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Emotional Reactivity, Behavior Problems, and Social Adjustment at School Entry in a High-risk Sample

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Abstract

Prior research suggests that heightened emotional reactivity to emotionally distressing stimuli may be associated with elevated internalizing and externalizing behaviors, and contribute to impaired social functioning. These links were explored in a sample of 169 economically-disadvantaged kindergarteners (66 % male; 68 % African American, 22 % Hispanic, 10 % Caucasian) oversampled for elevated aggression. Physiological measures of emotional reactivity (respiratory sinus arrhythmia [RSA], heart rate [HR], and cardiac pre-ejection period [PEP]) were collected, and teachers and peers provided ratings of externalizing and internalizing behavior, prosocial competence, and peer rejection. RSA withdrawal, HR reactivity, and PEP shortening (indicating increased arousal) were correlated with reduced prosocial competence, and RSA withdrawal and HR reactivity were correlated with elevated internalizing problems. HR reactivity was also correlated with elevated externalizing problems and peer rejection. Linear regressions controlling for age, sex, race, verbal proficiency, and resting physiology showed that HR reactivity explained unique variance in both teacher-rated prosocial competence and peer rejection, and contributed indirectly to these outcomes through pathways mediated by internalizing and externalizing problems. A trend also emerged for the unique contribution of PEP reactivity to peer-rated prosocial competence. These findings support the contribution of emotional reactivity to behavior problems and social adjustment among children living in disadvantaged urban contexts, and further suggest that elevated reactivity may confer risk for social difficulties in ways that overlap only partially with internalizing and externalizing behavior problems.

Keywords

Emotional reactivity; physiological assessments; behavior problems; social adjustment; economic disadvantage

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Children growing up in poverty are particularly likely to face adversities that undermine healthy social-emotional development (Blair & Raver, 2012). For example, in economically-disadvantaged communities, 20-30% of children enter elementary school with externalizing problems (Ritsher, Warner, Johnson, & Dohrenwend, 2001), often associated with

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Compliance with Ethical Standards
The authors report no conflict of interest. Study procedures followed ethical standards of the American Psychological Association and were approved by the university institutional review board. Parents provided informed consent for child study participation.

internalizing problems and peer difficulties (Powers & Bierman, 2013). Research suggests that exposure to adverse early environments may affect children's emotional reactivity, getting "under their skin" in ways that influence their behavioral and social development (Obradović, 2012). Behavioral studies suggest that young, externalizing children who display heightened emotionality may be at specific risk for peer problems (Calkins, Gill, Johnson, & Smith, 1999; Eisenberg et al., 2001), but the nature of these links is not fully understood. This study utilized three physiological measures of emotional reactivity to examine the link between emotional functioning and social adjustment in young children over-sampled for externalizing problems in a high-risk community.

Emotional Reactivity and Early Externalizing and Internalizing Behaviors

At school entry, elevated externalizing problems such as aggressive-disruptive and oppositional behaviors are often comorbid with internalizing problems and interfere with the formation of positive peer relations (Masten et al., 2005). Externalizing kindergarten children are often rejected by their peers, contributing to a negative developmental cascade associated with escalating social alienation and chronic antisocial pathology (Powers & Bierman, 2013).

In recent years, interest in the emotional functioning of young aggressive children has increased, given evidence that it may influence developmental adaptation and affect social risk (Beauchaine, Gatzke-Kopp, & Mead, 2007). Emerging evidence suggests that the development of emotional reactivity, which reflects individual differences in the threshold and intensity of the experience of emotion, may be negatively affected by early adversity (Obradović, 2012). Conceptually, economic disadvantage is associated with chronic stress exposure that can heighten emotional reactivity by amplifying children's vigilance to threat and autonomic responding, while also undermining the development of their regulatory capacity to modulate distress (Blair & Raver, 2012). Elevated emotional reactivity and difficulty modulating emotional arousal may exacerbate behavior problems, particularly at school entry when children are faced with new demands for self-management and social engagement (Blair & Raver, 2012).

Considerable research supports a link between heightened emotionality, measured with behavioral observations or ratings, and both externalizing and internalizing behavior problems (Calkins et al., 1999; Eisenberg et al., 2001). For example, Eisenberg et al. (2001) found that 5-7 year old children who expressed more anger and sadness at home showed elevated externalizing and internalizing problems, respectively, at school. Furthermore, there was a significant increase in the expression of internalizing problems over time (Eisenberg et al., 2009). Similarly, in another study, maternal ratings of emotionality at age six predicted teacher ratings of reactive aggression in later childhood (Vitaro, Brendgen, & Tremblay, 2002).

Providing a basis for a more nuanced understanding of the associations between emotional functioning and behavior problems, research has also included physiological measures assessing the reactivity of the autonomic nervous system (ANS) in situations designed to evoke emotional responding. ANS reactivity is affected by both: 1) the sympathetic nervous system (SNS), which facilitates biological and behavioral readiness for action by increasing heart rate [HR], and 2) the parasympathetic nervous system (PNS), which has a damping effect on arousal, lowering heart rate and promoting calm affiliative states (Porges, 2001). Although HR can be increased though either an increase in sympathetic activation or a decrease in parasympathetic activation, the unique sympathetic and parasympathetic components can be extracted by measuring cardiac pre-ejection period (PEP) and respiratory sinus arrhythmia (RSA), respectively (Beauchaine et al., 2007; Cacioppo, Uchino, & Berntson, 1994). Compared with the robust and sometimes prolonged effects of SNS activation, PNS withdrawal (i.e., RSA reduction from baseline) is considered a more adaptive mechanism to increase arousal when individuals need to respond flexibly to cognitive and social challenges that are not dangerous (Porges, 2001). However, because decreased RSA (RSA withdrawal) is thought to reflect greater attentional engagement with a stimulus, exaggerated RSA withdrawal in response to emotional stimuli may indicate a heightened sensitivity to the affective distress (see Fortunato, Gatzke-Kopp, & Ram, 2013). The sympathetic and parasympathetic systems are not mutually exclusive in their operation (Berntson, Cacioppo, Quigley, & Fabro, 1994), and thus it is important to capture both sources of arousal in understanding affective reactivity.

An increasing number of studies have examined links between externalizing behavior problems and emotional reactivity, as indexed by changes in HR, RSA, and PEP in the face of emotionally evocative stimuli. For example, Beauchaine, Katkin, Strassberg, and Snarr (2001) found that youth with externalizing problems showed greater RSA withdrawal (i.e., increased arousal) during an emotionally evocative video clip, and two additional studies found links between increased HR reactivity to peer provocation and externalizing behaviors (Waschbusch et al., 2002; Williams, Lochman, Phillips, & Barry, 2003). In a meta-analysis of seven studies that assessed HR reactivity and child conduct problems, Lorber (2004) found a significant mean aggregate effect size of $d = .20$.

