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Preschoolers' Psychophysiological Responses to Mood Induction Tasks Moderate the Intergenerational Transmission of Internalizing Problems

Molly Davis, M.S., Cynthia Suveg, Ph.D., Monica Whitehead, M.S., Anna Jones, M.S., and Anne Shaffer, Ph.D.

Department of Psychology, University of Georgia, Athens, Georgia, 30602-3013, United States

Abstract

To identify factors that can both exacerbate risk for, and protect against, internalizing problems during early childhood, the present study examined whether children's respiratory sinus arrhythmia (RSA) suppression in response to emotionally-laden film clips would moderate the association between maternal and child anxious/depressive symptoms in a cross-sectional sample of 108 mothers ($M_{age} = 30.68$ years, $SD = 6.06$) and their preschool-age children ($M_{age} = 3.50$ years, $SD = .52$, 61.00% male). Results indicated that RSA suppression in response to the fear clip moderated the positive association between maternal and child anxious/depressive symptoms, such that higher suppression served a protective-stabilizing function while lower suppression exacerbated children's risk for internalizing symptoms in the context of higher maternal symptoms. Moderation findings involving RSA suppression in response to a happiness-inducing clip were consistent with biological sensitivity to context; the association between maternal and child symptoms was strongest for children higher in suppression.

Keywords

Preschool; Respiratory Sinus Arrhythmia; Intergenerational Transmission; Internalizing Symptoms

Extensive empirical and theoretical work has supported the link between maternal and child psychopathology, particularly in regard to internalizing symptoms and disorders (Goodman & Gotlib, 1999; McClure, Brennan, Hammen, & Le Brocque, 2001; Silk, Shaw, Forbes, Lane, & Kovacs, 2006). Yet, not all children at familial risk for the development of psychopathology ultimately exhibit socioemotional difficulties (Masten, 2001; Masten & Coatsworth, 1998). Therefore, there is a persistent need to examine variables that may confer further risk for, or protect against, maladjustment during early childhood. Children's physiological regulation, often measured via respiratory sinus arrhythmia (RSA) suppression

Correspondence concerning this paper should be addressed to Molly Davis, M.S., Department of Psychology, Psychology Building, University of Georgia, Athens, Georgia, 30602-3013. Phone: 706-542-1173. FAX: 706-542-3275. mfdavis2@uga.edu..

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(i.e., decreases in RSA from a resting state to a challenge task; Calkins, 2007), may be one promising moderator to consider given that greater RSA suppression has been found to protect against maladjustment in the context of environmental risk whereas lower RSA suppression may exacerbate risk for adverse outcomes (e.g., El-Sheikh, 2001; McLaughlin, Alves, & Sheridan, 2014). Thus, the present study examined whether child RSA suppression in response to emotion-inducing video clips moderates the relation between mothers' and preschoolers' anxious/depressive symptoms to demonstrate whether physiological functioning under emotionally-laden conditions can impact the intergenerational transmission of internalizing symptoms. Understanding factors that can both confer risk for, and buffer against, the onset of internalizing symptoms during the preschool period is critical given that problems in these domains can persist into later development (Luby, Si, Belden, Tandon, & Spitznagel, 2009; Mesman & Koot, 2001).

The Role of Child RSA Suppression in the Intergenerational Transmission of Risk

RSA change is a parasympathetic nervous system process governed by the vagus nerve (Porges, 2007) and is measured in terms of RSA suppression (the removal of vagal influence) or RSA augmentation (increased vagal influence) in the extant literature (e.g., Hinnant & El-Sheikh, 2009). RSA suppression has most often been conceptualized as being synonymous with vagal regulation (e.g., El-Sheikh & Whitson, 2006; Graziano, Keane, & Calkins, 2007; McLaughlin et al., 2014) and, given the present manuscript's focus on physiological regulation, we use this term throughout to describe the extent to which RSA decreased from a resting period to a challenge task (Calkins, Graziano, Berdan, Keane, & Degnan, 2008). To be sure, this does not mean that all children in the studies reviewed hereafter exhibited suppression, or that all children in the current sample demonstrated decreases in RSA. Rather, this term is used to describe a continuum of RSA change scores, with higher, more positive scores indicating a greater decline from a resting state to a task and therefore, greater regulation.

RSA suppression has been linked to indices of both adaptive and maladaptive functioning (Calkins & Keane, 2004; Calkins, Graziano, & Keane, 2007; Fortunato, Gatzke-Kopp, & Ram, 2013; Gentzler, Santucci, Kovacs, & Fox, 2009). These disparate findings suggest that examining bivariate relations between RSA suppression and internalizing problems is likely to yield an incomplete snapshot of this association; RSA suppression should instead be examined in context. Theory on vagal tone more broadly can help to shed light on the ways in which context matters when considering the role of child RSA suppression in indices of adjustment and maladjustment. According to Porges' Polyvagal Theory (Porges, 2007), vagal withdrawal promotes fight and flight behaviors. Thus, because decreases in RSA in response to a challenge can signify the ability to cope effectively during demanding situations (for a review, see Calkins, 2007), higher RSA suppression might be especially important for promoting adjustment in the context of higher levels of risk. In a low-risk context, such decreases in RSA are unnecessary and can contribute to maladaptation (Hastings et al., 2008). In line with this view, excessive vagal withdrawal has been deemed a

“nonspecific marker of emotional lability” (p. 198, Beauchaine, 2001). In sum, it is critical to examine child RSA suppression in context.

