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Social, Emotional, and Psychophysiological Risk Factors for Aggression in Pre-Adolescent Girls

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Social, Emotional, and Psychophysiological Risk Factors for Aggression in Pre-Adolescent Girls

A dissertation submitted in partial satisfaction of the requirements for the degree

Doctor of Philosophy in Psychology

by

Kelsey Stiles

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ABSTRACT OF THE DISSERTATION

Social, Emotional, and Psychophysiological Risk Factors for Aggression in Pre-Adolescent Girls

by

Kelsey Stiles

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2023

Professor Steve Sung-Yul Lee, Chair

Conduct problems in youth, including aggression, constitute a significant and increasing public health burden. Despite replicated evidence that conduct problems in girls predict numerous poor outcomes (e.g., health, substance use), research on aggression is focused almost exclusively on boys, thus perpetuating significant gaps in knowledge about risk factors, explanatory processes, and outcomes in girls. In boys, threat-biased social information processing is a correlate of aggressive behavior, particularly reactive aggression (i.e., retaliatory response to perceived threat/provocation). Elevated trait negative emotionality, the dispositional tendency to experience negative affective states such as anger and sadness, is a transdiagnostic risk factor for emotional and behavioral problems that may plausibly interfere with social cognition to promote aggression. Individual differences in autonomic functioning, including respiratory sinus arrhythmia (RSA), are also replicated risk factors for emotional and behavioral problems, as aberrant psychophysiological responding can have pronounced effects on emotional reactivity and regulation. Despite theoretical rationale and empirical support from research with boys and men, the associations of social information processing, elevated trait negative emotionality, and RSA with respect to aggression in girls remain largely unknown. To inform models of aggressive behavior in girls, the goals of these dissertation studies were to evaluate individual differences in negative emotionality, social information processing, and psychophysiology (i.e., RSA) as correlates of conduct problems, including separate dimensions of aggression (e.g., relational aggression). Using a sample of ethnically diverse pre-adolescent girls, Study I evaluated trait negative emotionality and threat-biased encoding and interpretation processes as sequential predictors of conduct problems. Preliminary evidence suggested that the hypothesized chain reaction effect marginally predicted both reactive relational aggression and general aggressive behavior. In the same sample, Study II assessed initial RSA and RSA withdrawal (i.e., reductions in RSA, also referred to as RSA reactivity), during a novel social information processing task, as correlates of conduct problems. Excessive RSA withdrawal was associated with higher levels of reactive relational aggression, and RSA initial values were inversely associated with rule-breaking behavior. Although these findings largely align with previous findings from male samples, reactive physical aggression was generally unrelated to aberrant social cognition and individual differences in RSA, unlike previous evidence based mostly on boys. Collectively, these preliminary findings fill critical gaps in knowledge on aggression and conduct problems in girls, informing the design of future studies that can propel targeted prevention and intervention approaches that are specific to risk factors and processes in girls.

The dissertation of Kelsey Stiles is approved.

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University of California, Los Angeles

2023

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SELECTED CONFERENCE PRESENTATIONS

Stiles, K. & Lee, S. S. (2020). *Dispositional, environmental, and social cognitive predictors of aggression: Which youth are most at-risk?* Accepted for presentation at the Society for Research on Adolescence Biennial Meeting, San Diego, CA.

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Stiles, K. & Lee, S. S. (2019). *Hostile attributions and aggression: Consideration of adult and peer interactions in the development and maintenance of biased interpretations*. Presented at the International Society for Research in Child and Adolescent Psychopathology Biennial Meeting, Los Angeles, CA.

Stiles, K., Lee, S. S., & Luthar, S. S. (2019). *Parental criticism and high expectations: Implications for psychological functioning among upper-middle class adolescents.* Presented at the Society for Research in Child Development Biennial Meeting, Baltimore, MD.