Links with internalizing problems have also emerged. Boyce and colleagues (2001) found that children with elevated internalizing symptoms showed greater RSA withdrawal in response to a series of emotional challenges. Similarly, in another study, responding to conflict with greater RSA withdrawal was associated with increased internalizing symptoms two years later (Hinnant & El-Sheikh, 2009). Focused on peer-rejected adolescents, Erath, Tu, and El-Sheikh (2012) found that both HR increases and RSA withdrawal in reaction to a social stress challenge were linked with internalizing symptoms of social anxiety. This pattern of HR increase and RSA withdrawal in emotionally-challenging situations has also been observed among children with co-morbid externalizing and internalizing problems (Calkins, Graziano, & Keane, 2007).

However, a more recent meta-analysis of 44 studies calls into question the association between RSA withdrawal and adverse behavioral outcomes. Graziano and Derefinko (2013) report that across studies, greater RSA withdrawal was associated with better psychosocial functioning. Importantly, however, several factors were found to significantly moderate this association, including racial composition of the sample as well as the extent of symptom severity represented in the sample. Specifically, whereas greater RSA withdrawal was adaptive in community samples, it was more often associated with maladaptive outcomes among clinical or high-risk samples. Given the importance of sample characteristics in moderating associations between RSA reactivity and psychosocial measures, it is important to have more research that examines traditionally under-represented populations (see Gatzke-Kopp, in press).

Across these studies, different stimuli were used to evoke emotion, including exposure to novel, threatening or frustrating tasks and emotionally-evocative video clips. In the meta-analysis by Graziano & Derefinko (2013), no significant effect of experimental stimulus was found, although this was tested across broad categories such as negative emotion induction, cognitive challenge, and peer provocation. Some theories of affect suggest that motivational aspects (i.e., withdrawal/approach) are important in addition to the valence (positive/negative). Some research, including data from our lab, suggests that reactivity to withdrawal-based (fear, sadness) and approach-based (happiness, anger) emotion inductions are differentially related to internalizing and externalizing behaviors, respectively (Eisenberg et al., 2001; Fortunato et al., 2013).

Relative to studies assessing RSA, fewer studies have examined links between PEP and psychopathology, likely due in part to the need for additional equipment to do so. To date, research with PEP has more typically focused on conditions of reward rather than affect (Beauchaine, 2012; Brenner, Beauchaine, & Sylvers, 2005; Crowell et al., 2006). However, to better understand the role of PEP as an index of sympathetic functioning and its role in emotional reactivity, PEP must be assessed in emotion-induction conditions like those used in studies of RSA and HR and emotional functioning. Further, when included among indices of RSA and HR, assessment of PEP promises to provide novel information about SNS functioning in a way that will contribute to a more comprehensive picture of ANS functioning in conditions of emotional challenge.

Emotional Functioning and Social Adjustment

Although less often studied than behavior problems, poor social functioning and peer rejection have also been linked with heightened emotional reactivity (Eisenberg et al., 2001). For example, Calkins and colleagues (1999) found that toddlers displaying behavioral signs of heightened emotional reactivity during a stress-inducing task were less prosocial than toddlers who were less reactive. By elementary school, Pope and Bierman (1999) found children rated as dysregulated by teachers (e.g., irritable, negatively reactive) experienced elevated levels of peer rejection, ostracism, and victimization. Among studies using physiological measures to assess emotional reactivity, associations with peer relations have been mixed. For example, in one study of preschool children, low levels of prosocial behavior were associated with greater RSA withdrawal in response to emotionally challenging tasks (Blair & Peters, 2003). In contrast, two other studies found associations between low social skills and less RSA withdrawal in response to challenging tasks, suggesting attenuated emotional responding rather than emotional reactivity in less socially competent children (Calkins & Keane, 2004; Calkins et al., 2007).

The Present Study

Prior research suggests that physiological reactivity to emotionally distressing stimuli may be associated with elevated internalizing and externalizing behaviors and contribute to impairments in social functioning. Emotional reactivity may be particularly prevalent among children facing the adversities associated with urban poverty (Blair & Raver, 2012), and may contribute to poor social adaptation at school entry. However, relatively few studies have assessed emotional functioning with physiological measures in samples of high-risk children growing up in difficult circumstances. The present study utilized a demographically high-risk sample, oversampled for early externalizing behaviors, assessed at school entry. Three indices of autonomic nervous system reactivity (RSA withdrawal, increased HR, and shortened PEP; all of which indicate increases in arousal via different physiological pathways) were assessed as children viewed emotionally evocative movie clips designed to elicit fear, sadness, happiness, and anger. Teachers and peers provided ratings of internalizing and externalizing behavior, as well as ratings of social adjustment (prosocial behavior and peer rejection). Prior research with this sample demonstrated links between RSA withdrawal to fear and sadness, and teacher-rated internalizing symptoms (Fortunato et al., 2013). This study extended this line of inquiry to examine cardiac arousal more comprehensively by assessing RSA, HR, and PEP in response to video clips designed to portray specific emotional events, and focusing on social adjustment difficulties using peer sociometric nominations and teacher ratings. It was anticipated that increased arousal in response to emotionally challenging stimuli through both the SNS (i.e., shortened PEP) and PNS (i.e., RSA withdrawal), and their combined effect (i.e., increased HR) would undermine social adjustment at school entry, mediated (at least in part) by elevated internalizing and externalizing behaviors. Parallel to earlier findings in this sample (Fortunato et al., 2013), it was anticipated that reactivity to video clips depicting fear and sadness would be related to internalizing behaviors, whereas reactivity to video clips depicting anger would be related to externalizing behaviors. Existing research and theory did not provide a sufficient basis to generate specific a priori hypotheses regarding differences in the way that RSA reactivity (i.e., RSA withdrawal), HR reactivity (i.e., increased HR), and PEP reactivity (i.e., shortened PEP) might be linked with child behavior problems and social adjustment; possible differences were explored.

Method

Participants

Kindergarten children were recruited from ten elementary schools in an economically-disadvantaged urban area for a prevention program targeting early-onset conduct problems. This study uses baseline assessments collected prior to intervention. School achievement levels were in the bottom 5% for the state, the district graduation rate was 38%, and 74% of the student body qualified for free/reduced price lunch. High levels of violence and substance abuse characterized the surrounding community. In the fall of two successive years, kindergarten teachers rated the externalizing problems of all children in their classrooms (N = 1,192) using the *Authority Acceptance Scale*, described below (TOCA-R; Werthamer-Larsson, Kellam, & Wheeler, 1991). Children in the upper 25% in each class were recruited (N = 297), and 207 received parent consent for participation (73% African American, 19% Latino, 8% Caucasian; 66% male; mean age = 5.62 years, *SD* = .36). Of those, 169 participants had the physiological data that was needed for this study, and they represent the final sample.

Teacher and Peer Ratings

Three months after the initial screening, research assistants delivered measures to teachers, who completed them on their own time and were compensated $15 per child. All classmates were invited and most (89%) received parental consent to participate in sociometric interviews. Trained research assistants interviewed children individually. After viewing photographs of all classmates to check for familiarity, children nominated classmates who fit different behavioral descriptions (described below). Same- and cross-sex, unlimited nominations were accepted, and scores reflected the proportion of raters in each class who nominated a child for an item. Means and ranges for the teacher and peer ratings are presented in Table 1.