Overall, research examining child RSA suppression as a moderator of the links between adverse environmental conditions and children’s psychosocial functioning has garnered support for two primary conceptualizations of higher RSA suppression, with some researchers reporting results consistent with the biological sensitivity to context theory (e.g., Obradovi , Bush, Stamperdahl, Adler, & Boyce, 2010; Shanahan, Calkins, Keane, Kelleher, & Suffness, 2014) and others illustrating that higher RSA suppression serves a protective function in the context of environmental risk (e.g., El-Sheikh, Erath, & Keller, 2007; El-Sheikh & Whitson, 2006; McLaughlin, et al., 2014). The biological sensitivity to context theory posits that children who exhibit high levels of biological reactivity thrive under positive environmental conditions but experience the worst psychological and physical health outcomes in the context of adversity (Boyce & Ellis, 2005). Alternatively, research from a traditional risk/protective framework has indicated that whereas lower RSA suppression serves as a risk factor for child maladjustment, greater RSA suppression may buffer against adjustment problems (e.g., El-Sheikh & Whitson, 2006). For instance, RSA suppression has been found to moderate the concurrent relation between marital conflict and children’s internalizing problems among elementary school children such that the positive association between marital conflict and child internalizing problems was only found for children lower in RSA suppression (El-Sheikh & Whitson, 2006). Furthermore, longitudinal results suggested that greater RSA suppression continued to serve a protective function for girls in the context of increased marital conflict when internalizing problems were measured 2 years later (El-Sheikh & Whitson, 2006). Obradovi , Bush, & Boyce (2011) posit that the divergent interaction patterns involving children’s autonomic nervous system reactivity found across the extant literature may be, at least in part, due to differences in the lab tasks employed to measure such reactivity. In this study, Obradovi et al. (2011) defined higher RSA reactivity as lower RSA during a challenge than would be expected given the child’s baseline RSA and the sample’s regression line. Thus, this construct is akin to RSA suppression. The authors concluded that traditional biological sensitivity to context patterns may be specific to studies that employ a cognitive challenge task (e.g., a digit span task in which children receive corrective feedback for errors). Alternatively, interpersonal challenge tasks (e.g., watching an emotionally-evocative film clip of a child being bullied) may yield opposite findings in which environmental risk has no impact on child adjustment problems for children higher in RSA suppression (Obradovi et al., 2011). Though helpful in beginning to explain the discrepant moderation findings involving child RSA suppression, these explanations leave unanswered questions about mood induction tasks that are neither interpersonally- or cognitively-focused, suggesting this is an area ripe for further investigation.

Of note, recent meta-analytic findings revealed a marginally significant impact of the type of challenge task employed on the average weighted effect size for the correlation between RSA suppression and child adjustment problems (i.e., internalizing, externalizing, social, and cognitive/academic problems; Graziano & Derefinko, 2013). Specifically, the magnitude of the negative correlation between RSA suppression and child adjustment problems was stronger for studies that used a negative mood/stressor task compared to studies using a

cognitive task to calculate RSA suppression. The authors concluded that negative mood/stressor tasks may be “tapping a key element of RSA withdrawal that elucidates its influence on adaptive outcomes” (p. 27, Graziano & Derefinko, 2013). Therefore, examining child RSA suppression in response to negative mood induction tasks may be particularly informative for understanding the joint effects of maternal psychopathology and child RSA suppression on child adjustment problems.

In line with the field’s growing emphasis on the need to consider RSA in context, recent research has examined how child RSA suppression is implicated in the links between maternal psychopathology and child adjustment (e.g., Blandon, Calkins, Keane, & O’Brien, 2008). Because RSA suppression (i.e., vagal withdrawal) reflects one’s capacity to manage environmental challenges (for a review, see Calkins, 2007; Porges, 1995), studying RSA suppression as a moderator of the association between maternal and child anxious/depressive symptoms may be particularly informative for elucidating how children’s regulation at a physiological level plays a role in child adjustment under conditions of environmental risk. To date, the limited research that has examined child RSA suppression as a moderator of the association between maternal psychopathology and child adjustment has yielded mixed findings. For instance, Blandon et al. (2008) demonstrated that the interaction between mothers’ depression symptoms and children’s RSA suppression did not significantly predict children’s emotion regulation or negativity trajectories from ages 4 to 7, nor did this interaction predict levels of emotion regulation or negativity at age 7. However, marginally significant moderation findings indicated that the positive association between maternal depression and child negativity at age 7 was stronger for children higher in RSA suppression (Blandon et al., 2008). Using data from the same larger study as Blandon et al. (2008), Shanahan et al. (2014) explicitly examined the joint contributions of maternal internalizing symptoms and child RSA suppression to children’s internalizing symptoms from ages 4 to 10 years old, demonstrating that higher RSA suppression was positively associated with children’s internalizing symptoms between the ages of 4-7, but not after age 7, when maternal internalizing symptoms were above the median. However, RSA suppression was not significantly associated with child internalizing symptoms when mothers scored below the median on internalizing symptoms. Importantly, the measures of RSA suppression that Shanahan et al. (2014) relied on for testing interactions used between-persons estimates because the within-persons values were generally not significantly associated with child internalizing problems. Additionally, Shanahan et al. (2014) oversampled children with externalizing problems, suggesting it is important to investigate similar research questions in more representative community samples to enhance generalizability. Thus, further research is needed to clarify how the interplay between mothers’ internalizing symptoms and child RSA suppression relates to child internalizing problems during the preschool period.

The Present Study

Collectively, research strongly supports the intergenerational transmission of internalizing symptoms between mothers and their children (Garber & Cole, 2010; McClure et al., 2001; Vostanis et al., 2006). Given the chronicity of internalizing problems across development, further research is needed to elucidate factors that can both augment and reduce the

likelihood that this intergenerational transmission will occur. In the present study, we sought to examine whether child RSA suppression could moderate the relation between maternal and child internalizing symptoms during the preschool period. Importantly, no known study has examined how varying levels of preschoolers' RSA suppression in response to video-mediated emotion challenges may serve as vulnerability and protective factors in the intergenerational transmission of risk for anxious and depressive symptoms. This study engaged a demographically-diverse sample, thus enhancing the generalizability of the findings. Furthermore, measuring RSA suppression in response to fear and sadness mood induction tasks can demonstrate how physiological responses to emotionally-laden tasks potentially influence the relation between maternal and child anxious/depressive symptoms. The mood induction tasks of sadness and fear were particularly relevant contexts given that difficulties regulating fear and sadness are core features of internalizing symptoms in childhood (e.g., Blumberg & Izard, 1986; Cannon & Weems, 2006). Moreover, anxious and depressive symptoms are associated with atypical physiological responses to emotion challenges (Rottenberg, Wilhelm, Gross, & Gotlib, 2003; Thayer, Friedman, & Borkovec, 1996). Research has also consistently implicated the dysregulation of happiness in depressive symptoms (Cannon & Weems, 2006; Jacques & Mash, 2004; Suveg, Hoffman, Zeman, & Thomassin, 2009) and positive affect has been implicated in the social functioning of anxious youth (Jacob, Suveg, & Whitehead, 2014). However, Fortunato et al. (2013) found lower RSA suppression during a happiness condition to be associated with externalizing, but not internalizing, symptoms. Nonetheless, the Fortunato et al. (2013) study did not include the additional context of maternal internalizing symptoms. Thus, we also examined RSA suppression in the context of happiness. The inclusion of both negative and positive film clips allows for an increasingly nuanced examination of the ways that RSA suppression functions in a variety of contexts.

