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Mediating and Moderating Effects of Child Respiratory Sinus Arrhythmia Reactivity in the Association Between Early Childhood Adversity and Later Adjustment

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Abstract

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Early childhood adversity has been shown to predict mental health problems, although the influence of adversity on child adjustment varies significantly (Caspi et al., 2002). Biologically based individual differences in arousal and regulatory systems are thought to influence the relation between adversity and adjustment. Individual differences in the regulation of physiological reactivity have been related to adjustment problems, although less is known about how adversity and physiological regulation interact (Graziano & Derefinko, 2013). One indicator of physiological regulation, cardiac vagal control, can be measured by Respiratory Sinus Arrhythmia Reactivity (RSA-R). This study examined whether RSA-R mediates and moderates the relation between childhood adversity (e.g., stressful events, low-income, parental psychopathology) and adjustment (externalizing problems, internalizing problems, social

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competence). There are proposed conceptual models for understanding the relations among childhood adversity, physiological regulation, and adjustment outcomes: Diathesis-stress, Biological Sensitivity to Context (BSC) and the Adaptive Calibration Model (ACM). Although there is some evidence to support these models, they have not been tested using longitudinal data, nor have they been tested alongside each other. To fully test the influence of children's context and physiological regulation on adjustment, RSA-R is also examined as a moderator in the relation between indicators of supportive environments (family functioning, positive parenting) and adjustment. RSA-R was collected from a community sample of 306 children when they were 3- and 4-years-old. Exposure to childhood adversity and supportive context were assessed by mother report when the children were 3-years-old. Adjustment was collected when the children were 8-years-old. Results suggest RSA-R moderates, but does not mediate, the relation between both childhood adversity and supportive contexts and adjustment. Children with high RSA-R had more externalizing and internalizing problems in the context of low family income while all children had fewer problems in the context of high family income. In contrast, children with low RSA-R fear had more externalizing problems when exposed to high cumulative risk. Examining supportive contexts, children with high RSA-R had more externalizing and internalizing problems in the context of high family functioning, while children with low RSA-R frustration had more externalizing and internalizing problems, and lower social competence in the context of low family functioning. Children with high RSA-R had more externalizing and internalizing problems in the context of low positive parenting and all children had few problems in the context of high positive parenting. These results vary by the type of early adversity or supportive context, the task during which RSA-R is collected, as well as the adjustment outcome being predicted.

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Mediating and Moderating Effects of Child Respiratory Sinus Arrhythmia Reactivity in the Association Between Early Childhood Adversity and Later Adjustment

Childhood adversity predicts mental health problems that begin in early childhood and persist throughout the lifespan (Luthar, 2006; Rutter, 1983; Sameroff, 2006). Children experiencing adversity such as poverty, single parent households, and parental psychopathology have been identified as at greater risk for psychopathology (Burchinal, Roberts, Hooper, & Zeisel, 2000; Cummings & Davies, 2002; Essex, Klein, Cho, & Kalin, 2002), and early experiences of adversity can put children on trajectories for emotional, social, and behavioral problems (Blair & Raver, 2012; Goodman & Gotlib, 1999). However, not all children experiencing adversity are susceptible to adjustment problems. Research has demonstrated that individuals vary in the extent to which they are influenced by childhood adversity (Caspi et al., 2002) and how much they benefit from interventions and positive support (Blair, 2002; Quas, Bauer, & Boyce, 2004). It has been suggested that individual differences in the regulation of physiological reactivity result in some individuals being more vulnerable to adverse environments, while those same individuals are more likely to benefit from positive environments, such as interventions and support (Bakermans-Kranenburg & van Ijzendoorn, 2007; Belsky 1997; Boyce & Ellis, 2005; Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2011). Respiratory Sinus Arrhythmia Reactivity (RSA-R), an indicator of the regulation of stress reactivity, is understood to be a marker of children's susceptibility to their environment. The present study will assess how RSA-R operates in conjunction with childhood adversity to predict later adjustment.

Respiratory Sinus Arrhythmia (RSA)

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RSA is a sensitive index of the variation in heart rate controlled by the vagus nerve fibers. Structurally, the vagus is the tenth cranial nerve that contains fibers that communicate between the brain structures and visceral organs. While the autonomic nervous system increases heart rate and respiratory rate in addition to other physiological changes in response to perceived danger or threatening situations, the parasympathetic nervous system helps to restore homeostasis during perceived safety. The parasympathetic nervous system supports biological and behavioral regulatory abilities (Porges, 2007). According to the polyvagal perspective, vagal tone in calm states (baseline) measures the ability of the mammal to maintain homeostasis by decreasing the sympathetic nervous system activity and slowing down the heart rate by increasing output from the vagus nerve to the sino-atrial node of the heart (Porges, 2007). Vagal tone during stressful situations speeds up the heart rate by removing the 'brake' on the vagal nerve and decreasing the vagal output to the sino-atrial node. By measuring the changes from baseline vagal tone to stressful situations we are able to examine individual differences in regulation of the vagal brake. According to the polyvagal perspective, successful vagal regulation is when the vagal tone decreases from baseline to a stressful situation, indicating the withdrawal of RSA (Porges, 2007).

The vagal brake developed to slow down the organs and promote social engagement and behavior regulation by the parasympathetic ventral vagal system (Porges, 2007). In safe environments, the vagal brake should slow physiological reactivity to allow for successful social engagements. In threatening situations, the brake on the sympathetic nervous system is removed to prepare the body for a fight or flight response. While this reverse phylogenetic response system is adaptive in many ways, long-term use of these structures might change the response system to promote continued use of the more primitive systems, such as the fight/ flight response

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(Beauchaine, 2001). For children faced with chronic stress or dangerous situations, this may result in the over activity of the stress response systems, even in non-threatening situations (Whitson & El-Sheikh, 2003).

RSA is a noninvasive measure of the parasympathetic nervous system stress response and is uniquely suited to record instantaneous responses to contexts, unlike other noninvasive methods (Beuchaine, 2001; Obradović & Boyce 2012; Porges, 2001, 2003, 2007). RSA is measured by using an echocardiogram (EKG) to assess the amount of time between heartbeats. When measured at baseline (resting period), RSA is understood to be a measure of an individual's autonomic regulation and has been thought of as an indicator of stable individual differences associated with emotional reactivity (Beauchaine, 2001; Porges, 2007). RSA measurement during a stressful task, typically an emotion-eliciting task, is an indicator of arousal in reaction to the environment (Belsky & Pluess, 2009; Obradović, Bush, & Boyce, 2011; Obradović, Bush, Stamperdahl, Adler, & Boyce, 2010). A change in RSA from baseline in response to stressful situations (RSA-R) is considered an index of regulatory abilities and is thought to support regulation of behavior and attention. Successful regulation is when RSA decreases from baseline to challenging task (RSA withdrawal), which is theorized to assist in coping with challenges by increasing heart rate (Beauchaine, 2001; Porges, 2001). RSA augmentation is when RSA increases from baseline to a challenging task, which results in a negative RSA score. RSA-R has been extensively studied and associated with indicators of both positive and negative adjustment.

RSA-R and Child Adjustment

RSA has been associated with a wide range of mental health outcomes. Polyvagal theory states that successful vagal regulation in highly stressful situations is RSA withdrawal (or high

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RSA-R), which helps regulate behavior in challenging contexts. When a challenging situation requires more engagement, the withdrawal of the vagal brake assists in adaptive regulation. Higher RSA-R has been related to better self-regulation and emotion regulation (e.g., Huffman et al., 1998; Gentzler, Santucci, Kovacs, & Fox, 2009; Calkins, 1997; Suess, Porges, & Plude, 1994), higher sociability (Doussard-Roosevelt, Montogomery, & Porges, 2003), fewer externalizing behaviors (e.g., Mezzacappa et al., 1997; Pine et al., 1998), and to a lesser extent, fewer internalizing problems and better social competence (e.g., Boyce et al., 2001; for review see Graziano & Derefinko, 2013). Generally, a negative relation has been found between RSA-R and children's problem behaviors (Boyce et al., 2001; Calkins, Graziano, & Keane, 2007; Calkins & Keane, 2004). However, evidence to the contrary also exists showing higher RSA-R is associated with more adjustment problems (Boyce et al., 2001; Doussard-Roosevelt et al., 2003; Obradović, 2010; Obradović et al., 2011).

Vagal augmentation, or lower RSA-R, is thought to be adaptive when the environment is perceived as safe. The sympathetic nervous system activates as the myelinated vagus nerve inhibits the sino-atrial node (Porges, 2001). This has been found to be adaptive when social engagement is required, such as in a social challenge context (Katz, 2007; Hastings et al., 2008), although RSA withdrawal (or higher RSA-R) has also been found to be adaptive in social contexts as well (Calkins 1997; Calkins, Graziano, & Keane, 2007). In addition, polyvagal theory would suggest that vagal augmentation in stressful situations (lower RSA-R) is associated with internalizing problems and externalizing problems. Some studies have found associations between lower RSA-R and more adjustment problems (Beauchaine, 2001; Boyce et al., 2001; Calkins & Dedmon, 2000; Musser et al., 2011; Thayer & Lane, 2000). However, studies have also failed to find a correlation between RSA-R and adjustment problems (e.g., Beauchaine,

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Gatzke-Kopp, & Mead, 2007; Eisenberg, Huerta, & Edwards, 2012; Erath, Tu, & El-Sheikh, 2011) and other studies have found the opposite, with higher RSA-R associated with more adjustment problems (Boyce et al., 2001; Hastings et al., 2008; Hinnant & El-Sheikh, 2009).

Porges' theory posits that greater RSA-R during stressful situations is beneficial for children in all contexts. However, contradictory findings in the association between RSA-R and adjustment outcomes may be due to the differences in early exposure of adversity. Understanding the way in which contextual factors are associated with children's physiological regulation may help differentiate why some children with higher RSA-R experience more positive adjustment. For children exposed to greater early adversity a different pattern of physiological regulation may be more beneficial, as opposed to those raised in consistent, supportive environments.

In relation to the effects of adversity, it is possible that RSA-R might moderate or mediate the association between children's experiences of stress or adversity and adjustment, and conjecture about this can be guided by existing theoretical models of individual differences in response to contextual experiences. Some models, such as Diathesis Stress and Biological Sensitivity to Context (BSC), suggest that RSA-R may interact with early childhood adversity to predict later adjustment. Another model, the Adaptive Calibration Model, suggests that RSA-R mediates the relation between adversity and adjustment, with the physiological system recalibrating and changing based on the early environment. These models provide guidance for developing hypotheses and interpreting findings when examining RSA-R as a mediator and moderator of the relation between exposure to childhood adversity and adjustment.

RSA-R as a Moderator in the Relation Between Adversity and Adjustment

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Children's ability to regulate their stress reactivity has been suggested to condition the effects of adversity on adjustment. The impact that the children's environment has on their later adjustment may depend on children's physiological regulation. Two models, Diathesis Stress Model and Biological Sensitivity to Context, hypothesize that children will respond differently to their experiences depending on individual differences in reactivity, implying moderating effects of RSA-R. According to one model, the Diathesis Stress Model, children who have particular vulnerabilities are more adversely impacted by stress and are at greater risk for negative outcomes. Derived from the Diathesis Stress Model, Biological Sensitivity to Context (BSC; Boyce & Ellis, 2005) hypothesizes that highly sensitive (or reactive) children are at greater risk for negative outcomes in contexts of adversity. Children who are more sensitive are hypothesized to display greater physiological reactivity in both positive and negative contextual factors, and therefore may also benefit more from positive contexts. These models help guide our predictions when testing interactions among adversity, RSA-R, and adjustment outcomes.

In interaction with measures of adversity, some studies have found that greater RSA-R was related to more externalizing problems (Conradt et al., 2016; Conradt et al., 2014; Dengnan, Calkins, Keane, & Hill-Soderlund, 2008; Hastings et al., 2008; Obradović et al., 2011; Obradović et al., 2010), while others studies reported lower RSA-R was related to more externalizing and internalizing problems and less social competence in the context of adversity (Diamond, Fagundes, & Cribbet, 2012; El-Sheikh, 2001; El-Sheikh & Whitson, 2006; Hastings, Klimes-Dougan, Kendziora, Brand, & Zahn Waxler, 2014; Katz, 2007; Katz & Gottman, 1997; Leary & Katz, 2004; McLaughlin et al., 2013; Whitson & El-Sheikh, 2003). Furthermore, the majority of studies found no effects of the interaction between RSA-R and adversity in predicting externalizing problem, internalizing problems, or social competence (Conradt et al.,

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2016; Conradt et al., 2014; Eisenberg et al., 2012; El-Sheikh & Whitson, 2006; McLaughlin et al., 2013; Obradović et al., 2010; Sijtsema, Van Roon, Groot, & Riese, 2015; Zhang & Gao, 2015). Given these mixed findings and the large number of nonsignificant results, there is no clear pattern of RSA-R and adversity interactions predicting externalizing problems. It is likely that RSA-R plays a role in positioning children at-risk for developing internalizing problems and lower social competence in the context of high adversity, although the direction of effects is unknown given the contradictory evidence.

Supportive environment. In addition to the influence of children's exposure to adversity on the development of adjustment problems, exposure to supportive or positive environments may also interact with the regulation of physiological reactivity to influence later adjustment. Children with physiological profiles who are more sensitive to their environments and experience greater maladjustment in the context of adversity may also experience more positive adjustment in the context of supportive environments. Conversely, children who are less sensitive to their environments may not benefit from positive environments. Both diathesis-stress and BSC hypothesize specific outcomes from supportive contexts. Diathesis-stress suggests that in supportive contexts, both children with low and high reactivity have fewer problems compared to those in adverse environments, although children who are sensitive may still have more adjustment problems compared to children who are less sensitive. BSC hypothesizes that in supportive contexts, children who are more physiologically sensitive to their environments will perform better, and have fewer problems, compared to children who are less sensitive to their environments.

Many studies have operated under the assumption that the lack of adversity is equivalent to a supportive environment (Conradt, Measelle, & Ablow, 2013; Ellis, Essex, & Boyce, 2005;

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Essex et al., 2011; Obradović et al., 2011). However, the lack of adversity can be an extremely different environment than one that is considered supportive (Obradović et al., 2010). For example, a mother who does not display hostility may be different from a mother who displays high warmth. This evolutionary hypothesis specifies that children raised in supportive conditions are disproportionately sensitive to their environment in order to maximize the benefits from those environments (Belsky & Pluess, 2009).

Only three studies have examined interactions between supportive environments and RSA-R in relation to adjustment outcomes. RSA-R in preschoolers did not moderate the relation between supportive maternal reactions and child emotion regulation (Blandon, Calkins, Keane, & O'Brien, 2010) or child negativity (Perry, Calkins, Nelson, Leerkes, & Marcovitch, 2011). One significant interaction was reported out of ten interactions analyzed in one study (Hastings et al., 2014). High supportive emotion socialization predicted fewer mother-reported internalizing problems in 11-16 -year-olds who showed higher RSA-R in response to fear-eliciting video clips, but not youths who showed less RSA-R. There were no differences in environments of high supportive parenting (Hastings et al., 2014). To support BSC, we would expect the more sensitive children (higher RSA-R) to have fewer internalizing problems compared to less sensitive children (lower RSA-R) in highly supportive contexts. The current study uniquely examines indicators of supportive environments (positive parenting and positive family functioning) and indicators of childhood adversity in the same sample.

While RSA-R has been tested as a moderator in the relation between supportive and adverse contexts and adjustment, gaps in the literature remain. Specifically, there are few studies examining RSA-R in the preschool period with a wide range of adversity in a longitudinal sample. Additionally, moderation is typically tested without using a measure of positive social

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adjustment as an outcome, such as social competence. This is important to include, as the polyvagal theory specifically associates the vagal brake with promoting social engagement by the parasympathetic ventral vagal system (Porges, 2007). Finally, curvilinear effects are frequently not tested. The polyvagal theory and BSC hypothesize that there may not be a linear association between stress responsivity and exposure to early adversity. Instead, some have suggested that some exposure to stress or adversity is beneficial for the stress response system and that there is a curvilinear, or U- shaped relation with the highest level of physiological vulnerability found at both low and high levels of exposure to adversity and moderate levels of exposure to adversity being optimal (Bush, Obradović, Adler, & Boyce, 2011; Ganzel, Morris, & Wethington, 2010; Nielsen, Seeman, & Hahn, 2007). Using a large longitudinal sample with a wide range of adversity and supportive context indicators will allow for the unique opportunity to comprehensively examine RSA-R as a moderator.

RSA-R as a Mediator of the Relation Between Adversity and Adjustment

Alternatively or concurrently, exposure to early adversity may directly influence a child's parasympathetic nervous system by changing the stress response system which then influences child adjustment throughout development. Alterations to physiological regulation caused by early exposure to adversity may in turn impact the child's adjustment outcomes. One theory that helps to guide this hypothesis, the Adaptive Calibration Model (ACM), states that the stress response system mediates the relation between the environment and adjustment outcomes by receiving information from the environment and converting it into behavioral and physiological responses to the environment (Del Giudice, Ellis, & Shirtcliff, 2011). The stress response system calibrates based on early contextual influences to adjust the system's susceptibility to the environment. The ACM hypothesizes that contextual unpredictability results in frequent, high

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intensity activation of the stress response system, which includes the parasympathetic nervous system. A secure, predictable environment results in infrequent, low intensity activation of the stress response system. The stress response system is thought to adaptively respond to the environment to improve chances of survival. Individual differences in the stress response system result from conditional adaptation, in contrast to models that suggest maladjustment results from dysfunctional development. The ACM hypothesizes that the role of the stress response system is to adjust the person's response to meet the physical and social demands of their environment, as well as encode information about the environment and regulate the person's responses in ways that increase their chance for survival. RSA-R mediating that relation would suggest that vagal regulation is a potential mechanism through which childhood adversity influences adjustment. Experiences of adversity are predicted to shape reactivity, with very low and very high levels of stress predicting high reactivity (higher RSA-R).

There is little evidence suggesting RSA-R mediates the relation between childhood adversity and adjustment. RSA-R did not mediate the relation between child maltreatment and later PTSD symptoms in adolescent females (Shenk, Putnam, & Noll, 2012) nor did it mediate the relation between early childhood adversity and later antisocial behavior in 16-year-olds (Sijtsema et al., 2015). RSA-R mediated the relation between observed maternal negative control and child externalizing problems and approached significance in predicting self-regulation in preschoolers aged 2-5, in that children with lower RSA-R had fewer problems and greater self-regulation in the context of negative control parenting (Hastings et al., 2008). However, RSA-R did not mediate the relation between maternal negative control and internalizing problems in the same sample (Hastings et al., 2008). Preschool may be the optimal time to capture the mediational effects of RSA-R, as the vagal nerve is in the process of

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myelination, and thus, may adapt based on early experiences. Noteworthy, the majority of the participants in this study were from middle to upper class families. A sample that includes the full range of exposure to adversity may allow for the detection of mediating effects of RSA-R.

While there seems to be little evidence in the literature supporting RSA-R mediating the relation between childhood adversity and adjustment limiting the conclusions that can be drawn about RSA-R as a mediator, the studies that have been conducted indicate that RSA-R may not mediate the relation between adversity and adjustment in middle childhood or adolescence. There was some evidence for RSA-R as a mediator in preschoolers, tentatively suggesting that there may be some recalibration of the parasympathetic nervous system in the preschool period. Importantly, in each of these studies where RSA-R did not act as a mediator, both adversity and adjustment were measured concurrently. It is possible that RSA-R mediates the relation between earlier adversity and later adjustment, but this relation is undetectable if all three variables are assessed at the same time point. Furthermore, one intervention study found that children who were randomly placed with a foster family before 18 months exhibited lower RSA-R at age 12 during a stressful social situation compared to children were placed in a foster home after 18 months, suggesting the environment may be one source of change for RSA-R (McLaughlin et al., 2015).

It has been hypothesized that instead of a linear relation, a curvilinear, U-shaped association exists between physiological regulation and stressful environments, suggesting a disproportionate number of children exposed to high levels of adversity and high levels of supportive contexts to have high physiological regulation. ACM hypothesizes a curvilinear, U-shaped association between high and low levels of adversity exposure and physiological regulation. Additional research is needed to test this hypothesis, specifically longitudinal studies

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including children whose experiences represent the full range of adversity, in order to increase our understanding of the mediational effects of RSA-R.

RSA-R Fear and Frustration

Many different tasks are used to measure RSA-R. Most commonly, studies use a wide range of emotion-eliciting tasks, including tasks designed to elicit frustration or fear. Other types of tasks have been used, such as mood inducing tasks or cognitively challenging tasks. While it is unclear as to whether the type of challenging task or emotion that is elicited influences the associations RSA-R has with adversity or adjustment outcomes, some studies have found that frustrating tasks result in greater RSA withdrawal compared to other mood inducing tasks (Calkins et al., 2007; Musser et al., 2011), implying that some tasks require more or less RSA-R than others. The type of task needs to be considered when assessing RSA withdrawal, especially considering that typically, multiple different types of tasks are aggregated.

The different tasks may also influence the adaptive response of cardiac vagal tone. An adaptive response to a stressful or threatening task may be the suppression of RSA in order to activate physiological resources to handle the stressor. In a more positive context or one that is not seen as threatening, an adaptive response may be stable RSA from baseline to the task, or augmentation (Hastings et al., 2008).

There has been evidence of differences in predicting internalizing and externalizing problems based on the type of emotion-eliciting task (Fortunato, Gatzke-Kopp, & Ram, 2012). RSA-R collected during tasks eliciting fear or sadness (classified as withdrawal-based emotions) was associated with internalizing symptoms, whereas anger and happiness eliciting tasks (classified as approach-based emotions) was associated with externalizing problems. RSA-R may in fact differentiate based on whether or not the child feels threatened. Calkins and Dedmon

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(2000) found that toddlers exhibited more RSA-R during emotionally and cognitively challenging tasks compared to an audiotape of a toddler crying. Other researchers have posited that RSA withdrawal (decrease in RSA from baseline to reactivity) may be associated with fear, which requires regulation from the fight or flight response, but RSA augmentation (increase of RSA from baseline to reactivity) to be associated with sadness (Kreibig, 2010). It is important to keep RSA-R collected during fear- and frustration- eliciting tasks separately in order to clarify the associations between RSA-R during unique emotional tasks and later adjustment problems. Furthermore, it can be theorized that early childhood adversity would be associated with differences in RSA-R during frustration and fear eliciting tasks. Lower RSA-R collected during a fear-eliciting task might be associated with more internalizing problems when in the context of adversity, as physiological dysregulation of fear is associated with anxiety disorders. Lower RSA-R collected during a frustration eliciting task may be associated with externalizing problems in the context of adversity, as frustration dysregulation is commonly associated with externalizing problems, such as ADHD or oppositional defiant disorder.

Childhood Adversity

Low income has been associated with parental stress and mental health problems, family conflict, residential instability, and other risk factors that have long-term effects on children's mental health and adjustment outcomes (Ackerman, Kogos, Youngstrom, Schoff, & Izard, 1999; Evans, 2003; Linver, Brooks-Gunn, & Kohen, 2002; Mistry, Vandewater, Huston & McLoyd, 2002). Using a cumulative risk approach, which assumes that while overlapping, most of these risk factors are not redundant, allows for a more powerful approach than using a single risk factor when predicting behaviors (Conradt et al., 2013; Evans & Kim, 2012; Conradt et al., 2016). RSA-R has been associated with individual indicators of adversity, such as parental

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psychopathology (Blandon, Calkins, Keane, & O'Brien, 2008; Shanahan, Calkins, Keane, Kelleher, & Suffness, 2014), marital conflict (Cipriano, Skowron, & Gatzke-Kopp, 2011; El-Sheikh & Whitson, 2006; El-Sheikh, Harger, & Whitson, 2001; Katz & Gottman, 1997; Whitson & El-Sheikh, 2003), and child abuse (Skowron, Cipriano-Essel, Gatzke-Kopp, Teti, & Ammerman, 2014). As mentioned above, conflicting results have been reported in the interaction between adversity exposure and physiological regulation predicting adjustment. One reason for these conflicting results may be that many studies only assess one indicator of adversity, which may not capture the full picture of the child's environment. However, it has been suggested that a cumulative risk factor, including multiple indices of adversity, would most effectively capture the context in which children's physiological regulation would respond to or interact with the environment (Conradt et al., 2016; Conradt et al., 2014; Gordis, Feres, Olezeski, Rabkin, & Trickett, 2010; McLaughlin et al., 2013; Obradović et al., 2010). A cumulative risk variable may interact with physiological regulation to predict adjustment more consistently compared to using a single index of risk.

This Study

This research clarifies the role of physiological regulation in the relation between childhood adversity and child adjustment. This study adds to the existing literature by conducting rigorous tests of two models of the relation among physiological regulation, adversity, and adjustment. By examining both moderation and mediation concurrently with the same dataset, this study will clarify the moderation and mediation effects of regulation in the relation between contextual risk and adjustment. In addition, much of the current literature examines only either high or low risk children. This study investigated the influence of RSA-R across a wide range of adversity, including both positive and negative contexts, and with a range

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of mental health outcomes. Finally, the current study examined the varying effects of two unique indicators of childhood adversity, economic adversity and cumulative risk. By elucidating the relation between a physiological indicator of regulation, childhood adversity, and child adjustment, we may better understand which children are at greatest risk for maladjustment.

The first aim of this study was to test RSA-R as a moderator of the relation between adversity and adjustment. RSA-R is hypothesized to moderate the relation between childhood adversity and child adjustment and the interaction of childhood adversity and RSA-R would significantly improve the predictive ability of child adjustment outcomes. Based on previous literature and the polyvagal theory, I hypothesized that children who had lower RSA-R would have more adjustment problems when exposed to high childhood adversity. In addition, given the polyvagal theory's understanding of the importance of higher RSA-R in successful social engagement, I hypothesized that children with higher RSA-R would have higher levels of social competence in adverse contexts. Curvilinear effects are expected to be significant, with children with moderate exposure to adversity having the highest levels RSA-R, and children with the highest and lowest levels of exposure to adversity having lower levels of RSA-R. I expect reverse J-shaped effects, with highest levels of exposure to adversity having the lowest levels of RSA-R, and the lowest level of exposure to adversity having slightly lower RSA-R than moderate levels of exposure to adversity.

This study is unique in that RSA will be collected during both a fear- and frustration-eliciting task. When exposed to childhood adversity, children with lower RSA-R during the fear-eliciting task are expected to have more internalizing problems. Children with lower RSA-R in

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the frustration-eliciting task are hypothesized to exhibit more externalizing behaviors in the context of greater adversity.

As an exploratory aim, I examined whether the interaction of RSA-R and supportive contexts would result in some children having more positive outcomes. Based on the previous literature, I hypothesized that there will be differences in adjustment problems at low levels of supportive environments such that children with low RSA-R will have more problems at low levels of supportive contexts. Based on the previous literature, I hypothesized that there will be no differences in adjustment outcomes based on RSA-R at high levels of supportive environments.

The second aim of the study was to test RSA-R as a mediator of the relation between childhood adversity and adjustment problems. I hypothesized that RSA-R will mediate the relation between childhood adversity and child adjustment outcomes, where children who are exposed to more adversity will have lower RSA-R, which will then result in more adjustment problems (Baron & Kenny, 1986; Selig & Preacher, 2009). Curvilinear effects are expected to be significant, with a greater number of children who were exposed to high and low levels of adversity having lower levels of RSA-R.

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Method

Participants

This study is part of a larger longitudinal study conducted by Liliana Lengua, PhD. (R01HD054465) examining the development of self-regulation in a group of children at elevated risk for adjustment problems. This larger study uses a longitudinal design to test how childhood adversity, physiological regulation, and parenting influence the development of self-regulation and adjustment outcomes. Participants are a community sample (n = 306) of children assessed at five time points, beginning when the children were 36-months old (*M* = 36.75 months, *SD* = 1.31, Range = 35.52-40.34). The first, third, and fifth time points will be used for the purposes of this study. The first four time points are separated by 9 months, and the fifth time point is two years after the fourth time point. Henceforth, Time 1 will be referred to as T1, Time 2 as T2, and Time 3 as T3. At T2, the children were 54-months of age (*M* = 55.08 months, SD = 1.13, Range = 54.70-76.19). Data for T3 was collected when children were 8 years old (M = 97.07, SD = 4.83, Range = 84.00-111.00).

The majority of participants (68%) were recruited from the University of Washington Subject Pool, a voluntary database of mothers who consented to be contacted for participation in research studies. University staff approached mothers at the University of Washington Medical Center after giving birth. Researchers at University of Washington are given access to this database by university staff for a fee. The remainder of the participants (32%) were recruited from various public and privately funded locations including daycares, health clinics, charitable agencies, preschools, libraries, and organizations serving low income families (e.g., food banks, Catholic Community Services). These participants were sent an informational letter explaining the study goals and providing contact information for the study coordinator.

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The child and his/her female caregiver came to the university for a laboratory visit including neuropsychological assessments, questionnaires, and physiological data collection. The participants span the full range of income, with 29% of participants at or near poverty (at or below 150% of the 2009 federal poverty threshold), 28% low income (between poverty and local median income), 25% middle to upper income (between local median income and $100,000), and 18% affluent (above $100,000). This allows for equal representation of both supportive and stressful contexts. Children with disabilities or families who did not speak English were excluded. Participants were recruited from various public and private facilities including preschools, daycares, and health clinics. At T1, participants were 50% female, 64% European American, 10% Latino or Hispanic, 9% African-American, 3% Asian American, 2% Native or American Indian, and 12% with other or multiple racial backgrounds.