Externalizing and internalizing behavior problems—Externalizing problems were rated with a 7-item version of the TOCA-R *Authority Acceptance* scale (e.g., "yells at others," "breaks rules"; α = .88), and internalizing problems with a 6-item version of the TOCA-R *Social Contact* scale (e.g., "tends to withdraw," "sad, unhappy"; α = .88; Werthamer-Larsson et al., 1991). Items were rated on a 6-point scale; average item scores were analyzed. Peers nominated classmates who "start fights and hurt other kids" (externalizing problems), and classmates who were "afraid and upset at school; they are sad and sometimes cry at school" (internalizing problems).

Social adjustment—Teachers rated prosocial behavior with seven items from the *Social Competence Scale* (CPPRG, 1995) using a 6-point scale (e.g., sharing, helping, understanding others' feelings; α = .94). To assess prosocial behavior, peers nominated those who were "really good to have in your class because they share and help and take turns." To assess rejection, they nominated classmates they "liked the least."

Psychophysiological Assessments

Psychophysiological assessments were conducted inside a mobile RV driven to each elementary school. To minimize children's apprehension, the RV was decorated with an outer-space motif, including a familiar cartoon character dressed in an astronaut suit. Research assistants (RAs) escorted children to the RV, explained the assessment procedures, and acquired verbal assent. Only three children refused participation. Extensive details of the physiological measures and procedures are available elsewhere (Gatzke-Kopp, Greenberg, Fortunato, & Coccia, 2012). The cardiac data used in this study were collected continuously at 500 Hz via the Biolab 2.4 acquisition system (Mindware, Westerville, OH). Disposable, pre-gelled cardiac electrodes were placed over the distal right collar bone, lower left rib, and lower right rib. An additional 4 electrodes were used to assess impedance, which was also used to estimate respiration frequency.

Prior to starting the video, RAs explained that children would "travel through space" to a planet where they would watch a movie. Children were told to sit very still for two minutes while watching a moving star-field video, and baseline recordings were made. Children were then shown a series of video clips depicting different emotions selected from the movie *The Lion King* (see Gatzke-Kopp, Jetha, & Segalowitz, 2014 for more details). This film was chosen for its age appropriateness, its emotionally-charged story line, the animal characters that avoided individual differences in racial saliency, and its use in prior research (von Leupoldt, Rohde, Beregova, Thordsen-Sorensen, Nieden, & Dahme, 2007). In general, the use of this kind of film-based emotion-induction paradigm is consistent with meta-analyses showing that film clips are the most effective way to elicit discrete emotions (Schaefer, Nils, Sanchez, & Philippot, 2010; Westermann, Spies, Stahl, & Hesse, 1996), likely due to the multiple channels of sensory information provided via film (e.g. facial expression, musical score, story-line).

Each clip lasted between 2-3 minutes and followed a fixed order consistent with the movie chronology. The emotion clips were as follows: fear (Simba is chased by hyenas); sadness (Simba's father is dying); happiness (characters are singing a joyous song); and anger (Simba is fighting the evil Scar). After each emotional scene, a 30-second neutral film clip was presented to facilitate children's return to baseline. These neutral clips displayed no specific emotional content, and if relevant, showed the resolution of conflict depicted in the previous clip. After the 30-second neutral film clip, a 30-second fixation baseline was presented prior to the start of the next emotional clip. RSA, HR and PEP were averaged across the four 30-second neutral clips to establish a baseline from which reactivity could be calculated. Video baselines were used rather than fixation baselines in order to control for the cognitive and attentional engagement with the video, with only emotional content changing between video baseline and emotion scenes.

Cardiac data were computed in 30 second epochs across the task. Trained RAs visually inspected the cardiac ECG data using Mindware Technologies (Columbus, OH) software HRV v. 3.*, noting erroneous identification of beats and correcting them when possible, or identifying data as contaminated by excess noise or movement artifact (to be eliminated from analysis). Heart rate was quantified as beats per minute within each 30-sec epoch, and then averaged across epochs to provide a single index of heart rate during each of the emotion clips. RSA was computed as the power in the respiration frequency band, 0.12 – 0.40 Hz for each 30-sec epoch. Any epoch in which the estimated respiratory frequency deviated from this range was not scored (fewer than 1% of the epochs). All valid epochs were averaged to create a single RSA score for each condition. PEP was computed using Mindware Technologies software IMP v.3.*. Data were ensemble averaged to produce one impedance wave for each 30-sec epoch. Trained RAs visually inspected each waveform to determine whether the resultant ensemble average was of sufficient quality. An automated algorithm identified the Q point on the average ECG waveform, and the B point on the average dz/dt waveform. Epochs determined to valid were averaged to create a single PEP score for each condition.

For RSA, HR, and PEP, levels of arousal averaged across the neutral film clips (i.e., video baseline) were subtracted from the levels of arousal recorded during each emotion film clip.

Thus increases in affective arousal to the emotion film relative to the neutral film are reflected by higher values for HR (higher heart rate during the emotion clip relative to baseline), smaller values for RSA (RSA withdrawal; lower RSA during the emotion clip relative to baseline), and smaller values for PEP (shorter intervals of PEP during the emotion clip relative to baseline).

Control variables

Demographic variables (e.g., child age, sex, and race) and language skills served as control variables, as these might also influence emotional reactivity, behavior problems, and social functioning. Language skills were assessed with the *Expressive One-Word Picture Vocabulary Test* (EOWPVT; Brownell, 2000), administered individually at school. On this test, children identified pictures with words (α = .94). Measures of resting RSA, HR, and PEP assessed prior to the start of the film were also included as baseline control variables in the predictive models.

Results

Preliminary Analyses

Missing data included teacher ratings (21 children) and peer nominations (2 children) and was imputed with SPSS v.21, which generated 20 data sets in a model that included all study variables and covariates. In order to minimize the impact of a few outliers, study variables were truncated at three standard deviations from the mean. Means, standard deviations, and ranges for all variables are shown in Table 1. Tests indicated no sex differences on RSA, HR, or PEP reactivity, but significant sex differences on all teacher-rated measures, peer-nominated externalizing behaviors, and rejection, with boys receiving less favorable scores than girls. Although children in this sample were all elevated in teacher-rated aggression when they were first recruited, there was variability in teacher-rated externalizing behaviors when the assessments used in this study were collected three months later. As shown in Table 1, some children had settled into the school routine and 20% scored in the “almost never” to “rarely” range on externalizing behavior, whereas others still exhibited elevated externalizing problems.

Correlations between RSA, HR, and PEP across the four emotion clips are shown in Table 2. Resting RSA and HR were highly intercorrelated ($r = -.78$) but not associated with resting PEP. With the exception of a small association between resting HR and HR reactivity to fear ($r = .13$), none of the resting measures were significantly associated with any of the reactivity measures. This suggests that resting physiology was unique from the change scores computed between neutral and affective stimuli. RSA reactivity (i.e., RSA withdrawal) and HR reactivity were moderately correlated, ranging from $r = -.24$ (sad clip) to $r = -.40$ (fear clip), reflecting the overlapping and distinct information provided by each measure; however, neither were associated with PEP reactivity. Across the four emotion clips, within-measure correlations were moderate for RSA (range $r = .34$ to $r = .48$) and HR (range $r = .24$ to $r = .53$), and large for PEP (range $r = .61$ to $r = .86$). Reflecting individual differences, some children were more reactive across the different emotional clips and others were less reactive across the emotions.