Despite the mixed and limited empirical work on the role of children's RSA suppression in the intergenerational transmission of internalizing symptoms, theory and empirical work has highlighted the benefits of RSA suppression for child adjustment (Calkins, 2007; Calkins & Keane, 2004; Gentzler et al., 2009; Graziano & Derefinko, 2013; Porges, 2007), even under conditions of risk (e.g., El-Sheikh & Whitson, 2006). Accordingly, it was hypothesized that children's RSA suppression, as measured using changes in RSA from a neutral video clip to the sadness and fear mood inductions, would moderate the positive association between maternal and child anxious/depressive symptoms. Specifically, it was expected that the positive association between maternal and child anxious/depressive symptoms would be strongest in the context of lower RSA suppression in response to the fear and sadness clips. In contrast, we expected the relation between maternal and child anxious/depressive symptoms to be weakest in the context of higher RSA suppression in response to the fear and sadness clips. Given the relatively scant literature on RSA suppression in the context of happiness conditions, no hypotheses were offered in this regard.

Method

Participants

This study included 108 mothers ($M_{\text{age}} = 30.68$ years, $SD = 6.06$) and their 3-5 year-old children ($M_{\text{age}} = 3.50$ years, $SD = .52$, 61.00% male). Participants were recruited through fliers posted at local businesses and Head Start centers. This study was part of a project that involved genetics data collection and, therefore, only biological mothers and their children were included; all mothers were required to have lived with their children for at least two years. Inclusion criteria specified that mothers and their children were required to be fluent in reading and speaking in English. Mothers were excluded if they were currently pregnant given that pregnancy can alter women's typical physiological responses. Additionally, children were excluded if they had a developmental disability that could hinder their ability to participate in the lab visit.

The present sample was diverse economically and racially. Nearly half (47.20%) of women indicated they were Black; 42.50% reported they were Caucasian; 0.90% were Asian; 4.70% were Hispanic; and 4.70% identified as "other." Because this study included biological families, the children had a relatively similar racial breakdown (47.60% Black; 38.1% Caucasian; 0.00% Asian; 2.9% Hispanic, and 11.4% identified as "other"). More than half (52.00%) of families had a total household income of less than \$30,000; 14.70% were between \$30,000 and \$49,999; 8.80% were between \$50,000 and \$69,999; and 24.50% had a total income above 70,000. In terms of marital status, nearly half (45.70%) of mothers indicated they were currently married; 42.90% reported they had never been married; and 11.50% were engaged, separated, divorced, or widowed. For maternal education levels, 20.80% had graduate school training; 27.40% were college graduates; 21.70% had some college training; and 30.10% had their General Equivalency Diploma (GED), high school diploma or less.

Procedures

First, research assistants conducted phone screenings with the mothers to determine their eligibility. Mothers who were eligible received a packet of measures in the mail to complete before their lab visit; incomplete measures were filled out the day of the visit. At the lab visit, mothers provided consent and permission for their child to participate and children provided assent. To collect RSA data, electrodes were placed on the child before the behavioral observation tasks. In total, children participated in a maximum of about 16 minutes of physiological data collection. All children participated in a 4-minute adaptation period, during which time children and their mothers were instructed to remain quiet and sit still with their hands resting on the table. The adaptation period was meant to help families acclimate to the lab setting. The present study focused on data from mood induction tasks that were meant to elicit fearful, sad, happy, and neutral responses. During the fear task, children watched a 93-second clip of the movie *Poltergeist* while their mothers sat at the back of the room. The film clip showed a young child enduring a thunderstorm; all children were prompted about the content of the clip prior to watching the film and were instructed to imagine that they were experiencing the thunderstorm themselves. Of note, *Poltergeist* has been used in the extant literature to induce emotions in young children (e.g., Eisenberg et.

al., 1988), despite its R rating. The *Poltergeist* clip shown in the present study did not include the graphic content that caused this film to receive an R rating. The 74-second sadness film clip was also from *Poltergeist* and depicted a young girl who was upset about the death of her pet bird. Before the clip, children were told to pretend that it was their pet bird that was dying. The order of the fear and sadness clips was counterbalanced. The neutral clip, which was 91 seconds long, involved geometric shapes moving across the screen without background noise. Finally, the 65-second happiness clip depicted puppies exploring the outdoors with an upbeat theme song playing in the background; children watched the happiness clip last. Before the first video clip, the children were shown five faces representing different emotions (i.e., happiness, sadness, fear, anger, and neutral). A research assistant read aloud the following statements to the child while pointing at each one: “Here are some faces. This face is crying, this is a sad face. This face is smiling, this is a happy face! This face looks mad, this is an angry face. This face looks afraid, this is a scared face. This face doesn’t seem to be feeling anything at all, this is a neutral face.” The children were then asked to choose the face that best represented how they felt “right now” (i.e., their baseline emotion). After each video, the research assistant said, “Tell me how that clip made you feel” and asked the child to point to the face of that emotion.

Efforts to validate the video tasks involved examination of mean heart rate changes from the neutral (M heart rate = 100.45, SD = 12.58) to the fear (M heart rate = 99.18, SD = 12.45), sadness (M heart rate = 98.66, SD = 12.48), and happiness (M heart rate = 98.54, SD = 13.07) clips. Repeated-measures ANOVAs indicated that mean heart rate changed significantly from the neutral to the fear, $F(1, 85) = 5.65$; $p < .05$; $\eta_p^2 = .06$, sadness, $F(1, 82) = 13.87$; $p < .001$; $\eta_p^2 = .15$, and happiness, $F(1, 82) = 15.65$; $p < .001$; $\eta_p^2 = .16$, clips. Given that all heart rate changes were in the same direction (i.e., heart rate decelerated from the neutral to the fear, sadness, and happiness clips), heart rate changes alone did not distinguish between different emotional experiences in the present study. Furthermore, we cannot completely rule out the possibility that heart rate decelerations across the tasks were reflective of attention processes (Porges & Raskin, 1969). Additionally, behavioral observation coding, which was completed using Noldus behavioral research software (Noldus Information Technology, 2007), was used to delineate the emotions children exhibited in response to the film clips meant to induce fear, sadness, and happiness. Trained coders unaware of the particular video the child was watching rated the intensity of each emotion (i.e., fear, sadness, and happiness) using separate 7-point scales for each emotion. All scales ranged from “Very Low/No Display” to “Very High Display.” For instance, on the happiness scale, a score of 1 (i.e., “Very Low/No Display of Happiness”) described a child who essentially showed no expressions of happiness while watching the film clip whereas a “7” (i.e., “Very High Display of Happiness”) indicated that expressions of happiness were apparent throughout nearly the entire film clip. Coders were instructed to focus on facial displays of emotions when providing global ratings of each emotion for the film clips. Inter-rater reliability (i.e., percentage agreement) was calculated for about 20% of the videos and was calculated separately for each emotion scale within each video. Agreement meant that the two independent raters assigned a code within one point of each other; percentage agreement for the present study ranged from 95-100%, with the exception of 75% agreement for fear ratings in the fear clip. Repeated-measures ANOVAs, with film clips as the repeated