Introduction

Consisting diversely of aggression, oppositionality, and delinquency, conduct problems constitute a significant public health concern nationally: they are increasingly prevalent, frequently co-occur with other emotional and behavioral problems, and uniquely predict poor health, academic, and occupational outcomes into adulthood (Loeber & Keenan, 1994; Moffitt et al., 2001; Stringaris & Goodman, 2009). Long-term outcomes secondary to conduct problems are particularly concerning for racial/ethnic minority youth who are disproportionately adjudicated for behavioral problems (rather than receiving mental health services) and are overrepresented in criminal justice settings (Cuffe et al., 1995; Stewart et al., 2020). Although there are efficacious interventions for conduct problems, they often produce modest gains, are limited to specific domains, and infrequently generalize across settings (e.g., therapeutic gains at home do not extend to peers; Blair et al., 2014; Webster-Stratton et al., 2004).

Overall, conduct problems are more prevalent in boys (relative to girls), which has perpetuated problematic assumptions that conduct problems are governed by identical risk factors, mediating processes, and outcomes in boys and girls (Keenan et al., 1999; Moffitt et al., 2001). Historically, research has focused explicitly on sex differences in specific conduct problem behaviors, including differential correlates of physical aggression, relational aggression, rule-breaking, and delinquency (Crick, 1995; Vitaro, Brendgen, et al., 2006). For example, whereas fighting, stealing, vandalism, and school discipline were elevated in boys, lying, truancy, running away, substance use, and prostitution were more common in girls (Maughan et al., 2004). Phenomenologically, these diverse behaviors reflect established taxa such as oppositional defiant disorder (ODD) and conduct disorder (CD) which are similarly sensitive to sex differences in prevalence, risk factors, and developmental course (Canino et al., 2010).

However, while evidence of sex differences is informative, innovations in understanding the origins, development, and outcomes secondary to conduct problems will be obstructed by exclusive reliance on tests of sex differences. Intensive characterization of risk factors for aggression should be prioritized specifically in girls rather than exclusively in the context of sex differences, which is characteristic of much of the extant literature.

Current knowledge gaps on early aggression in girls are especially concerning given replicated evidence that aggression predicts a highly dispersed pattern of dysfunction (i.e., multifinality) across psychosocial, occupational, and health outcomes. Compared to controls, adolescent girls with conduct problems exhibited worse young adult outcomes including poor overall health, substance dependence, early pregnancy, dependence on public assistance, and being a victim of physical partner violence (Bardone et al., 1996; Pajer et al., 2007). Despite its clinical significance, limited investigation of the etiology and development of aggression in girls is reflected in evidence of delayed identification (and hence delayed delivery of interventions) in girls (Dalsgaard et al., 2020); this delay contributes to worse treatment outcomes in girls relative to boys (Hipwell & Loeber, 2006). Intergenerationally, aggressive/antisocial girls assortatively mate with partners with similar traits that increase genetic vulnerability and potentiate risk processes (e.g., parent-child interactions) that accelerate conduct problem development (Auty et al., 2017; Bardone et al., 1996; Krueger et al., 1998). Thus, intensive and extensive characterization of risk factors and risk processes is a priority.

Attesting to the plausibility of potentially unique clinical and psychosocial correlates of aggression in girls, conduct problems concurrently and prospectively predict internalizing problems more strongly in girls than in boys (Keenan et al., 1999; Konrad et al., 2022; Teplin et al., 2006; Wasserman et al., 2005; Zahn-Waxler et al., 2008). This is particularly concerning given that co-occurring psychopathology designates more persistent maladjustment, greater functional impairment, and worse treatment outcomes relative to aggression without comorbidities (Brown & Barlow, 1992; Clarkin & Kendall, 1992; Verhulst & Van Der Ende, 1997). Similarly, conduct problems are also more strongly associated with suicidal behavior in girls than in boys (Fergusson et al., 2005; Joffe et al., 1988), and specific types of problem behaviors are acutely sensitive to sex differences: relational aggression (i.e., purposeful acts of exclusion, gossiping, and manipulation of social status) in girls predicts psychosocial maladjustment (e.g., reduced peer acceptance) more strongly than relational aggression in boys (Crick, 1996; Crick & Grotpeter, 1995; Rys & Bear, 1997). Finally, correlates of reactive aggression (i.e., "hot" or impulsive aggression) may also differ between boys and girls: whereas reactive aggression was correlated with hyperactive/impulsive behaviors in boys, it was associated with early traumatic stress and low verbal IQ in girls (Connor et al., 2003). Examination of individual differences (e.g., dispositional traits, cognition) combined with careful attention to different forms of aggressive behavior (e.g., relational, reactive) may reveal key correlates that are essential to understand and ultimately prevent significant aggression in girls.