Correlations among the teacher and peer ratings are shown in Table 3. Teacher and peer ratings were moderately correlated for externalizing behavior ($r = .39$, $p < .01$), and mildly correlated for prosocial competence ($r = .23$, $p < .01$) and internalizing behavior ($r = .18$, $p < .05$). As anticipated, externalizing and internalizing behaviors were significantly correlated with poor social adjustment, particularly low teacher-rated prosocial behavior and elevated peer rejection.

Correlations Between Indices of Physiological Reactivity and Adjustment Measures

Partial correlations controlling for sex and linking RSA, HR, and PEP reactivity with behavior problems and social adjustment are presented in Table 4. With the exception of an association between higher PEP scores (indicating PEP lengthening and less reactivity) during the happiness film clip and greater peer-rated prosocial competence ($r = .20$, $p < .01$), emotional reactivity to the happiness film clip was unrelated to behavior or social adjustment. However, four of the 36 correlations (11%) linking reactivity to stressful film clips (anger, fear, or sadness) with behavior problems were statistically significant. These included increased HR reactivity to fear with higher teacher-rated externalizing ($r = .24$, $p < .01$) and internalizing problems ($r = .23$, $p < .01$), RSA reactivity (withdrawal) to anger with higher peer-rated internalizing problems ($r = -.16$, $p < .05$), and RSA reactivity (withdrawal) to fear with higher teacher-rated internalizing problems ($r = -.16$, $p < .05$). PEP reactivity to the negative emotion clips was not associated with any of the behavior measures. Nine of the 27 correlations (33%) linking emotional reactivity to stressful film clips with social adjustment were statistically significant, including increased HR reactivity to fear with lower teacher- and peer-rated prosocial competence ($r = -.28$ and $-.26$, respectively, $p < .01$), and increased HR reactivity to sadness with lower peer-rated prosocial competence and higher peer rejection ($r = -.18$, and .18, respectively, $p < .05$). In addition, higher RSA scores (indicating less withdrawal and less reactivity) to both anger and fear correlated with higher peer-rated prosocial competence ($r = .20$, $p < .01$ and .16, $p < .05$, respectively), but unexpectedly, lower RSA scores (indicating more withdrawal and more reactivity during the film clip) to anger predicted higher teacher-rated prosocial competence ($r = -.18$, $p < .05$). Lower PEP scores (greater reactivity, increased arousal) to fear and sadness were associated with lower peer-rated prosocial competence ($r = .26$, and .27, respectively, $p < .01$).

Thus, a consistent pattern across correlations linked increased HR reactivity with poorer teacher- and peer-rated behavior and social adjustment, as well as increased PEP reactivity with poorer peer-rated social adjustment. However, RSA reactivity was variably associated, predicting poorer peer-rated but better teacher-rated prosocial competence. HR reactivity to the fear and sad film clips was most reliably linked with social adjustment, accounting for four of the nine significant correlations. PEP reactivity was least reliably linked to behavior or social adjustment, accounting for only two of the 13 significant correlations between emotional reactivity and behavior or social adjustment.

Regressions Exploring Direct and Indirect Associations

Next, step-wise regressions were computed to test the extent to which associations between RSA, HR, and PEP reactivity, and measures of social adjustment were direct or indirect, mediated by behavior problems. Separate regressions were run for each measure of social adjustment (teacher-rated prosocial, peer-nominated prosocial, and peer rejection). In each case, covariates were added in step one, including child age, sex, race, verbal proficiency (EOWPVT), and resting physiology. Indices of physiological reactivity were added in step two (i.e., RSA, HR, and PEP reactivity to anger, fear and sadness). Internalizing and externalizing behavior problems were added in step three.

The first set of regressions focused on teacher-rated prosocial competence as the outcome. These analyses revealed that, after accounting for the control variables, RSA reactivity (withdrawal), HR reactivity, and PEP reactivity (shortening) (with responses to anger, fear, and sadness entered as a block) accounted for 8% of the variance in teacher-rated prosocial competence, $p < .05$. Increased HR reactivity to fear made a unique contribution, $\beta = -.29$, $p < .05$. When teacher and peer ratings of externalizing and internalizing behavior were added at step three, they accounted for an additional 47% of the variance in teacher-rated prosocial competence, with teacher-rated externalizing and internalizing behaviors each making unique contributions, $\beta s = -.57$ and $-.30$, $p < .01$. With behavior problems added, the block of physiological variables made a much weaker contribution, accounting for only 3% of the variance in teacher-rated prosocial competence. A formal test of mediation was conducted using the Preacher and Hayes (2008) method. This method incorporates multiple mediators, testing mediation for the set of teacher- and peer-rated internalizing and externalizing behaviors, but can handle only a single predictor. Hence, the reactivity measure showing a unique association with the outcome was used as the predictor in each model. 1000 bootstrap resamples were specified in each model. This first model revealed full mediation, 95% CI of total indirect effects [−.111, −.035], with the total effect of HR reactivity to fear on prosocial behavior, $\beta = -.076$, $SE = .026$, $p < .01$, becoming insignificant when the four behavior problems were added to the model, $\beta = -.006$, $SE = .018$, $p > .10$. To explore the extent to which the four behavior variables contributed to the indirect effect, contrast tests were employed. These results of the contrast tests indicated that teacher-rated externalizing behavior provided a significantly greater contribution than the three other behaviors, and that teacher-rated internalizing behavior provided a significantly greater contribution than peer-rated externalizing behavior. These results support an indirect model in which HR reactivity to fear contributed to teacher-rated prosocial competence indirectly via its association with internalizing and externalizing behavior, with the majority of the indirect effect being driven by teacher-rated externalizing behavior.

The second set of regressions targeted peer-nominated prosocial competence as the outcome. After accounting for the control variables, RSA reactivity (withdrawal), HR reactivity, and PEP reactivity (shortening) (with responses to anger, fear, and sadness entered as a block) accounted for 15% of the variance, $p < .01$. PEP lengthening (less reactivity) to sadness made a marginally significant unique contribution, $\beta = .27$, $p < .10$. When behavior problems were added at step three, they accounted for an additional 4% of the variance, but did not decrease the variance accounted for by the reactivity block. In this case, emotional reactivity contributed directly to peer-nominated prosocial competence in ways that were distinct from internalizing and externalizing problems.

The third set of regressions used peer rejection as the outcome. Beyond the control variables, RSA reactivity (withdrawal), HR reactivity, and PEP reactivity (shortening) (responses to anger, fear, and sadness entered as a block) accounted for 4% of the variance in peer rejection, $p > .10$. Despite this non-significant contribution at the level of the block of reactivity measures, increased HR reactivity to sadness made a unique contribution to peer rejection, $\beta = .28$, $p < .01$. Behavior problems added at step three accounted for an additional 17% of the variance in peer rejection, with peer-nominated externalizing and internalizing behaviors making significant unique contributions, $\beta s = .32$ and .20 respectively, $p < .01$. With behavior problems in the model, HR reactivity to sadness no longer made a significant contribution. The Preacher and Hayes (2008) method evaluating multiple mediators revealed full mediation, 95% CI of total indirect effects [.001, .008], with the total effect of HR reactivity to sadness on peer rejection, $\beta = .007$, $SE = .003$, $p < .05$, becoming insignificant with behavior problems in the model, $\beta = .003$, $SE = .003$, $p > .10$. Follow-up contrast tests indicated no significant differences among the contributions of the four behavior variables to the indirect effect. These results support an indirect model in which HR reactivity to sadness contributed to peer rejection indirectly via its association with teacher and peer-rated internalizing and externalizing behaviors.