Missing Data

Complete data was available for child gender, family income and cumulative risk variables. Ninety-eight percent of data regarding family functioning are available, and 94% of positive parenting data are available. Complete data were available for mother reported child social competence, internalizing problems, and externalizing problems for 99% of participants at T1 and 92% of participants at T3. There were significantly more missing data for the RSA-R variables due to equipment malfunction and child difficulty or noncompliance with the tasks, and therefore, RSA-R data cannot be considered missing at random. At T1, data for RSA-R in the fear tasks were available for 65% of children (n = 200), and data for RSA-R in the frustration task were available for 62% of children (n = 191). At T3, data was available for 71% of children for RSA-R fear (n = 218) and 82% of children for RSA-R frustration (n = 252).

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Participants with missing data on any variable were compared to participants with complete data on all variables. For variables included in the moderation analyses examining childhood adversity, t-tests indicated that participants with any missing data (n = 141) differed from those with no missing data (n = 165) on family income. Families without any missing data reported higher incomes (missing, $M = 8.24$, $SD = 3.97$; no missing, $M = 9.18$, $SD = 3.52$, $t(304) = 2.10$, $p = .036$). However, the relation of family income to missingness was a small effect ($r = .12$) and did not reach thresholds for introducing substantial bias ($r > .40$; Collins, Schafer, & Kam, 2001), which suggests little bias was introduced to missing data. For variables included in the moderation analyses examining supportive contexts, t-tests indicated that participants with any missing data (n = 146) differed from those with no missing data (n = 160) on child gender, positive parenting, and T3 internalizing problems. Families without any missing data were more likely to be girls (missing, $M = 0.56$, $SD = 0.50$; no missing, $M = 0.44$, $SD = 0.50$, $t(304) = -2.18$, $p = .030$) and have more positive parenting (missing, $M = 3.91$ $SD = 0.46$; no missing, $M = 4.07$, $SD = 0.38$, $t(285) = 3.23$, $p = .001$). In addition, families without any missing data were more likely to have children with fewer internalizing problems at the end of the study (missing, $M = 6.95$ $SD = 5.60$; no missing, $M = 5.69$, $SD = 4.72$, $t(235) = -2.01$, $p = .046$). However, the relation of child gender, positive parenting, and internalizing problems were small ($r = .12$, $r = .19$, $r = .12$ respectively) and did not reach thresholds for introducing substantial bias. For variables included in the mediation analyses examining childhood adversity, T-tests indicated that participants with any missing data (n = 102) differed from those with no missing data (n = 204) on family income. Families without any missing data reported higher incomes (missing, $M = 8.01$, $SD = 4.06$; no missing, $M = 9.11$, $SD = 3.82$, $t(304) = 2.33$, $p = .020$). However, the relation of family income to missingness was a small effect ($r = .14$). Again, this suggests little

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bias was introduced due to missing data. Therefore, analyses included the complete sample of 306 participants.

Procedure

Children came to the University of Washington with their female primary caregiver for structured 2-hour laboratory visits. Mother consent and child assent were obtained prior to the assessment. Children then participated in a series of behavioral and neurocognitive tasks administered by trained research assistants. A physiological baseline was collected for the children during a neutral task. Mothers were asked to answer a series of questionnaire measures in an adjacent room while tasks were administered to children. Questionnaires were administered to mothers by trained research assistants, who read the instructions and each item to mothers to minimize interpretation errors and address potential problems with literacy for parents. Assessment procedures were identical across the first four time points. Families received $70 compensation for participation at Time 1, $110 at Time 2, and $50 at Time 3. The lower compensation at Time 3 was due to a shorter laboratory visit (30 minutes as opposed to 2 hours due to funding constraints).

Measures

Family Income. Parents were asked to report information on family income for their household from all sources at T1. Household income was reported on a 14-point Likert scale that uses an income-to-means ration based on the 2009-2010 Federal Department of Health and Human Services Poverty Guidelines (1 = $14,570 or less, 2 = $14,571-18,310, 3 = 18,311-22,050, etc.). This 14-point Likert scale represented the full range of possible incomes.

Cumulative risk. At Time 1, mothers reported on eight risk factors and their household income. Mothers answered questions regarding their education, single parent status, adolescent

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parent, divorce, depression, negative events, household density, and residential instability. Risk factors were scored as 0 = not present and 1 = present. Risks were defined as not graduating from high school, being a single parent, having the child as an adolescent, family moving households three times in three years, divorce during the child's life, and high household density (number of people living in house divided by number of rooms). Mothers also reported on negative life events, assessed using the General Life Events Schedule for Children (Sandler, Ramirez, & Reynolds, 1986). Parents reported the number of negative life events the child had experienced in the past 9 months. Maternal depressive symptoms were reported using the Center for Epidemiological Studies- depression scale (Radloff, 1977). The scores for the questionnaires were converted into proportions out of the total possible score of each questionnaire. Using a 14-point Likert scale with options provided of income brackets, mothers reported their family income from all sources.

Positive Parenting. Parenting was observed during a four segment, 25-minute parent-child interaction at T1. In the first segment (7 minutes) the parents were instructed not to allow the children to play with restricted toys, permitting the observation of parental control and consistency of directive enforcement. The second segment (7 minutes) was unrestricted play, in which children were permitted to play with previously restricted toys, which encouraged the display of maternal responsiveness, involvement, and positive affect. The third segment (7 minutes) was a Lego figure task, where parents were asked to help children build a difficult structure, allowed the display of maternal scaffolding, including guidance and intrusiveness. The fourth segment was a cleanup task (3 minutes), which was designed to observe control strategies and consistency of maternal behavior. The parent-child interaction was administered at the first four time points.

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Parenting behaviors were coded based on the coding system adapted from The System for Coding Interactions and Family Functioning (Lindahl & Malik, 2000), The Parenting Style Ratings Manual (Cowan & Cowan, 1992), and the Parental Warmth and Control Scale (Rubin & Cheah, 2000). The parent-child interaction was coded based on frequency of behaviors and affect for warmth (positive affect and interactiveness), limit setting (clarity and consistency of directives), scaffolding (negative control, autonomy, guidance), and responsiveness (sensitivity to cues of child). Mothers' behaviors were coded based on quality and quantity of behaviors during the tasks, rated on a 5-point Likert scale with 1 indicating the lowest and 5 the highest level of behavior. These behaviors were coded minute-by-minute, and then averaged across epochs and tasks. Scores for warmth, limit setting, scaffolding, and responsiveness were then averaged for a positive parenting score. Undergraduate research assistants coded these behaviors from videotapes and were unfamiliar with participants and hypotheses of this study. Inter-rater reliability was assessed using 20% of the interactions. The intra-class correlations (ICCs) for warmth was 0.80, limit setting was 0.73, scaffolding was 0.81, and responsiveness was 0.67. Negativity was also coded, although not included in these analyses.

Family Functioning. The Family Functioning Scale includes 15 items, 5 each assessing cohesion, organization and conflict. The cohesion and organization subscales were used to indicate positive family functioning. Participants responded to each item using a four-point Likert scale (0 = very untrue, 1 = fairly untrue, 2 = fairly true, and 3 = very untrue). The cohesion subscale consisted of five questions about how well the family gets along (e.g., "family members helped and supported one another", "There was a feeling of togetherness in our family"). The organization subscale consisted of five questions about the cleanliness and organization of the household (e.g., "Being on time was very important", "Family made sure our

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rooms were neat", "Dishes are usually done immediately after eating"). The average of the five questions was calculated for each subscale, and the cohesion and organization scores were averaged for an overall family functioning measure. Cronbach's alpha for all items included in the family functioning scale is .75.

Respiratory Sinus Arrhythmia (RSA). RSA was measured at T1 and T2 using materials from Biopac PRO Lab (Goleta, CA). A 2-lead electrocardiograph (ECG) was used, with electrodes placed on the child's right clavicle and lower left abdomen, with a ground electrode placed on the left chest. The respiratory band was placed under the child's ribcage. Specifically, RSA was collected during three tasks: a baseline measure, the Scary Spider task, and The Transparent Box Task. Baseline RSA was measured when the child listened to a neutral story for 5 minutes.

RSA reactivity, collected during the fear- and frustration-eliciting tasks (described below) was subtracted from RSA baseline. RSA from the fear and frustration eliciting tasks was analyzed separately to examine the different relations with internalizing and externalizing symptoms. At T1, 50% of the sample showed a positive RSA fear score and 59% of the sample showed a positive RSA frustration score, indicating RSA withdrawal. At T2, 48% of the sample showed withdrawal for RSA fear and 72% of the sample showed withdrawal for RSA frustration. The tasks used in this study to elicit fear and frustration appear to have effectively captured variability in children's RSA responses.

Biopac's Acknowledge software 3.9.2 (Goleta, CA) was used to score and analyze the data. This software uses Grossman, Van Beek, and Wientjes's (1990) peak and valley formula to calculate RSA scores. The moderation analyses used RSA withdrawal at the first time point,

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when the children were 36 months old. Mediation analyses used RSA collected at the third laboratory visit, when the children were 54 months old.

RSA baseline. RSA baseline was collected after the electrodes and respiratory band were securely placed on the child. To collect the baseline RSA, the experimenter read the child a neutral story for 3.5 minutes. Experimenters were trained to read the stories in a neutral tone of voice without eliciting verbal responses from the child, as speaking is known to influence RSA.

RSA-R fear. In the Scary Spider task, designed to elicit fear reactivity, the child is prompted by an experimenter to approach and touch a toy spider that is triggered to jump when touched. There were three total prompts for the child to pet the toy spider. RSA collected during the Scary Spider task was subtracted from RSA collected during the neutral story resulting in a RSA-R fear variable.

RSA-R frustration. In the Transparent Box Task, designed to elicit frustration reactivity, a desired toy is locked in a clear box that cannot be opened. Children were asked to take the prize out of the box but were given the wrong keys to open the box. The child worked to open the box for 2 minutes, without interaction from the experimenter. RSA collected during the Transparent Box Task was subtracted from RSA collected during the neutral story resulting in a RSA-R frustration variable.

Child adjustment. Children's problem behaviors and social skills were assessed at both 36 months and 8 years using parent reports on the Child Behavior Checklist (CBCL, 4-18 years; Achenbach, 1991). The CBCL has been shown to be a reliable and valid measure of children's mental health problems (Achenbach, 1991). The problem behavior items from the preschool version (2-3 years) were added to the scale in order to administer the same questionnaire at each time point. Responses were made on a three-point Likert scale, with 0 indicating "not true", 1

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indicating “somewhat/ sometimes” and 2 indicating “very/ often true”. Externalizing behaviors were assessed by taking the sum of the Aggression and Delinquency scales (21 items; e.g., “demands must be met immediately”, “stubborn, sullen, or irritable”), and internalizing behaviors were assessed by summing the Anxiety and Depression scales (24 items; e.g., “fears certain animals, situations, or places”, “unhappy, sad, or depressed”). Mothers reported on their children’s social skills using the Social Skills Rating System (SSRS; Gresham & Elliot, 1990). The SRSS was established based on the Child Behavior Checklist (Achenbach & Edelbrock, 1986) and has shown very good validity, internal reliability, and test-retest reliability (Rich, Shepherd, & Nangle, 2008). Social competence was assessed using the items on cooperation (nine items; e.g., “controls temper in conflict situations with peers”), assertiveness (nine items; e.g., “responds appropriately to peer pressure”), responsibility (10 items; e.g., “easily makes transition from one classroom activity to another”), and self-control (10 items; e.g., “ignores peer distractions when doing class work”). In this study, the alphas for externalizing problems were .74 at T1 and .82 at T3. For internalizing problems, the alphas were .69 at T1 and .83 at T3. The alphas for the composite SSRS scales were .83 at T1 and .86 at T3.

Analytic Plan

Testing the relations among RSA-R fear and RSA-R frustration, childhood adversity, and adjustment outcomes using moderation and mediation analyses provided a detailed understanding of the mechanisms with which these variables related. Before testing study hypotheses, correlations among study variables were examined. Specifically, the correlations between RSA-R fear and RSA-R frustration were examined to determine if they should be kept separate in the analyses. Family income and cumulative risk variables were examined to determine if they should be kept separate for analyses. Child adjustment indicators were kept

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separate for analyses due to specific hypotheses regarding each outcome. Child gender was examined to determine if it should be included as a covariate.

All data analyses were conducted in Mplus version 8 (Muthén & Muthén, 2009) using Full Information Maximum Likelihood Estimation (FIMLE) to account for missing data. FIMLE uses all data available to calculate parameter estimates for the missing data (Kline, 1998). Participants with and without missing data were compared on all study variables to assess for biases due to the missing data. Compared to other techniques used to handle missing data, such as listwise and pairwise deletion, FIMLE has been found to introduce fewer biases into the data (Arbuckle, 1996). Regression analyses were used to assess the moderating and mediating effects of RSA-R in the relation between childhood adversity and adjustment outcomes. Regression analyses were performed to determine if childhood adversity predicted child adjustment outcomes. Separate regression equations were analyzed for each adjustment outcome (externalizing problems, internalizing problems, and social competence). Both linear and quadratic terms of cumulative risk were included in both the moderation and mediation models to address hypothesized curvilinear effects.

Moderation analyses were performed to explore if RSA-R influences the strength of the relation between childhood adversity and child adjustment outcomes. Multiple regression analyses were used to conduct the analyses for moderation (Baron & Kenny, 1986). In all regressions, child gender and T1 adjustment were covaried. Cumulative risk, family income, RSA-R fear and RSA-R frustration were included in the regression equation, in addition to the four interaction terms for childhood adversity X RSA-R. The interaction variables were calculated by subtracting the mean of the predictors and moderator from the raw variable to center the variable. Next, the centered predictor and moderator were multiplied create an

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interaction term. Four interaction terms were included in each regression equation: family income X RSA-R fear, family income X RSA-R frustration, cumulative risk X RSA-R fear, cumulative risk X RSA-R frustration. To address the hypothesized curvilinear effects, this analysis included the quadratic cumulative risk variable. The centered direct term of cumulative risk was squared and included in each regression equation, in addition to the direct term of cumulative risk. Significant interactions were plotted and simple slope analyses were conducted (Aiken & West, 1991; Dawson, 2014; Dawson & Richter, 2006; Preacher, Curran, & Bauer, 2006). Significant interaction terms in the regression analyses indicated that the relation between adversity and adjustment differed based on the value of RSA-R. Significant interactions were graphed using an excel template created by Dawson and Richter (2006) to graph the simple slopes. Tests indicated whether the simple slopes statistically differed from zero. Simple slopes of the relation of adversity to adjustment were tested at low (one standard deviation below the mean) and high (one standard deviation above the mean) levels of RSA-R and the predictor. Significant simple slopes signify that there is an association between the predictor and outcome at 1SD (standard deviation) above or 1SD below the moderator (RSA-R).

Due to recent criticisms of plotting slopes based on coefficient estimates at 1SD above and below the mean, plots are also presented using two additional approaches (McCabe, Kim, & King, 2018; Roisman et al., 2012). The region-of-significance plot has been used to plot the simple slopes, which show the simple slope coefficient and its 95% confidence region (Johnson & Neyman, 1936; Dearing & Hamilton, 2006). This plot shows how the slope of the predictor in the interaction changes across the range of the moderator, as opposed to only 1SD above or below the moderator and predictor. However, these simple slope plots do not show how much data is presented in the region of significance, as they display 3SD above and below the mean.

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In addition, these graphs can be difficult to interpret because the Y-axis is the slope of the predictor on the outcome. Finally, one additional and novel method of plotting was used to show data using a new technique by using the program interActive (McCabe et al., 2018). This graph shows five small graphs showing the simple slopes at 2SD below the mean, 1SD below the mean, the mean, 1SD above the mean, and 2SD above the mean of the moderator over a scatterplot of the observed data to show the actual data in each plot. However, this graph uses listwise deletion, and therefore does not account for FIMLE, which is necessary with this dataset given the large amount of missing data. Comparing all three graphs allows for a better understanding of the data.

Similar analyses were used to explore if RSA-R influenced the strength of the relation between supportive environments and child adjustment outcomes. In all regressions, child gender, family income, and T1 adjustment were covaried. Positive parenting, family functioning, RSA-R fear, and RSA-R frustration were included in the regression equation, in addition to the four interaction variables for supportive environment X RSA-R. The interaction variables were calculated by subtracting the mean of the predictors and moderator from the raw variable to center the variable. Next, the centered predictor and moderator were multiplied create an interaction term. Four interaction terms were included in each regression equation: positive parenting X RSA-R fear, positive parenting X RSA-R frustration, family functioning X RSA-R fear, and family functioning X RSA-R frustration. Probing significant interactions for supportive environment was completed using the same calculations and graphing methods as used for childhood adversity (described above).

Regression analyses were also used to test whether RSA-R mediated the relation between childhood adversity and child adjustment outcomes. In all regressions, child gender and T1

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adjustment were covaried. First, the regression of child adjustment outcomes on childhood adversity was examined. Then the regression of RSA-R on childhood adversity was analyzed, followed by the regression of child adjustment outcomes on RSA-R controlling for childhood adversity. Both the direct and squared terms of childhood adversity were included in order to assess for curvilinear effects.

Bootstrapping analyses were used to assess indirect effects of RSA-R on the relation between childhood adversity and adjustment outcomes. Bootstrapping randomly samples the data 5,000 times to ensure stability (Shrout & Bolger, 2002) and results in estimates of indirect effects and confidence intervals with higher accuracy (MacKinnon, Lockwood, & Williams, 2004).

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Results

Descriptive statistics for study variables are found in Table 1. Correlations among study variables were examined first to evaluate plausibility of the study hypotheses (Tables 3-5).

Correlations Among Study Variables

All RSA variables used in this study, including RSA-R fear, RSA-R frustration, and RSA during a neutral story at T1 and T2 were significantly inter-correlated between .303 and .698 (Table 2). Despite the high inter-correlation among RSA-R in fear- and frustration- eliciting tasks (r = .56 at T1 and .56 at T2), those variables were kept separate as one of the aims of the study was to examine if RSA collected during different tasks performs differently in the relation of early adversity and later adjustment outcomes.

When examining the variables used in the moderation analyses, including RSA-R at T1, childhood adversity at T1, adjustment at T1 and adjustment at T3, correlations among RSA-R at T1, mother reported child adjustment at T1 and T3, as well as cumulative risk and family income were significant (Table 3). RSA-R fear was significantly and positively associated with RSA-R frustration at T1. Cumulative risk was significantly and negatively associated with family income, indicating that the more adverse experiences the child had experienced the less his or her total family income. Cumulative risk was also associated with more externalizing problems at T1 and T3, as well as more internalizing problems at T3. Cumulative risk was also negatively associated with social competence at T3. Family income was negatively associated with externalizing problems at T3 and positively associated with social competence at T3. Externalizing problems at T1 was positively associated with externalizing problems and internalizing problems at T3 and negatively associated with social competence at T3. Internalizing problems at T1 was associated with lower social competence at T1 and T3 and

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higher internalizing and externalizing problems at T3. Social competence at T1 was positively associated with social competence at T3, and negatively associated with externalizing and internalizing problems at T1. At T3, externalizing problems was positively associated with more internalizing problems and negatively associated with social competence. T3 internalizing problems was negatively associated with T3 social competence.

Variables indicating a supportive context were also assessed (Table 4). Family functioning was significantly and negatively correlated with internalizing and externalizing problems at T1 as well as externalizing problems at T3, and positively associated with social competence at T1 and T3 and positive parenting. Positive parenting was positively associated with family income and T3 social competence, and negatively associated with externalizing problems at T1 and T3. These correlations suggest the plausibility of RSA-R moderating the relation between early childhood adversity and later adjustment.

For mediation analyses, correlations examined included RSA-R at T2, in addition to gender, cumulative risk, family income, internalizing problems at T1 and T3, externalizing problems at T1 and T3, and social competence at T1 and T3 (Table 5). T2 RSA-R frustration was not significantly correlated with any of the other study variables. RSA-R fear was negatively associated with social competence at T1.

Aim 1: RSA-R Moderates the Relation Between Childhood Adversity and Adjustment

To test the proposed hypothesis that children's RSA-R moderates the relation between early childhood adversity and later adjustment problems (Figure 1), three parallel regression models were tested predicting T3 of the three adjustment outcomes (externalizing problems, internalizing problems, social competence). Results from moderation analyses are presented in Table 6. T1 adjustment and gender were controlled for in each of these models. Each outcome

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was regressed on RSA-R fear, RSA-R frustration, income and cumulative risk, as well as four interaction terms: cumulative risk X RSA-R fear, cumulative risk X RSA-R frustration, family income X RSA-R fear, and family income X RSA-R frustration. In this model, all T1 adjustment problems were correlated with one another, cumulative risk and family income were correlated, RSA-R fear was correlated with RSA-R frustration, and the interaction terms were correlated with one another. The model fit the data well ($\chi 2$ (17) = 31.67, p = .02, CFI = 0.96, RMSEA = .05).

In the regression equation with T3 externalizing problems as the dependent variable, T1 externalizing problems significantly predicted higher T3 externalizing problems (b = 0.39, SE = .05, p < .001, β = 0.38), and there was a trend toward an association of cumulative risk predicting higher externalizing problems (b = 0.58, SE = .31, p = .059, β = 0.13). Three out of four of the interaction terms were significant: family income X RSA-R fear (b = -0.20, SE = .10, p = .047, β = -0.21), family income X RSA-R frustration (b = -0.30, SE = .14, p = .026, β = -0.27), and cumulative risk X RSA-R fear interaction (b = -1.02, SE = .49, p = .038, β = -0.20).

The family income X RSA-R fear interaction predicted externalizing problems such that family income was positively related to externalizing problems for children low in RSA-R fear (b = 0.55, t = .05, p = .963; Figure 4a), whereas it was negatively related to externalizing for children higher in RSA-R fear (b = -0.60, t = -.05, p = .959), although neither slope was significant. Examining this interaction further, the regions-of-significance graph (Figure 4b) shows that the simple slope of family income on externalizing problems is negative for children with higher RSA-R fear. When assessing five simple slope plots (Figure 4c), it appears that for children with RSA-R fear at 1SD or 2SD below the mean, income is unrelated to externalizing

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problems. For children with RSA-R fear at the mean or 1SD or 2SD above the mean, family income is negatively related to externalizing problems.

Similarly, the family income X RSA-R frustration interaction predicted externalizing problems such that family income was negatively related to externalizing problems for children with high RSA-R (b = -1.71, t = -0.14, p = .887), but positively related to externalizing for children with low RSA-R frustration (b = 1.50, t = 0.15, p = .879; Figure 5a), although again, neither slope was significant. The regions-of-significance plot (Figure 5b) shows that the simple slope of family income on externalizing problems is negative for children with higher RSA-R frustration. When assessing five simple slope plots (Figure 5c), for children with RSA-R frustration at the mean or 1SD or 2SD below the mean, income is unrelated to externalizing problems. For children with moderate to high RSA-R frustration, family income is negatively related to externalizing problems.

The cumulative risk X RSA-R fear interaction predicted externalizing problems such that cumulative risk was positively related to externalizing problems for children with low RSA-R fear (b = 3.58, t = 3.71, $p < .001$), whereas it was negatively but non-significantly related to externalizing problems for children with high RSA-R fear (b = -2.29, t = -0.81, $p = .422$; Figure 6a). The simple slope was significant for children with low RSA-R fear. The regions-of-significance plot (Figure 6b) shows that the simple slope of cumulative risk on externalizing problems is positive for children with low RSA-R fear. When assessing five simple slope plots (Figure 6c), cumulative risk is unrelated to externalizing problems for children with RSA-R fear at 1SD or 2SD above the mean. For children with RSA-R fear at the mean or 1SD or 2SD below the mean, cumulative risk is positively related to externalizing problems. However, the

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scatterplot shows that there are very few cases of children who have low RSA-R fear, high cumulative risk, and high externalizing problems

In the regression equation with T3 internalizing problems as the dependent variable, T1 internalizing problems significantly predicted higher T3 internalizing problems (b = 0.65, SE = .06, $p < .001$, β = 0.45). Cumulative risk was also associated with higher internalizing problems (b = 1.07, SE = .42, $p = .012$, β = 0.17). RSA-R frustration was significantly and positively associated with internalizing problems (b = 1.13, SE = .43, $p = .009$, β = 0.19), and there was a trend toward an association of RSA-R fear predicting higher internalizing problems (b = 0.64, SE = .36, $p = .070$, β = 0.12). One out of the four interaction terms were significant: family income X RSA-R fear. There was a trend toward an association of two interaction terms predicting internalizing problems: family income X RSA-R frustration (b = -0.31, SE = .19, $p = .099$, β = -0.19) and cumulative risk X RSA-R frustration (b = -1.10, SE = .64, $p = .085$, β = -0.19).

The family income X RSA-R fear interaction predicted internalizing problems such that family income was negatively related to internalizing problems for children with high RSA-R fear (b = -1.19, t = -0.10, p = .917), whereas children with low RSA-R had fewer internalizing problems (b = 1.40, t = -0.10, p = .907; Figure 7a). Neither simple slope was significant. The regions-of-significance graph (Figure 7b) shows that the simple slope of family income on internalizing problems is negative for children with higher RSA-R fear. When assessing five simple slope plots (Figure 7c), for children with RSA-R fear at -2SD below the mean, family income is positively associated with internalizing problems. For children with RSA-R fear at -1 SD below the mean, income is unrelated to internalizing problems. For children with RSA-R fear at the mean or 1SD or 2SD above the mean, family income is negatively associated with internalizing problems.

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In the regression equation with T3 social competence as the dependent variable, T1 social competence was significantly associated with T3 social competence (b = 0.33, SE = .05, $p <$ .001, β = 0.32). None of the other variables were significant.

RSA-R moderates the relation between supportive contexts and adjustment. To test the proposed hypothesis that children's physiological regulation, RSA-R, would moderate the relation between child supportive environment and later adjustment problems (Figure 2), three parallel regressions equations were conducted with T3 externalizing problems, T3 internalizing problems, and T3 social competence. Results from moderation analyses are presented in Table 7. T1 adjustment, family income, and gender were included as covariates in each of these equations. Each outcome was regressed on RSA-R fear, RSA-R frustration, positive parenting, and family functioning as well as four interaction terms: positive parenting X RSA-R fear, positive parenting X RSA-R frustration, family functioning X RSA-R fear, and family functioning X RSA-R frustration. T1 adjustment problems were correlated with one another, family functioning and positive parenting were correlated, RSA-R from the fear-eliciting task was correlated with RSA-R from the frustration-eliciting task, and the interaction terms were correlated with one another. The model fit the data well ($\chi 2$ (18) = 20.60, p = 0.30, CFI = 0.99, RMSEA = .02).

In the first regression equation, study variables were regressed on T3 externalizing problems. Of the covariates, T1 externalizing problems and lower family income significantly predicted higher T3 externalizing problems (T1 externalizing problems b = 0.37, SE = .05, $p <$ .001, β = 0.36; family income b = -0.11, SE = .05, p = .041, β = -0.12). Positive parenting approached significance in predicting lower externalizing problems (b = -0.95 SE = 0.52, p = .067, β = -0.11). Two out of the four interactions terms were significant: positive parenting X

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RSA-R frustration (b = -1.91, SE = 0.92, p = .039, β = -0.17) and family functioning X RSA-R frustration (b = 0.46, SE = 0.19, p = .016, β = 0.20).

The positive parenting x RSA-R frustration interaction predicted externalizing problems such that positive parenting was negatively associated with externalizing problems for children with high RSA-R frustration (b = -7.53, t = -6.07, p < .001), whereas positive parenting was positively associated with externalizing problems for children with low RSA-R frustration (b = 5.05, t = 5.00, p < .001; Figure 8a). The slope for both low RSA-R frustration and high RSA-R frustration were significant. Examining this interaction further, the regions-of-significance graph (Figure 8b) shows that the simple slope of positive parenting on externalizing problems is negative for children with high RSA-R frustration. When assessing five simple slope plots (Figure 8c), it appears that for children with RSA-R frustration 2SD and 1SD below the mean, positive parenting is positively associated with externalizing problems. For children with RSA-R at the mean, positive parenting is unrelated to externalizing problems. For children with RSA-R frustration at 1SD or 2SD above the mean, positive parenting is negatively related to externalizing problems, however, the scatterplot shows few cases of children who have high RSA-R, high externalizing problems, and low positive parenting.

The second significant interaction predicting externalizing problems, family functioning X RSA-R frustration, predicted externalizing problems such that low family functioning was related to higher externalizing problems for children who were lower in RSA-R frustration (b = -1.39, t = -0.24, p = .811), whereas children with higher RSA-w frustration had fewer problems (b = 1.64, t = 0.30, p = .761; Figure 9a). Neither slope was significant. Examining this interaction further, the regions-of-significance graph (Figure 9b) shows that the simple slope of family functioning on externalizing problems is positive for children with high RSA-R frustration.

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When assessing five simple slope plots (Figure 9c), it appears that for children with RSA-R frustration 2SD and 1SD below the mean, high family functioning is related to fewer externalizing problems, while family functioning is unrelated to externalizing problems for children with RSA-R frustration at the mean. For children with RSA-R frustration 1SD or 2SD above the mean, family functioning is positively associated with externalizing problems.

In the second regression equation with T3 internalizing problems as the dependent variable, T1 internalizing problems was positively associated with T3 internalizing problems (b = 0.65, SE = .07, $p < .001$, $\beta = 0.44$), and there was a trend toward an association of family income predicting lower internalizing problems (b = -0.12, SE = .07, $p = .094$, $\beta = -0.09$). No direct effects of RSA-R or supportive environment were significant. Two out of the four interactions were significant: positive parenting X RSA-R fear (b = -2.31, SE = 1.02, $p = .023$, $\beta = -0.20$) and family functioning X RSA-R frustration (b = 0.66, SE = 0.27, $p = .015$, $\beta = 0.20$).