Contextualized by evidence of critical cognitive, emotional, and biological correlates of aggression, which independently and interactively affect conduct problems, individual differences in social cognition may innovate understanding of aggression specifically in girls. For example, misinterpretations of social cues may condition ineffective responses, including hostile or maladaptive communication. Aberrations in specific aspects of social information processing, such as goal orientation, beliefs about aggression, and response selection, were diversely associated with different types of youth aggression (Bellmore et al., 2005; de Castro et al., 2005; Harper et al., 2010). In particular, whereas face emotion labeling (FEL) is an encoding process necessary for accurate social perception, deficient FEL (e.g., inaccurate labeling, delayed processing of facial expressions), particularly in response to ambiguously threatening facial expressions, is uniquely associated with irritability, conduct problems, and ADHD (Cadesky et al., 2000; Rich et al., 2009). Consistent with models of social cognition, inaccurate encoding may predict aggression through labeling innocuous, but equivocal, social cues as malicious (Crick & Dodge, 1994). In other words, the tendency to appraise others as angry or provocative may contribute to increased perceptions of threat/provocation, thus promoting aggressive responding.

Deficient FEL may be independently associated with aggressive responding and/or may affect downstream processes, such as interpretation of social situations or evaluation of possible responses. FEL deficits may specifically relate to hostile attribution bias (HAB), defined as negatively biased interpretations of ambiguous behavior during social interactions (e.g., peers). HAB predicts youth aggression, particularly in response to perceived provocation or threat (i.e., reactive aggression; Martinelli et al., 2018). Despite their shared relevance to threat processing and aggression, deficient FEL and HAB are rarely considered simultaneously, particularly in children. Given that accurate encoding is necessary for subsequent social information processes, inaccurate FEL, particularly for potential expressions of anger or hostility, may predict reactive aggressive behavior through HAB. Alternatively, given that HAB involves interpretation of cues beyond facial expressions, HAB may also operate independently of inaccurate FEL with respect to associations with aggression. Given that affiliative relations, cooperation, and shared goals are particularly relevant to female friendships (Block, 1983; Cross & Madson, 1997), inaccurate FEL and/or HAB may be acutely negative (i.e., socially detrimental) for girls. Overall, threat-biased social cognition is reliably associated with aggression in boys, but these factors may be even more crucial for understanding the development of aggression in girls. Despite its plausibility, these factors have not be rigorously prosecuted with girls.

Defined by the dispositional tendency to experience negative affective states (e.g., anger, sadness, frustration; Rothbart & Bates, 2006), trait negative emotionality is a *causal* transdiagnostic risk factor for psychopathology in children, adolescents, and adults (Compas et al., 2004; Eisenberg et al., 2009; Hankin et al., 2017; Khan et al., 2005a; Lahey et al., 2017), including aggression (Martel, 2009). Thus, negative emotionality likely operates synergistically with other risk factors, including social information processes, to predict aggression (Lemerise & Arsenio, 2016; Rothbart & Bates, 2007; Vitaro, Barker, et al., 2006). These hypothesized influences are supported by prevailing theories that emotional states and cognitive processes (Forgas, 2008), including social cognition (Crick & Dodge, 1994; Lemerise & Arsenio, 2016), transact and share neural structures (e.g., amygdala, medial prefrontal cortex) underlying key social cognition and emotional processes (Adolphs, 2009; Damasio, 1994). Negative affect is diversely implicated in several distinct stages of social information processing, including experimental induction of negative affect that increased hostile attribution bias (de Castro et al., 2003; Dodge & Somberg, 1987). Thus, beyond plausibly contributing to individual differences in aggressive behavior, negative emotionality may affect cognitive factors that predict aggression, such as specific threat-biased social information processing deficits (e.g., deficient FEL, HAB.