measure, showed that the highest levels of fear [$F(5, 73) = 20.08; p < .001; \eta_p^2 = .58$], sadness [$F(5, 73) = 11.79; p < .001; \eta_p^2 = .45$], and happiness [$F(5, 72) = 15.90; p < .001; \eta_p^2 = .53$] were observed in the video clips that were intended to induce these specific emotions (see Table 1).

Lastly, chi-square tests were computed to compare the frequency with which children reported feeling sad, happy, angry, and neutral following each of the film clips. Children were more likely to report that they experienced fear after the fear clip than other emotions, $\chi^2(4) = 9.64, p < .05$. Following the happiness, $\chi^2(4) = 46.77, p < .001$, sadness, $\chi^2(4) = 10.90, p < .05$, and neutral, $\chi^2(4) = 16.04, p < .01$, videos, children were most likely to endorse feeling happy.

For their participation in the study, mothers were compensated \$100 and children chose a small prize. All study procedures were conducted in accordance with the sponsoring university's Institutional Review Board.

Measures

Demographics

Demographics Questionnaire: Caregivers provided background information (e.g., child and maternal race, child and maternal age, child sex, total household income, and maternal marital status) on a demographics questionnaire. Responses on this questionnaire were used in the present study to examine whether any demographics factors should be entered into the moderation analyses as covariates.

Maternal psychopathology symptoms

Symptom Checklist-90-Revised (SCL-90-R; Derogatis, 1994): The SCL-90-R is a 90-item self-report measure, which was used to assess mothers' current levels of anxious and depressive symptoms. Mothers reported on their psychological distress using a 5-point Likert scale (0 = *not at all*, 4 = *extremely*). Whereas the Depression dimension included items such as "feeling blue" and "feeling no interest in things," the Anxiety dimension included items pertaining to "feeling fearful" and "feeling tense or keyed up." This study relied on a composite of the unstandardized scores for the Depression (13 items) and Anxiety (10 items) dimensions due to the high degree of intercorrelation ($r = .84$) between these two scales. The composite was created by averaging the unstandardized scores across the two dimensions for each participant, with higher scores reflecting greater levels of anxious and depressive symptoms. In the present sample, 11.30% and 7.30% of mothers scored in the clinical ranges (T scores greater than or equal to 65) for the Depression and Anxiety dimensions, respectively. The reliability and validity of the SCL-90-R has been previously established (Derogatis, 1994) and Cronbach's alpha for the present study was .87 and .82 for the Depression and Anxiety dimensions, respectively.

Child RSA suppression

RSA Suppression During Fear, Sadness, and Happiness Tasks: RSA data were collected from children while watching the video clips using MindWare BioLab 3.0.6 software and analyzed using MindWare HRV 3.0.17 software (MindWare Technologies, Ltd., Gahanna,

OH.) in 30-second epochs following recommendations of the Society for Psychophysiological Research Committee on Heart Rate Variability (Berntson et al., 1997). Thus, only the first three epochs (i.e., a maximum of 90 seconds) of RSA data were used from the fear and neutral segments and the first two 30-second epochs were used for the sadness and happiness segments. The amount of data used for each task is in accordance with recommendations from the Society for Psychophysiological Research Committee, which indicate that a minimum of one minute of data should be used for the high frequency band (i.e., RSA; Berntson et al., 1997). In terms of the electrode configuration, disposable silver chloride electrodes were placed on the right collarbone (i.e., the right clavicle area), in the cleft of the throat (i.e., below the Adam's apple), at the base of the rib areas on the left and the right sides of the body, near the xiphoid process, midway down the back, and below the base of the skull upon the back.

In the MindWare HRV 3.0.17 software, an interbeat interval series was created via a peak-identification algorithm and the EKG signal was digitized at 1000 Hz. MindWare calculated a 4 Hz time series via interpolation before the time series was linearly detrended using the second order polynomial in order to minimize nonstationaries in the data (Litvack, Oberlander, Carney, & Saul, 1995). Using a Hamming window, the residual series was tapered and then submitted either to a Discrete Fourier transformation (DFT) or to a fast Fourier transformation (FFT) through the LabVIEW module (National Instruments, Austin, TX), thus yielding the spectral distribution (MindWare HRV Module, Gahanna, Ohio). A radix-2 FFT was used if the number of data points was a factor of 2 whereas DFT was implemented in all other cases. Respiration was monitored by impedance cardiography (Ernst, Litvack, Lozano, Cacioppo, & Berntson, 1999) and the respiration signal was also subject to FFT so that the respiratory frequencies were within the specified respiratory frequency band (0.12 to 0.40 Hz). We manually checked the respiration frequency values and determined that all participants included in the present analyses fell within this respiratory frequency band. Using similar aged samples as ours, Perry et al. (2013) cited using a frequency band of .24-1.04 Hz and Gatzke-Kopp, Greenberg, and Bierman (2015) reported a band of .12-40 Hz with kindergarten-aged children. Using 5-13 year-olds, Gentzler et al. (2009) likewise reported a frequency band of .15-.50 Hz. Thus, though there is some variability, our specified range does appear consistent with the extant literature. For data editing, an algorithm developed by Berntson, Quigley, Jang, and Boysen (1990), as well as visual scanning, was implemented to identify artifact peaks prior to manually removing these artifacts. We removed 30-second epochs in which greater than 10% of peaks needed to be edited, similar to procedures outlined in the extant literature (Perry et al., 2013). One participant's sadness mean RSA score, and therefore suppression value in response to the sadness task, was removed as a result of being an outlier compared to the sample mean. Based on the extant literature (e.g., Kogan, Gruber, Shallcross, Ford, & Mauss, 2013; Obradović et al., 2010), we defined outliers as RSA values that were 3 standard deviations above or below the sample mean for a given task. RSA values were computed in MindWare as the integral power within the respiratory frequency band, which was equivalent to the statistical variance of the time series within the frequency band. In the current analyses, mean scores for children's RSA during each task were calculated separately before computing suppression values. To calculate the mean, children were required to have at least

two clean 30-second epochs (i.e., epochs in which no more than 10% of the data points needed to be edited) for a given task.