Lastly, in order to investigate the potential interplay between PNS and SNS functioning and effects on social adjustment, we explored interactions between RSA reactivity and PEP reactivity for each of the adjustment outcomes. Interaction terms between RSA reactivity and PEP reactivity were created for each of the emotion conditions (RSA reactivity to anger x PEP reactivity to anger, RSA reactivity to fear x PEP reactivity to fear, RSA reactivity to sadness x PEP reactivity to sadness) and were added after all of the reactivity measures in Step 2 for the regressions predicting teacher-rated prosocial competence, peer-nominated prosocial competence, and peer rejection. None of the interactions in any of the models were significant.

Discussion

In this sample of economically-disadvantaged kindergarten children, heightened ANS arousal (RSA withdrawal, HR reactivity, PEP shortening) in response to emotionally evocative films clips was associated with lower levels of prosocial competence and elevated peer rejection, as well as with internalizing and externalizing behavior problems. Emotional reactivity contributed directly to reduced peer-rated prosocial competence and it contributed indirectly to reduced teacher-rated prosocial competence and elevated peer rejection in pathways mediated by internalizing and externalizing behavior problems.

Emotional Reactivity and Behavior Problems

The associations between emotional reactivity and elevated internalizing and externalizing behavior problems found here are consistent with prior research that used behavior ratings to assess emotional reactivity (Calkins et al., 1999; Eisenberg et al., 2001; Vitaro et al., 2002). They are also consistent with prior research linking RSA withdrawal (Beauchaine et al., 2001; Boyce et al., 2001) and HR reactivity (Erath et al., 2012; Waschbusch et al., 2002; Williams et al., 2003) with internalizing and externalizing problems, particularly in high-risk samples (Graziano & Derefinko, 2013). A unique feature of this study was the focus on young children growing up in a very high-risk urban context and the collection of physiological measures at school, making it possible to represent a group of children that is generally overlooked in laboratory-based studies (see also Fortunato et al., 2013; Gatzke-Kopp et al., 2014; Gatzke-Kopp, in press). The consistent pattern of associations that emerges across age and samples supports the hypothesis that heightened autonomic arousal in reaction to emotionally evocative events increases risk for the development of both externalizing ("fight") and internalizing ("flight") behaviors (Beauchaine et al., 2007; Calkins et al., 2007).

In this study, associations with internalizing and externalizing problems differed with regard to the emotional film to which reactivity was meaningful. Based on prior theory, we anticipated reactivity to fear would increase risk for internalizing problems whereas reactivity to anger would increase risk for externalizing problems (Eisenberg et al., 2001). Consistent with this hypothesis, HR reactivity to fear was associated with elevated internalizing problems. Somewhat surprisingly, however, HR reactivity to fear was also associated with externalizing problems, and RSA reactivity (withdrawal) in response to anger was associated with internalizing problems in this sample. These unexpected associations may reflect the high risk contexts experienced by the children studied here, as well as comorbidity between internalizing and externalizing problems. In addition to high levels of poverty, children in this sample were exposed frequently to high levels of threat. As an example of how this threat affected their daily life, the schools attended by the participants had a specific alarm indicating "active shooter on school grounds," which alerted teachers and students to move away from the windows and onto the ground. Due to a high level of drug trafficking and gang activity in the neighborhoods, such alarms were not uncommon and, in fact, occurred during the course of this study. Children growing up in such conditions may develop a heightened vigilance and reactivity to signs of threat. They may also experience more pervasive distress with concurrent activation of "fight" and "flight" impulses, and show more frequent comorbid internalizing and externalizing behavior problems (Calkins et al., 2007). Relatively few studies have examined associations between adversity and autonomic functioning, and mixed findings have emerged, with adversity associated with both heightened and attenuated levels of sympathetic functioning (Davies et al., 2009; Saltzman, Holden, & Holahan, 2005; Taylor et al., 2004). Given that these few studies have also varied in the age of participants (e.g., toddlers, elementary-aged children, young adults) and in their measures of autonomic functioning (e.g., baseline HR, HR reactivity, cardiac sympathetic index), it difficult to establish general conclusions regarding the nature of the complex relationship between violence exposure and autonomic reactivity. The present study did not include a lower risk sample, leaving unanswered questions about the degree to which the unexpected associations found here (e.g., reactivity to anger linked with internalizing problems, reactivity to fear linked with externalizing problems) might be specific to children growing up in risky contexts; the findings raise important questions that should be examined in future research.

Emotional Reactivity and Social Adjustment

Only a few studies have examined associations between emotional reactivity and social adjustment in young children. The associations documented here are consistent with behavioral research demonstrating links between ratings of emotional reactivity and poor social competence (Calkins et. al., 1999), as well as research linking heightened autonomic reactivity with reduced prosocial behavior (Blair & Peters, 2003). These findings are also consistent with the hypothesis derived from polyvagal theory that individuals with higher levels of automatic reactivity are less able to modulate their arousal to support socially competent interaction (Porges, 2001).

This study explored indirect, as well as direct links between emotional reactivity and social adjustment. For both teacher-rated prosocial competence and peer rejection, an indirect link emerged, in which RSA reactivity (withdrawal), HR reactivity, and PEP reactivity (shortening) increased risk for social maladjustment through their associations with elevated internalizing and externalizing behavior problems. For peer-rated prosocial competence, however, the link was direct. The indirect versus direct associations found between emotional reactivity and teacher-rated versus peer-rated prosocial competence warrants consideration. Although both raters responded to items describing prosocial competence, teachers may have focused primarily on behaviors observed in the classroom. In the structured classroom setting, prosocial behaviors such as waiting for a turn, helping, and sharing may reflect compliance with classroom rules and routines, and thus be closely associated with low levels of internalizing and externalizing behaviors. In contrast, peer ratings may reflect primarily prosocial behaviors observed in the unstructured context of the playground. In this context, a child's ability to join effectively in collaborative play with a spontaneous prosocial orientation may have developmental underpinnings that are independent of behavior problems, including positive interpersonal socialization experiences and secure internal working models for relationships (Fabes, Hanish, Martin, Moss, & Reesing, 2012). Heightened reactivity to anger and/or fear may contribute to amplified negative responses to everyday peer slights, thereby undermining children's capacity to sustain collaborative play.

Results of the mediational analyses revealed that the indirect link between HR reactivity to fear and teacher-rated prosocial behavior was best accounted for by teacher ratings of child externalizing behavior, followed by teacher ratings of child internalizing behavior. For the indirect link between HR reactivity to sadness and peer rejection, no significant differences in contribution emerged among the teacher and peer-rated externalizing and internalizing behaviors. This set of findings challenges the notion that there are orthogonal associations between physiological reactivity to approach emotions (e.g., anger) and externalizing behavior, and between physiological reactivity to withdrawal emotions (e.g., fear, sadness) and internalizing behavior. Instead, the findings suggest a more complex and nuanced association between the nature of the emotional experiences coinciding with physiological arousal and the type of behaviors that accompany such arousal.

