temperament, such as negative emotionality, may be more consistent predictors of emotional reactivity. Studies of attachment, temperament, and emotion in response to specific stressors are needed to test these speculations.

In terms of emotional recovery, more securely attached children showed a significant rise in positive affect after stress was removed. This extends the finding by Borelli et al. (2010) that securely attached children experience a steeper decline in negative affect after fear removal. The fact that more securely attached children experienced more of a rise in positive affect after a short recovery period indicates the plasticity of their emotional responses to stress, and is consistent with the idea that securely attached children are more emotionally flexible in responding to environmental demands (Cassidy, 1994). It could be that more securely attached children do not engage in ruminations regarding their performance after the task, or more positively evaluate their task performance, which allows them to more quickly recover positive emotion. It is not clear why securely attached children did not show a significant recovery effect for HF-HRV. Findings for the whole sample indicated no significant change in HF-HRV between the speech and rest period, suggesting that the recovery period (3 minutes) was not sufficiently long to allow for changes in HF-HRV. The present study is one of only two studies (along with Borelli et al., 2010) to investigate emotional recovery effects. We would suggest it is important for future research on attachment and emotion flexibility to examine emotional recovery as well as emotional reactivity, and we further speculate that attachment may be more related to the former than the latter.

More avoidantly attached children showed less reactivity in negative affect, as reflected in less of a rise in negative affect in response to the social stress. There were no effects for positive affect or HF-HRV. The latter finding conflicts with a study of 13 month old infants in which avoidant infants showed a significant decrease in RSA during the separation episodes in the Strange Situation (Hill-Soderlund et al., 2008). This discrepancy in findings could be the result of the substantial difference between the age groups in the two studies. Hill-Soderlund et al. speculated that although avoidant infants may be physiologically reactive, at older ages avoidant children may show a pattern of underarousal in response to repeated early stress. Additional studies of avoidant children at different ages, using similar types of stress tasks, are needed to test this developmental hypothesis. The finding for negative affect is consistent with our expectation, based on findings from younger children, that more avoidant children adopt a strategy of minimizing emotion and are more affectively neutral (Ainsworth et al, 1978; Cassidy, 1994). The current study suggests the same emotion dynamic is evident in middle childhood for avoidant children. Several different mechanisms might explain this effect. Avoidant children might suppress their emotions to avoid parental rejection (Main & Solomon, 1986), a response pattern they then generalize to other contexts. Consistent with this idea is evidence that avoidant adults are able to actively suppress attachment related emotions (Farely and Shaver, 1997). Mikulincer, Shaver, & Pereg (2003) argued that suppression of emotional experiences decreases perceived threats that have been already encoded. Alternatively, rather than active suppression, Borelli and colleagues (Borelli, David, Crowley, Snavely, & Mayes, 2013) suggested that reports of low negative affect by avoidant children might indicate they are unaware of their emotions, or if aware, they might be unable to express their emotions. This explanation is consistent with evidence that more avoidant adults are less attentive to emotional events when encoding the information (Farely, Garner, & Shaver, 2000). Borelli et al. (2013) also proposed that avoidant children might prefer not to report their emotions, as a means not to notice their distress, which is consistent with evidence that avoidant children in middle childhood underreport their distress compared to their physiological response (Borelli et al, 2013; White et al., 2012). Additional studies with children are needed to determine whether the low reactivity to emotional events by more avoidant children reflect a lack of awareness of their emotions, or more active efforts to suppress their emotions. Coding facial affect as a supplement to self-reported affect might shed light on whether more avoidantly attached children are actively suppressing or failing to be consciously aware of negative emotional states.

In terms of recovery from stress, avoidance did not predict changes in positive affect or HF-HRV. More avoidant children showed less recovery of negative affect (less of a decline in negative emotions after the speech was over), although this effect was only marginally significant. This finding is consistent with the data from the Strange Situation that shows avoidant children express less pleasure at reunion with the caregiver (Ainsworth, 1978). Although the Strange Situation does not parallel the experiment in this study, the emotional flatness of avoidant children during the Strange Situation episodes is similar to what was found in the present study.

Ambivalent children showed a significant increase in negative affect and HF-HRV during the social stress, although they did not evidence changes in positive affect. The finding for negative affect is consistent with findings at younger ages that ambivalent children express more negative emotion (Ainsworth et al, 1978; Cassidy, 1994). The high levels of negative affect of more ambivalent children is interpreted as an effort to draw their caregiver's attention, as the unavailability of the caregiver keeps the attachment system activated in situations of threat (Cassidy, 1994). The present study suggests that the emotion dynamics shaped in response to caregiving behaviors could generalize to other emotionally challenging situations at older ages, even when the caregiver is not present. Thus, the tendency to show an elevated level of negative affect during stressful encounters could be a chronic social signaling behavior that more ambivalent children use as the main regulatory strategy to reassure themselves that they can get the support when needed. The finding for HF-HRV indicates that vagal tone was not significantly suppressed under the stress. To our knowledge, this is the first study to find that ambivalent attachment is associated with poor vagal regulation under conditions of stress. Since HF-HRV reflects the vagal (PNS) influences, its suppression helps the organism to cope with environmental challenges (Porges, 1995), and suppression of HF-HRV in response to environmental challenge is an indicator of self-regulation capability under stress (Porges, 2007; Porges, 1995; Porges, Doussard-Roosevelt, Portales, & Suess, 1994; Zinser & Beauchaine, in press). The lack of HF-HRV suppression during the social challenge would indicate that the PNS in these children failed to function to prepare the child physiologically to cope with the challenge. One of the possibilities that could be tested in future research is whether the two parts of the autonomic nervous system (SNS and PNS), which should synchronize in stress situations in a way that more energy is provided for the body (Zinser & Beauchaine, in press; Berntson, Cacioppo, & Quigley, 1991; Berntson, et al., 1994), might fail to synchronize well in more ambivalent children.