Given that respiration has been found to influence RSA magnitude (e.g., Grossman, Karemaker, & Wieling, 1991), mean respiration rates (breaths/minute) were compared across tasks using a repeated-measures ANOVA to determine whether respiration needed to be accounted for in subsequent analyses. Results indicated respiration rates significantly varied across conditions, $F(3, 76) = 6.72$; $p < .001$; $\eta_p^2 = .21$. In particular, a significant difference in respiration rate was found between the neutral ($M = 19.01$) and fear ($M = 20.78$) conditions, $p < .001$, as well as between the neutral and happiness ($M = 21.02$) conditions, $p < .001$. No significant differences in respiration were found between the neutral and sadness ($M = 20.20$), $p = .17$, fear and sadness, $p = .49$, happiness and sadness, $p = .37$, or happiness and fear, $p = .64$, conditions. Nonetheless, in order to be able to draw conclusions about the role of RSA suppression in the intergenerational transmission of internalizing symptoms, beyond the potential impact of respiration, we regressed mean RSA values on respiration rate for each of the individual tasks. For example, a linear regression was run with the mean respiration rate for the fear segment predicting mean fear RSA; this process was repeated for each task. These regression methods for controlling for the potential impact of respiration on RSA values were adapted from techniques employed in the extant literature (for a review, see Grossman & Taylor, 2007). Recent research has suggested that rather than entering respiration as a covariate, generally using analysis of covariance (ANCOVA) models, regressing RSA against respiration and using the residual score as an index of vagal tone is a preferable way to account for the potential impact of respiration on RSA magnitude (for a review, see Graziano & Derefinko, 2013; Grossman & Taylor 2007).

We measured RSA suppression as changes from the neutral to the fear, sadness, and happiness clips using the unstandardized residuals from the simple linear regressions described above. Thus, RSA suppression was calculated per task as the difference between the neutral residual and the residuals for the fear, happiness and sadness clips, with higher, more positive change scores reflecting greater vagal regulation or RSA suppression. To ensure we are remaining consistent with conceptualizations of RSA suppression put forth in the extant literature, we based our calculations on widely-used methods for obtaining these values (e.g., Calkins et al., 2008). Similar to other published studies (e.g., Butler, Wilhelm, & Gross, 2006; Kogan et al., 2013), we relied on an emotionally-neutral task to assess resting RSA. In the current study, examining RSA suppression values from the film tasks allowed for an understanding of how children's physiological responses to mildly emotionally-evocative situations are implicated in the relation between maternal and child internalizing symptoms. Importantly, child RSA suppression has been measured in response to similar video-mediated mood induction tasks in the extant literature (e.g., Fortunato et al., 2013).

Child psychopathology symptoms

Child Behavior Checklist/1^{1/2}-5 (CBCL/1^{1/2}-5; Achenbach & Rescorla, 2000): Mothers filled out the CBCL regarding their children's psychosocial functioning during the past 6

months. The CBCL includes 100 items (99 specific problem items and 1 item for parents to write in additional problems) rated on a 3-point Likert scale, (0 *not true*, 1 *somewhat or sometimes true*, and 2 *very true or often true*) and allows for the calculation of several narrowband scales, including an Anxious/Depressed Problems scale (8 items). Unstandardized scores from this scale were used in the present analyses. The Anxious/Depressed Problems scale includes items regarding the extent to which the child has displayed emotional difficulties in each of these domains (e.g., “looks unhappy without good reason”; “too fearful or anxious”). In the present sample, 6.50% of children were in the borderline (*T* scores of 65-69) or clinical ranges (*T* scores greater than or equal to 70) on the Anxious/Depressed Problems scale. Psychometric properties for the CBCL have been demonstrated in the extant literature (Achenbach & Rescorla, 2000; $\alpha = .71$ in the current study for the Anxious/Depressed Problems scale).

Analytic Plan

To assess relations between the variables of interest, all of which were continuous, Pearson bivariate correlations were calculated between the independent (maternal anxious/depressive symptoms), dependent (child anxious/depressive symptoms), and moderator (child RSA suppression) variables. In addition, correlations were run between each of the main study variables and several demographic characteristics (i.e., child race, child sex, total household income, and maternal marital status) to determine if any demographic variables needed to be statistically controlled for in the moderation models.

Moderation analyses were run using the linear regression function in SPSS. Mean centering was implemented prior to computing the interaction term in order to reduce nonessential multicollinearity between the independent variable, moderator variable and interaction term (Aiken & West, 1991). Moderation was present when the interaction term between the predictor (maternal anxious/depressive symptoms) and moderator (child RSA suppression) was significant and the 95% confidence interval did not include zero. For significant moderation models, interaction terms were probed further by examining conditional effects (i.e., simple slopes) at lower (-1 *SD* below the mean) and higher ($+1$ *SD* above the mean) levels of the moderator using a publicly-available program (<http://www.quantpsy.org/interact/mlr2.htm>) based on procedures outlined in Preacher, Curran, & Bauer (2006). Simple slopes were graphed using online resources from www.jeremydawson.com/slopes.htm. Further information about these resources can be found in Dawson (2014).