The positive parenting x RSA-R fear interaction predicted internalizing problems such that low positive parenting was related to more internalizing problems for children with high RSA-R (b = 6.70, t = 4.76, $p < .001$) and low positive parenting was related to fewer internalizing problems for children with low RSA-R fear (b = -6.64, t = -5.08, $p < .001$; Figure 10a). Both simple slopes were significant. Examining this interaction further, the regions-of-significance graph (Figure 10b) shows that the simple slope of positive parenting on internalizing problems is negative for children with high RSA-R fear and positive for children with low RSA-R fear. When assessing five simple slope plots (Figure 10c), for children with RSA-R fear 2SD and 1SD below the mean, positive parenting is positively related to internalizing problems. For children with RSA-R fear at the mean and 1SD and 2SD above the mean, positive parenting is negatively related to internalizing problems, however, the scatterplot reveals few cases of

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participants with low positive parenting and low internalizing problems at 1SD and 2SD above the mean for RSA-R.

The family functioning X RSA-R frustration interaction predicted internalizing problems such that family functioning was negatively associated with internalizing problems for children with low RSA-R (b = -1.97, t = -0.34, p = .735), whereas family functioning was positively associated with internalizing problems for children with high RSA-R frustration (b = 2.39, t = 0.44, p = .659; Figure 11a). Neither slope was significant. Examining this interaction further, the regions-of-significance graph (Figure 11b) shows that the simple slope of family functioning on internalizing problems is negative for children with low RSA-R frustration and positive for children with high RSA-R frustration. When assessing five simple slope plots (Figure 11c), for children RSA-R frustration 1SD and 2SD below the mean, family functioning is negatively associated with internalizing. For children with average levels of RSA-R frustration, family functioning is unrelated to internalizing problems. Family functioning is positively related to internalizing problems for children with RSA-R frustration 1SD and 2SD above the mean.

In the third regression equation with T3 social competence as the dependent variable, two covariates, T1 social competence and family income, were significantly associated with higher T3 social competence (social competence b = 0.31, SE = .05, p < .001, β = 0.30; family income b = 0.26, SE = .13, p = .045, β = 0.12). Family functioning also significantly predicted higher social competence (b = 0.70, SE = 0.25, p = .005, β = 0.17). One out of the four interactions was significant: family functioning X RSA-R frustration (b = -1.00, SE = 0.42, p = .018, β = -0.18).

The family functioning X RSA-R frustration interaction predicted social competence such that family functioning and social competence were positively associated for children with high RSA-R frustration (b = -2.74, t = -0.51, p = .612), whereas family functioning and social

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competence were negatively related for children with low RSA-R (b = 3.84, t = 0.66, p = .501; Figure 12a). Neither slope was significant. Examining this interaction further, the regions-of-significance graph (Figure 12b) shows that the slope of family functioning on social competence is positive when RSA-R is below the mean. When assessing five simple slope plots (Figure 12c), it becomes apparent that for children 1SD and 2SD of RSA-R frustration below the mean, family functioning is positively associated with social competence. For children with average levels of RSA-R frustration and 1SD above the mean, family functioning is unrelated to social competence. Finally, for children RSA-R frustration 2SD above the mean, family functioning is negatively related to internalizing problems.

Aim 2: RSA-R Mediates the Relation Between Childhood Adversity and Adjustment

Indirect effects of T1 childhood adversity on T3 adjustment through T2 RSA-R were examined to test whether RSA-R mediated this relation (Figure 3). First, regression analyses were used to test the effects of family income and cumulative risk on RSA-R fear and RSA-R frustration. Next, three regression equations were conducted with each outcome as a dependent variable. Cumulative risk, family income, T2 RSA-R fear, and T2 RSA-R frustration were all included as predictors in each equation. In addition, T1 adjustment outcomes were included. Finally, 12 total indirect effects were examined for both family income and cumulative risk on each of the adjustment variables (externalizing problems, internalizing problems, and social competence) through RSA-R fear and RSA-R frustration utilizing bootstrapping estimates. For example, the pathway from cumulative risk through RSA-R fear predicting externalizing problems was examined. Correlations indicated that RSA-R fear and RSA-R frustration were not associated with family income or cumulative risk, however, indirect effects may still be

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present (MacKinnon, Fairchild, & Fritz, 2007). The model fit the data well ($\chi 2$ (20) = 37.25, p = .01, CFI =0.95, RMSEA = .05).

Neither family income nor cumulative risk significantly predicted RSA-R fear or RSA-R frustration. There were no significant indirect effects from either family income or cumulative risk predicting T3 externalizing, internalizing or social competence through RSA-R fear or RSA-R frustration.

Study variables were first regressed on T3 externalizing problems. T1 externalizing problems significantly predicted T3 externalizing problems (b = 0.39, SE = .05, $p < .001$). There were no significant indirect effects from either family income or cumulative risk to T3 externalizing problems through RSA-R fear or RSA-R frustration.

Next, study variables were regressed on T3 internalizing problems. T1 internalizing problems significantly predicted T3 externalizing problems (b = 0.65, SE = .07, $p < .001$). There were no significant indirect effects from either family income or cumulative risk to T3 internalizing problems through RSA-R fear or frustration.

Finally, study variables were regressed on T3 social competence. T1 social competence significantly predicted T3 social competence (b = 0.34, SE = .05, $p < .001$). There were no significant indirect effects using bootstrapping analyses from either family income or cumulative risk to T3 social competence through RSA-R fear or RSA-R frustration. The quadratic term of cumulative risk was not significant.

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Discussion

Exposure to childhood adversity increases children's risk for developing adjustment or mental health problems (Luthar, 2006; Rutter, 1983; Sameroff, 2006). It is important to identify children who are at greater risk for developing psychopathology within those adverse contexts, as it allows for greater understanding of how to intervene with children who are more susceptible to their environment. The aims of this study were to test the moderation and mediation of the relation between early childhood adversity and later child adjustment by RSA-R, a measure of the regulation of physiological reactivity. RSA-R operated as a moderator of the effects of childhood adversity and supportive contexts with adjustment. No evidence of mediation was found.

RSA-R Conditions the Effects of Context on Adjustment

RSA-R interacts with childhood adversity to predict adjustment. As hypothesized, significant interactions of childhood adversity and RSA-R predicted later adjustment problems. Three different outcomes (externalizing problems, internalizing problems, social competence) were predicted with two measures of childhood adversity (cumulative risk, family income) and two measures of RSA-R (RSA-R fear and RSA-R frustration). Out of the 16 interactions tested, four interactions were significant, with two additional interactions approaching significance. Given that there were 16 interactions tested, the interactions that were approaching significance were not interpreted. However, they do provide additional evidence of a pattern of results supporting RSA-R moderating the relation between exposure to adversity and adjustment. This percentage of significant interactions is similar to what was found in a comprehensive review of the literature testing interactions between childhood adversity and RSA-R, in which 41/151 interactions were significant. This implies that physiological regulation moderates the effects of

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adversity somewhat consistently, suggesting that models such as BSC or Diathesis Stress are plausible.

One significant interaction was consistent with the hypothesis and previous literature: children with lower levels of RSA-R in contexts of high cumulative risk had more externalizing problems, whereas at high levels of RSA-R cumulative risk was unrelated to externalizing problems. This interaction pattern suggests that in high stress environments certain children are more susceptible to experiencing maladjustment, while in low stress environments most children do not have problems. This also suggests that in environments of high adversity, higher RSA-R may help protect or buffer children from exhibiting more psychopathology. This interaction provided support for the Diathesis Stress model and was consistent with the hypothesis based on previous literature showing the same pattern of findings (El-Sheikh 2001; El-Sheikh & Whitson 2006; Hastings, 2014; McLaughlin et al., 2013).

Three of the significant interactions were inconsistent with the hypothesis in this study, showing that at higher levels of RSA-R, income is negatively associated with externalizing problems, whereas at low levels of RSA-R income is not related to externalizing problems. It appears that for children with lower RSA-R family income is not associated with externalizing problems, whereas children with higher RSA-R and lower family income have the highest levels of externalizing problems. Notably, these interactions suggest that high RSA-R is a vulnerability rather than a protective factor in the contexts studied, which is inconsistent with the Polyvagal theory, which, as discussed in the introduction, considers greater regulation of physiological reactivity in stressful situations to be adaptive. When RSA-R is high (RSA withdrawal), it signifies that the vagal brake is being removed, decreasing output to the sino-atrial nerve, which alerts the body to a fight or flight scenario. Vagal augmentation, when the vagal tone increases

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from baseline to stressful situation, is considered consistent with lower adaptive functioning. However, our findings suggest that while a stressful or threat perceiving context may call for a reduction or withdrawal of RSA in order to active cardiac activity and mobilize metabolic resources to deal with the stress/threat, a more positive or threat free context may not require prolonged decreases in RSA and in fact augmentation of RSA may be more adaptive in high risk contexts (Hastings et al., 2008). These results are consistent with Blandon et al. (2008) which found that in the context of high levels of stress exposure for caregivers, infants with higher RSA-R had more symptoms of behavior dysregulation at 3-years-old. Shanahan et al. (2014) also had similar findings, reporting that for children ages 4-7, children with higher RSA-R had more internalizing symptoms in the presence of high maternal internalizing symptoms, while all children had low levels of problems in the context of low maternal internalizing symptoms.

It will be important for future research to examine RSA-R not only in a continuous manner but also in terms of a dichotomous variable to identify differences between RSA withdrawal and RSA augmentation. While approximately 50% of participants in this sample experienced RSA withdrawal, which is consistent with data from studies of similar aged participants (Obradović et al., 2010), it may be that augmentation of RSA is a better indicator of physiological dysfunction rather than lower levels of RSA withdrawal, in which using a dichotomous variable to test these associations with RSA-R will be the most informative.

The variables use to assess exposure to childhood adversity, family income and cumulative risk, show effects in the opposite directions. This may be due to the cumulative risk variable used. While we hypothesized that this variable would be associated with RSA-R similar to family income, there are differences between these two variables. While cumulative risk is highly correlated with family income, this sample was specifically chosen to equally represent all

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income levels. The scatterplot graphs show that the majority of children have low cumulative risk. The sample was not stratified based on cumulative risk and, thus, there is a lack of substantial variability of cumulative risk compared to family income. Specifically, there are few cases of children in this sample with exposure to high levels of cumulative risk and low RSA-R, which these analyses predict would result in high externalizing problems. As this is the first known study to assess both cumulative risk and income separately within one sample, there is no literature to guide our interpretations. However, this does provide strong evidence for continuing to analyze cumulative risk and income separately in analyses, as they appear to be associated with physiological regulation in different ways. Further exploration will have to be conducted to thoroughly understand these different patterns of results, specifically examining a sample with a wide range of both family income and cumulative risk exposure.

Three of the significant interactions predicted externalizing problems, and one predicted internalizing problems. This differs from the current literature, in which the majority of significant interactions predicted internalizing problems (Graziano & Derefinko, 2013). However, this was the first known study to examine internalizing and externalizing problems as separate outcomes in preschoolers. Externalizing problems may be more likely to be reported in preschoolers as they are visible to parents, as opposed to internalizing problems which require a level of language to communicate the symptoms that preschoolers may have not yet developed. Maternal reports of those externalizing problems may in fact be more accurate at this age compared to internalizing problems, which may be under-reported. In addition, both cumulative risk and RSA-R had direct effects on internalizing problems, and two additional interactions (RSA-R X family income and RSA-R X cumulative risk) approached significance in predicting internalizing problems. This suggests that it is important to include both internalizing and

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externalizing problems as outcomes, as RSA-R likely directly influences both outcomes and also interacts with childhood adversity to influence both outcomes. Including outcomes at a later age may allow for more thorough reporting of internalizing symptoms, and additional interactions predicting internalizing problems may become significant.

Social competence was not predicted by family income, cumulative risk, or RSA-R in this study. There is little previous research in preschoolers examining social competence as the outcome (Graziano & Derefinko, 2013). However, childhood adversity and RSA-R have been shown by previous literature to interact to significantly predict social competence in older populations (Leary & Katz, 2004; Obradović et al., 2010). In a comprehensive meta-analysis of RSA-R and adjustment outcomes, Graziano & Derefinko (2013) were surprised to find no significant association between RSA-R and social competence. This finding was unexpected, as the polyvagal theory states that the removal of the vagal brake, which results in activating the metabolic change, is required to support social engagement (Porges, 2007). The theory suggests that a well-regulated physiological state contributes to better control of the facial muscles, allowing for more sophisticated facial movements, gestures, and vocalizations. While this may be true, there might not be a noticeable difference in the sophistication of facial movements and vocalizations in preschoolers, or the changes might be too subtle for other preschoolers to observe. Perhaps including an additional timepoint of adjustment outcomes when the children are older would allow for more observation of differences. In addition, Porges' theory assumes that sophisticated facial movements and gestures translates into better social engagement. Our measure of social competence includes much more than facial gestures- it also includes cooperation, responsibility, etc. It is possible that Porges' theory does not consider the complexities required for social competence, such as paying attention to others, inferring the

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needs of others, or empathy. Finally, this difference may exist only if RSA-R is collected during a social task. These relations among RSA-R, adversity, and adjustment may only appear in the context of social engagement, whereas the tasks used in this study were administered when the children were alone. Additional research is needed to understand if social competence is associated with adjustment outcomes in preschoolers and under what conditions that association is evident.

Contrary to the hypotheses, three of the four significant interactions when assessing childhood adversity involved RSA-R during a fear-eliciting task, while one of the significant interactions involved RSA-R collected during a frustration-eliciting task. Two of the significant interactions with RSA-R fear predicted externalizing problems, one significant interaction with RSA-R fear predicted internalizing problems, and one significant interaction with RSA-R frustration predicted externalizing problems. The pattern of findings did not appear to differ based on the type of emotion RSA-R was collected during. One potential explanation is that physiological dysregulation may not be an appropriate predictor of distinguishing internalizing versus externalizing problems. RSA-R might identify children with emotion or physiological dysregulation, while the child's observed behavior or thoughts is more important in distinguishing internalizing or externalizing behaviors. Alternatively, the tasks used in this study to elicit emotions may not be effective at distinguishing different emotions. The scary spider task might cause a fear reaction in some children and frustration/anger in other children. Although few previous studies have examined two emotion-eliciting tasks in the same sample, this is in contrast to previous studies, which have found a greater number of significant interactions using frustration-eliciting tasks as opposed to other mood eliciting tasks (Calkins et al., 2007; Musser et al., 2011). Many studies have combined RSA-R collected during multiple

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emotion-eliciting tasks into one variable, thus making it difficult to understand how these variables would differentially interact with adversity (Blandon et al., 2010; Obradović et al., 2011; Skowron, Cipriano-Essel, Gatzke-Kopp, Teti, & Ammerman, 2013). In previous literature, two studies have assessed RSA-R during a frustration-eliciting task, and two out of three interactions examined in that study showed that children with lower RSA-R in adverse contexts have more problems compared to children with higher RSA-R (Perry et al., 2011; Skowron et al., 2013). It may be that the adaptiveness of RSA withdrawal or augmentation is based on the contextual demands the child is facing, therefore changing the relation among early childhood adversity, RSA, and adjustment outcomes based on the task during which RSA is collected (Blair & Peters, 2003; Hastings et al. 2008). It is also possible that in this study, the task used to elicit a fear reaction was more successful at eliciting a physiological reaction compared to the task used to elicit frustration. Future research should examine the direction of children's RSA-R across multiple contexts including emotion-eliciting tasks and cognitively demanding tasks, as well as ecologically valid settings such as the school or home rather than in the laboratory.

Contrary to expectations, curvilinear effects were not significant. I expected to see curvilinear effects of cumulative risk, indicating that moderate exposure to adversity results in optimal RSA-R levels and higher functioning (Bush et al., 2011). This is the first known study to assess these effects with RSA-R, so there is no prior research guiding our understanding of the results. Bush and colleagues (2011) examined a measure of HPA axis regulation, cortisol levels, which may operate differently when children are exposed to high levels of adversity. Furthermore, curvilinear effects were found when analyses were separated by race, and different curvilinear effects were found for children who were white versus children categorized as ethnic

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minorities, which was not examined in these analyses. Given the polyvagal theory's suggestion that some exposure to stress may be beneficial and curvilinear effects found in other areas of research, future research should continue to examine curvilinear effects in addition to linear associations of adversity to RSA-R in order to fully understand the shape of this association.

RSA-R interacts with supportive contexts to predict adjustment. Consistent with our expectations and previous literature, we found significant interactions suggesting RSA-R moderates the relation between supportive contexts and adjustment. However, each of the interactions showed significant differences in high RSA-R at the low end of supportive contexts. This is consistent with the hypothesis and Diathesis Stress, but inconsistent with BSC. BSC hypothesizes that children with high RSA-R would have the fewest problem behaviors and better social competence in the context of high supportive contexts, which in this study was conceptualized as positive parenting and family functioning. These results are consistent with one previous study (Hastings et al., 2014) finding support for low RSA-R interacting with low supportive parenting to predict more internalizing problems compared to children with high RSA-R. In the present study, two out of the five significant interactions showed children with high RSA-R had more problems in contexts of low supportive contexts, while the other three significant interactions showed the opposite effect, that children with low RSA-R had more problems in low supportive contexts. The mixed findings of the interactions make interpretations and conclusions about the results difficult.

Differences between the interactions are apparent based on the supportive context. Interactions examining family functioning showed children with lower RSA-R had more problems and less social competence in the context of low family functioning. In the context of low positive parenting, children with higher RSA-R show more problems. These differences

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may be due to different way that family functioning operates compared to positive parenting. Family functioning encompasses a broader measure of how the child's family relates to one another and models behaviors for the child, while positive parenting captures how only one person interacts with the child. Furthermore, these differences may be due to the way the variables of supportive contexts were measured in this study. Positive parenting was measured by observing mother-child play sessions, while family functioning was measured by mother-reported questionnaire. We would expect that positive parenting would be a more objective assessment of children's supportive environment, however, it is based only on a limited observation; parent report of family context might be biased but would reflect children's experiences over time. High RSA-R interacting with low positive parenting to predict more problems is consistent with the Diathesis Stress model, showing that in both low supportive and high adverse environments children with high RSA-R are more sensitive and develop more problem behaviors, while there are few differences based on physiological regulation for children in high supportive contexts. This does not provide support for BSC, as there would have been differences in RSA-R at the high end of the supportive contexts. In addition, this adds further evidence that future research should continue to assess different contexts to better understand the unique interactive effects of contexts and physiological regulation on adjustment.

The context or task in which RSA-R is being assessed appears to make an important difference in the pattern of findings with supportive contexts. Four out of the five significant interactions for supportive environments were found with RSA-R from the frustration-eliciting task. It is possible that there is something about the frustration-eliciting task which allows for the observation of the interactions between RSA-R and supportive context. However, the opposite was true for childhood adversity, where the majority of significant interactions were

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found using RSA-R collected during the fear-eliciting task. This points to RSA-R collected in different tasks relating to adversity in different ways. When examining supportive contexts, children's reaction to frustration may be a bigger predictor of adjustment problems, although further research is needed to replicate and comprehend these results. In three out of four of these interactions, children with low RSA-R show more externalizing problems or lower social competence in the context of low supportive context, suggesting that there are likely differences in what task RSA-R is collected during that influence the findings. Future research should continue to collect RSA-R during different emotion-eliciting tasks to explore these differences further.

Similarly, there were mixed findings among the outcomes predicted by the significant interactions. Two of the interactions predicted externalizing problems, two predicted internalizing problems, and one predicted social competence. To further complicate the findings, one interaction predicting externalizing problems showed that children with high RSA-R had more problems in the context of low positive parenting, while the other interaction predicting externalizing problems showed the opposite, with low RSA-R predicted more externalizing problems in the context of low family functioning. The same pattern was present for internalizing problems as the outcome. These complicated results may indicate that it is the task used to collect RSA-R and the supportive context variable that drive the results, as opposed to the adjustment outcomes.

Given the large number of significant interactions found in this study, it is likely that RSA-R does moderate the relation between context and adjustment. However, the inconsistent pattern of findings here makes it difficult to draw conclusions regarding the type of context, emotion-eliciting task used to collect RSA-R, or adjustment outcome. One reason for these

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confusing results may be due to the age of the children in the study. To reiterate, preschool is a time of rapid myelination of the vagus nerve and therefore changes may be taking place to RSA-R during the preschool period (Porges & Furman, 2011), resulting in variations in how RSA-R interacts with adversity for this age group. Furthermore, recent evidence suggests that due to differences in breathing frequencies in preschoolers, researchers may be underestimating RSA reactivity and overestimating baseline RSA (Shader et al., 2018). Future research should re-analyze the data to see if specifying the data using new breathing frequency guidelines influences the results.

Finally, this pattern of findings may be due to the use of inappropriate tasks utilized to collect RSA-R data. The BSC hypothesis is specifically for children who frequently experience dangerous or threatening situations. It may be that measuring RSA-R in fear- or frustration-eliciting laboratory tasks does not capture the full range of individual differences that exist. Similarly, measuring RSA-R during fear- or frustration-eliciting laboratory tasks may not help us understand which children are most sensitive to supportive contexts. Vagal augmentation is considered adaptive when the environment is perceived as safe, and it might be adaptive to perceive these laboratory environments as safe, despite the frustration or fear that may arise. Future research should experiment with collecting RSA-R during ecologically valid situations that children objectively classify as dangerous or supportive, to capture the full range of individual differences in RSA-R.

RSA-R Mediates the Effects of Childhood Adversity on Adjustment

Contrary to our predictions, there was no evidence that RSA-R mediates the relation between risk and adjustment. As discussed above, ACM hypothesizes that RSA-R mediates the relation between early childhood adversity and later adjustment outcomes suggesting that vagal

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regulation adapts over time and is a mechanism through which childhood adversity and risk influences later adjustment. The hypothesis that RSA-R would mediate the relation between early childhood adversity and later adjustment was based on the only longitudinal study that has assessed this relation (Hastings et al., 2008). This study showed that RSA-R mediated the relation between early adversity and outcomes assessed 6-10 months later. Based on previous literature, the lack of evidence for mediation in our study is not entirely surprising (El-Sheikh, 2001; Shenk et al., 2012; Sijtsema2015) suggesting that in this sample we may not see mediational effects of RSA-R, even if the outcome could be collected after a longer period of time. Furthermore, only one previous study, which also found no significant mediational effects, assessed more than one aspect of childhood adversity (Sijtsema et al., 2015). The study that found significant mediational effects only assessed one aspect of adversity, maternal negative control (Hastings et al., 2008). This was also the only other study to assess children during the preschool period.

The preschool period is thought to be the ideal time to examine mediational effects, as the vagus nerve has not been fully myelinated. As explained in the introduction, it is thought that exposure to adversity influences the myelination of the vagal nerve. However, it is plausible that the myelination has already been developed fully and it is too late to be influenced by context, or the influence is too small to be noticeable in mediation analyses. It is possible that if RSA-R is assessed earlier in development mediational effects may be detectable. Alternatively, the lack of evidence for mediation may suggest that vagal regulation does not adapt to the environment the child is exposed to, nor is it a mechanism through which adversity influences later adjustment.

There was no evidence of curvilinear effects. I expected to see curvilinear effects of cumulative risk, indicating that both higher and lower levels of cumulative risk would be related

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to children with lower RSA-R. Contrary to the hypothesis, the quadratic term was not significant in these analyses. This is the first known study to assess these effects in a mediation model and using RSA-R, so there is no prior research guiding our understanding of the results. While ACM does hypothesize curvilinear effects, the theory specifies that there will be more children with higher RSA-R in contexts of high adversity and high supportive environments, however, this study did not capture bipolar effects in one variable. ACM specifically hypothesizes a curvilinear, U-shaped association between high levels of adversity exposure and high levels of supportive context and physiological reactivity, expecting a disproportionate number of children exposed to high levels of adversity and high levels of supportive contexts to have high physiological reactivity. This model instead tested curvilinear effects at lower levels of adversity versus higher levels of adversity. Future research should create one variable that signifies high adversity exposure at one end and high supportive environment at the other end, thus capturing both ends of the scale in one variable.

Strengths and Limitations

The strengths of this study include the longitudinal design allowing clarification of the direction of effects of adversity and physiological reactivity on children's adjustment. The stratified economic status of the sample allows for variation in childhood adversity, which is necessary to test Diathesis-stress, BSC and ACM models as they posit different relations at different levels of risk. This study is unique in that it assesses multiple indicators of adversity and includes measures of adjustment and maladjustment. In addition, this study takes advantage of multiple assessment measures using questionnaire measures and physiological data. Specifically, the physiological data were collected during two unique emotion-eliciting tasks in addition to a baseline measure. Finally, this is the only known study to specifically assess

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indicators of a supportive context and adverse context in the same sample. There are a few limitations with this study as well. Mother-reported questionnaire data were used to measure children's adjustment, which can be biased, and problem behaviors may only be present in certain contexts. While this is a highly diverse community sample, problem behaviors will be more limited than they would be in a clinical sample.

Conclusion and Future Directions

Future research should examine RSA-R in a large longitudinal sample with a range of exposure to risk and supportive variables. The contradictory results presented here may be largely due to the different variables used to measure adversity and supportive contexts or the lack of variability in exposure to supportive and adverse contexts. Future research should strive to measure multiple contextual variables in a variety of methods to help understand whether these variables interact differently with RSA-R or the method in which contextual variables were measured produce contradictory results. In addition, to fully test models that suggest differences in RSA-R will be found at high levels of exposure to adversity and high levels of supportive environments, a bipolar variable should be examined in relation to RSA-R in a sample that experiences the full range of the variable. Future research should also measure RSA-R collected in more ecologically valid settings. Our laboratory assessments may not fully capture situations that cause measurable physiological arousal. Finally, new research should attempt to use additional statistical techniques to understand these results. For example, using a dichotomous variable of RSA-R indicating withdrawal or augmentation or latent profile analyses to categorize children's RSA-R response may lead to greater understanding of the function of different RSA profiles.

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This study supports and extends previous research, showing that RSA-R moderates the relation between exposure to childhood adversity and adjustment in a longitudinal sample of preschoolers with the full range of income. This study primarily provides support for the Diathesis Stress model, showing that high RSA-R in fear- and frustration-eliciting situations may be a vulnerability and result in more adjustment problems when exposed to low family income or low supportive contexts. As hypothesized in Diathesis Stress, children without this vulnerability, or with low RSA-R, had fewer adjustment problems regardless of context.

By clarifying the role of physiological regulation of stress reactivity in the relation between childhood adversity and adjustment we will increase our ability to identify children at risk for maladjustment and be better able to predict the effects of supportive interventions. This study refined the current theoretical models and focusses future research on the theory with the greatest evidence, Diathesis Stress. Furthermore, this study clarified our understanding of the role of regulation in the development of psychopathology by utilizing a physiological measure of regulation in stressful situations with a sample of preschoolers representing a range of incomes. In order to best identify and intervene with children at risk for psychopathology, we must understand why certain children are more susceptible to the negative impact of childhood adversity.

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Table 1. *Descriptive Statistics for Income and Cumulative Risk at Time 1*

	N	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
Income	306	8.75	3.93	0	14.00	-0.78	-0.57
Cumulative risk	306	0.90	0.81	0	4.50	1.83	3.21
RSA-R Fear T1	200	0.03	1.00	-2.93	2.85	0.01	0.34
RSA-R Frustration T1	191	0.26	0.86	-2.89	3.71	0.39	2.00
RSA-R Fear T2	218	0.01	1.14	-3.46	3.80	0.24	0.53
RSA-R Frustration T2	252	0.48	0.88	-1.71	3.32	0.04	0.16
Externalizing problems T1	303	5.87	3.49	0	19.00	0.95	1.56
Internalizing problems T1	304	4.67	3.55	0	20.57	1.22	2.15
Social competence T1	304	45.53	8.42	17.00	66.00	-0.03	-0.24
Externalizing problems T3	282	4.41	3.69	0	28.00	1.75	6.36
Internalizing problems T3	282	6.23	5.15	0	23.00	1.21	1.11
Social competence T3	282	53.35	8.62	24.00	71.00	0.36	-0.10
Positive parenting T1	288	4.00	0.42	2.15	4.79	-1.32	2.50
Family functioning T1	306	11.30	2.10	3.50	15.50	-0.69	0.73

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Table 2. *Descriptive Statistics for Raw Data of Respiratory Sinus Arrhythmia at Times 1 and 2*

	N	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
RSA Fear T1	203	5.87	1.22	2.07	8.49	-0.31	0.04
RSA Frustration T1	193	5.61	1.03	2.42	8.39	0.01	0.68
RSA Baseline T1	234	5.93	1.18	2.85	8.71	-0.06	-0.13
RSA Fear T2	249	6.33	1.16	3.41	8.96	0.08	-0.41
RSA Frustration T2	252	6.25	1.07	3.48	8.96	-0.13	-0.32
RSA Baseline T2	267	6.75	1.09	4.15	9.11	-0.14	-0.55

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Table 3. *Correlations among study variables for moderation analyses examining childhood adversity*

	Gender	Income	Cumulative risk	Externalizing problems T1	Internalizing problems T1	Social competence T1	RSA-R fear T1	RSA-R frustration T1	Externalizing problems T2	Internalizing problems T3	Social competence T3
Gender	--	-.50	-.01	.13*	.02	-.07	-.07	-.11	.13*	.01	-.12
Income		---	.59**	-.02	.06	.03	-.01	-.07	-.19**	-.10	.18**
Cumulative risk			--	.15*	.03	-.11	-.03	-.01	.22**	.18**	-.19
Externalizing problems T1				--	.34**	-.23**	.03	-.09	.47**	.25**	-.26**
Internalizing problems T1					--	-.12*	.06	-.02	.13*	.48**	-.14*
Social competence T1						--	.02	.01	-.10	.01	.33**
RSA-R fear T1							--	.34**	.03	.13	.08
RSA-R frustration T1								--	-.02	.15*	.02
Externalizing problems T3									--	.48**	-.49
Internalizing problems T3										--	-.35**
Social competence T3											--

Note: *$p < .05$, **$p < .01$

.