In terms of recovery of affect, ambivalent children showed significantly greater recovery of negative affect (greater declines) after the stressor was removed. We did not expect this finding, since studies of adults have revealed that ambivalent adults tend to ruminate regarding threats (Mikulincer et al., 2003), which could lead to less recovery of emotion after removing threats. The observed recovery effect, in addition to the reactivity finding, suggests more ambivalent children show emotional lability under stress rather than a heightening of emotion both during and after stress. By contrast, ambivalent children showed less HF-HRV recovery, which is contrary to the normative pattern of increased HF-HRV following a remover of a stressor. Unlike self-reports of affect, the HF-HRV results indicate ambivalent children do not easily recover from stress. We conclude that autonomic regulation under stress is not well attuned in these children. A plausible possibility is that early caregiving practices could shape the function of physiological hidden regulators (Polan & Hofer, 2008) towards becoming dysfunctional in stress situations. This hypothesis has been tested in rodents, and it has been found that maternal care (grooming and licking) alters production of stress related hormones, which results in changes in behavioral, emotional, autonomic, and endocrine components of stress response (Polan & Hofer, 2008; Parent et al., 2005; Liu et al., 1997; Caldji et al., 1998). It requires further testing to see if similar processes can account for the emotion dysregulation we found for more ambivalently attached children.

Strengths of the study include examining attachment in relation to “real time” changes in the emotion system in response to introduction of a stressor, and examination of insecure patterns (avoidance and ambivalence) in addition to attachment security. There are also some limitations of the study. Disorganization was difficult to score in this sample and was not examined, and thus looking at attachment disorganization in relation to emotion regulation would be an important goal for the future studies, especially given evidence in infants that disorganized attachment is linked to difficulties in emotion regulation such as a failure to suppress vagal tone under conditions of stress (Oosterman et al., 2010). We examined the parasympathetic component of the stress response, but did not utilize measures of the sympathetic component of autonomic system such as changes of cortisol or skin conductance. Including both of types of measures in future studies would be important to see a full picture of autonomic responses under social stress in relation to attachment. Another limitation of this study was presence of pet dogs while testing almost half of the participants. Although we controlled for this influence in our analyses, future studies should consider more robust experimental condition that do not include other extraneous influences on children’s emotional responses. Finally, we used a single measure of attachment based on narrative responses to story stems. There is no single “gold standard” for assessing attachment in middle childhood (Bosmans & Kerns, 2015), and thus the generalization of the findings could be tested in future studies that use other techniques to assess attachment such as autobiographical interview measures (e.g., Schmueli-Goetz, Target, Fonagy, & Datta, 2008; Steele & Steele, 2005).

In conclusion, our findings show security, avoidance, and ambivalence to some extent are all related to emotional responses under stress, even in the absence of the caregiver. In socially stressful situations, secure attachment was most strongly associated with recovery of positive affect after stress. Dysregulation of negative affect seemed to be the prominent emotion dynamic for more avoidant and ambivalent children, with the former showing suppression or lack of awareness of negative affect and the latter showing emotional lability. We speculate that these findings could be evidence for different regulatory goals, with securely attached children regulating their distress to focus on challenges, and insecurely attached children focusing on managing their attachment system (more avoidant individuals deactivate, and more ambivalent individuals hyper-activate their attachment system). Future studies can replicate and extend the current findings by examining how different attachment patterns predict children's responses to other types of stressors (e.g., peer rejection, academic challenges) using additional measures of emotion (e.g., facial affect coding). Another step would be to investigate other specific mechanisms (e.g., cognitive appraisals) that might explain why attachment patterns are related to emotion dynamics outside the attachment relationship. Due to the automatic and unconscious nature of emotion regulation strategies (Main, 1990), and the findings for more ambivalent children, another possibility to investigate would be if emotional responses have been embedded in biological wiring shaped through early relationships (e.g. neural substrates of affective responding such as amygdala-prefrontal development; Gee et al., 2014).