Missing Data

In total, between 80 and 84 children out of the full sample of 108 children had usable RSA data to calculate RSA suppression values for the film clips. Paired-samples *t*-tests were conducted to assess whether any given 30-second epoch for each task differed significantly from other epochs for that task in terms of having greater percent error. No epochs were excluded based on this criterion. Several factors accounted for the rate of missing RSA data in the present study: technological difficulties (particularly early in data collection), failure of children to participate in the video tasks, as well as the stringent data editing methods used. In the total sample, 106 families filled out the SCL-90-R and CBCL. To maximize our sample size and minimize bias, missing data techniques were employed. First, Little's

MCAR test (Little, 1988) was run to determine the pattern of missing data for all variables ultimately used in the main moderation models. Little's MCAR was not statistically significant $\chi^2(64) = 42.02, p = .99$, thus supporting the assumption that the data are missing completely at random (Little, 1988). In turn, multiple imputation procedures were implemented for the main study variables and covariates prior to conducting the moderation analyses to ensure that the total sample of 108 families was included in the primary analyses. Predictors were centered and product terms were calculated prior to imputation, following recommendations set forth in the extant literature that specify the importance of creating product terms before imputation (Graham, 2009; Von Hippel, 2009). To conduct multiple imputation, 100 imputations were employed to minimize loss of power (Graham, Olchowski, & Gilreath, 2007) and pooled statistics were utilized in subsequent analyses. Multiple imputation is a superior and less biased method for handling missing data when compared to deletion methods or other stochastic imputation methods because multiple imputation acknowledges the uncertainty of the missing values and takes into account numerous imputed data sets signifying a random sample of the missing values (Schlomer, Bauman, & Card, 2010).

Results

First, correlations between the main study variables and several demographic characteristics (i.e., child race, child sex, total household income, and maternal marital status) were computed to determine if any demographic variables needed to be controlled for in the moderation analyses. Given that total household income was significantly correlated with children's anxious/depressive symptoms ($r = -.32, p = .001$), and consistent with previous research suggesting that intergenerational relations of internalizing problems may vary by socioeconomic status (Goodman, Rouse, Connell, Broth, Hall, & Heyard, 2011), total household income was entered as a covariate in the moderation models. The rest of the demographic characteristics examined (i.e., child race, child sex, and maternal marital status) were not significantly associated with the main study variables.

In regard to intercorrelations between the main study variables, mothers' anxious/depressive symptoms were significantly, positively correlated with children's anxious/depressive symptoms. The child RSA suppression variables were significantly, positively correlated with one another. All correlations and descriptive statistics are displayed in Table 2; these values were all calculated prior to conducting multiple imputation. To control for the potential influence of initial levels of RSA on RSA suppression values, neutral RSA was entered as a covariate in all moderation analyses.

Moderation analyses indicated that children's RSA suppression in response to the fear clip significantly moderated the positive association between maternal and child anxious/depressive symptoms (see Table 3 and Figure 1). The R^2 change due to the interaction term was .04. Simple slopes analyses yielded a significant conditional effect at lower levels of children's RSA suppression in response to the fear clip ($b = 2.76, t = 5.22, p < .001, 95\% \text{ CI } [1.72, 3.80]$) such that the positive association between maternal and child anxious/depressive symptoms was strongest for children with lower levels of RSA suppression. Children experiencing lower levels of RSA suppression in response to the fear clip

demonstrated higher levels of anxious/depressive symptoms when mothers' symptoms were higher than when they were lower, thus supporting lower levels of child RSA suppression as a risk factor. For children higher in RSA suppression in response to the fear clip, RSA suppression served a protective-stabilizing function (e.g., El-Sheikh & Whitson, 2006; Perry, Calkins, Nelson, Leerkes, & Marcovitch, 2012), as the association between maternal and child anxious/depressive symptoms was attenuated and not statistically significant ($b = 1.02$, $t = 1.66$, $p = .10$, 95% CI $[-.18, 2.22]$).

Children's RSA suppression in response to the happiness clip significantly moderated the positive association between maternal and child anxious/depressive symptoms (see Table 4 and Figure 2). The R^2 change due to the interaction term was .04. Simple slopes analyses yielded a significant conditional effect at higher levels of child RSA suppression in response to the happiness clip such that the positive association between maternal and child anxious/depressive symptoms was strongest for children with higher levels of RSA suppression in response to the happiness clip ($b = 2.53$, $t = 5.37$, $p < .001$, 95% CI $[1.61, 3.45]$). Children experiencing higher levels of RSA suppression in response to the happiness clip demonstrated higher levels of anxious/depressive symptoms when mothers' symptoms were higher than when they were lower. The simple slope at lower levels of RSA suppression in response to the happiness clip was non-significant ($b = .59$, $t = .87$, $p = .39$, 95% CI $[-.74, 1.92]$).

Child RSA suppression in response to the sadness video did not moderate the relation between maternal and child symptoms ($b = .13$, $t = .15$, $p = .88$, 95% CI $[-1.49, 1.74]$).

Discussion

The links between maternal and child anxious and depressive symptoms are robust, yet research has typically focused on children's psychopathology during middle childhood and adolescence (e.g., Hammen, Shih & Brennan, 2004; Piche, Bergeron, Cyr, & Berthiaume, 2011). Findings from the current study provide further evidence that relations between maternal and child internalizing symptoms can be observed as early as the preschool period. Further, results indicated that child RSA suppression assessed in response to fear- and happiness-inducing tasks moderated the association between maternal and child internalizing symptoms. Given the developmental continuity between preschoolers' internalizing problems and later maladjustment (Luby et al., 2009; Mesman & Koot, 2001), identifying factors that can confer risk for, and protect against, anxious and depressive symptoms during the preschool period has important implications for early intervention work.

As we hypothesized, child RSA suppression in response to the fear clip moderated the association between maternal and child anxious/depressive symptoms such that for children who exhibited lower levels of RSA suppression in response to the fear clip, the positive relation between maternal and child internalizing symptoms was strongest. Our results are in line with previous research that has demonstrated that whereas lower levels of child RSA suppression can confer risk for child maladaptation under adverse environmental conditions, higher levels of RSA suppression may buffer against maladjustment in such circumstances