Similar to trait negative emotionality, differences in autonomic nervous system functioning are transdiagnostic correlates of emotional and behavioral problems, including aggression. Naturally occurring individual differences may be evident at rest (i.e., baseline) as well as during emotion processing activities (e.g., threat processing). Key psychophysiological biomarkers confer risk diversely for psychopathology, as well as the general psychopathology factor (Baskin-Sommers & Foti, 2015; Beauchaine & Thayer, 2015; McTeague & Lang, 2012). Respiratory sinus arrhythmia (RSA), an index of parasympathetic nervous system influence on heart rate variability, is correlated with emotion dysregulation in emotional and behavioral problems (Beauchaine, 2015b; Zisner & Beauchaine, 2016). Excessive RSA withdrawal (i.e., reductions in RSA, also referred to as RSA reactivity) in youth is consistently associated with behavioral problems (Beauchaine et al., 2019). Whereas diminished baseline RSA is consistently associated with aggression and conduct problems in boys, its association with aggression in girls is complicated by underpowered studies (Lorber, 2004; Zhang & Gao, 2015) that also ignore key facets of aggression (e.g., reactive, relational), thus producing inconsistent results (El-Sheikh & Hinnant, 2011; Gordis et al., 2009; Hinnant & El-Sheikh, 2013). The prevailing reliance on boys is even more problematic given evidence of sex differences in psychophysiological processes (e.g., stress-induced heart rate and epinephrine reactivity; Stoney et al., 1987), including the experience of emotions and stress and also while viewing emotional stimuli (Inslicht et al., 2013; Kring & Gordon, 1998; Ordaz & Luna, 2012; Sagarin et al., 2012). Finally, given dynamic biological changes associated with pubertal development, sex differences in the psychophysiology of social and emotional functioning must attend to specific developmental periods (Murray-Close, 2013). For example, studies must properly attend to psychophysiologically-mediated differences secondary to pubertal timing, especially in girls.

In addition to evidence of poor long-term outcomes and of limited treatment efficacy for aggression in girls, the burden of conduct problems may be increasing for girls specifically. For example, although arrest rates recently decreased for boys and girls, declines in girls are modest relative to boys, leading to an increased proportion of female arrests (Puzzanchera, 2013; Puzzanchera & Ehrmann, 2018; Snyder, 2008). These trends convey the urgent need to identify explanatory factors for aggression specifically in girls. To improve traction on developmentally sensitive processes in girls relevant to conduct problem development (e.g., pubertal status, psychophysiology), my dissertation includes two studies that intensively characterized individual differences in emotional functioning, social information processing, and psychophysiological reactivity and associations with aggressive behavior and other conduct problems in girls.

For Study I, we utilized a sample of 44 pre-adolescent girls enriched for high levels of negative emotionality to test sequential associations of trait negative emotionality, inaccurate FEL, and HAB with aggression. We employed path analysis to test direct and indirect associations among constructs. This analytic plan reflects evaluation of a hypothesized "chain reaction" effect initiated by trait negative emotionality that sequentially influences successive stages of social information processing, which in turn affect aggressive behavior (see Figure 1.1). We tested multiple dimensions of aggressive behavior and conduct problems to promote specificity of predictions.

Using the same sample, Study II associated RSA initial values and RSA reactivity during social information processing with aggression. Individual differences in these psychophysiological indicators were associated with aggression using multilevel modeling, which intensively characterizes multiple datapoints within an individual across repeated measures. Similar to Study I, we assessed and evaluated several types of aggressive behavior and conduct problems to identify specific associations with RSA. Collectively, these studies tested social cognitive, emotional, and biological correlates of aggression in pre-adolescent girls, thus focusing on a key developmental period.