Table 4. *Correlations among study variables for moderation analyses examining supportive environments.*

	Gender	Income	Positive parenting T1	Family functioning T1	Externalizing problems T1	Internalizing problems T1	Social competence T1	RSA-R fear T1	RSA-R frustration T1	Externalizing problems T3	Internalizing problems T3	Social competence T3
Gender	--	-.50	-.11	.02	.13*	.02	-.07	-.07	-.11	.13*	.01	-.12
Income		---	.32**	.06	-.02	.06	.03	-.01	-.07	-.19**	-.10	.18**
Positive parenting T1			--	.15*	-.17**	-.03	.05	.04	-.02	-.27**	-.10	.21**
Family functioning T1				--	-.31**	-.24**	.13*	-.12	.04	-.13*	-.09	.24**
Externalizing problems T1					--	.34**	-.23**	.03	-.09	.47**	.25**	-.26**
Internalizing problems T1						--	-.12*	.06	-.02	.13*	.48**	-.14*
Social competence T1							--	.02	.01	-.10	.01	.33**
RSA-R fear T1								--	.34**	.03	.13	.08
RSA-R frustration T1									--	-.02	.15*	.02
Externalizing problems T3										--	.48**	-.49
Internalizing problems T3											--	-.35**
Social competence T3												--

Note: *$p < .05$, **$p < .01$

.

Table 5. *Correlations among study variables for mediation analyses examining childhood adversity*

	Gender	Income	Cumulative risk	Externalizing problems T1	Internalizing problems T1	Social competence T1	RSA-R fear T2	RSA-R frustration T2	Externalizing problems T3	Internalizing problems T3	Social competence T3
Gender	--	-.50	-.01	.13*	.02	-.07	-.10	.01	.13*	.01	-.12
Income		---	.59**	-.02	.06	.03	.03	-.03	-.19**	-.10	.18**
Cumulative risk			--	.15*	.03	-.11	-.01	.04	.22**	.18**	-.19
Externalizing problems T1				--	.34**	-.23**	.03	-.03	.47**	.25**	-.26**
Internalizing problems T1					--	-.12*	.06	-.07	.13*	.48**	-.14*
Social competence T1						--	-.15*	.11	-.10	.01	.33**
RSA-R fear T2							--	-.04	-.05	-.03	-.05
RSA-R frustration T2								--	-.09	-.09	.06
Externalizing problems T3									--	.48**	-.49
Internalizing problems T3										--	-.35**
Social competence T3											--

Note: *$p < .05$, **$p < .01$

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Table 6. *Unstandardized and standardized regression coefficients and standard errors from regression analyses of interactions between RSA-R and childhood adversity*

	Externalizing problems			Internalizing Problems			Social Competence		
	B	SE	b	B	SE	b	B	SE	b
Adjustment outcome T1	0.39**	-0.06	0.38	0.65**	0.06	0.45	0.32**	0.05	0.32
Child sex	0.42	0.51	0.06	-0.15	0.51	-0.02	-1.38	0.95	-0.08
Income	-0.03	0.10	-0.04	0.08	0.10	0.06	0.13	0.17	0.06
Cumulative risk	0.58^{t}	0.42	0.13	1.05*	0.42	0.17	-1.01	0.76	-1.0
RSA-R fear T1	0.13	0.25	0.04	0.65^{t}	0.36	0.12	0.29	0.67	0.03
RSA-R frustration T1	0.28	0.32	0.07	1.13**	0.43	0.19	-0.63	0.77	-0.06
Income x RSA-R fear	-0.20*	0.10	-0.21	-0.45**	0.14	-0.33	0.32	0.27	0.14
Income x RSA-R frustration	-0.30*	0.14	-0.26	-0.31^{t}	0.19	-0.19	0.46	0.33	0.16
Risk x RSA-R fear	-1.02*	0.49	-0.20	-1.09	0.69	-0.15	0.17	1.27	0.01
Risk x RSA-R frustration	-0.49	0.47	-0.12	-1.10^{t}	0.64	-0.19	1.38	1.14	0.14

Note: *$p < .05$, **$p < .01$

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Table 7. *Unstandardized and standardized regression coefficients and standard errors from regression analyses of interactions between RSA-R and supportive environment*

	Externalizing problems			Internalizing Problems			Social Competence		
	B	SE	b	B	SE	b	B	SE	b
Adjustment outcome T1	0.37**	0.05	0.36	0.65**	0.07	0.44	0.31**	0.05	0.30
Child sex	0.37	0.37	0.05	-0.07	0.52	-0.01	-1.30	0.92	-0.08
Income	-0.11*	0.05	-0.12	-0.12t	0.07	-0.09	0.26*	0.13	0.12
Family Functioning	0.05	0.10	0.03	0.11	0.14	0.05	0.70**	0.25	0.17
Positive Parenting	-0.95[t]	0.52	-0.11	-0.12	0.72	-0.01	1.88	1.27	0.09
RSA-R fear T1	0.04	0.26	0.01	0.41	0.38	0.08	0.90	0.64	0.11
RSA-R frustration T1	0.12	0.32	0.03	0.74	0.45	0.12	-0.20	0.72	-0.02
Positive Parenting x RSA-R fear	-0.91	0.67	-0.11	-2.31*	1.02	-0.20	2.45	1.70	0.13
Positive Parenting x RSA-R frustration	-1.91*	0.92	-0.17	-1.51	1.32	-0.09	1.25	2.06	0.05
Family Functioning x RSA-R fear	-0.02	0.10	-0.02	0.02	0.15	0.01	0.05	0.25	0.01
Family Functioning x RSA-R frustration	0.46*	0.19	0.20	0.66*	0.27	0.20	-1.00*	0.42	-0.18

Note: *$p < .05$, **$p < .01$

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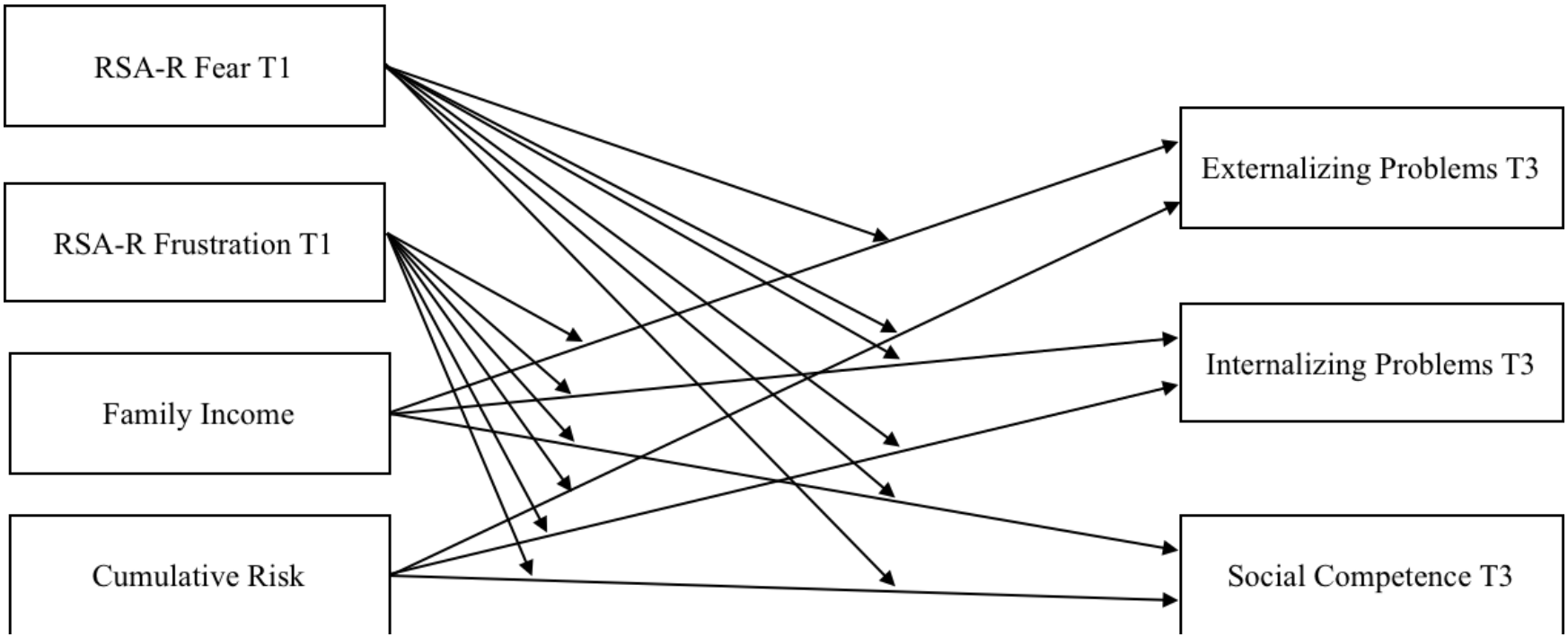
Figure 1. *Model depicting proposed moderation effects of RSA-R on the relation between early childhood adversity and adjustment.*



Note: Child gender is controlled for in moderation analysis. Separate regression equations were conducted for externalizing problems, internalizing problems, and social competence.

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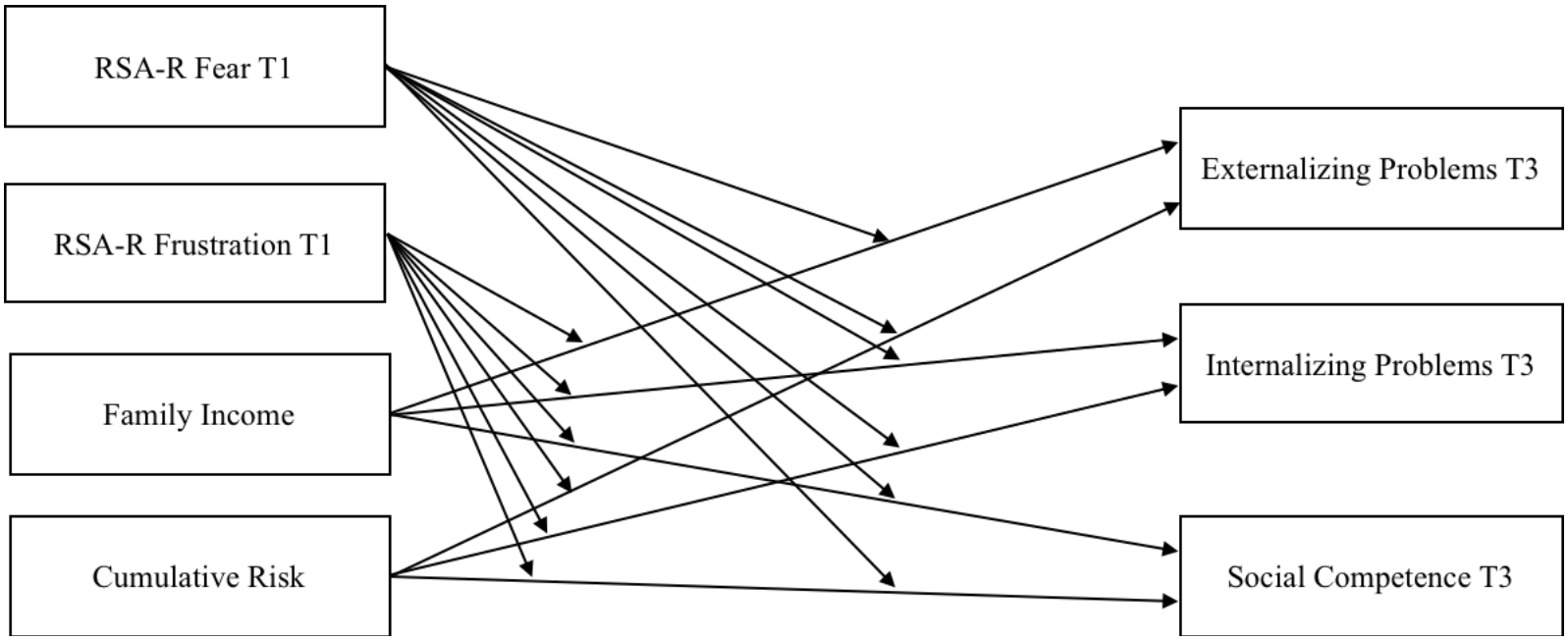
Figure 2. *Model depicting proposed moderation effects of RSA-R on the relation between early supportive context and adjustment.*



Note: Child gender and family income are controlled for in moderation analysis. Separate regression equations were conducted for externalizing problems, internalizing problems, and social competence.

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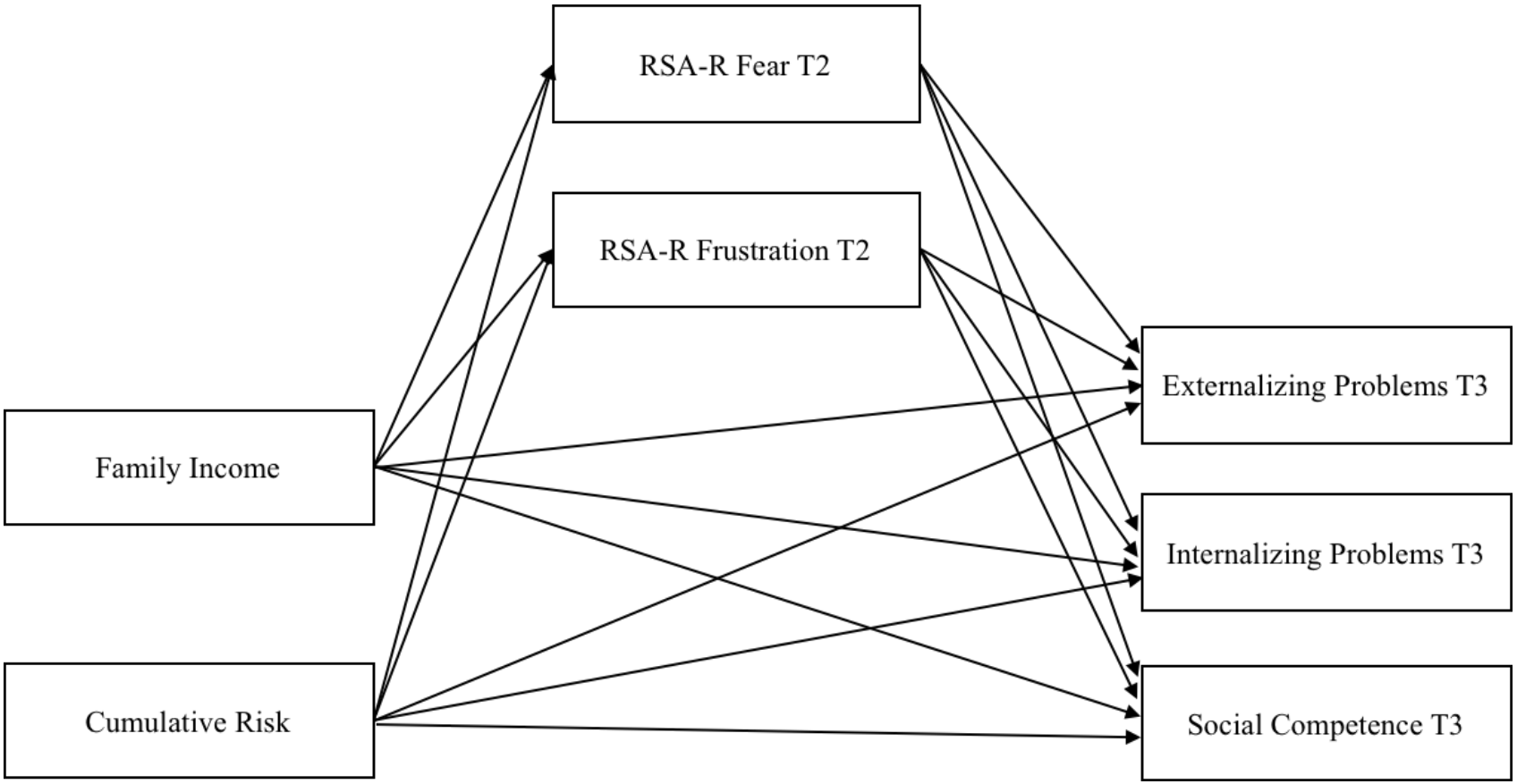
Figure 3. *Model depicting proposed mediation effects of RSA-R on relation between childhood adversity and adjustment outcomes.*



Note: Child gender is controlled for in moderation analysis. Separate regression equations were conducted for externalizing problems, internalizing problems, and social competence.

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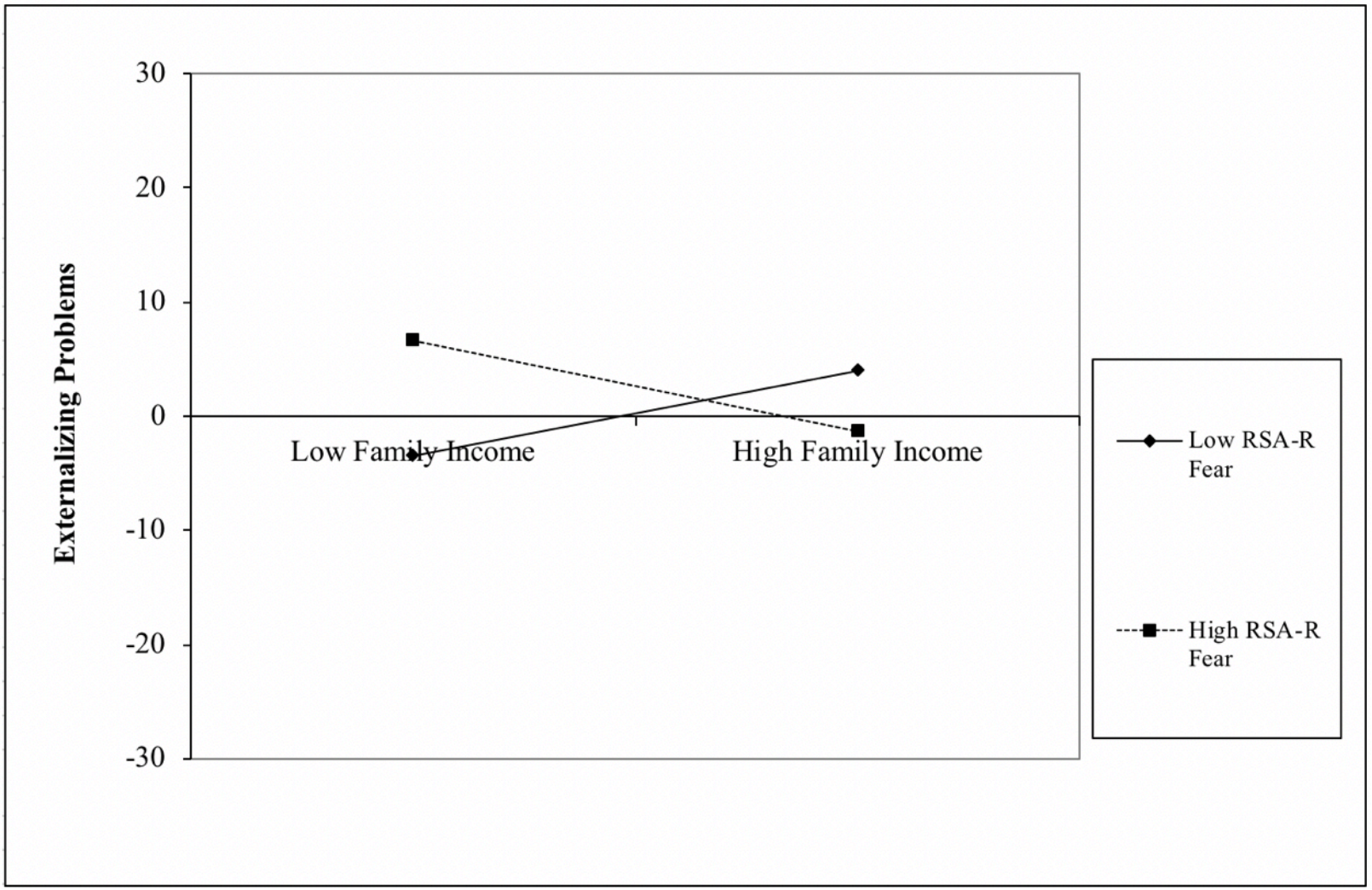
Figure 4a. *Simple-slopes plot RSA-R fear interacting with family income predicting externalizing problems.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both income and RSA-R fear.

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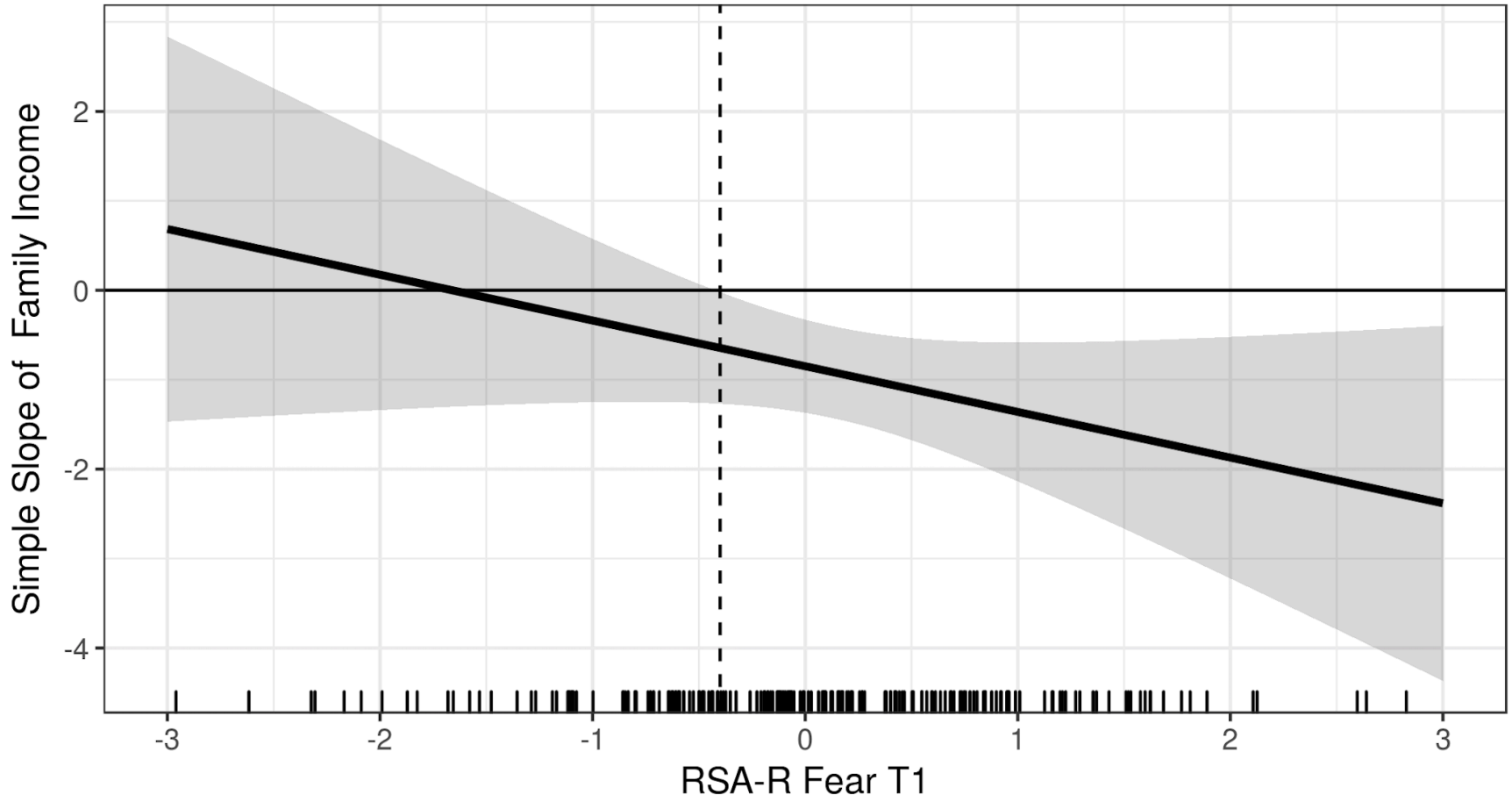
Figure 4b. *Regions-of-significance plot of RSA-R fear interacting with family income predicting externalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed externalizing problems. The vertical dashed line represents the point of RSA-R fear at which externalizing problems becomes significantly associated with family income.

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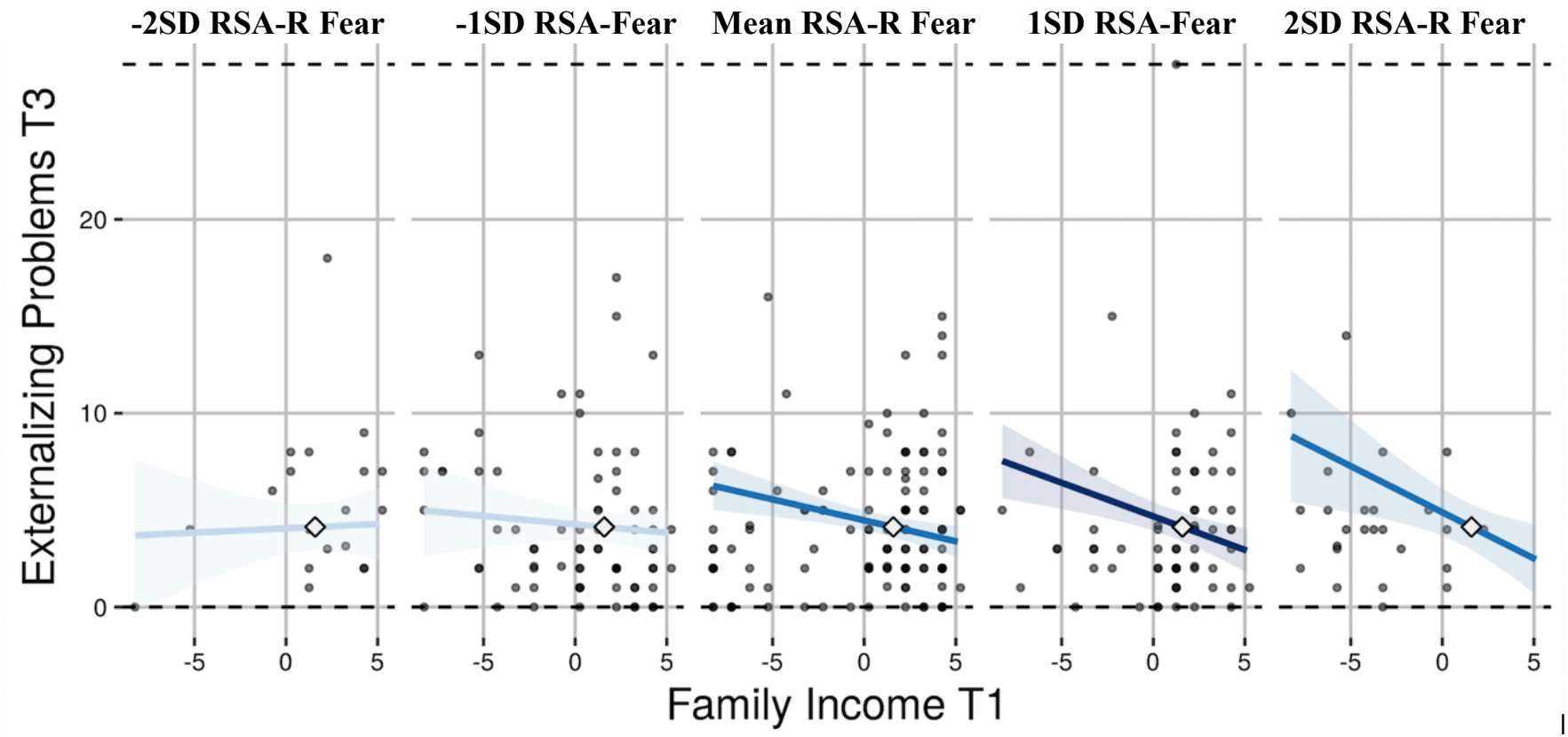
Figure 4c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R fear interacting with family income predicting externalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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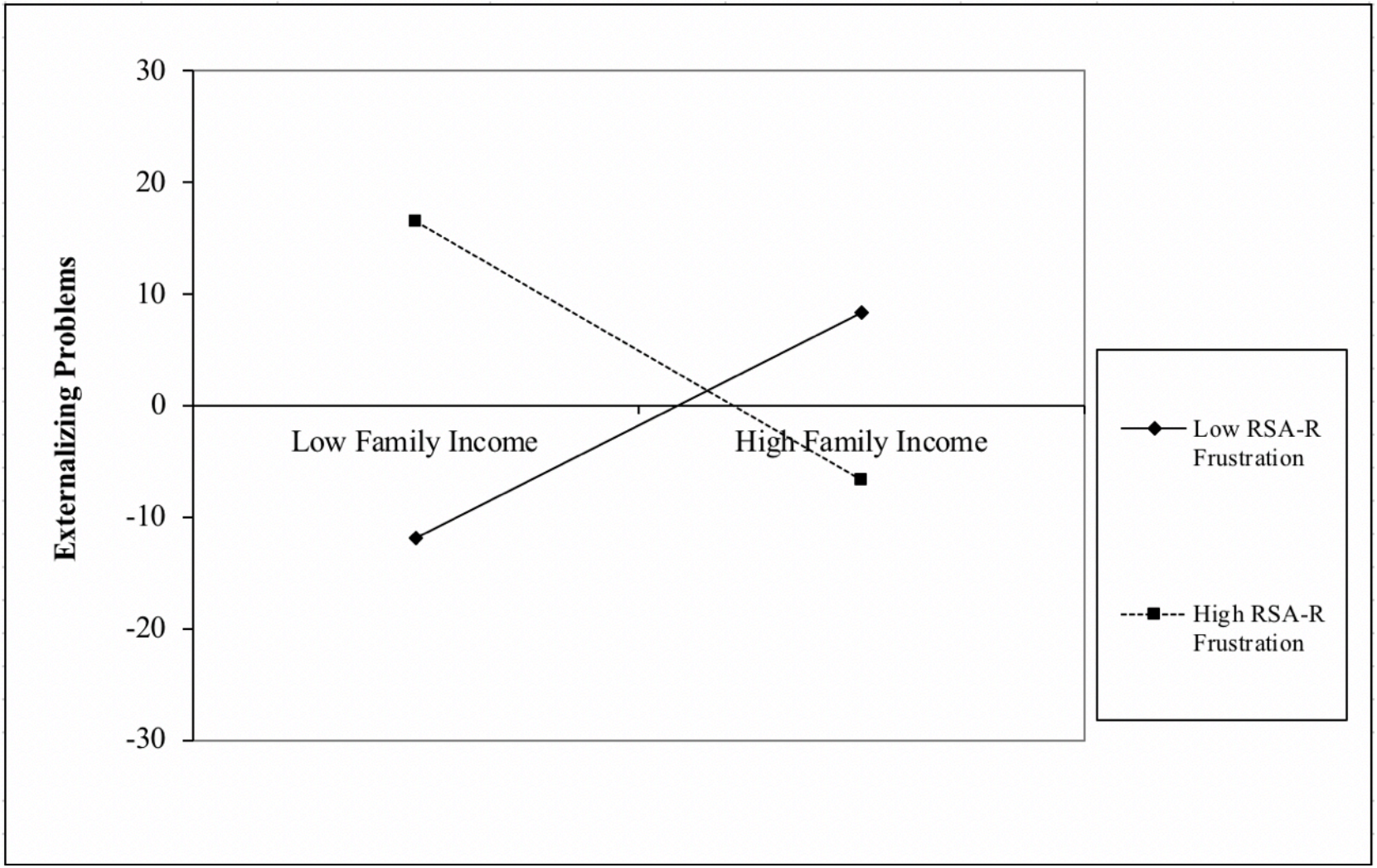
Figure 5a. *Simple-slopes plot of RSA-R frustration interacting with family income predicting externalizing problems*.