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Table 1

Partial Correlations between ratings of attachment with indicators of emotion in each stage of the experiment, controlling for condition (presence of pet dog) and gender

		Baseline (N=99)	**Preparation (N=99)**	**Speech (N=99)**	**Rest (N=98)**
Positive affect	Security	.17*	.24**	.13	.22**
	Avoidance	−.08	−.21**	−.08	−.12
	Ambivalence	−.05	−.001	.02	−.03
		Baseline (N=98)	**Preparation** (N=99)	**Speech** (N=99)	**Rest** (N=98)
Negative affect	Security	−.23**	−.15	−.05	−.12
	Avoidance	.15	.10	−.15	−.001
	Ambivalence	.05	−.13	.11	−.08
		Baseline (N=98)	**Preparation** (N=99)	**Speech** (N=95)	**Rest** (N=95)
HF-HRV	Security	.21*	.06	−.04	.13
	Avoidance	−.13	.001	−.14	−.04
	Ambivalence	−.07	.001	.26**	−.13

* $p<.10$,

** $p<.05$

Table 2

Hierarchical regression analyses to predict positive affect, negative affect and HF-HRV after speech (Reactivity)

Variable	*B*	*SE B*	*β*	*t*	*p*	R^2	ΔR^2
Positive Affect							
Step 1							
Experimental Condition	.33	.21	.16	1.55	.12	.02	-
Gender	−.00	.21	−.00	−.01	.99		
Step 2							
Positive Affect-After Preparation	.70	.07	.75	10.26	.001	.55	.52
Security	−.05	.06	−.05	−.74	.45		
Step 2							
Positive Affect-After Preparation	.70	.07	.75	10.40	.001	.55	.52
Avoidance	.07	.07	.08	1.06	.30		
Step 2							
Positive Affect-After Preparation	.68	.07	.74	10.37	.001	.54	.52
Ambivalence	.03	.10	.03	.36	.72		
Negative affect							
Step 1							
Experimental Condition	.10	.10	.09	.97	.33	.04	-
Gender	.17	.10	.16	1.62	.10		
Step 2							
Negative Affect-After Preparation	.87	.13	.56	6.48	.001	.34	.30
Security	.01	.04	.03	.36	.72		
Step 2							
Negative Affect-After Preparation	.89	.13	.58	6.90	.001	.37	.34
Avoidance	−.09	.04	−.21	−2.43	.02		
Step 2							
Negative Affect-After Preparation	.90	.13	.58	6.91	.001	.37	.33

Variable	B	$SE\ B$	β	t	p	R^2	ΔR^2
Ambivalence	.13	.06	.20	2.24	.03		
HF-HRV							
Step 1							
Experimental Condition	7.24	4.89	.15	1.48	.14	.04	-
Gender	−6.50	4.89	−.14	−1.33	.19		
Step 2							
HF-HRV-After Preparation	.28	.13	.21	2.08	.04	.09	.04
Security	−1.11	1.98	−.05	−.56	.58		
Step 2							
HF-HRV-After Preparation	.27	.13	.20	2.01	.05	.10	.06
Avoidance	−3.12	2.16	−.15	−1.45	.15		
Step 2							
HF-HRV-After Preparation	.27	.13	.20	2.06	.04	.15	.10
Ambivalence	7.71	3.00	.27	2.57	.01		

Table 3

Hierarchical regressions to predict positive affect, negative affect, and HF-HRV after rest (Recovery)

Variable	*B*	*SE B*	*β*	*t*	*p*	R^2	ΔR^2
Positive Affect							
Step 1							
Experimental Condition	.33	.22	.15	1.51	.13	.02	-
Gender	.04	.22	.02	.18	.85		
Step 2							
Positive Affect-After Speech	.87	.05	.84	15.97	.001	.75	.73
Security	.10	.05	.11	2.05	.04		
Step 2							
Positive Affect-After Speech	.87	.05	.85	15.95	.001	.74	.72
Avoidance	−.05	.05	−.05	−.93	.35		
Step 2							
Positive Affect-After Speech	.88	.05	.85	16.10	.001	.74	.71
Ambivalence	−.07	.07	−.05	−.92	.35		
Negative affect							
Step 1							
Experimental Condition	.10	.07	.14	1.41	.16	.02	-
Gender	.05	.07	.07	.68	.49		
Step 2							
Negative Affect-After Speech	.52	.05	.75	11.19	.001	.59	.56
Security	−.02	.02	−.07	−1.05	.29		
Step 2							
Negative Affect-After Speech	.54	.04	.78	11.52	.001	.60	.57
Avoidance	.04	.02	.12	1.73	.08		
Step 2							
Negative Affect-After Speech	.54	.05	.78	11.82	.001	.61	.59

Variable	B	SE B	β	t	p	R^2	ΔR^2
Ambivalence	−.08	.03	−.17	−2.57	.01		
HF-HRV							
Step 1							
Experimental Condition	−1.13	3.47	−.03	−.32	.74	.11	-
Gender	−11.64	3.47	−.33	−3.35	.001		
Step 2							
HF-HRV-After Speech	.13	.07	.17	1.72	.09	.15	.04
Security	1.62	1.41	.11	1.14	.25		
Step 2							
HF-HRV-After Speech	.12	.08	.16	1.63	.10	.14	.03
Avoidance	.27	1.57	.02	.17	.86		
Step 2							
HF-HRV-After Speech	.16	.08	.22	2.13	.03	.17	.06
Ambivalence	−4.27	2.24	−.20	−1.91	.06		