Interestingly, HR reactivity demonstrated more consistent associations with the measures of social adjustment than did RSA or PEP reactivity. A robust link emerged between HR reactivity to fear and sadness and social functioning, present in both the correlations and the regressions predicting the social adjustment outcomes, with RSA and PEP reactivity controlled. In addition, when included with HR reactivity in these regressions, the few significant associations between RSA or PEP reactivity and social adjustment that had been present in the correlations no longer yielded unique predictability. Although the dissociation of cardiac arousal into parasympathetic and sympathetic components offers the opportunity to examine whether different pathways to regulating arousal are differentially associated with adverse behavioral outcomes, our results suggest that it is the final product of arousal rather than the mechanism mediating it that is most strongly associated with behavioral measures. HR reactivity was more robustly and uniquely associated with outcomes than either cardiac component. The implications of this pattern of results await further study, but suggest a value in retaining HR as a variable in analyses rather than relying solely on RSA.

Study Limitations

Several study limitations deserve attention. First, the cross-sectional nature of the study precludes an assessment of the directionality of the associations among emotional reactivity, social behavior and peer outcomes. The direction of influence tested here (e.g., that behavior problems mediate the association between emotional reactivity and social adjustment) is consistent with the developmental timing of this study, positioned at the start of kindergarten when children are making their first transition into formal schooling. At this transition point, we postulate that the behavioral tendencies children bring with them to school play a key role in facilitating or undermining the establishment of positive peer relations in the new school context. However, over time, bi-directional influences would also be expected. For example, repeated school experiences of social isolation (Fabes et al., 2012) and peer rejection (Erath et al., 2012) may distress young children, contributing over time to elevated vigilance and anticipatory anxiety associated with peer interactions, resulting in elevated reactivity to negative peer responses and reactive internalizing or externalizing behavior problems.

A second methodological limitation was the lack of a “manipulation check” to determine how successfully the video clips induced the intended emotions. Although the clips were designed to evoke fear, sadness, anger, and happiness, children may have experienced different or mixed emotions, depending upon their interpretation of the film. In addition, individual differences in the amount of prior exposure to the film *The Lion King* may have led to some habituation or sensitization, contributing non-systematic error into the measurement that may have attenuated findings. Measures indexing children’s subjective emotional state to each of the film clips, or detailed facial coding of emotional expressiveness, would have provided helpful information regarding the efficacy of the film clips in eliciting the intended emotions. Still, even if some children experienced emotions discrepant from those targeted by the clips, this is unlikely to have threatened the interpretation of our findings. On the contrary, such individual variability would represent the meaningful differences in emotional reactivity intended by our assessment of physiological reactivity. For instance, children who are overly aroused during the sad condition may have activated fear-related emotions, and this may in fact be a facet of the affective information processing tendencies that contribute to their internalizing symptoms.

A third limitation involves the potential effect of a shared reporter bias on the mediation models. For each mediation model, the significant mediators and social adjustment outcomes shared the same reporter (i.e., teacher-reported externalizing and internalizing behavior were related to teacher-rated prosocial competence, peer-reported externalizing and internalizing behavior were related to peer rejection). Further research exploring the associations among physiological reactivity, externalizing and internalizing behavior, and social adjustment should employ additional multiple assessment methods (e.g., parent, teacher and peer report, observation) to provide a more rigorous test of mediational pathways.

A fourth limitation involves the interpretation of the findings involving HR reactivity. Because HR is influenced by the functioning of the PNS and SNS, the HR findings do not readily lend themselves to interpretation regarding the relative roles of PNS and SNS influence on behavioral or social functioning. Patterns of HR reactivity undoubtedly reflect overall levels of autonomic arousal with strong psychophysiological implications about an individual's reaction to emotion stimuli. In the present study, the inclusion of RSA and PEP reactivity with HR reactivity in the regressions indicated that even with PNS contributions (i.e., RSA) and SNS contributions (i.e., PEP) accounted for, HR offered additional unique information. It is possible that the differential prediction of HR relative to its components is a function of the between-person analysis design of the study. The adaptive value of arousal is known to follow a quadratic function with compromised cognitive function occurring when arousal is too low or too high. As an illustration, for an individual on the lower phase of their arousal curve, a decrease in RSA is adaptive to push arousal closer to the optimum state. However, for an individual on the upper phase of their arousal curve, an increase in RSA may be adaptive as in moving the individual toward a lower, more optimal arousal state. As such, between-person differences in change in RSA may be less meaningful than the overall arousal level that results from the change.

Relatedly, the interplay between parasympathetic and sympathetic functioning may importantly contribute to an individual's achievement of an overall level of arousal. Although in the present study no significant findings emerged for the role of RSA by PEP, it is likely that the sample size and lack of specific a priori hypotheses across different emotion resulted in an analysis that was underpowered for such examination. Future research specifically designed to capture the interplay between systems and within-person dynamics is needed to better understand the role individual autonomic processes have within the larger system.

Lastly, the current sample of children was recruited from a very high-risk community and oversampled for aggression. It is important to understand how emotional development is associated with social adjustment among these high-risk children, but the findings may not generalize to other samples.

Future Directions and Clinical Implications

The present findings indicate that the emotional functioning of children growing up in adverse circumstances deserves greater attention in developmental research, particularly in terms of understanding the developmental determinants of elevated emotional reactivity in these high-risk contexts and their associations with social maladjustment over time. To this end, physiological indices of emotional functioning provide a very helpful tool, as they can help elucidate discrete processes involved in emotional functioning, as well as their specific roles in the manifestation of social behavior and related peer outcomes.

Prior research has suggested that inconsistencies in the literature on autonomic functioning and social behavior may reflect the use of different methodologies for assessing autonomic processes (Lorber, 2004). In light of this, research should continue to explore how different processes of autonomic functioning may be linked with different forms of social behavior and different profiles of problematic social functioning, including internalizing and externalizing behavior, and their various forms (e.g., proactive versus reactive aggression). Research exploring these patterns with an earlier developmental study frame and a longitudinal design would be particularly useful. In addition, some research suggests that associations between heightened autonomic reactivity and social maladjustment are amplified (or, in some cases, attenuated) in at-risk populations who may have more dysregulated stress response systems due to biological and environmental influences (Beauchaine et al., 2007; Graziano & Derefinko, 2013). This possibility, consistent with the present study findings, should be further investigated in order to elucidate the nature of physiological processes and their interaction with contextual influences, particularly for children growing up in adverse contexts. A more thorough understanding of the different processes of emotional functioning and their implications for social adjustment may inform the design of more effective intervention programs aimed at promoting social competence and positive peer relations.