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both income and RSA-R frustration.

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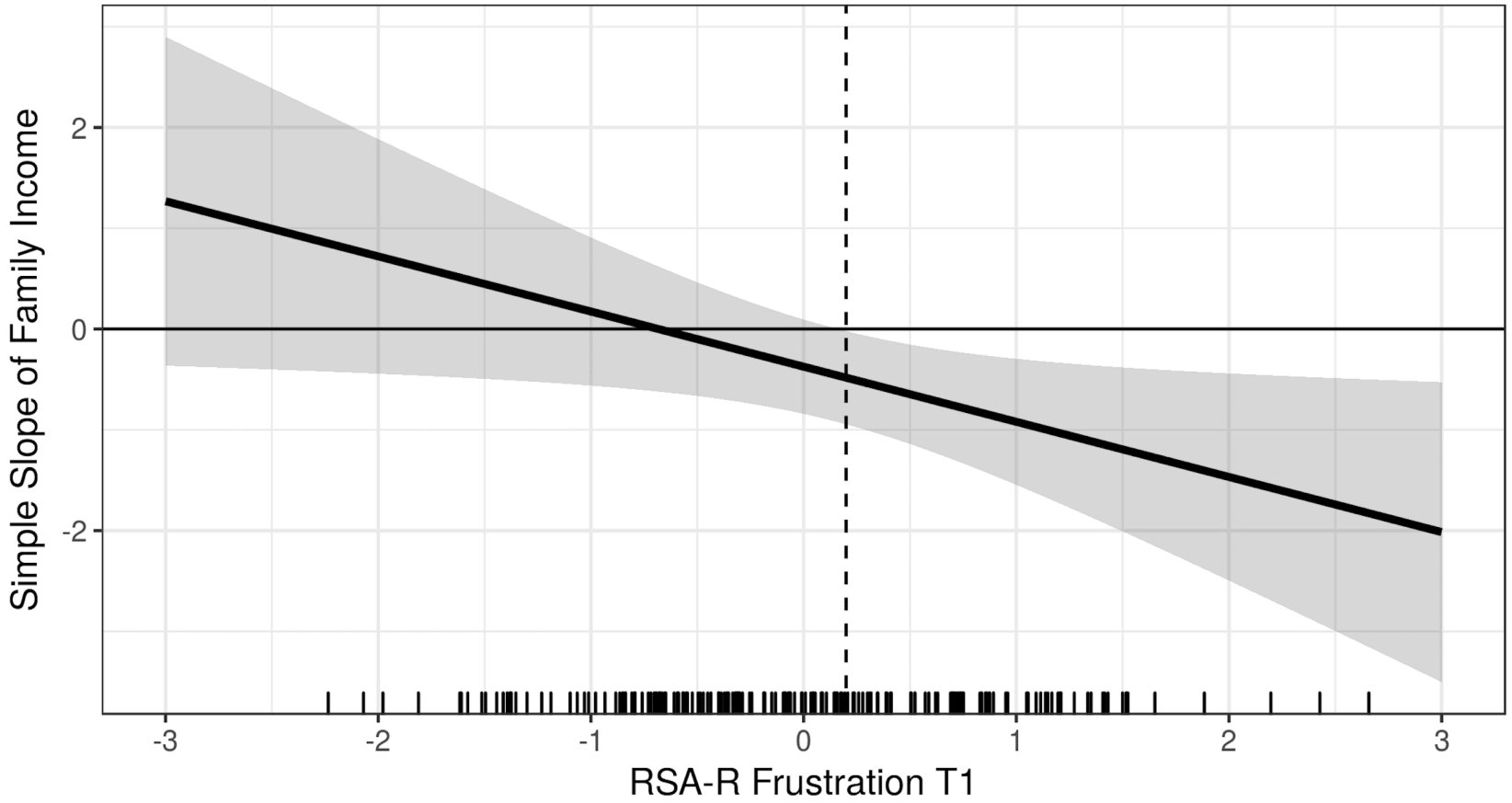
Figure 5b. *Regions-of-significance plot of family income interacting with RSA-R frustration predicting externalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed externalizing problems. The vertical dashed line represents the point of RSA-R frustration at which externalizing problems becomes significantly associated with family income.

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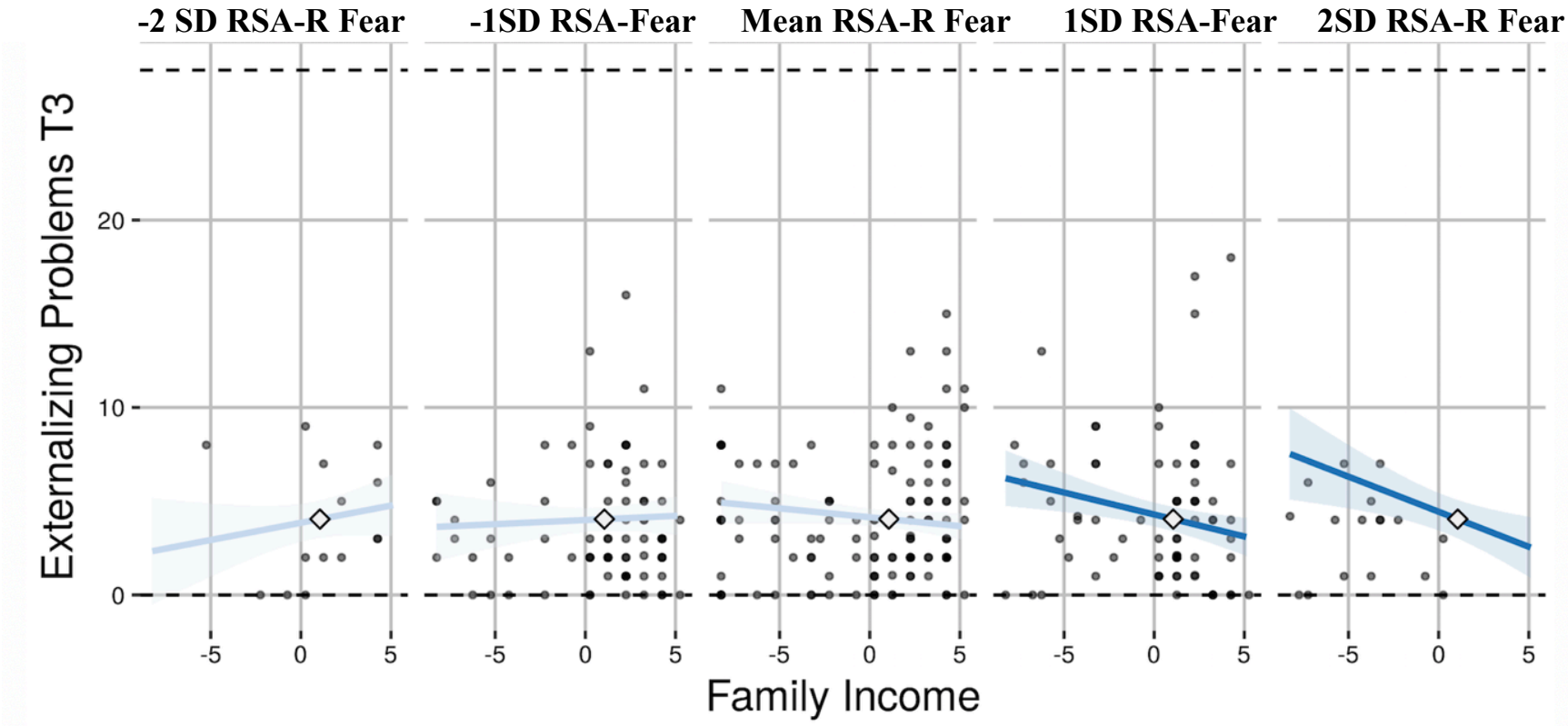
Figure 5c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R frustration interacting with family income predicting externalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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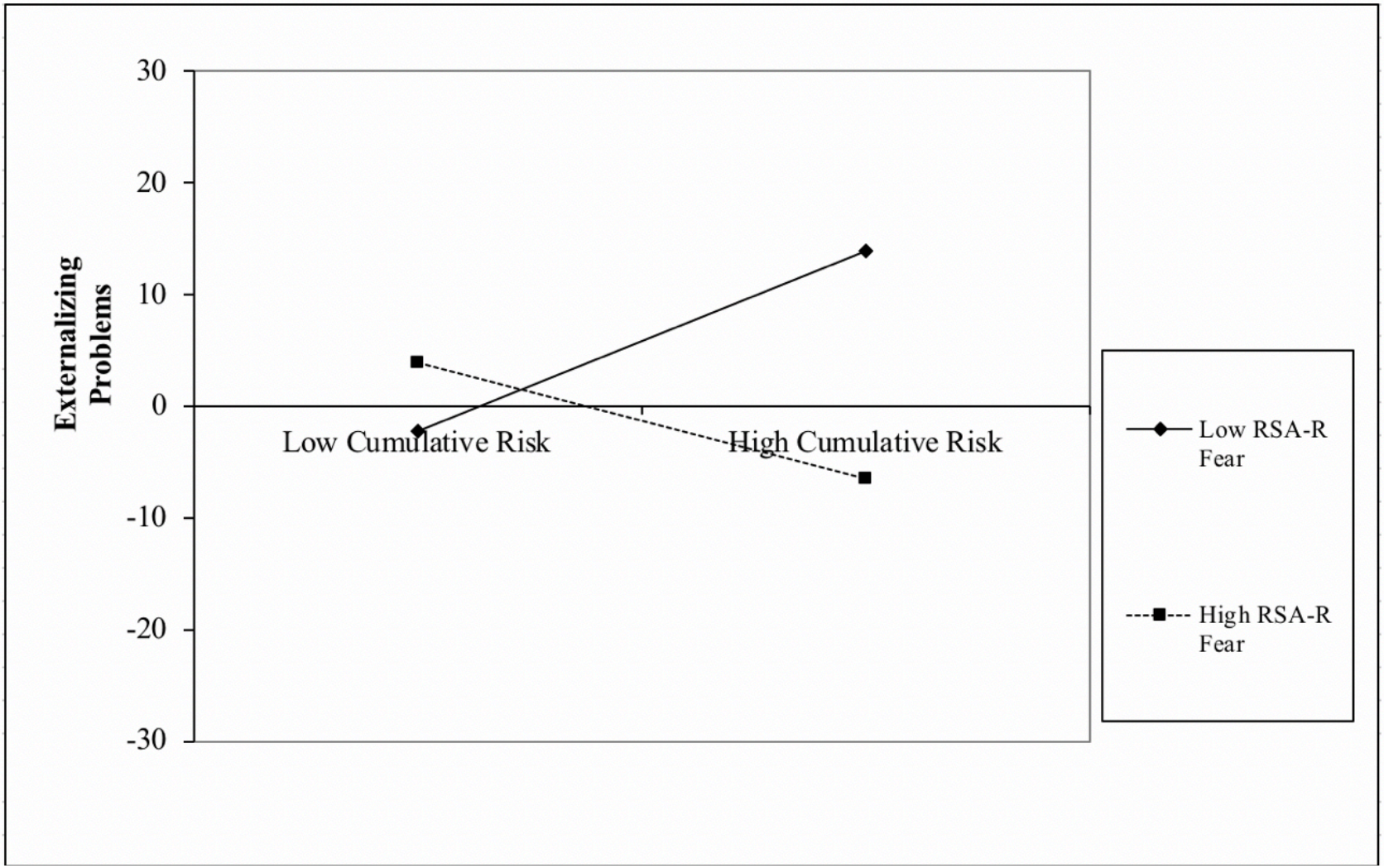
Figure 6a. *Simple-slopes plot of RSA-R fear interacting with cumulative risk predicting externalizing problems.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both cumulative risk and RSA-R fear.

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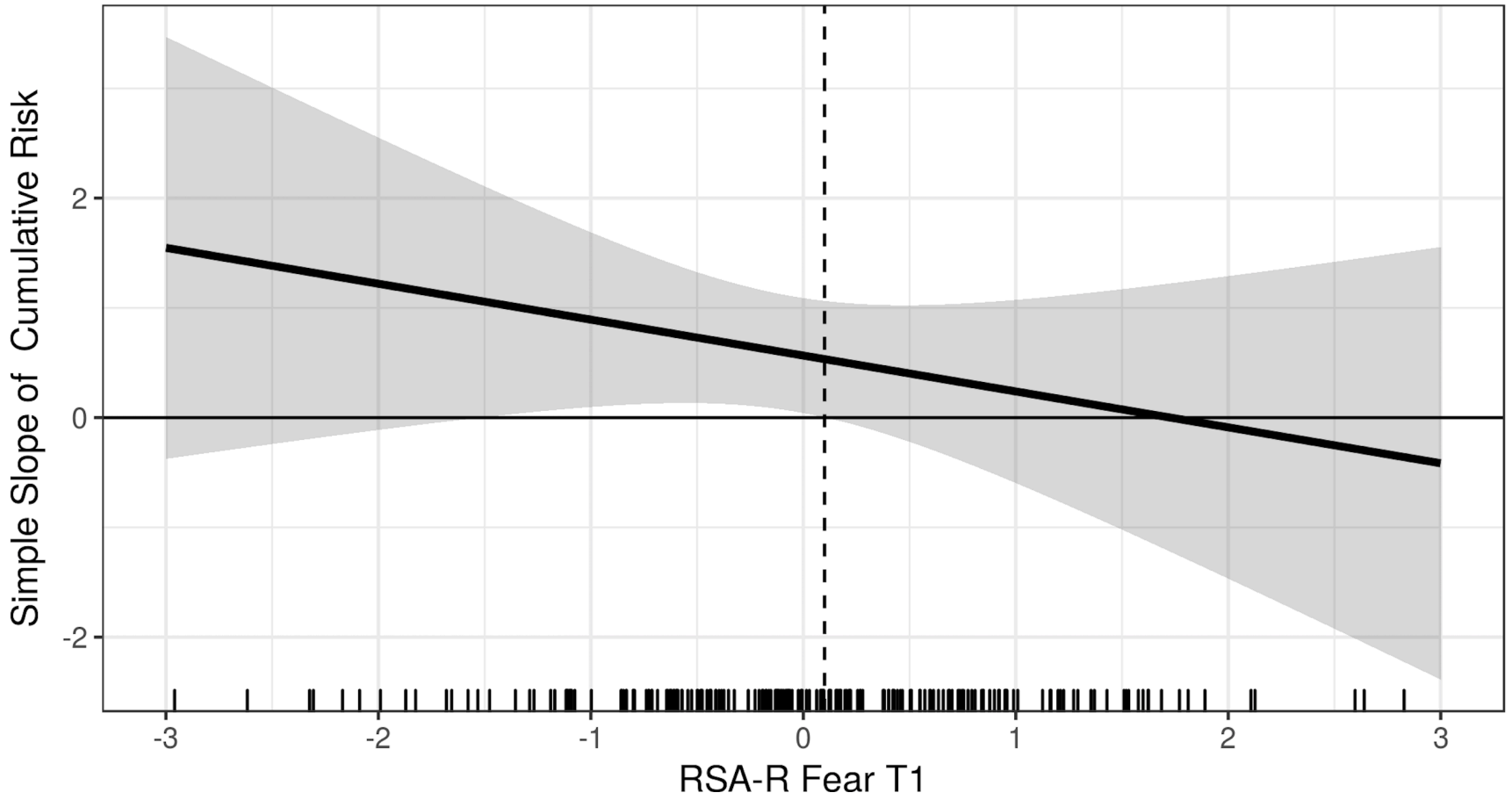
Figure 6b. *Regions-of-significance plot of RSA-R fear interacting with cumulative risk predicting externalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed externalizing problems. The vertical dashed line represents the point of RSA-R fear at which externalizing problems becomes significantly associated with cumulative risk.

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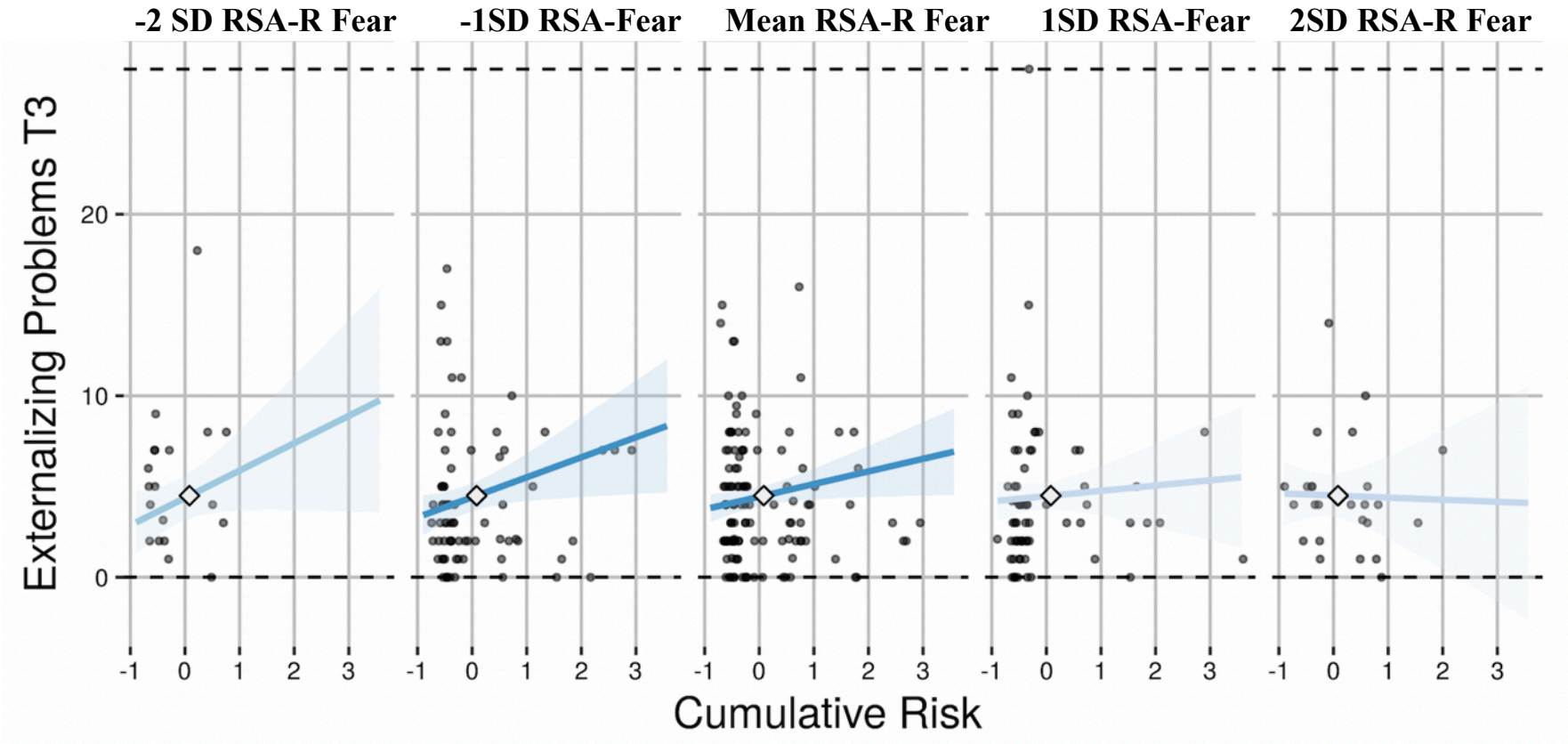
Figure 6c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R fear interacting with cumulative risk predicting externalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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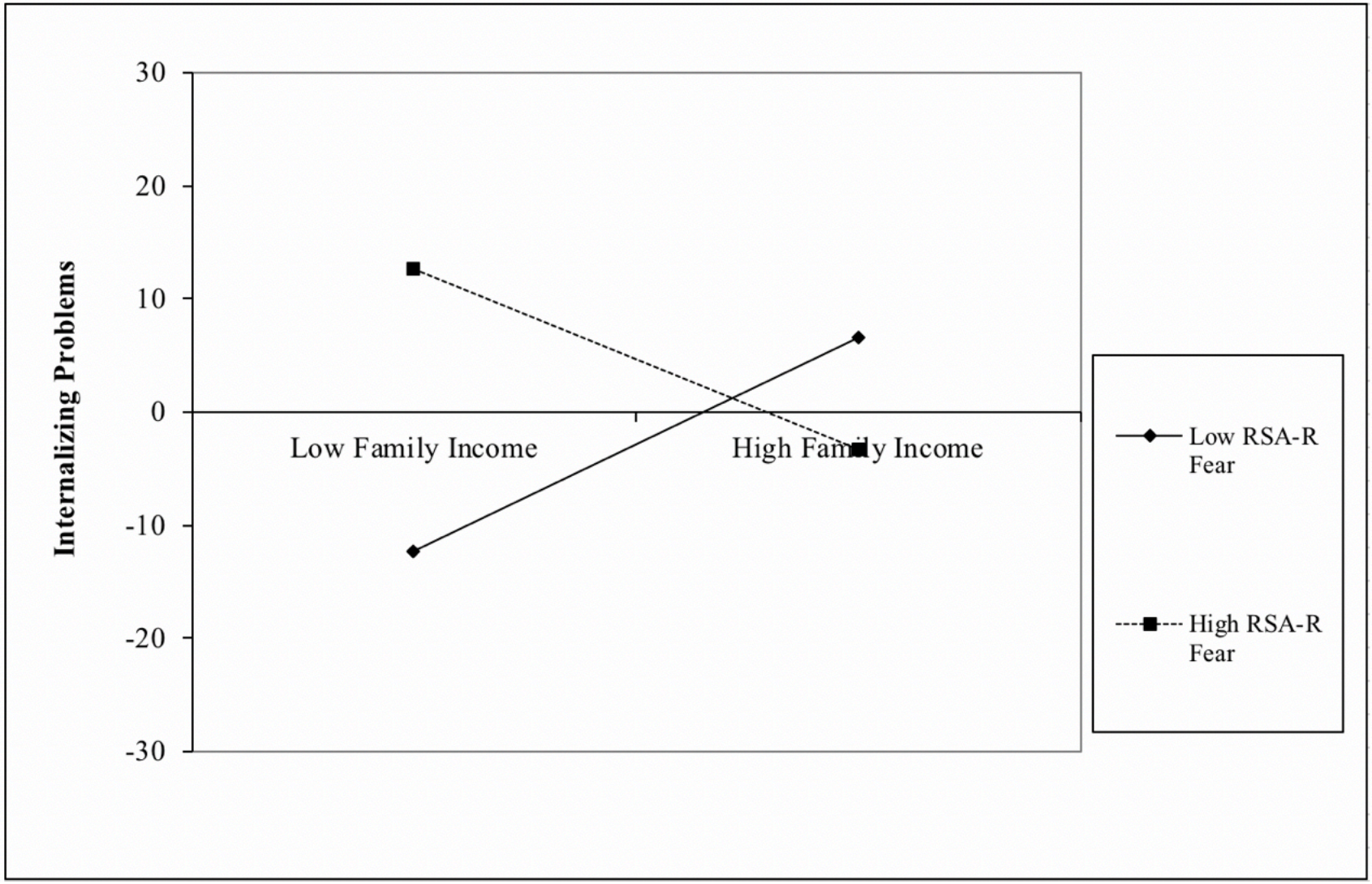
Figure 7a. *Simple-slopes plot of RSA-R fear interacting with family income predicting internalizing problems.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both income and RSA-R fear.

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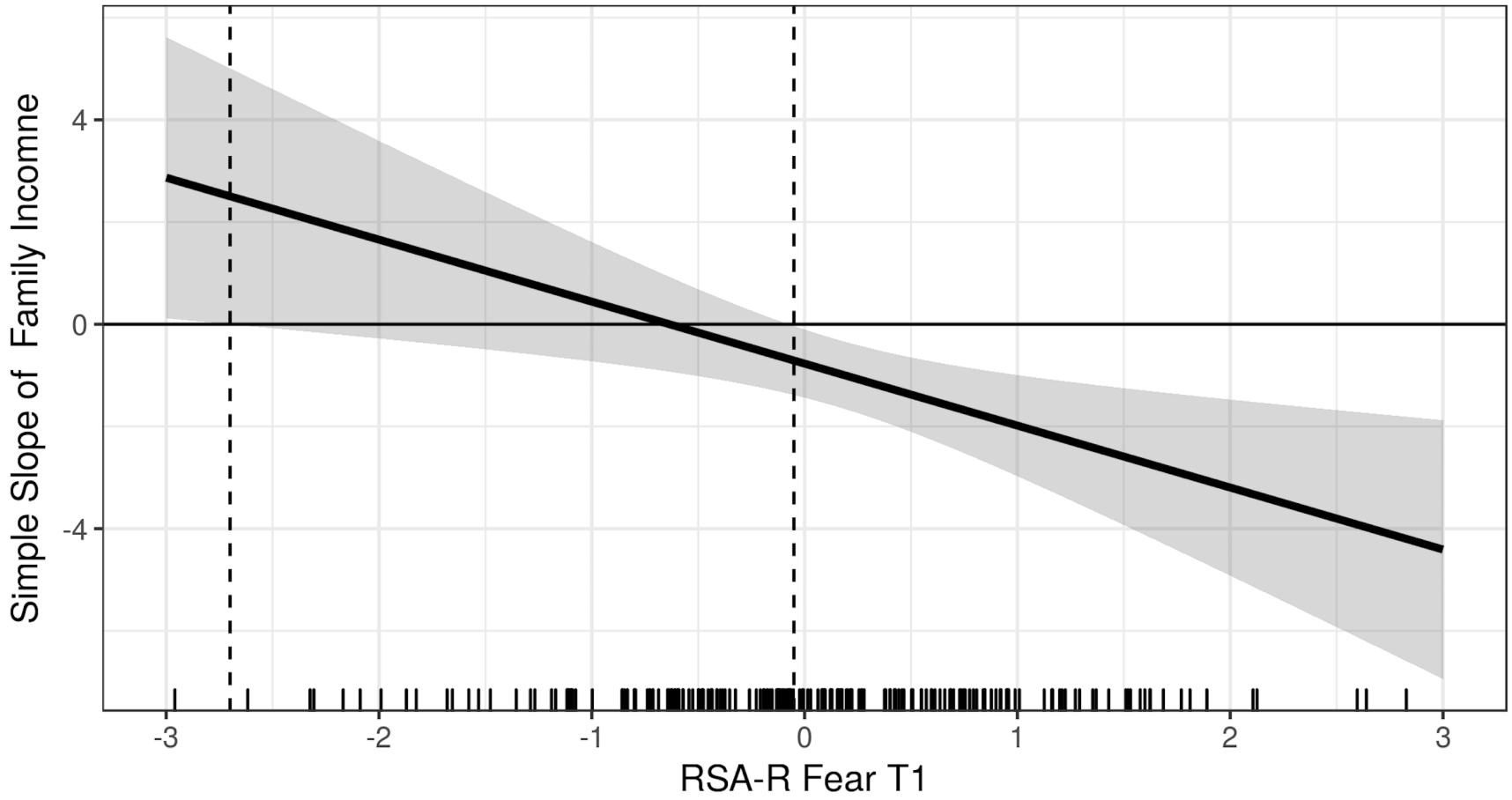
Figure 7b. *Regions-of-significance plot of RSA-R fear interacting with family income predicting internalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed internalizing problems. The vertical dashed line represents the point of RSA-R fear at which internalizing problems becomes significantly associated with family income.