(e.g., El-Sheikh & Whitson, 2006; McLaughlin et al., 2014; Perry et al., 2012). The present findings extend previous work by demonstrating that lower levels of child RSA suppression in response to a fear-inducing task specifically can exacerbate risk for the intergenerational transmission of internalizing symptoms. Furthermore, findings from the present study suggest that among preschoolers, higher levels of RSA suppression in response to fear-inducing stimuli serve a protective-stabilizing function in the context of maternal anxious/depressive symptoms. Our findings lend support to conclusions made by Graziano and Derefinko (2013) that perhaps negative mood induction tasks are particularly helpful for capturing the benefits of RSA suppression for child adjustment; our results suggest that this is especially true when those tasks involve fear-inducing stimuli. Interestingly, when maternal anxious/depressive symptoms were lower, children who were lower in RSA suppression in response to the fear clip showed the lowest levels of symptoms. These findings are in line with the idea that in lower risk contexts, RSA suppression may be unnecessary and may actually contribute to maladjustment (Hastings et al., 2008). Alternatively, in higher risk environments, decreases in RSA in response to fear-inducing stimuli may signify the ability to cope successfully when faced with adversity. Preparing for a flight and fight response via vagal withdrawal (Porges, 2007) is likely adaptive in the context of risk. It is important to note that even though greater RSA suppression in response to the fear task was found to serve as a protective factor in the present study, the pattern of findings suggests that regardless of the degree of RSA suppression, child symptoms were higher when maternal symptoms were also higher. Thus, maternal psychopathology is a significant risk factor for child maladjustment during the preschool period. Collectively, the present results contribute to the extant literature by demonstrating that higher and lower levels of RSA suppression in response to a fear-inducing condition serve as unique protective and risk factors, respectively, in terms of the intergenerational transmission of internalizing symptoms during the preschool period.

Child RSA suppression in response to the happiness clip also moderated the association between maternal and child internalizing symptoms, but demonstrated a pattern that was opposite to our findings from the fear clip. In particular, the relation between maternal and child internalizing symptoms was strongest in the context of higher levels of RSA suppression in response to the happiness clip. The pattern of findings is consistent with a biological sensitivity to context perspective in that greater levels of RSA suppression seemed to function differently depending on context. When maternal symptoms were lower, children with higher levels of RSA suppression in response to the happiness condition likewise showed lower levels of symptoms. However, when maternal internalizing symptoms were higher, children showed the highest levels of symptoms. The different patterns of results across the negative- and positive-mood induction tasks draw attention to the importance of examining RSA suppression in context. The results found here echo those of others in that the meaning of RSA reactivity during childhood can best be understood within the context in which it is measured (Obradović et al., 2011). Perhaps in lower-risk environments, being physiologically reactive to happiness-inducing stimuli reflects the capacity to benefit from exposure to positive emotional contexts. Alternatively, in the presence of greater environmental risk, greater decreases in RSA following exposure to happiness-inducing

conditions may represent a generalized tendency to overreact physiologically, even when faced with innocuous or pleasant situations.

It is unclear why RSA suppression in response to the sadness video did not moderate the relation between maternal and child anxious/depressive symptoms. It could be that fear is a more potent emotional context for preschoolers. In part, data regarding the validity of the video-mediated mood inductions supports this notion. Coders blind to condition rated children as looking predominately sad, in comparison to other emotions, during the sadness clip. Yet, preschoolers indicated feeling happy more than any other emotion following the sadness clip. Though it does seem initially surprising that the children were most likely to report experiencing happiness in response to the sadness clip, other research has likewise found that some children, even children older than those included in the current study, report happiness after a sadness-inducing clip (e.g., Gentzler et al., 2009). There are a few potential explanations for such findings. Young children are less adept at identifying emotions than older children. For instance, Eisenberg et al. (1988) found that in response to viewing a film that portrayed a young child who was unable to walk from a handicap, many 4-year-olds did not report sadness or sympathy. In terms of the present study, it could be that the experience of sadness in the context of a pet dying is less salient for preschoolers. Though all preschoolers can likely readily identify with a thunderstorm, many preschoolers may have never had the experience of a pet dying. It could also be that there is something about reactions during a fear-specific situation that is most meaningful in this age group in terms of the development of internalizing symptoms. Furthermore, research has suggested that activating sadness, which often involves crying and may occur in anticipation of a loss (e.g., watching a film clip in which a character is talking to a dying relative), evokes physiological responses similar to stimuli that induce fear/anxiety (for a review, see Kreibig, 2010). However, deactivating sadness, which is often synonymous with a lack of crying and occurs in response to film clips depicting a past loss, may be associated with a different pattern of autonomic responding (Kreibig, 2010). The sadness film clip used in the present study may have induced predominately deactivating, rather than activating sadness, thus potentially explaining our contrasting findings involving the fear and sadness film clips. Nonetheless, we found a high degree of correlation between RSA suppression scores in response to the fear and sadness conditions, suggesting that children in the present study likely experienced similar physiological regulation across negative emotional contexts. This high degree of correlation coincides with the fact that, albeit non-significant, the RSA suppression scores in response to the sadness clip yielded a moderation pattern that was similar in some respects to that found for RSA suppression in response to the fear clip. Further research is needed to help clarify the nature of these findings and to delineate the ways in which RSA suppression in response to film clips that induce specific subtypes of sadness, as well as fear, may impact the intergenerational transmission of internalizing problems during the preschool period.

Limitations of the current study include reliance on maternal reports of their own, as well as their children's, psychopathology symptoms. It will be important for future research to utilize multiple informants to assess the relations between mothers' and preschoolers' anxious and depressive symptoms. Additionally, findings from the present study were based on cross-sectional data. Longitudinal research on this topic will be helpful for demonstrating how child RSA suppression impacts the association between maternal and child

internalizing symptoms over time. Moreover, given that the relation between maternal and child internalizing symptoms is likely bidirectional (e.g., Hughes & Gullone, 2010), longitudinal research will help to elucidate the transactional relations between maternal and child anxious and depressive symptoms at various levels of child RSA suppression. Our sample was a community, rather than a clinical, sample, and thus the majority of mothers and children were not exhibiting clinical levels of psychopathology symptoms. Undoubtedly, this truncated the spectrum of “risk” children were exposed to in terms of maternal internalizing symptoms. Nonetheless, studying maternal and child internalizing symptoms on a continuum in a community sample allowed us to demonstrate how a wide variety of symptom severities, including subclinical levels of psychopathology, can be transmitted across generations. The behavioral observation ratings of children’s emotions during the film clips relied on 7-point scales in an attempt to capture variability in emotion expression; however, the observed ratings did not span the entire 7-point scales for fear, sadness, or happiness. A narrower scale might be more appropriate when coding preschoolers’ emotions (e.g., a 5-point scale; Lindsey & Colwell, 2013). Moreover, it will be helpful to use multiple physiological indices, along with modified behavioral ratings, to validate similar video-mediated mood inductions with preschoolers going forward. Though children were instructed to sit still and remain quiet during the adaptation segment, this instruction was not reiterated throughout the remainder of the tasks. Similarly, children’s movements and verbalizations were not documented. Given that movement (Porges et al., 2007) as well as talking (Tininenko, Measelle, Ablow, & High, 2012) can influence RSA measurements, it will be important for the present findings to be replicated with the addition of experimental controls for verbalizations and movements. However, the impact of movement on RSA measurements is likely specific to more extensive physical activity (e.g., exercise) rather than minor movements (Porges et al., 2007), suggesting that the impact of movement in the present study was likely negligible. Counterbalancing of the fear and sadness videos was employed to control for potential order effects; however, given the lack of recovery periods between videos, we cannot completely rule out that RSA suppression carried over into subsequent tasks. Finally, the present study focused on mothers; however, research has documented the role of paternal internalizing symptoms in children’s maladjustment as well (Ramchandani, Stein, Evans, & O’Connor, 2005).