The present study represents an important progression in the exploration of emotional functioning and social behavior, as it is the first to our knowledge to investigate the relations among autonomic indices of emotional functioning, social behavior, and peer relationships in kindergarten children. While such relationships have often been explored using behavioral measures of emotional functioning, the use of physiological indices in the present study allowed for more discrete measures of these emotional processes and their associations with social adjustment. The results of the study support the contribution of autonomic reactivity to externalizing and internalizing behavior, reduced prosocial competence, and peer rejection, and further suggest that elevated autonomic reactivity may confer risk for social maladjustment by contributing to higher levels of problem behavior. In this way, the study highlights the complexity of young children's emotional functioning and the important role of physiological processes of emotional functioning in children's social adjustment, as well as the contribution of these processes to the formation of early peer relationships.

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Table 1

Descriptive Statistics for all Study Variables

	Full Sample (N = 169)		Male (N = 112)	Female (N = 57)
Variables	***M (SD)***	**Range**	***M (SD)***	***M (SD)***
Resting RSA	6.54 (1.18)	3.04 – 9.52	6.47 (1.22)	6.68 (1.08)
Resting HR	103.73 (15.10)	57.05 – 149.16	103.85 (15.37)	103.48 (14.62)
Resting PEP	95.42 (11.46)	66.40 – 134.99	95.76 (11.78)	94.73 (10.82)
Baseline RSA	6.29 (1.07)	2.77 – 9.07	6.27 (1.07)	6.34 (1.08)
Baseline HR	94.62 (10.66)	68.56 – 128.27	94.56 (10.80)	94.76 (10.47)
Baseline PEP	104.06 (15.31)	51.68 – 153.78	103.47 (15.70)	105.23 (14.57)
Happy RSA	6.22 (1.10)	2.80 – 9.18	6.20 (1.11)	6.27 (1.07)
Happy HR	93.41(10.56)	68.67 – 128.21	93.22 (10.66)	93.78 (10.45)
Happy PEP	104.13 (15.70)	54.76 – 155.98	102.96 (16.01)	106.45 (14.92)
Anger RSA	6.06 (1.07)	2.21 – 8.78	6.06 (1.03)	6.07 (1.15)
Anger HR	95.48 (10.75)	71.83- 126.93	95.53 (11.17)	95.37 (9.98)
Anger PEP	104.23 (15.65)	54.40 - 155.70	103.28 (15.98)	106.10 (14.93)
Fear RSA	6.13 (1.09)	3.43- 8.76	6.09 (1.08)	6.20 (1.13)
Fear HR	93.99 (11.05)	71.68 – 133.19	93.82 (11.05)	94.33 (11.15)
Fear PEP	103.84 (15.88)	50.08 – 160.23	103.04 (15.97)	105.42 (15.73)
Sad RSA	6.26 (1.16)	3.07 – 10.07	6.24 (1.15)	6.29 (1.21)
Sad HR	93.92 (10.87)	68.17 – 130.95	93.89 (10.94)	93.99 (10.83)
Sad PEP	103.79 (15.57)	49.90 – 155.47	102.93 (15.58)	105.47 (15.53)
Externalizing (T)	3.04 (1.06)	0.55 – 5.73	3.19 (1.05)	2.75 (1.02)
Externalizing (P)	0.15 (0.16)	0.00 – 0.63	0.19 (0.16)	0.09 (0.13)
Internalizing (T)	2.55 (0.87)	0.21 – 5.04	2.65 (0.93)	2.35 (0.70)
Internalizing (P)	0.10 (0.13)	−0.10 – 0.64	0.10 (0.12)	0.12 (0.14)
Prosocial (T)	3.11 (0.94)	0.72 – 5.72	2.99 (0.90)	3.33 (0.99)
Prosocial (P)	0.10 (0.08)	−0.01 – 0.33	0.10 (0.08)	0.11 (0.08)
Peer Rejection (P)	0.16 (0.12)	−0.01 – 0.55	0.17 (0.13)	0.13 (0.11)

Note: RSA = Respiratory sinus arrhythmia, HR = Heart rate, PEP = Pre-ejection period, T = Teacher rating, P = Peer nomination. Resting physiology measures were taken prior to the start of the emotion induction series. Baseline measures were computed as the average response to a neutral film clip. Physiological arousal scores represent raw scores during each emotional clip. Sex differences were significant for teacher-rated externalizing, $F(1, 167) = 6.20$, peer-nominated externalizing, $F(1, 167) = 16.32$, teacher-rated internalizing, $F(167) = 3.96$, teacher-rated prosocial, $F(1, 167) = 4.24$, and peer rejection, $F(1, 167) = 5.06$.

Table 2

Correlations among RSA, Heart Rate, and PEP Reactivity Scores

	Resting Physiology		Happy			Anger			Fear			Sad		
	HR	PEP	RSA	HR	PEP	RSA	HR	PEP	RSA	HR	PEP	RSA	HR	PEP
Resting RSA	−.78**	.03	.05	.04	<.01	−.09	.14	−.05	.06	−.09	.06	.08	−.01	.02
Resting HR		−.06	−.06	−.05	.03	.06	−.12	.06	−.05	.13*	−.02	−.02	.03	.03
Resting PEP			−.03	<.01	.07	−.09	.09	.10	−.10	−.05	.16	.02	.11	.09
Happy RSA				−.29**	−.10	.48**	−.04	−.14	.34**	−.02	−.03	.39**	−.06	−.05
Happy HR					−.07	−.16	.37**	−.04	−.05	.39**	−.04	<.01	.53**	−.08
Happy PEP						.08	−.08	.61**	.02	−.05	.68**	−.04	<.01	.69**
Anger RSA							−.32**	.10	.41**	−.06	.09	.43**	−.08	.12
Anger HR								−.17	.04	.26**	−.01	−.02	.24**	−.08
Anger PEP									.02	−.05	.65**	−.17	.01	.73**
Fear RSA										−.40**	.06	.47**	−.15	.03
Fear HR											−.12	−.10	.47**	−.04
Fear PEP												.04	−.03	.86**
Sad RSA													−.24**	.04
Sad HR														−.06

Note: RSA = Respiratory sinus arrhythmia, HR = Heart rate, PEP = Pre-ejection period. Resting physiology measures were taken prior to the start of the emotion induction series. Reactivity scores represent raw scores during each emotional clip minus baseline levels averaged across neutral film clips; since RSA reactivity = RSA withdrawal, HR reactivity = increased HR, and PEP reactivity = PEP shortening, increased reactivity is indicated by negative RSA and PEP scores and positive HR scores.

* $p < .05$,

** $p < .01$.

Table 3

Correlations among the Teacher and Peer Ratings of Behavior Problems and Social Adjustment

	Externalizing	Internalizing		Social Adjustment		
	Peer	Teacher	Peer	Teacher Prosocial	Peer Prosocial	Peer Rejection
Externalizing (T)	.39**	.39**	.08	−.67**	−.12	.22**
Externalizing (P)		.08	.17*	−.18*	.04	.41**
Internalizing (T)			.18*	−.57**	−.23**	.05
Internalizing (P)				−.16	.05	.24**
Prosocial (T)					.23**	−.20*
Prosocial (P)						−.10

Note: T = Teacher rating, P = Peer nomination.