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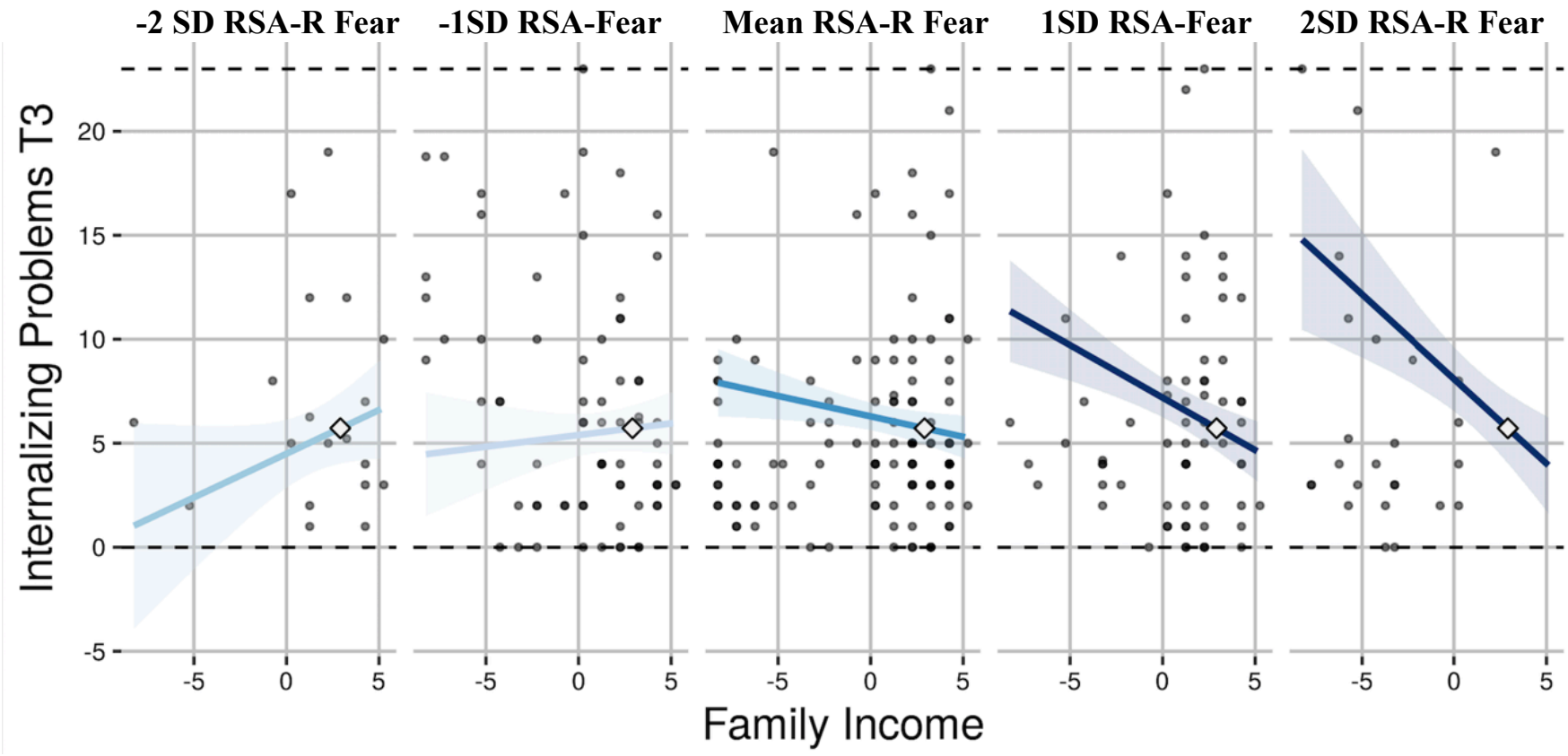
Figure 7c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R fear interacting with family income predicting internalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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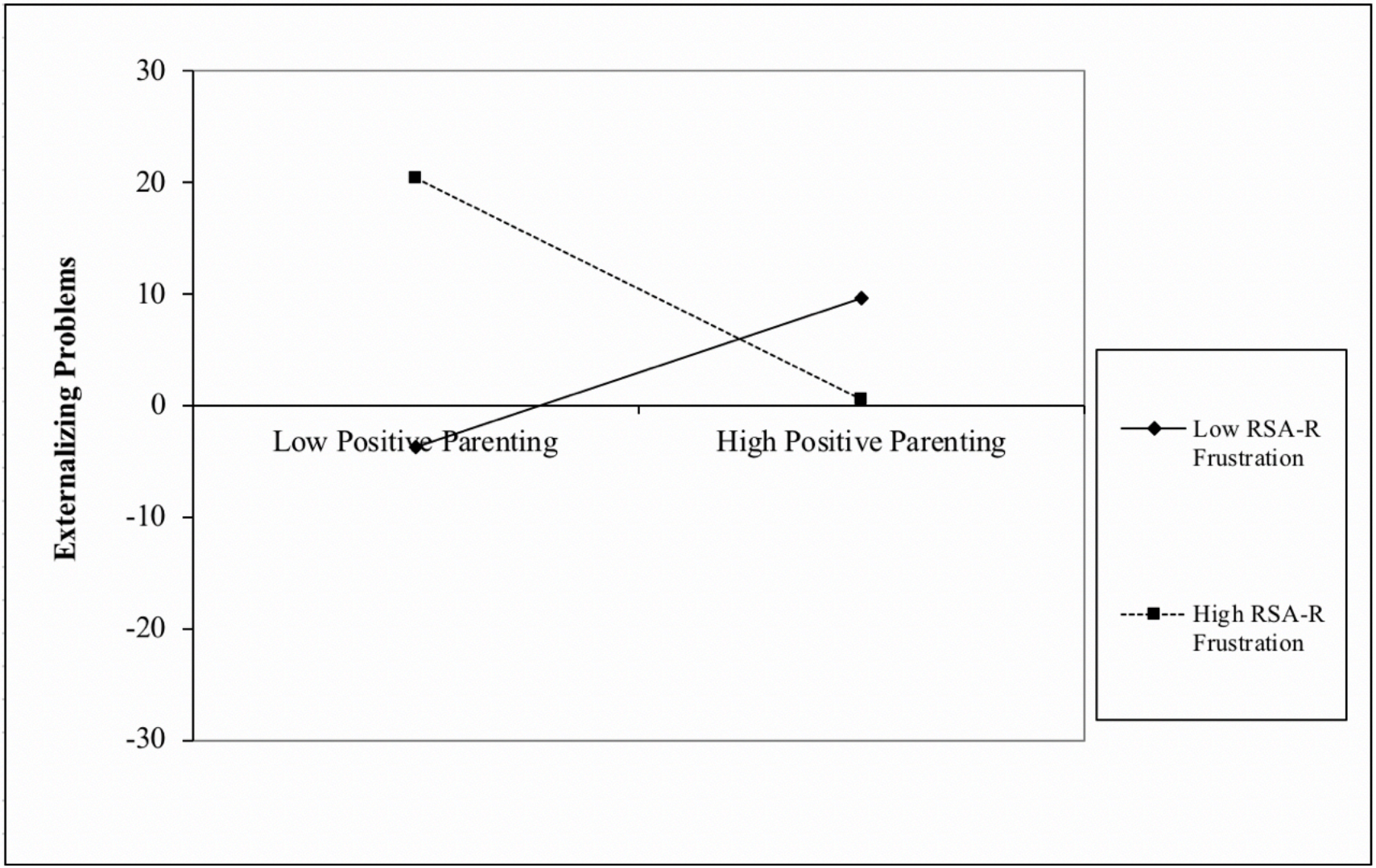
Figure 8a. *Simple-slopes plot of RSA-R frustration interacting with positive parenting predicting externalizing problems.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both positive parenting and RSA-R frustration.

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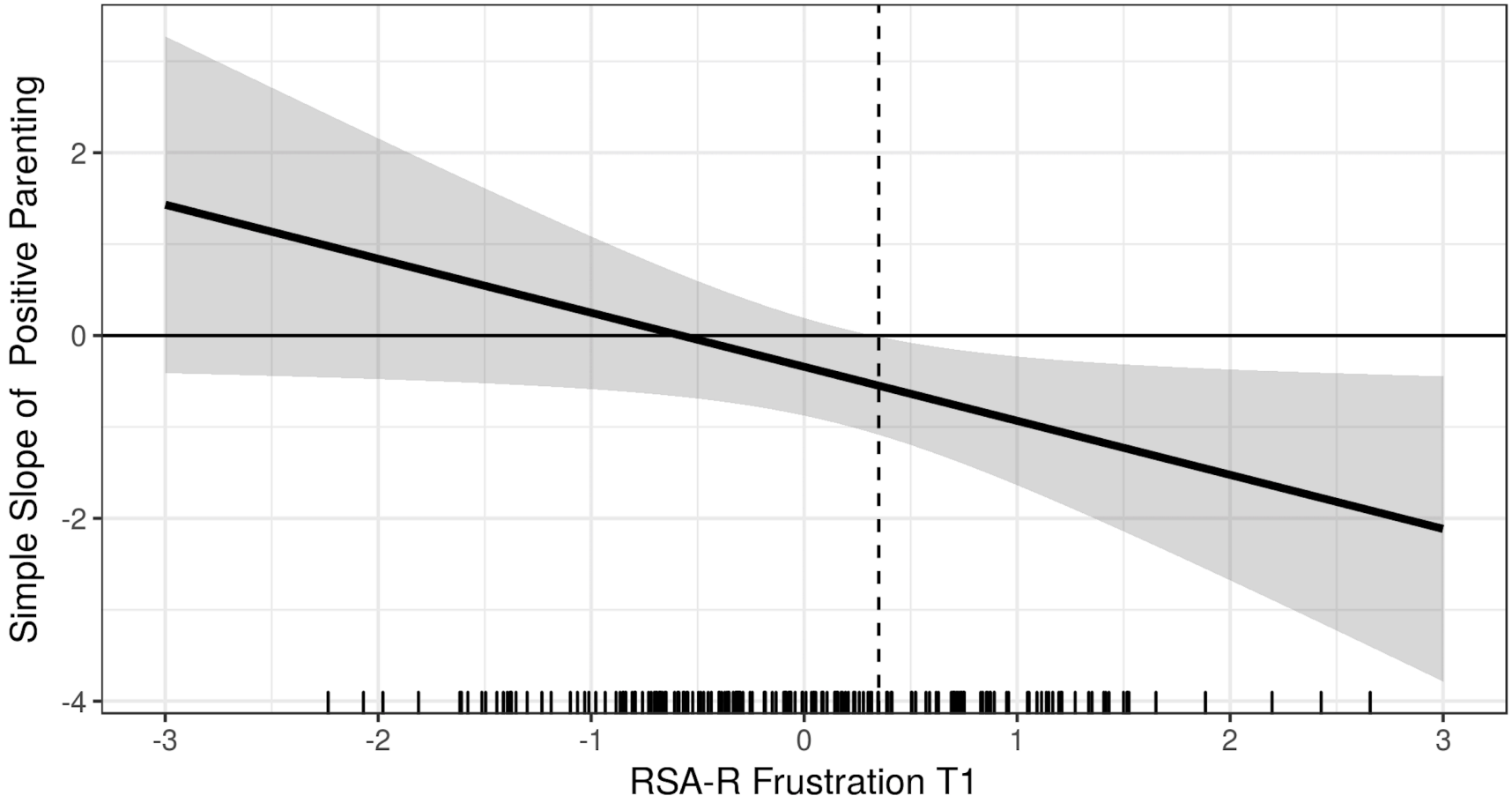
Figure 8b. *Regions-of-significance plot of RSA-R frustration interacting with positive parenting predicting externalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed externalizing problems. The vertical dashed line represents the point of RSA-R frustration at which externalizing problems becomes significantly associated with positive parenting.

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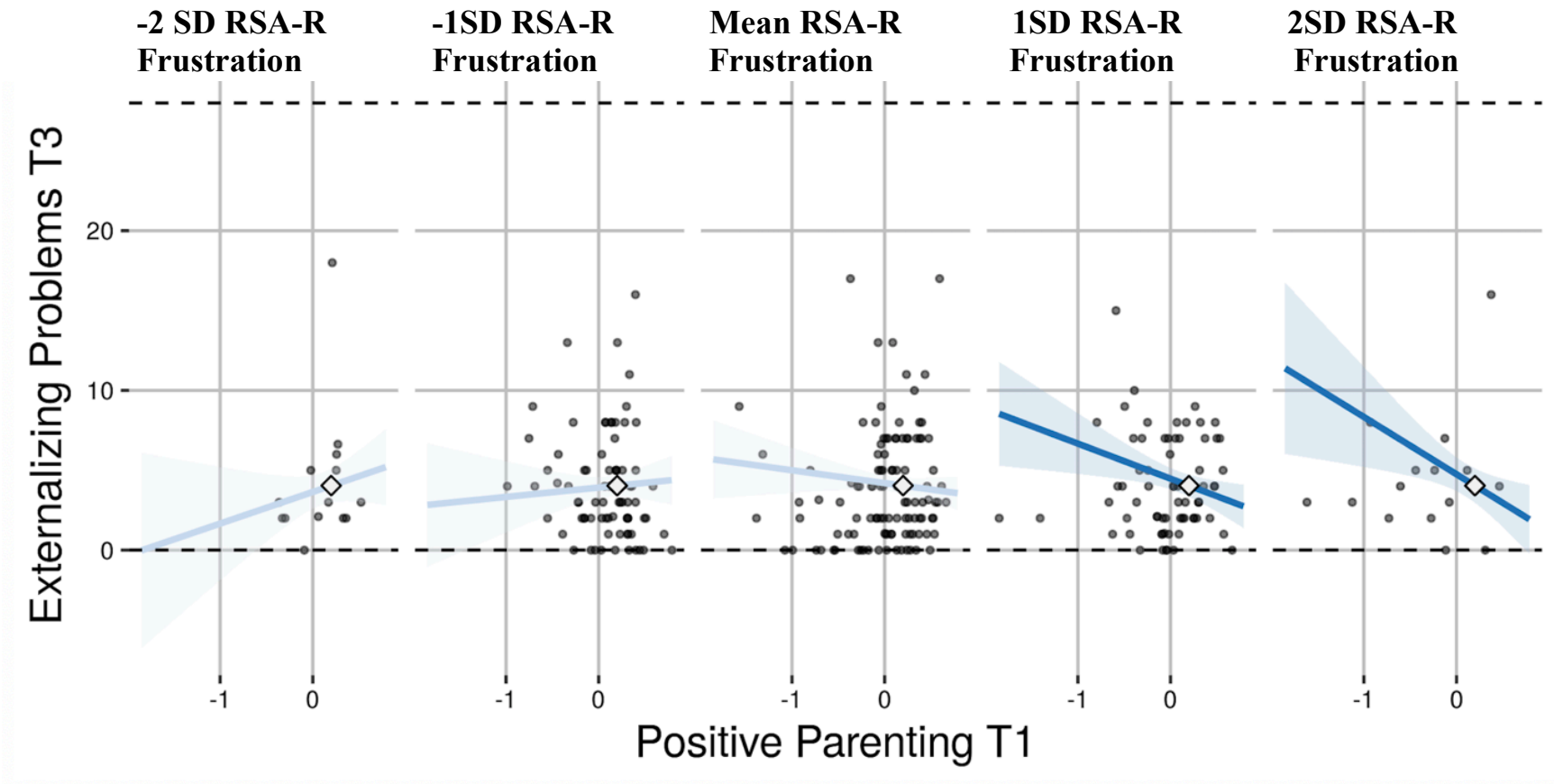
Figure 8c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R frustration interacting with positive parenting predicting externalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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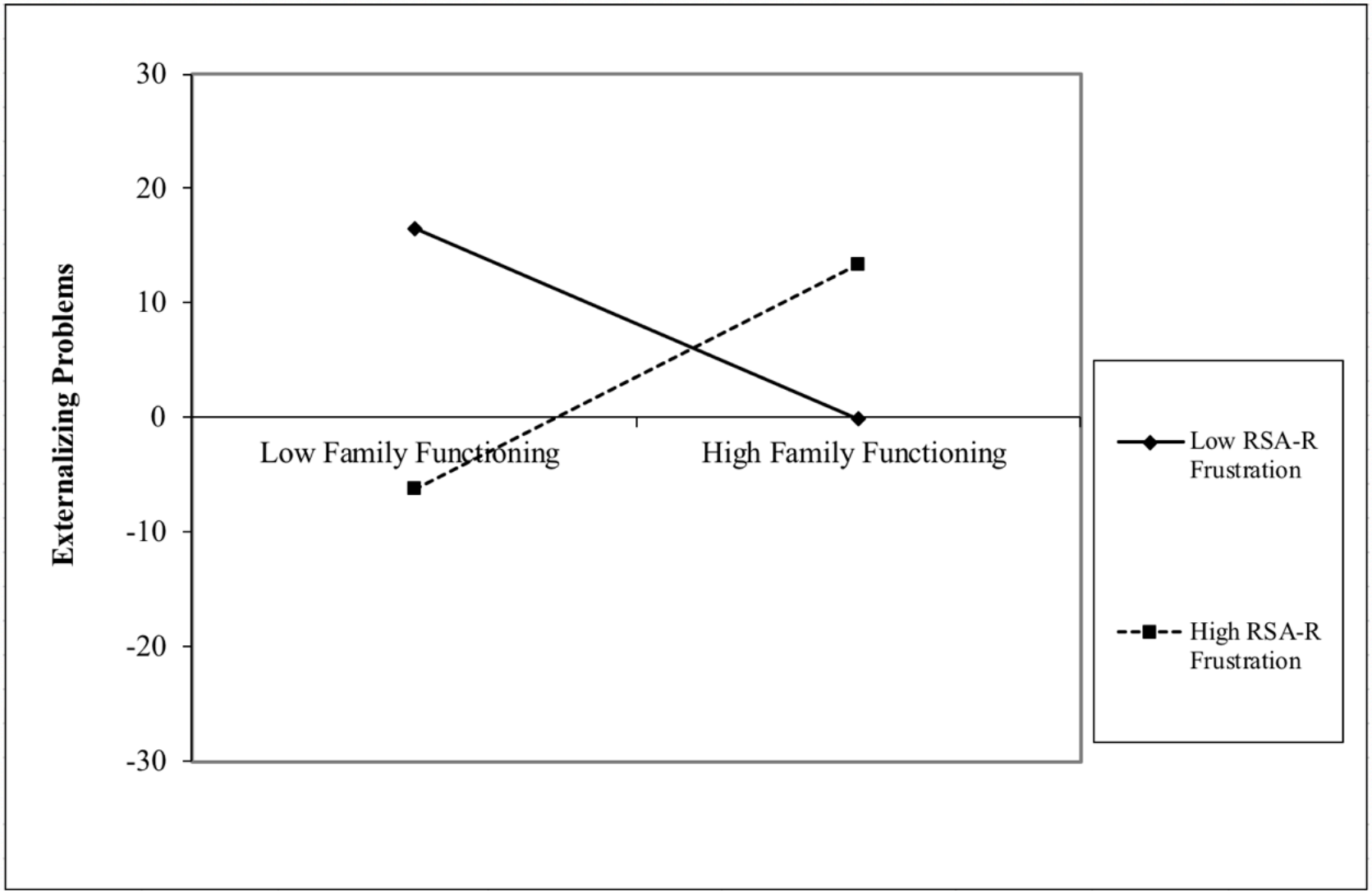
Figure 9a. *Simple-slopes plot of RSA-R frustration interacting with family functioning predicting externalizing problems.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both family functioning and RSA-R frustration.

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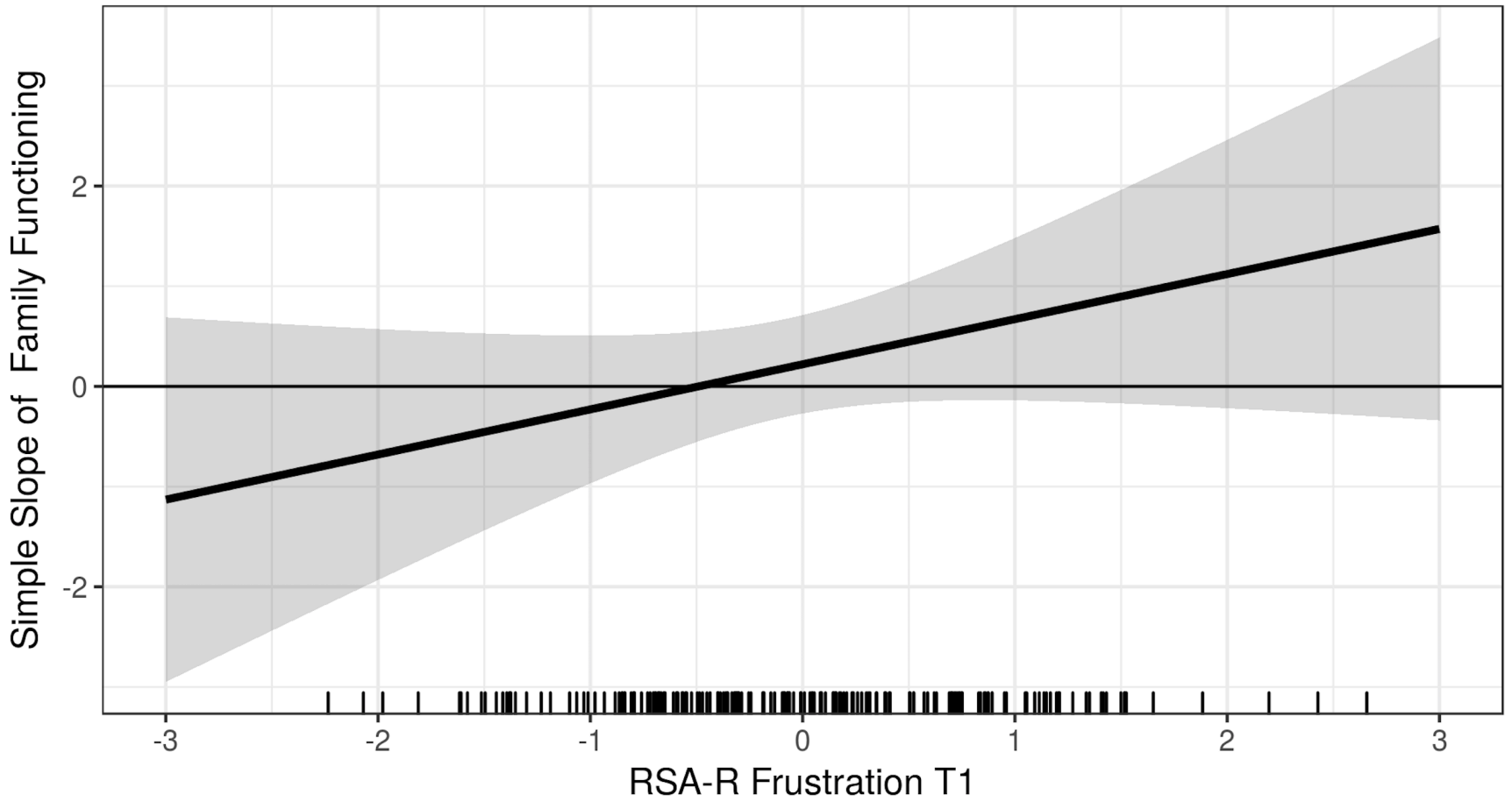
Figure 9b. *Regions-of-significance plot of RSA-R frustration interacting with family functioning predicting externalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed externalizing problems. The vertical dashed line represents the point of RSA-R frustration at which externalizing problems becomes significantly associated with family functioning.

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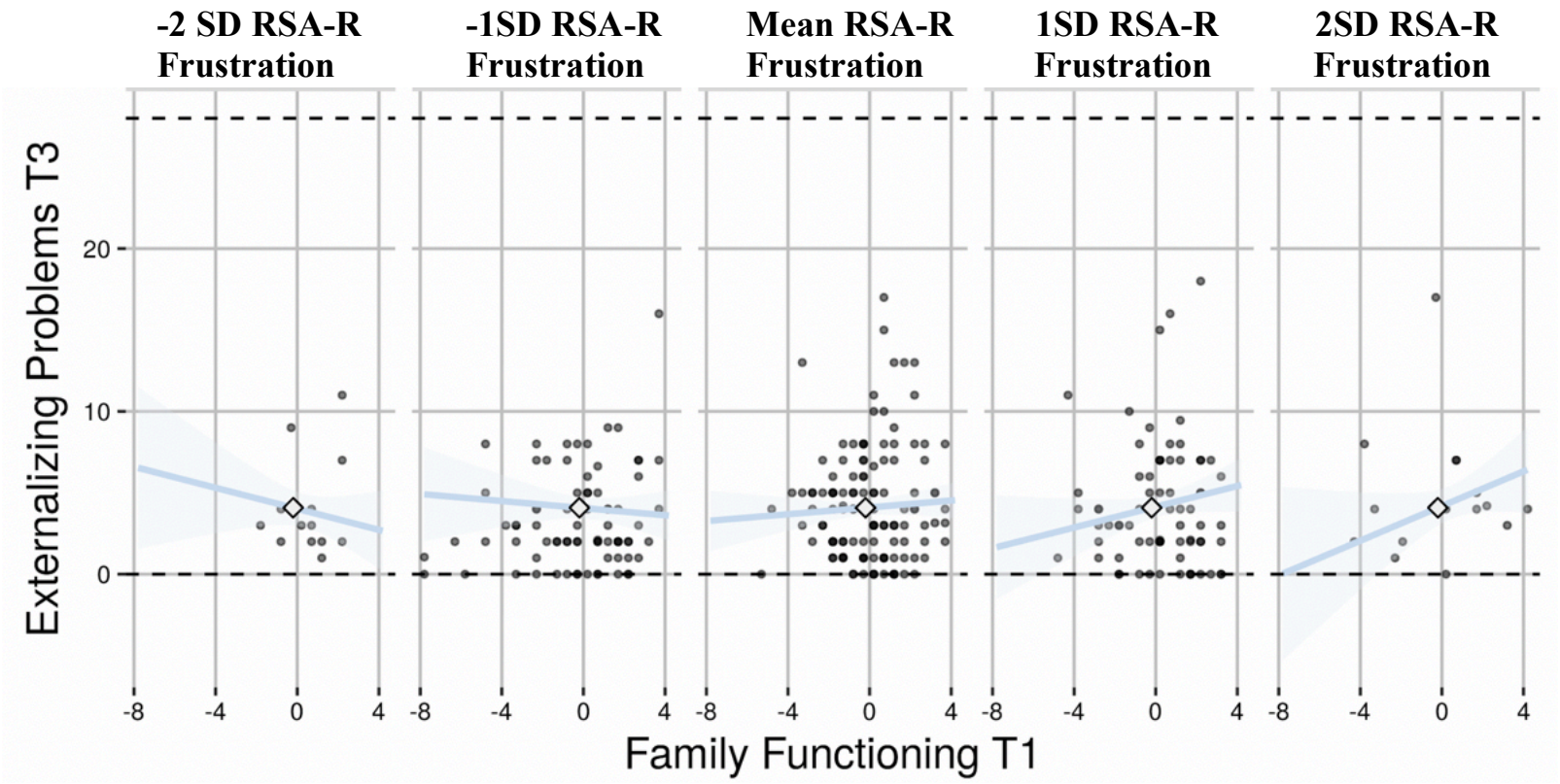
Figure 9c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R frustration interacting with family functioning predicting externalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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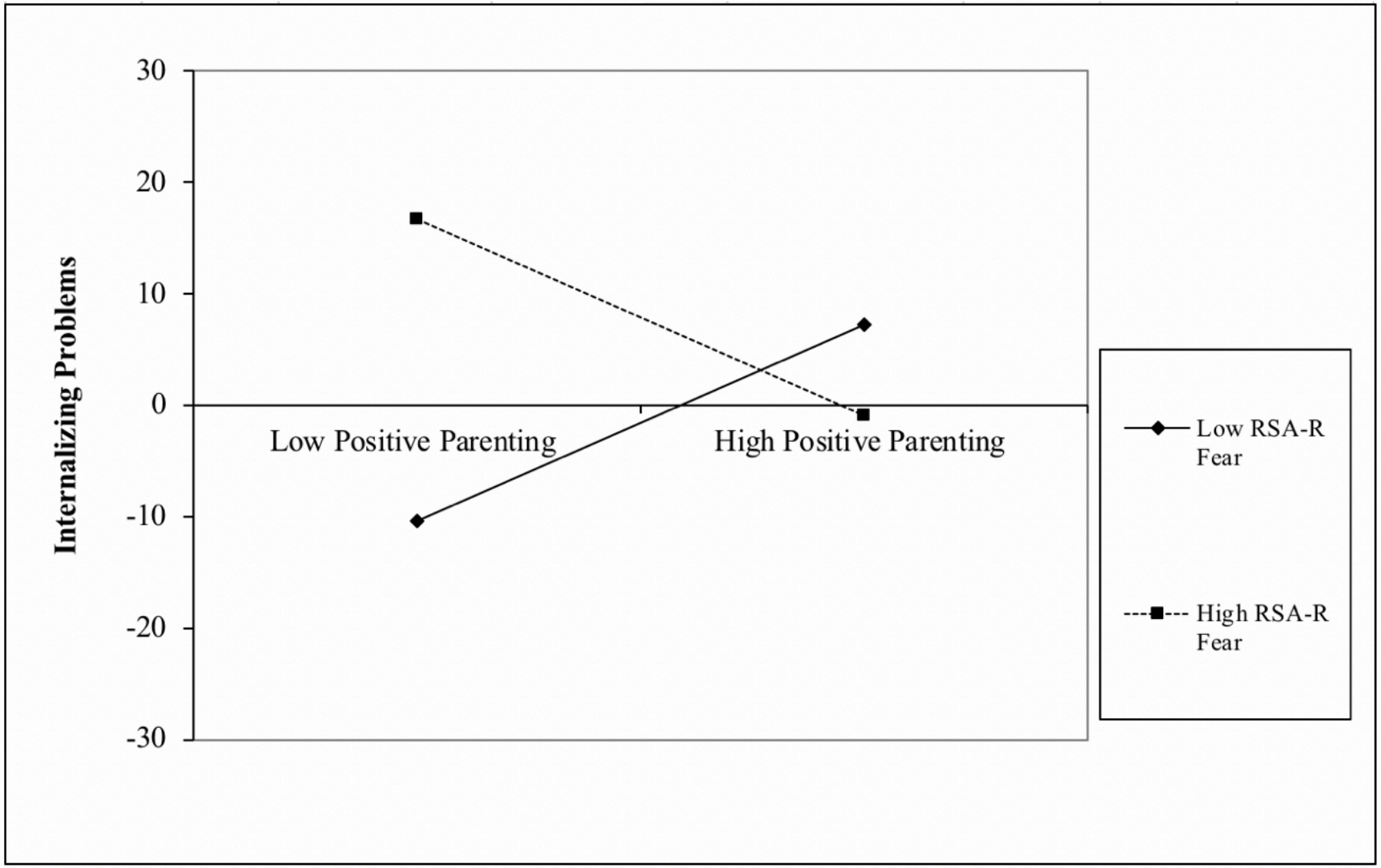
Figure 10a. *Simple-slopes plot of RSA-R fear interacting with positive parenting predicting internalizing problems.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both positive parenting and RSA-R fear.