In sum, findings from the present study strongly support the combined contributions of maternal psychopathology symptoms and children’s RSA responses to fear- and happiness-inducing stimuli to individual variability in preschoolers’ adjustment. The results can help to refine existing conceptualizations of the intergenerational transmission of internalizing symptoms between mothers and their young children. Future research would benefit from examining whether incorporating physiological assessments, as well biofeedback strategies for teaching children how to amplify or reduce physiological reactivity as needed, into established behavioral treatment modalities can facilitate early intervention efforts aimed at promoting well-being amongst children at familial risk for the development of internalizing symptoms.

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Highlights

- Child RSA moderated the relation between mom and child internalizing problems.
- Lower fear RSA suppression exacerbated risk for child internalizing problems.
- Higher fear RSA suppression served a protective-stabilizing function.
- Happiness RSA suppression followed a biological sensitivity to context framework.
- Results can advance models of the intergenerational transmission of psychopathology.

Figure 1.

Children with lower levels of RSA suppression in response to the fear clip showed greater anxious/depressive symptoms when maternal anxious/depressive symptoms were higher than when maternal symptoms were lower.

Figure 2.

Children with higher levels of RSA suppression in response to the happiness clip showed greater anxious/depressive symptoms when maternal anxious/depressive symptoms were higher than when maternal symptoms were lower.

Table 1
Means, Standard Deviations and Ranges for Observer-Rated Emotions in Each Film Clip

	Fear Clip		Sadness Clip		Happiness Clip	
	<i>M</i> (SD)	Range	<i>M</i> (SD)	Range	<i>M</i> (SD)	Range
Observer-Rated Emotions						
Fear	2.24 (0.98)	1.00–5.00	1.47 (0.55)	1.00–3.00	1.40 (0.54)	1.00–3.00
Sadness	1.41 (0.57)	1.00–3.00	1.77 (0.58)	1.00–3.00	1.52 (0.72)	1.00–5.00
Happiness	1.27 (0.57)	1.00–4.00	1.28 (0.56)	1.00–4.00	1.71 (0.84)	1.00–4.00

Note. All means of the observer-rated emotions were significantly ($p < .05$) greater for the intended emotion of the film clip compared to means of the other observer-rated emotions.

Table 2

Intercorrelations Among Main Study Variables

Variable	1	2	3	4	5	6	7	M (SD)	Range
1. Maternal Anxious/Depressive Symptoms	—	.45**	-.16	.30**	-.12	.07	-.002	0.44 (.50)	0.00, 3.21
2. Child Anxious/Depressive Symptoms		—	-.32**	.22	.09	.03	.14	2.50 (2.42)	0.00, 13.00
3. Total Household Income			—	-.10	.03	.02	.02	4.26 (3.06)	1.00, 9.00
4. Child Neutral RSA				—	.38**	.48**	.37**	.00 (1.37)	-3.49, 3.42
5. Child Fear RSA Suppression					—	.65**	.40**	-.05 (0.80)	-2.59, 1.30
6. Child Sadness RSA Suppression						—	.36**	-.016 (0.71)	-2.16, 1.20
7. Child Happiness RSA Suppression							—	-.05 (.73)	-2.41, 1.74

Note. All RSA suppression scores involve the residual RSA scores from regressing RSA during the tasks against respiration rates for those specific tasks. Neutral RSA also represents the residual of regressing neutral RSA mean values against respiration rates for that condition.

**
 $p < .01$.

*
 $p < .05$.

Table 3
Child Fear RSA Suppression as a Moderator of the Relation Between Maternal and Child Anxious/Depressive Symptoms (N = 108)

Outcome Variable	b (SE)	T	R ²	F (5, 102)	95% CI
Child Anxious/Depressive Symptoms			.32	9.58 **	
Maternal Anxious/Depressive Symptoms	1.87 (.44)	4.28 **			1.01, 2.73
Child Fear RSA Suppression	.37 (.31)	1.22			-.23, .98
Total Household Income	-.21 (.07)	-3.06 **			-.35, -.08
Neutral RSA	.05 (.18)	.29			-.30, .40
Interaction Term ^a	-1.11 (.52)	-2.11 *			-2.13, -.08

Note. All regression coefficients are unstandardized.

**
 $p < .01$.

*
 $p < .05$.

^a Interaction term is the interaction of maternal anxious/depressive symptoms and child RSA suppression in response to the fear task.

Table 4
Child Happiness RSA Suppression as a Moderator of the Relation Between Maternal and Child Anxious/Depressive Symptoms (N = 108)

Outcome Variable	b (SE)	t	R ²	F (5, 102)	95% CI
Child Anxious/Depressive Symptoms			.33	9.97 ^{**}	
Maternal Anxious/Depressive Symptoms	1.57 (.45)	3.48 ^{**}			.69, 2.45
Child Happiness RSA Suppression	.34 (.32)	1.07			-.29, .97
Total Household Income	-.21 (.07)	-3.00 ^{**}			-.34, -.07
Neutral RSA	-.01 (.18)	-.07			-.36, .33
Interaction Term ^a	1.32 (.57)	2.31 [*]			.20, 2.44

Note. All regression coefficients are unstandardized

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

^{*}
 $p < .05$.

^a Interaction term is the interaction of maternal anxious/depressive symptoms and child RSA suppression in response to the happiness task.