* $p < .05$,

** $p < .01$.

Table 4

Correlations between the Teacher and Peer Ratings, and RSA, Heart Rate, and PEP Reactivity

	Externalizing		Internalizing		Social Adjustment		
	Teacher	Peer	Teacher	Peer	Teacher Prosocial	Peer Prosocial	Peer Rejection
Resting RSA	.04	.04	−.16	.08	.03	.02	.08
Resting HR	−.05	−.04	.22**	−.04	−.08	−.07	.04
Resting PEP	.07	.01	−.14	−.08	.13	−.08	−.04
Happy RSA	.08	−.06	−.05	.03	−.05	.09	−.05
Happy HR	.01	−.01	.04	−.03	−.09	−.15	−.05
Happy PEP	.14	.05	.15	.05	.02	.20**	.09
Anger RSA	.15	−.01	.05	−.16*	−.18*	.20**	.00
Anger HR	−.07	.00	−.08	.08	−.04	−.11	−.01
Anger PEP	.11	−.02	.04	−.02	.04	.09	.09
Fear RSA	−.03	.02	−.16*	−.08	−.07	.16*	.01
Fear HR	.24**	.04	.23**	−.01	−.28**	−.26**	.04
Fear PEP	.04	−.11	−.04	−.01	.04	.26**	.01
Sad RSA	.00	.03	−.12	−.01	−.08	.09	.00
Sad HR	.13	.15	.03	.12	−.15	−.18*	.18*
Sad PEP	.12	−.01	.00	.01	.00	.27**	.03

Note: Sex was partialled out in this set of correlations. RSA = Respiratory sinus arrhythmia, HR = Heart rate, PEP = Pre-ejection period, T = Teacher rating, P = Peer nomination. Resting physiology measures were taken prior to the start of the emotion induction series. Reactivity scores represent raw scores during each emotional clip minus baseline levels averaged across neutral film clips; since RSA reactivity = RSA withdrawal, HR reactivity = increased HR, and PEP reactivity = PEP shortening, increased reactivity is indicated by negative RSA and PEP scores and positive HR scores.

* $p < .05$,

** $p < .01$.

Table 5

Autonomic Reactivity and Child Social Functioning Predicting Teacher Prosocial Competence

	Step 2			Step 3		
Variable	R^2	β	ΔF	R^2	β	ΔF
Step 1	.06		2.56*			
Age		.14			.12*	
Sex		−.20*			−.05	
Race		.12			.05	
Vocabulary		.08			<.01	
Resting RSA		−.05			−.04	
Resting HR		−.09			−.07	
Resting PEP		.14			.12	
Step 2	.14		2.51*	.03		2.23
Anger RSA		−.13			−.02	
Anger HR		.04			−.05	
Anger PEP		.09			.08	
Fear RSA		−.13			−.13	
Fear HR		−.29*			−.07	
Fear PEP		.01			−.05	
Sad RSA		.02			−.05	
Sad HR		−.07			−.07	
Sad PEP		−.02			.02	
Step 3				.61		44.95**
Externalizing (T)					−.57**	
Externalizing (P)					.10	
Internalizing (T)					−.30**	
Internalizing (P)					−.07	

Note. In step 1, df = 7, 154; in step 2, df = 16, 145; in step 3, df = 20, 141. RSA = Respiratory sinus arrhythmia, HR = Heart rate, PEP = Pre-ejection period, T = Teacher rating, P = Peer nomination. Resting physiology measures were taken prior to the start of the emotion induction series. Reactivity scores represent raw scores during each emotional clip minus baseline levels averaged across neutral film clips; since RSA reactivity = RSA withdrawal, HR reactivity = increased HR, and PEP reactivity = PEP shortening, increased reactivity is indicated by negative RSA and PEP scores and positive HR scores. No significant interactions emerged between physiological markers (e.g., PEP × RSA).

* $p < .05$,

** $p < .01$.

Table 6

Autonomic Reactivity and Child Social Functioning Predicting Peer Prosocial Competence

	Step 2			Step 3		
Variable	R^2	β	ΔF	R^2	β	ΔF
Step 1	<.01		1.09			
Age		.11			.12	
Sex		−.09			−.02	
Race		<.01			−.02	
Vocabulary		.05			.06	
Resting RSA		−.07			−.05	
Resting HR		−.14			−.07	
Resting PEP		−.09			−.07	
Step 2	.15		3.97**	.15		4.14**
Anger RSA		.16			.23*	
Anger HR		−.02			−.05	
Anger PEP		−.17			−.18	
Fear RSA		.02			.03	
Fear HR		−.17			−.07	
Fear PEP		.13			.16	
Sad RSA		−.07			−.13	
Sad HR		−.07			−.13	
Sad PEP		.27+			.25	
Step 3				.19		2.97*
Externalizing (T)					−.13	
Externalizing (P)					.11	
Internalizing (T)					−.17+	
Internalizing (P)					.12	

Note. In step 1, df = 7, 154; in step 2, df = 16, 145; in step 3, df = 20, 141. RSA = Respiratory sinus arrhythmia, HR = Heart rate, PEP = Pre-ejection period, T = Teacher rating, P = Peer nomination. Resting physiology measures were taken prior to the start of the emotion induction series. Reactivity scores represent raw scores during each emotional clip minus baseline levels averaged across neutral film clips; since RSA reactivity = RSA withdrawal, HR reactivity = increased HR, and PEP reactivity = PEP shortening, increased reactivity is indicated by negative RSA and PEP scores and positive HR scores. No significant interactions emerged between physiological markers (e.g., PEP × RSA).

$^{*}p < .05$,

$^{**}p < .01$.

Table 7

Autonomic Reactivity and Child Social Functioning Predicting Peer Rejection

	Step 2			Step 3		
Variable	R^2	β	ΔF	R^2	β	ΔF
Step 1	.05		2.30*			
Age		.01			−.01	
Sex		.19*			.09	
Race		−.05			−.06	
Vocabulary		−.18*			−.24*	
Resting RSA		.21			.19	
Resting HR		.22			.25+	
Resting PEP		−.05			−.10	
Step 2	.09		1.60	<.01		1.10
Anger RSA		.04			.09	
Anger HR		.01			.04	
Anger PEP		.18			.17	
Fear RSA		−.08			−.07	
Fear HR		−.14			−.10	
Fear PEP		−.15			.00	
Sad RSA		.08			.01	
Sad HR		.28**			.14	
Sad PEP		.02			−.10	
Step 3				.26		9.53**
Externalizing (T)					.14	
Externalizing (P)					.32**	
Internalizing (T)					−.14	
Internalizing (P)					.20**	

Note. In step 1, df = 7, 154; in step 2, df = 16, 145; in step 3, df = 20, 141. RSA = Respiratory sinus arrhythmia, HR = Heart rate, PEP = Pre-ejection period, T = Teacher rating, P = Peer nomination. Resting physiology measures were taken prior to the start of the emotion induction series. Reactivity scores represent raw scores during each emotional clip minus baseline levels averaged across neutral film clips; since RSA reactivity = RSA withdrawal, HR reactivity = increased HR, and PEP reactivity = PEP shortening, increased reactivity is indicated by negative RSA and PEP scores and positive HR scores. No significant interactions emerged between physiological markers (e.g., PEP × RSA).

*$p < .05$,

**$p < .01$.