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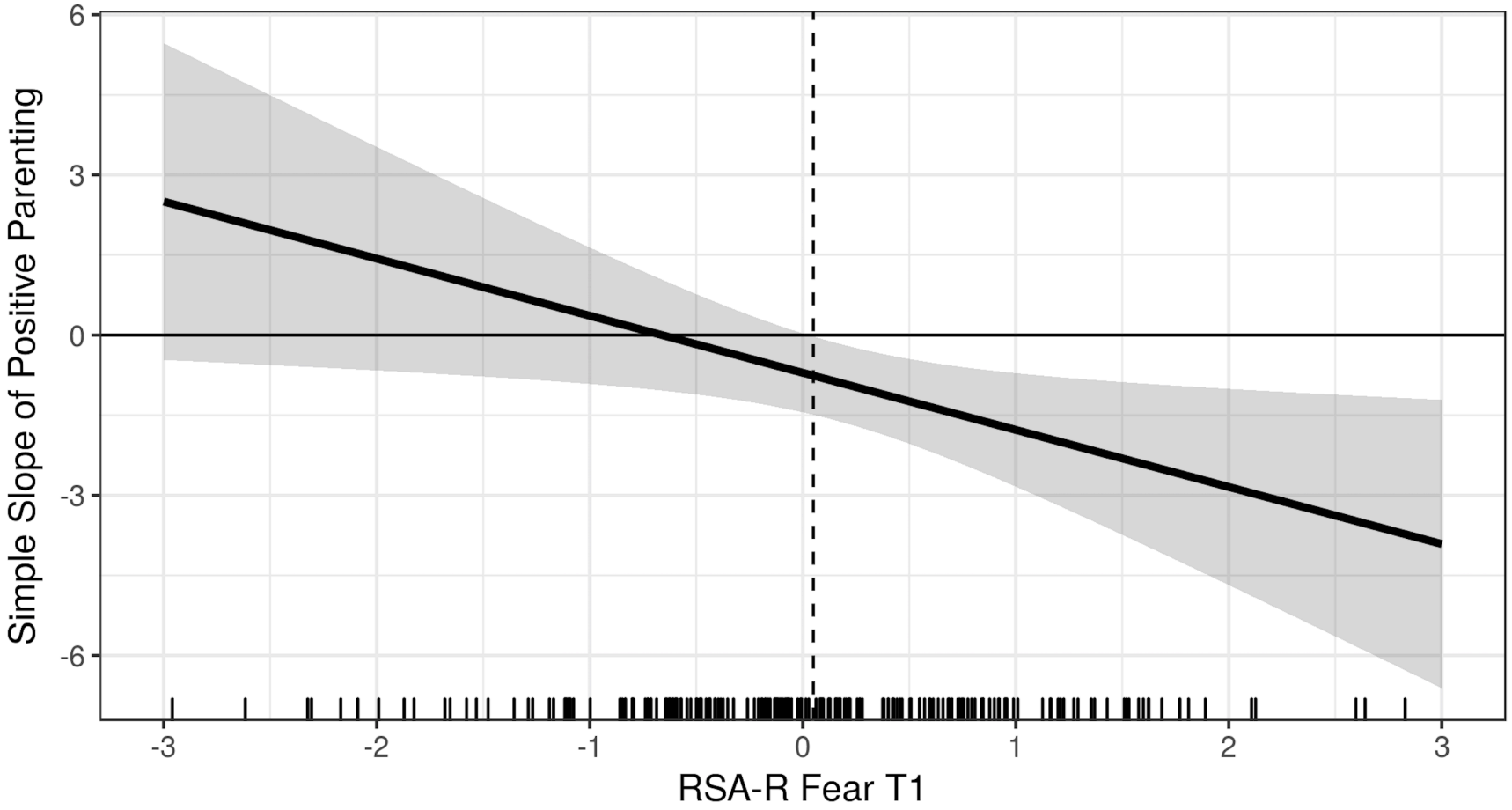
Figure 10b. *Regions-of-significance plot of RSA-R fear interacting with positive parenting predicting internalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed internalizing problems. The vertical dashed line represents the point of RSA-R fear at which internalizing problems becomes significantly associated with positive parenting.

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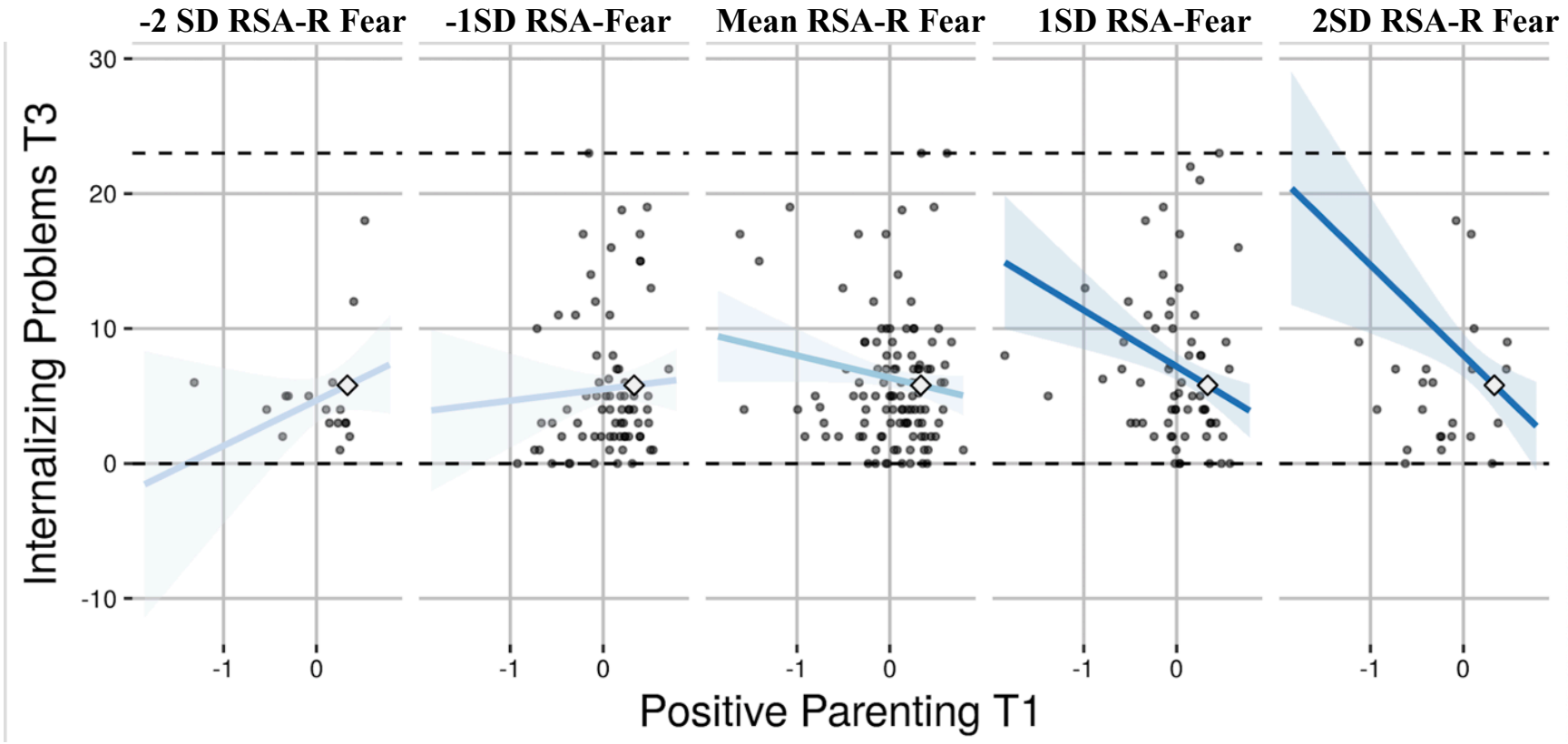
Figure 10c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R fear interacting with positive parenting predicting internalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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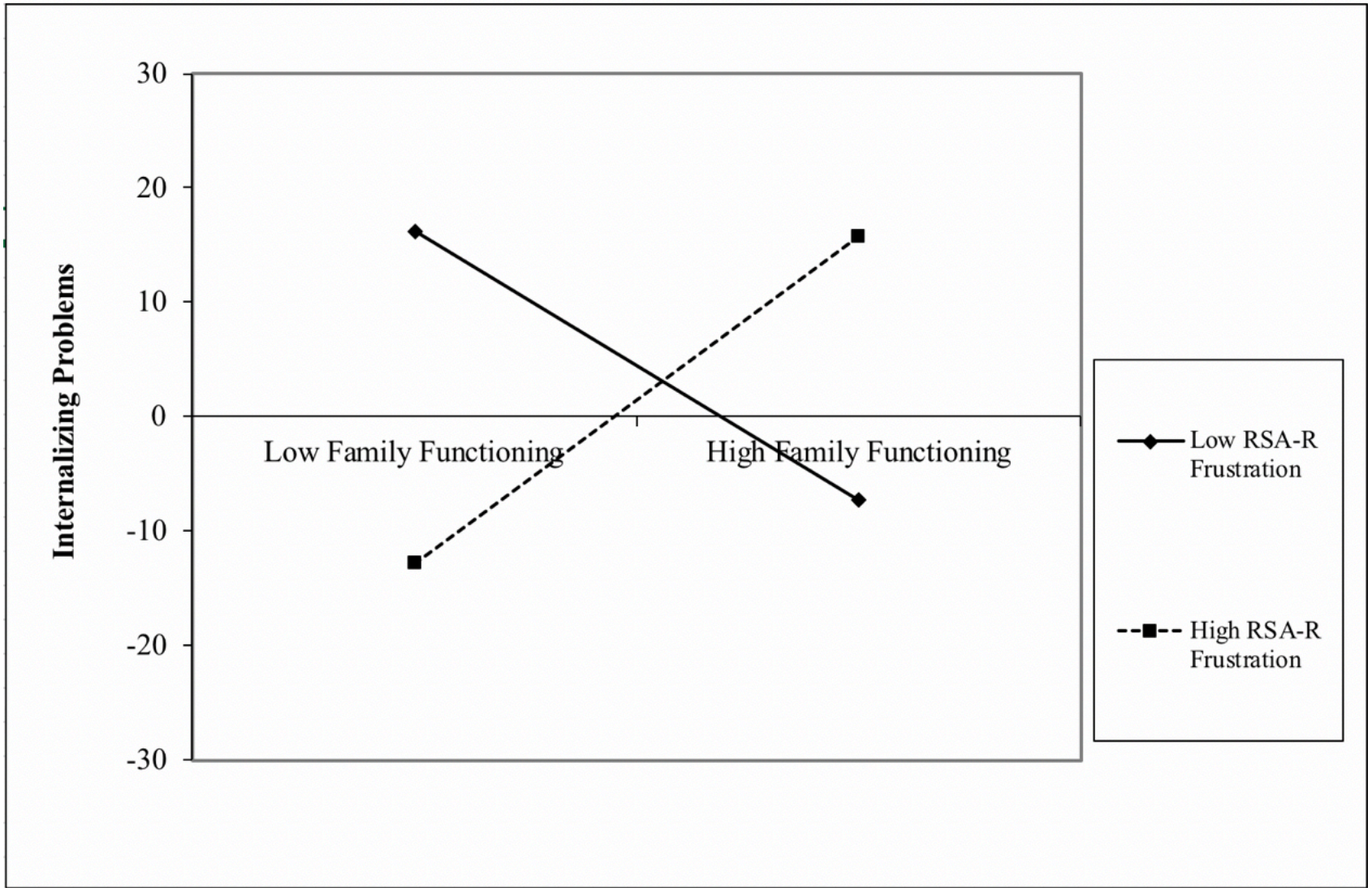
Figure 11a. *Simple-slopes plot of RSA-R frustration interacting with family functioning predicting internalizing problems.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both family functioning and RSA-R frustration.

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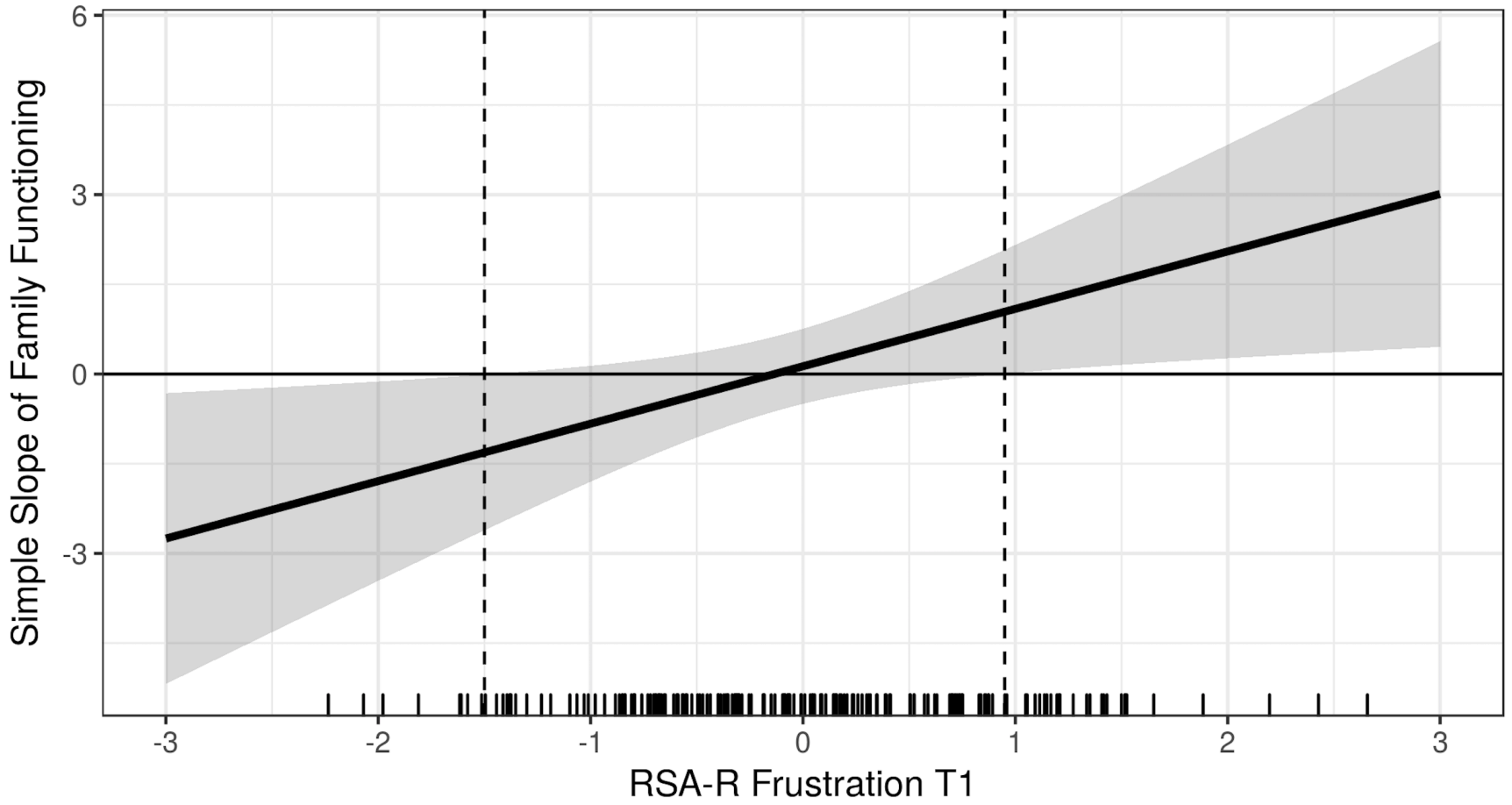
Figure 11b. *Regions-of-significance plot of RSA-R frustration interacting with family functioning predicting internalizing problems.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed internalizing problems. The vertical dashed lines represent the point of RSA-R frustration at which internalizing problems becomes significantly associated with family functioning.

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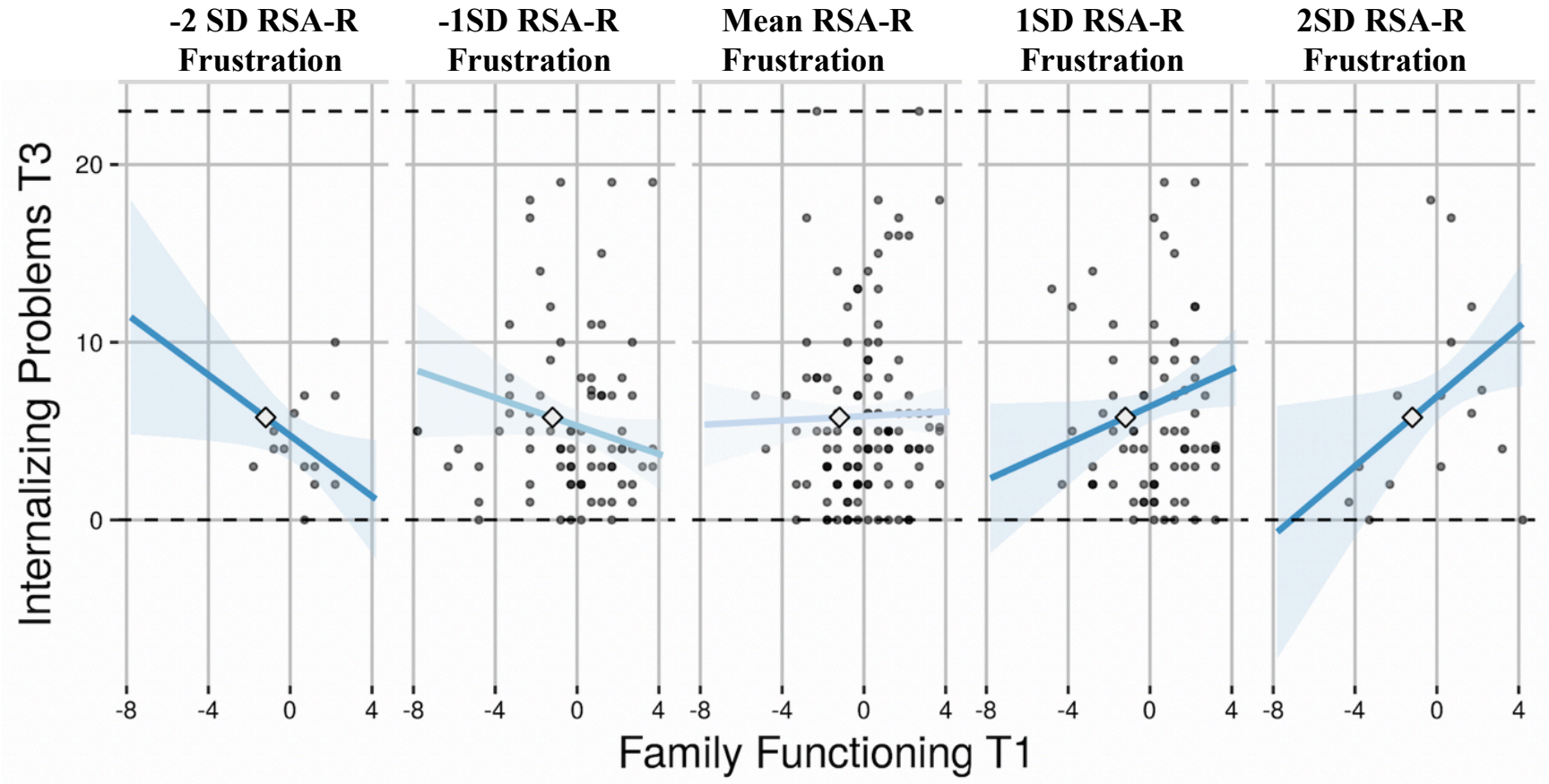
Figure 11c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R frustration interacting with family functioning predicting internalizing problems.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

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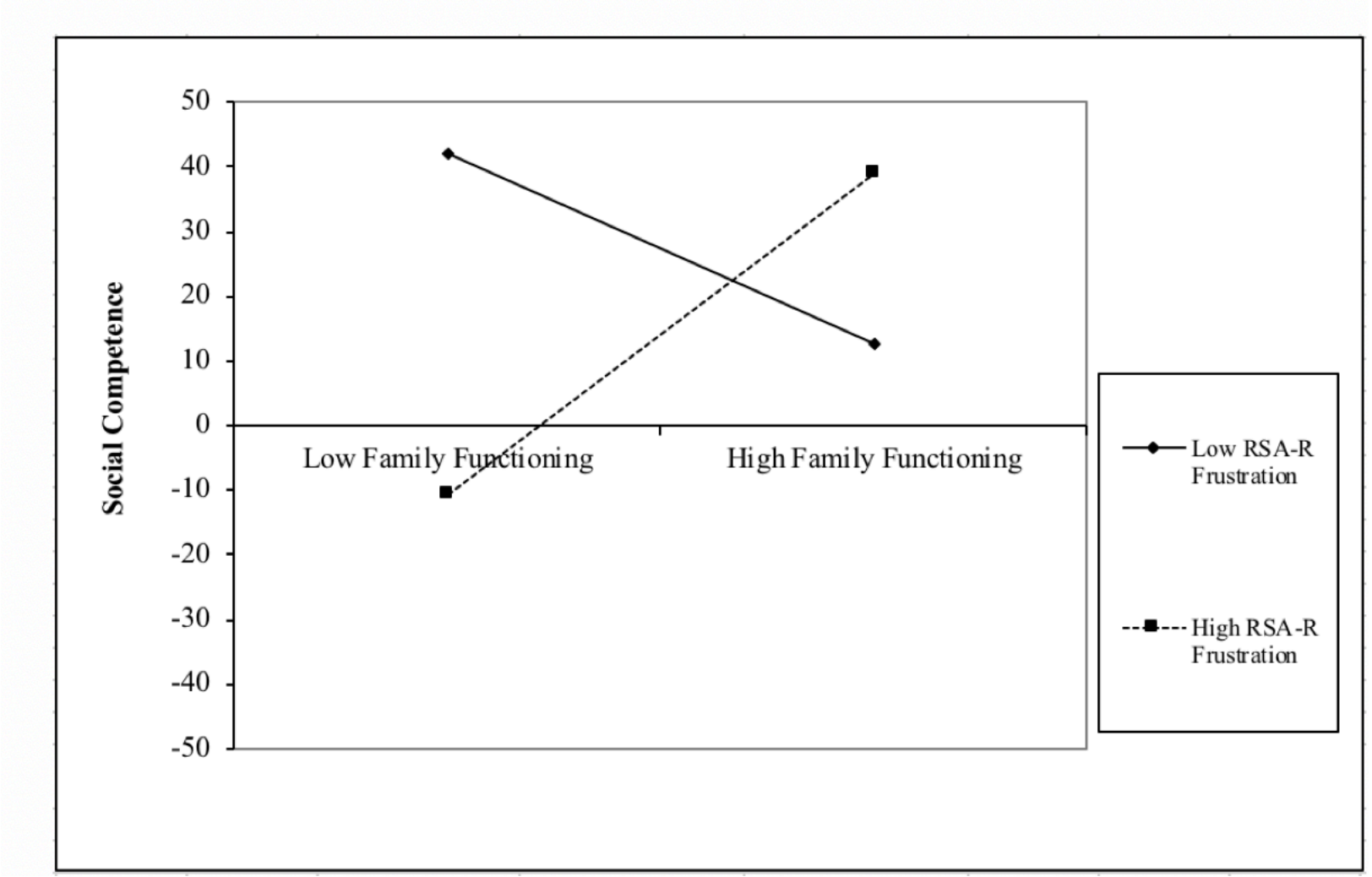
Figure 12a. *Simple-slopes plot of RSA-R frustration interacting with family functioning predicting social competence.*



Note: *Low* refers to 1 SD below the mean and *high* refers to 1 SD above the mean for both family functioning and RSA-R frustration.

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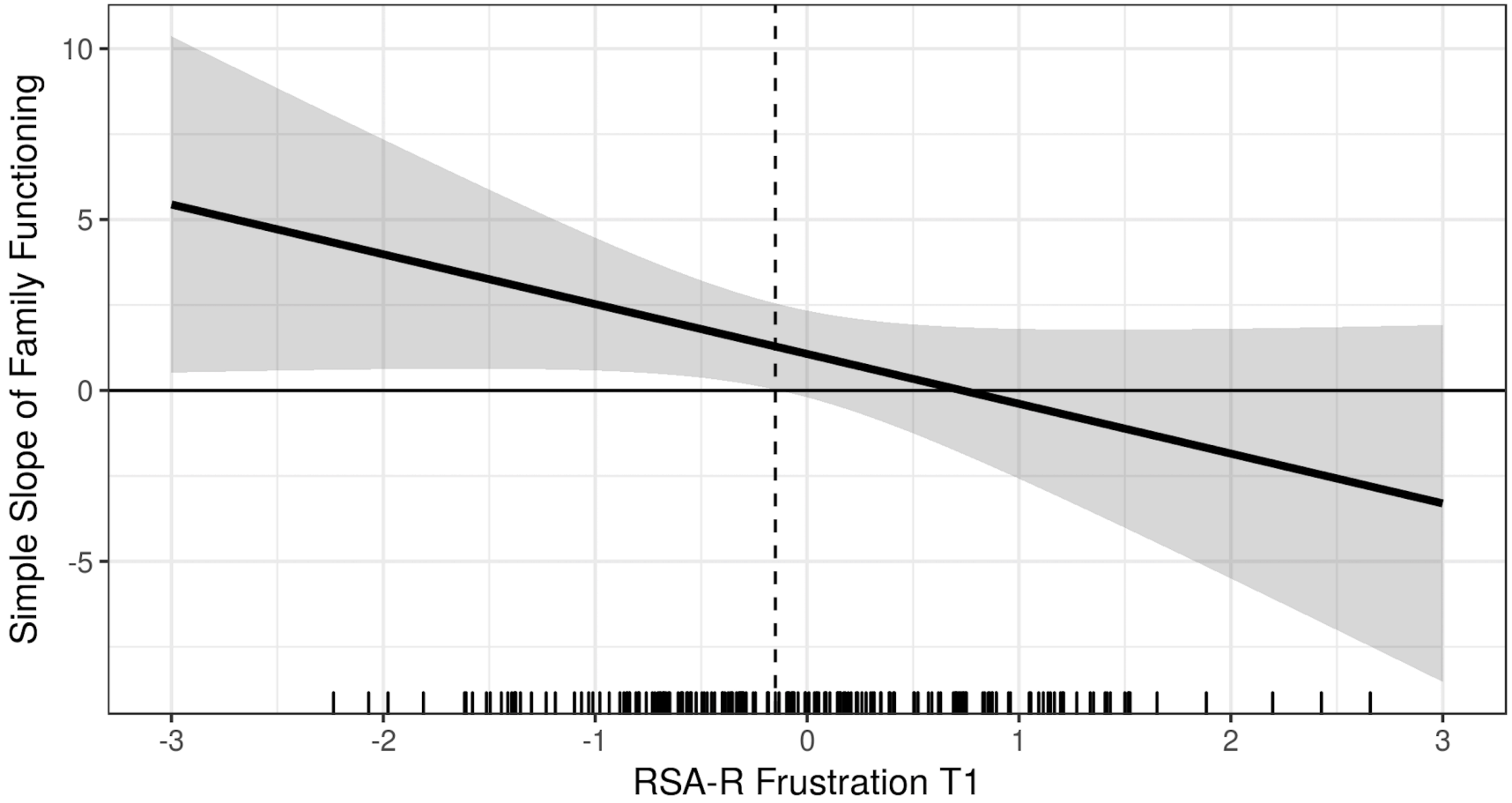
Figure 12b. *Regions-of-significance plot of RSA-R frustration interacting with family functioning predicting social competence.*



Note: The shaded region indicates 95% confidence region. The small vertical lines on the horizontal axis show the frequency of observed social competence. The vertical dashed line represents the point of RSA-R frustration at which social competence becomes significantly associated with family functioning.

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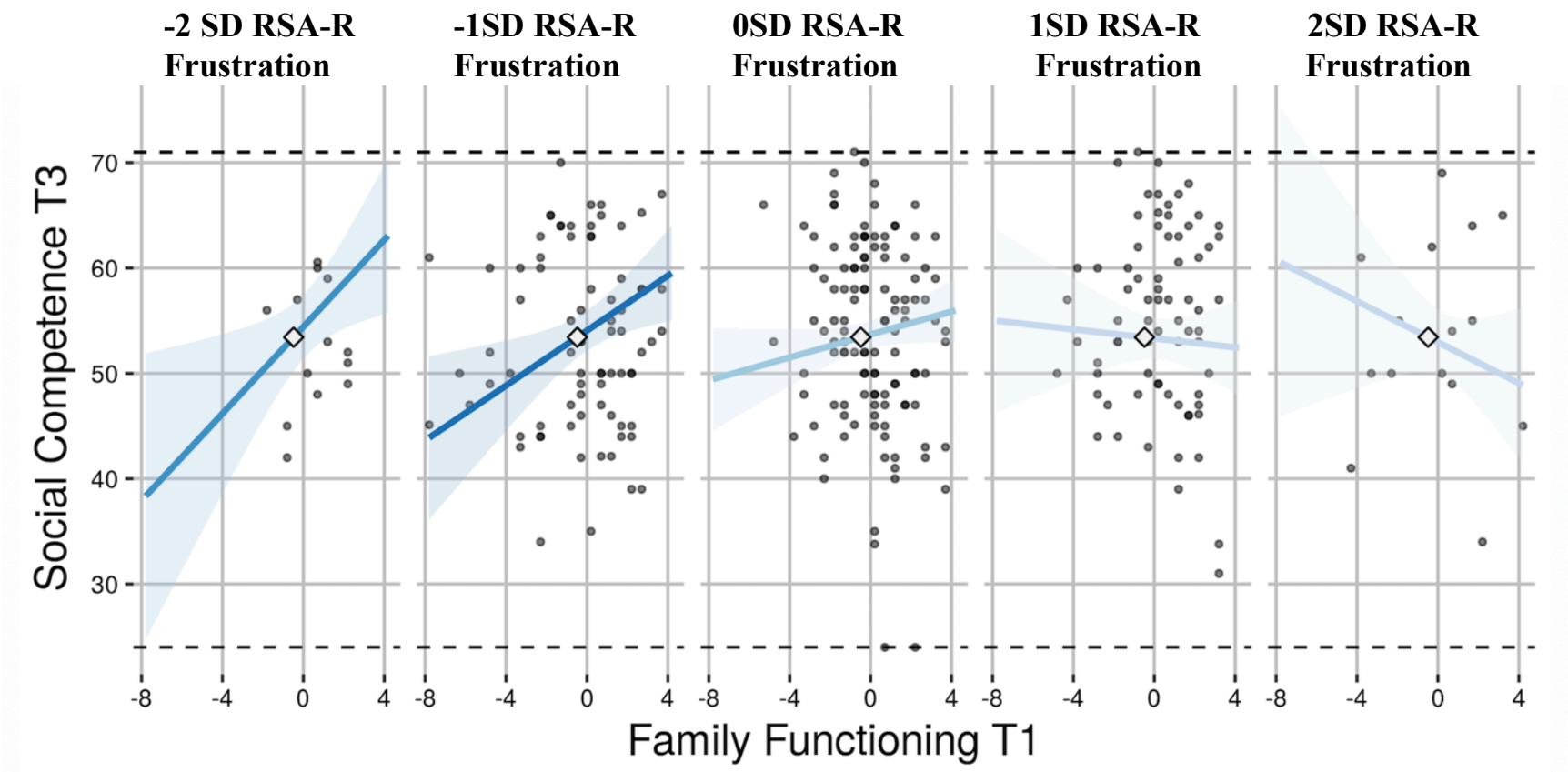
Figure 12c. *Five simple slope plots at -2 SD below mean, -1 SD below mean, mean, 1 SD above mean, and 2 SD above mean for the level of RSA-R frustration interacting with family functioning predicting social competence.*



Note: Gray circles indicate the observed data and shaded area shows 95% confidence region in five separate graphs. The white diamond shows the crossover point. This display shows observed data only and does not include data estimated using FIMLE.

Curriculum Vitae

MELANIE R. KLEIN

MRKlein@uw.edu

EDUCATION

03/15-Present **University of Washington**
Child Clinical Psychology, Ph.D.
Expected graduation: August 2019

Candidate for Doctorate in Philosophy awarded March 2017

Dissertation: Mediating and Moderating Effects of Child Respiratory Sinus Arrhythmia Reactivity in the Association Between Early Childhood Adversity and Later Adjustment
Committee Chair: Liliana Lengua, Ph.D.
Committee Members: Kate McLaughlin, Ph.D., Lynn Katz, Ph.D., James Mezza, Ph.D.
Dissertation defended: May 2018

06/18-06/19 **Pennsylvania State University Hershey Medical Center**
Predoctoral Clinical Internship

09/12-03/15 **University of Washington**
Child Clinical Psychology, Master of Science
Thesis: Bidirectional Relations Between Temperament and Parenting Predicting Preschool-age Children's Adjustment
Advisor: Liliana Lengua, Ph.D.

06/06-05/10 **Pennsylvania State University, Schreyer Honors College**
Psychology major, Bachelor of Arts
Thesis: Early Gender Differences in Emotion Expression May Be Age and Context Specific in Young Children
Advisor: Pamela Cole, Ph.D.

RESEARCH PUBLICATIONS

Lengua, L. J., Thompson, S. F., Moran, L. R., Zalewski, M., Ruberry, E. J., **Klein, M. R**., & Kiff, C. J. (2019). Pathways from early adversity to later adjustment: Tests of additive and bidirectional effects of executive control diurnal cortisol in early childhood. *Development and Psychopathology,* 1-14. doi:10.1017/S0954579419000373

Lengua, L. J., Ruberry, E. J., McEntire, C., **Klein, M. R.**, & Jones, B. (In press). Preliminary evaluation of an innovative, brief parenting program designed to promote self-regulation in parents and children. *Mindfulness,* 1-12.

Tandon, P. S., **Klein, M. R.,** Saelens, B. E., Marchese, A., Christakis, D., & Lengua, L. (2018). Short-term impact of physical activity vs. sedentary behavior on preschoolers' cognitive functions. *Mental Health and Physical Activity,* 15, 17-21. doi: 10.1016/j.mhpa.2018.06.004

Klein, M. R., Lengua, L. J., Cortes, R., Moran, L., & Zalewski, M. (2018). Temperament, mothers' reactions to children's emotional experiences, and emotion understanding predicting adjustment in preschool children. *Social Development, 27*(2), 351-365. doi:10.1111/sode.12282

Ruberry, E. J., **Klein, M. R.,** Kiff, C. J., Thompson, S. F., & Lengua, L. J. (2018). Parenting as a

moderator of the effects of cumulative risk on children's social-emotional adjustment and academic readiness. *Infant and Child Development*, *27(*3). doi:10.1002/icd.2071

Chaplin, T. M., **Klein, M. R**., Cole, P. M., & Turpyn, C. C. (2017). Developmental changes in emotion expression in frustrating situations: The role of context and gender. *Infant and Child Development*, *26*(6), 1-20. doi:10.1002/icd.2028

Moran, L., Lengua, L. J., Zalewski, M., Ruberry, E., **Klein, M. R.** Thompson, S., & Kiff, C. (2016). Variable- and person-centered approaches to examining temperament vulnerability and resilience to the effects of contextual risk. *Journal of Research in Personality, 67,* 61-74. doi:10.1016/j.jrp.2016.03.003

Klein, M. R., Lengua, L. J., Thompson, S. F., Moran, L., Ruberry, E. J., Kiff, C., & Zalewski, M. (2016). Bidirectional relations between temperament and parenting predicting preschool-age children's adjustment. *Journal of Clinical Child and Adolescent Development,* 1-14. doi:10.1080/15374416.2016.1169537

Manuscripts Under Review

Lengua, L. J., Thompson, S., Rubery, E. J., **Klein, M. R.,** Kiff, C., Moran, L., & Zalewski, M. (Under review). Concurrent and prospective effects of income, adversity and parenting behaviors on middle-childhood effortful control and adjustment.

Kiff, C. J., Zalewski, M., Thompson, S., Moran, L., Rubery, E. J., **Klein, M. R.,** & Lengua, L. J. (Under review). The cascading impact of children's respiratory sinus arrhythmia on changes in parenting across preschool.

Klein, M. R., Schindler, H. S., & Lengua, L. J. (Under review). Fathers contribute to middle-childhood adjustment problems above the effects of maternal parenting and depressive symptoms.

Thompson, S. F., **Klein, M. R.,** Ruberry, E., Kiff, C., Moran, L., Zalewski, M, & Lengua, L. J. (Under review). Examining the unique effects of pre- and post-natal depression on preschoolers' adjustment through parenting and child effortful control.

PROFESSIONAL PRESENTATIONS

Mayes, S., Baweja, R., Waxmonsky, J. Mattison, R., Memon, H., **Klein, M. R.,** Waschbusch, D., & Hameed, U. (2019, October). *Prescribing practices and symptom profiles of children with ADHD versus autism treated and not treated with psychotropic medication.* Poster session to be presented at the American Academy of Child and Adolescent Psychiatry, 2019, Chicago, IL.

Chung, J., **Klein, M. R.,** Patrick, K., Dimeff, L., & Koerner, K. (2017, November). *Secondary data analysis on effect of learning evidence-based practices on provider wellbeing*. Poster session presented at the Association for Behavioral and Cognitive Therapies, 2017, San Diego, CA.

Klein, M. R. & Lengua, L. J. (2017, April). *Does cardiac vagal withdrawal mediate or moderate the association between early childhood adversity and adjustment problems?* Poster session presented at the Society for Research in Child Development, 2017, Austin, TX.

Klein, M. R. & Lengua, L. J. (2016, October). *Temperamental surgency predicts later adjustment problems in the preschool period and middle childhood*. Poster session presented at the Occasional Temperament Conference, 2016, Seattle, WA.

Klein, M. R. & Lengua, L. J. (2015, March). *Temperamental surgency predicts later adjustment problems in the preschool period*. Poster session presented at the Biennial Meeting for Society for Research in Child Development, 2015, Philadelphia, PA.

Klein, M. R., Lengua, L. J., Thompson, S. F., Kiff, C. J., Zalewski, M., & Ruberry, E. J. (2014, November). *Bidirectional effects of child temperament and parenting on preschool children's adjustment*. Poster session presented at the Society for Research in Child Development: New Conceptualizations in the Study of Parenting-At-Risk, 2014, San Diego, CA.

Klein, M. R. & Teti, D. M. (2013, April). *Concurrent and previous depression in mothers, anger regulation, and emotional availability in mother-infant interaction*. Poster session presented at the Biennial Meeting for Society for Research in Child Development, 2013, Seattle, WA.

Klein, M. R., Chaplin, T. M., Cole, P. M., & Tan, P. Z. (2011, July). *Early gender differences in child emotion expressions may be age and context specific*. Poster session presented at the International Society for the Study of Behavioural Development 2012, Edmonton, Canada.

Klein, M. R., Chaplin, T. M., Cole, P. M., & Tan, P. Z. (2011, May). *Early gender differences in child emotion expressions may be age and context specific*. Poster session presented at the Association of Psychological Sciences 23rd Annual Convention, Washington, D.C.

Klein, M. R. & Cole, P. M. (2010, March). *Gender differences in emotion expression in young children*. Poster session presented at the Psi Chi Poster Session, University Park, PA.

CLINICAL EXPERIENCE

01/19-06/19 **Consultative Clinician, Children's Hospital Psychiatry Consultation/ Liaison**
Department of Psychiatry, Penn State Hershey Medical Center, Hershey, PA
Supervisor: Jolene M. Hillwig-Garcia, M.D.

- Provide consultation and liaison services for children admitted to the Children's hospital for inpatient services
- Assess, diagnose, and create treatment plans for children admitted for inpatient treatment for whom psychological services were requested by their primary physician

01/19-06/19 **Clinician, Penn State Sleep Research and Treatment Center**
Pediatric Sleep Medicine, Penn State Hershey Medical Center, Hershey, PA
Supervisor: Susan Calhoun, Ph.D.

- Assess, diagnose, and provide behavioral sleep training recommendations for parents and their children ages 0-18
- Provide recommendations for follow up care, including ordering sleep studies, multiple sleep latency tests, and referrals and consults to other providers

06/18-06/19 **Clinician, Adolescent Eating Disorders Partial Hospitalization Program**
Department of Pediatrics, Penn State Hershey Medical Center, Hershey, PA
Supervisor: Susan Lane-Loney, Ph.D.

- Lead weekly DBT skills groups for adolescents with severe eating disorders in partial hospitalization program
- Conduct weekly family therapy sessions for children with eating disorders in the partial hospitalization program providing behavior parent training and cognitive behavior therapy

08/18-03/19 **Assessor, Early Childhood Autism Diagnostic Clinic**
Department of Psychiatry, Penn State Hershey Medical Center, Hershey, PA
Supervisor: Susan Minnick, Ph.D., Sierra Brown, Ph.D.

- Administered cognitive assessments for children and adults ages 7-25 referred for

possible Autism Spectrum Disorder diagnosis
- Conducted behavioral interviews with parents regarding symptoms associated with Autism Spectrum Disorder using the Checklist for Autism Spectrum Disorder (CASD) and the Childhood Autism Rating Scale (CARS)
- Wrote integrated psychological reports for families and schools
- Observed administration of the ADOS by certified psychologists

06/18-12-18 **Assessor, Early Childhood Autism Diagnostic Clinic**
Department of Psychiatry, Penn State Hershey Medical Center, Hershey, PA
Supervisor: Susan Mayes, Ph.D.
- Administered cognitive assessments for children ages 0-5 referred for possible Autism Spectrum Disorder
- Conducted behavioral interviews with parents regarding symptoms associated with Autism Spectrum Disorder

06/18-12/18 **Clinician, Pediatric Anxiety Clinic**
Department of Psychiatry, Penn State Hershey Medical Center, Hershey, PA
Supervisor: Timothy Zeiger, PhD., Daniel A. Waschbusch, Ph.D., ABPP
- Assessed and diagnosed psychological symptoms in children with complex medical conditions
- Conducted weekly therapy sessions for children with anxiety disorders providing evidence-based treatments
- Conducted individual supervision for master's level psychology extern student

06/18-12/18 **Assessor, ADHD Diagnostic Clinic**
Department of Psychiatry, Penn State Hershey Medical Center, Hershey, PA
Supervisor: Daniel A. Waschbusch, Ph.D., ABPP
- Administered cognitive assessments for children ages 5-14 referred for possible ADHD diagnosis
- Conducted behavioral interviews with parents regarding symptoms associated with ADHD and feedback sessions with parents to review diagnoses and create treatment plans

08/17-05/18 **Clinician, Practicum at Adolescent Residential Facility**
Carson Valley Children's Aide, Flourtown, PA
Supervisors: Nicole Matthews, M.D., Charlotte Anderson, L.P.C.
- Led three weekly DBT skills groups for adolescent with severe behavioral problems in a residential treatment facility, including mindfulness, distress tolerance, emotion regulation, and interpersonal effectiveness
- Supervised residential house staff, providing live supervision for staff when interacting with adolescent residents, and conducted individual feedback sessions with staff

10/16-06/17 **Student Supervisor**
Psychological Services and Training Center
Psychology Department, University of Washington, Seattle, WA
Supervisor: Linda Dimeff, Ph.D.
- Provided second year clinical student weekly training and coaching in assessment procedures, validation, crisis management, and case formulation
- Conducted weekly supervision for student's first client, focused on administering cognitive behavior therapy for anxiety

09/16-03/17 **Clinician, Practicum in Trauma-Focused Cognitive Behavior Therapy**
King County Sexual Assault Resource Center, Renton, WA
Supervisor: Larraine Lynch, M.S.W.
- Administered Trauma-Focused Cognitive Behavior Therapy to child and adolescent clients, including family treatment when necessary
- Collaborated with lawyers, victim advocates, and law enforcement officers to ensure client awareness regarding perpetrator status

07/15-03/17 **Clinician, Practicum in Dialectical Behavior Therapy (DBT)**
Behavioral Research and Training Clinic
Psychology Department, University of Washington, Seattle, WA
Supervisors: Marsha Linehan, Ph.D., Melanie Harned, Ph.D., Kathryn Korslund, Ph.D., Adam Payne, Ph.D., Jared Michonski, Ph.D., Elizabeth LoTempio, Ph.D.
Clinic Director: Marsha Linehan, Ph.D.
- Attended weekly two-hour team supervision and consultation meetings
- Administered DBT to individual adolescent and adult clients who met criteria for Borderline Personality Disorder
- Led a weekly DBT multi-family skills group for adolescents with psychopathology and their parents

01/16-03/17 **Assessor, Research Study**
Psychology Department, University of Washington, Seattle, WA
Supervisor: Kate McLaughlin, Ph.D.
- Administered and scored assessments to the parents of children (ages 9-11) using the Kiddie Schedule for Affective Disorders and Schizophrenia for an R01 research study and Wechsler Abbreviated Scale of Intelligence (WASI-II) to children

11/13-03/17 **Staff Clinician**
Psychological Services and Training Center
Psychology Department, University of Washington, Seattle, WA
Supervisors: Ruth Herman-Dunn, Ph.D., Peter Doyle, Ph.D., Julia Hitch, Ph.D., Steven Behling, Ph.D., Leafar Espinoza, Ph.D.
- Delivered therapy in an outpatient clinic and administered treatment using evidence-based treatment (i.e., Coping Cat, Parent Management Training, Behavior Activation, Cognitive Behavior Therapy)

07/14-03/17 **Parent Management Therapy Practicum Student**
Parent and Child Clinic practicum
University of Washington, Seattle, WA
Supervisor: Neil Kirkpatrick, Ph.D.
- Lead therapist providing Parent Management Training therapy to four families with young children and four families with high risk adolescents (e.g., suicidal, violent)
- Administered Acceptance and Commitment Couples Therapy

10/14-05/15 **Clinician, Student Supervisor**
Functional Analytical Therapy practicum
University of Washington, Seattle, WA
Supervisor: Mavis Tsai, Ph.D.
- Received comprehensive training and completed coursework in Functional Analytic Therapy (FAP) from the treatment creator
- Provided consultation to peers regarding case conceptualizations and treatment plans

07/14-07/15 **Neuropsychological Assessor**

Neuropsychological Consultation Practicum
Department of Neuropsychology
Seattle Children's Hospital, Seattle, WA
Supervisors: David Breiger, Ph.D., Ruth Hilsman, Ph.D.

- Administered, scored, and interpreted assessments of children and adolescents at the inpatient psychiatric unit, heart transplant patients, and referred outpatients.
- Conducted semi-structured intake interviews assessing developmental history, medical history, social and emotional developmental history, and reason for referral with the patient and family members
- Wrote integrated reports summarizing critical assessment information, significant findings from administered assessments, and impressions and recommendations

01/14-04/14 **Child Group Co-Leader**
Incredible Years
Eastside Parenting Clinic, Bellevue, WA
Supervisors: Jannie Driver, Ph.D., Jamila Reid, Ph.D.

- Taught "Dinosaur School" curriculum to children with oppositional defiant disorder (ages 4-8) including emotion regulation skills, social skills, and impulse control strategies
- Provided feedback to parents concerning their children's progress

09/08-07/12 **Crisis Hotline Counselor**
Community Help Centre
State College, PA

- Received and provided crisis management supervision including suicide, self-harm, substance abuse and overdose
- Trained and supervised new volunteers in crisis management
- Worked in crisis intervention and provided short-term counseling, emergency food and shelter, and drug and alcohol intervention

09/09-05/10 **Mental Health Practicum Leader**
University Park, PA

- Led a group teaching social skills to children with behavior problems, created lesson plans, and managed classroom behavior

06/09-08/09 **Camp SHIP (Summer High Intensive Program) Counselor**
Charles County, MD

- Assisted with behavioral management, teaching, and supervision at a camp for children (ages 2-5) with severe forms of Autism Spectrum Disorder

RESEARCH EXPERIENCE

09/12-08/18 **Graduate Student Research Assistant**
Psychology Department, University of Washington, Seattle, WA
Supervisor: Liliana J. Lengua, Ph.D.
Project: 1, 2, 3 Go! – Longitudinal study examined parenting, income, physiology, and stress reactivity on the development of effortful control throughout the preschool period

- Assisted preparing, cleaning, and analyzing EEG and RSA data
- Trained and provided weekly supervision to undergraduate research assistants in conducting laboratory visits and coding behavioral tasks assessing child temperament

03/17-12/18 **Statistical Consultant**

Evidence-Based Practice Institute, Seattle, WA
Supervisors: Linda Dimeff, Ph.D. & Blair Beadnell, Ph.D.
Project: WILLOW – Randomized controlled trial aimed to assess the efficacy of an online computerized treatment for depression

- Analyzed data for a treatment study designed for participants comparing one group utilizing computer program to the treatment as usual group; examined data for growth trends at four assessment points
- Managed study data including cleaning, organizing, scoring, and interpreting research data; trained and supervised research assistant to help with data management
- Performed advanced statistical analyses and condensed findings into comprehensive report

07/15-10/16 **Assessment and Coding Consultant**
Psychology Department, University of Washington, Seattle, WA
Supervisor: Liliana Lengua, Ph.D.
Project: SEA-CAP – Randomized control treatment study designed to assess the effects of an intervention to increase parent self-regulation skills

- Assisted in training of research assistants to administer and score effortful control behavioral tasks pre-and post-treatment
- Supervised and coded parent-child interaction for specific parent behaviors to identify treatment success

01/16-03/17 **Graduate Student Research Assistant**
Psychology Department, University of Washington, Seattle, WA
Supervisor: Kate McLaughlin, Ph.D.
Project: Deprivation Threat – Follow up study designed to examine physiological and neurological effects of abuse and neglect

- Assisted in the development of a continuation of a longitudinal research study design and protocol, specifically aimed to continue measuring children's effortful control
- Administered assessments to study participants' parents including Kiddie Version – Schedule for Affective Disorders and Schizophrenia (KSADs), mental health history and treatment, Violence Exposure Scale for Children – Revised (VEX-R)
- Administered assessments to study participants, including an assessment of intelligence (WASI) and measures assessing children's anxiety, depression, and PTSD symptoms (e.g., UCLA PTSD index, SCARED, CDI)
- Performed crisis management duties including assessments and safety plans for children at risk of suicide or self-harm, intervened when children were living in dangerous environments, assessed and counseled parents using potentially dangerous consequences, and consulted Child Protective Services when necessary

04/15-03/17. **Research Consultant**
Seattle Children's Research Institute, Seattle, WA
Supervisor: Pooja Tandon, M.D.
Project: Project APPLE – Randomized control trial examining effects of immediate intense exercise on preschoolers' self-regulation skills

- Developed project protocol for behavioral assessment tasks to measure child self-regulation
- Trained and supervised research assistants in conducting laboratory visits behavioral tasks assessing self-regulation and utilized current technology to administer tasks (NIH Toolbox for the Assessment of Neurological and Behavioral Function)

04/15-05/17 **Research Consultant, Graduate Research Assistant**

Seattle Children's Research Institute, Seattle, WA
Supervisor: Dimitri Christakis, M.D., Heather Violette, Ph.D.
Project: Bright Start – Randomized controlled trial examining effects of long-term education of at-risk parents on their children's development of language and self-regulation from 0-3 years old

- Trained and supervised research assistants in conducting laboratory visits and coding behavioral tasks assessing self-regulation
- Led weekly supervision meetings with task administration team to consult on difficult cases, provided verbal feedback to study assessors

04/15-10/15 **Research Consultant**
Psychiatry and Behavioral Studies, University of Washington, Seattle, WA
Supervisor: Elizabeth McCauley, Ph.D.
Project: The Brief Intervention for School Clinicians – Pilot study designed to assess the feasibility and efficacy of an intervention designed for therapists to deliver to high school students

- Collaborated with project supervisor to create a manual for coding therapy sessions to assess the feasibility and efficacy of the intervention
- Listened to and coded sessions of therapists delivering the intervention to high school students reporting symptoms of depression and anxiety

05/10-07/12 **Research Coordinator**
Department of Human Development and Family Studies, Pennsylvania State University, University Park, PA
Supervisor: Douglas M. Teti, Ph.D.
Project: Minds of Mothers Study – Study designed to assess the effects of maternal depressive symptoms on parent-child interactions and EEG asymmetry

- Recruited and screened subjects and assessed mothers of 6-month-old babies for depressive symptoms
- Performed home visits, administered study questionnaires to parents, filmed and elicited emotions (anger, happiness) from babies
- Collected EEG data during laboratory visit, scored and analyzed EEG data
- Trained and supervised a team of undergraduate research assistants to code maternal and infant emotions and mother-child emotional availability

01/08-05/09 **Undergraduate Research Assistant**
Psychology Department, Pennsylvania State University, University Park, PA
Supervisor: Kristin A. Buss, Ph.D.
Project: Toddlers into Kindergarten Emotion Study (TIKES) – Longitudinal study designed to assess the development of childhood fearfulness

- Administered emotion eliciting laboratory tasks to preschoolers to assess child fearfulness
- Coded mothers' and children's vocalizations during assessment procedures designed to assess children's fearfulness and parents' reactions to children's fearful behavior

09/07-07/12 **Research Assistant**
Psychology Department, Pennsylvania State University, University Park, PA
Supervisor: Pamela M. Cole, Ph.D.
Project: Development of Toddler Study (DOTS) – Longitudinal project designed to understand the development of emotion regulation in toddlers from rural low-income families

- Coded second-by-second emotion expression for children in emotion-eliciting tasks

- Trained and supervised a team of undergraduate research assistants to assist in coding emotion expression data

TEACHING EXPERIENCE

01/18-06/18 **Teaching Assistant,** Personality Psychology
Psychology Department, University of Washington
Instructor: Jonathon Brown, Ph.D.

01/15-03/15 **Teaching Assistant,** Human Sexuality
Psychology Department, University of Washington
Instructor: Lois McDermott, Ph.D.

09/13-12/13; 03/14-06/14 **Teaching Assistant,** Psychobiology of Women
Psychology Department, University of Washington
Instructor: Nancy Kenney, Ph.D.

09/12-12/12 **Teaching Assistant,** Introduction to Psychology
Psychology Department, University of Washington
Instructor: Jody Ganniban, Ph.D.

07/14; 07/15; 07/16 **Guest Lecturer,** Clinical Personality Assessment
Instructor: Ronald Smith, Ph.D.

02/15 **Guest Lecturer,** Introduction to Statistics
Instructor: Dana Nelson

PROFESSIONAL SERVICE

06/18-06/19 **Chief Psychology Intern**
Hershey Medical Center, Hershey, Pennsylvania
Elected representative for psychology interns

07/15 **Dialectical Behavioral Therapy Intensive Training**
Behavioral Technology, New Canaan, Connecticut
Workshop Volunteer

10/16 **Occasional Temperament Conference: Temperament Across the Lifespan- From Biology to Intervention**
University of Washington, Department of Psychology
Conference Volunteer

12/15 **Executive Function and the Developing Brain, Lecture by Philip Zelazo, Ph.D.**
University of Washington, Department of Psychology
Lecture Volunteer

04/15 **Mindful Research Conference: Mindful Families, Schools, and Communities, Research to Practice Promoting Child Well-Being**
Center for Child and Family Well-Being, University of Washington
Conference Volunteer

07/14 **Science and Practice of Compassion Workshop, Rob Roeser, Ph.D.**
Center for Child and Family Well-Being, University of Washington
Workshop Volunteer

01/14 **Mindful Parenting Workshop with Jon Kabat-Zinn, Ph.D. & Myla Kabat-Zinn, Ph.D., B.S.N., R.N.**

Center for Child and Family Well-Being, University of Washington
Workshop Volunteer

04/13 **Mindfulness Research Conference: Mindful Living**
Center for Child and Family Well-Being, University of Washington
Conference Volunteer

PROFESSIONAL AFFILIATIONS

Society for Research in Child Development
Society for Clinical Child and Adolescent Psychology
Association for Psychological Science
American Psychological Association

CLINICAL TRAINING

06/15-03/17 **Dialectical Behavior Therapy Weekly Training Session**
Marsha Linehan, Ph.D., University of Washington
(1.5 hours per week)

07/15 **Dialectical Behavioral Therapy Intensive Training**
Adam Payne, Ph.D. & Nicholas Salsman, Ph.D., Behavioral Technology
(35 hours)

08/15-12/15 **Coping Cat Training and Supervision**
Leafar Espinoza, Ph.D., Seattle Children's Hospital, Seattle, WA
(25 hours)

01/15-03/15 **Dialectical Behavioral Therapy Skills Training**
Marsha Linehan, Ph.D., University of Washington, Seattle, WA
(30 hours)

07/14-07/15 **Behavior Parent Training Intensive and Supervision**
Neil Kirkpatrick, Ph.D., University of Washington
(2 hours weekly)

04/14-04/15 **Behavioral Activation for Depression Training and Supervision**
Ruth Herman-Dunn, Ph.D., University of Washington
(1 hour weekly)

03/14-06/14 **Trauma Focused Cognitive Behavioral Therapy**
Shannon Dorsey, Ph.D., University of Washington, Seattle, WA
(20 hours)

01/14-04/14 **The Incredible Years – Child Program**
Jamila Reid, Ph.D., Evidence Based Treatment Centers of Seattle
(20 hours)

01/14-03/14 **Cognitive Behavioral Therapy for Anxiety**
Behavioral Activation Therapy for Depression
Corey Fagan, Ph.D., University of Washington, Seattle, WA
(20 hours)

01/14-03/14 **Psychological Assessment of Children: DAS II,**
David Breiger, Ph.D., University of Washington, Seattle, WA
(30 hours)

09/13-12/13 **Helping the Noncompliant Child**

Suzanne Kerns, Ph.D., University of Washington, Seattle, WA
(20 hours)

07/13 **Prevention of Suicide Workshop**
Marsha Linehan, Ph.D., University of Washington, Seattle, WA
(30 hours)

01/13-03/13 **Psychological Assessment of Intelligence: WASI, WISC-IV, WAIS-IV**
David Breiger, Ph.D., University of Washington, Seattle, WA
(30 hours)

06/13-07/13 **Clinical Personality Assessment: MMPI-2, MMPI-A, MCMI-III**
Ronald E. Smith, Ph.D., University of Washington, Seattle
(20 hours)