Study I: Sequential Associations of Negative Emotionality and Social Information Processing With Aggressive Behavior in Girls

Social information processing models contend that deviant perceptions of the social environment are central to youth aggression (Dodge, 1986; Lemerise & Arsenio, 2016). Five stages of social perception and decision making are thought to affect children's engagement in competent or aggressive behaviors: encoding of cues, interpretation of cues, clarification of goals, response access or construction, and response decision (Crick & Dodge, 1994). Theories of aggression suggest that differences in the function of aggressive behavior correspond to aberrations in different social information processing stages. For example, whereas reactive or "hot" aggression is typically associated with feelings of anger or frustration and may reflect an impulsive response to threat, proactive aggression typically comprises deliberate, premeditated, and goal-directed behaviors (Dodge, 1991; Vitaro, Brendgen, et al., 2006). Similarly, proactive aggression reflects positive evaluations of aggression and expectations of rewards; reactive aggression is sensitive to perceptions, interpretations, and attributions of threat or danger (Crick & Dodge, 1996; Dodge, 2006). Thus, sensitivity to threat in early stages of social information processing (i.e., encoding and interpretation) is crucial to the development of reactive aggression.

Encoding processes such as face emotion labeling (FEL) are essential to create accurate mental representations of social information, which are deployed in subsequent stages of social information processing. While deficient FEL may be evident in several ways (e.g., slowed reaction time to label emotional facial expressions; Masten et al., 2008), inaccurate FEL, particularly for ambiguously threatening or angry facial expressions, is correlated with youth conduct problems and related psychosocial impairments (Mellentin et al., 2015; Rich et al., 2009). For example, children with conduct problems frequently mislabeled other emotional facial expressions as angry (Cadesky et al., 2000). Similarly, severe irritability, a reliable correlate of reactive aggression (Leibenluft, 2017), was associated with increased frequency of labeling ambiguous facial expressions as angry (as opposed to happy; Stoddard et al., 2016) and positively associated with self-reported fear when viewing neutral faces (Brotman et al., 2010). These findings support theories that, among youth at risk for aggression, hypersensitivity to threat is associated with encoding of social information by increasing the perception of danger.

Related threat biases in encoding also support associations of hypersensitivity to threat with aggression. For example, attentional biases for socially threatening information are evident among individuals high in reactive aggression and anger (N. V. Miller & Johnston, 2019; van Honk, Tuiten, de Haan, et al., 2001). Increased attention toward threatening stimuli is associated with aggression, but attention directed *away* from threat suggests that top-down processes fueled by hostile schemata (e.g., suppression of attention toward potentially threatening social cues) also affect attention, perception, and downstream social information processes (Horsley et al., 2010; Schippell et al., 2003; Wilkowski et al., 2007). These top-down processes may reinforce threat-biased social information processing by limiting opportunities to learn new associations for ambiguous or threatening stimuli, such as accurate identification of emotional facial expressions and other downstream social information processes. Although attentional biases toward/away from threat improve the understanding of social cognitive correlates of aggression, integration of other early-stage social information processes (e.g., FEL) is better positioned to elucidate the causal chain leading to reactive aggression.

Hostile attribution bias (HAB) is a central construct in interpretive processes associated with the development of aggression. Defined as the tendency to assign negative (e.g., malicious) attributions during ambiguous peer/social interactions, HAB is a significant risk factor for aggression in both boys and girls, particularly reactive behaviors in response to perceptions of threat (de Castro et al., 2002; Martinelli et al., 2018). Established risk factors for aggression, including maltreatment and early life adversity, predicted emergent HAB (Dodge, 2006; Mclaughlin et al., 2019): youth with maltreatment histories frequently attributed more hostile intent to ambiguous social situations (Dodge et al., 1990, 1995a). Similarly, negative paternal parenting behavior was associated with higher levels of HAB, with particularly strong associations noted for paternal psychological control with HAB in girls relative to boys (Nelson & Coyne, 2009). HAB is also sensitive to interpersonal adversity more generally, including peer victimization and bullying (Camodeca & Goossens, 2005; Perren et al., 2013). Thus, HAB may adaptively support development for youth who experienced early life maltreatment and hostility from others, as sensitivity to threat and provocation may adaptively facilitate identifying threat in the context of harmful environments; however, in other contexts, hostile attributions may maladaptively potentiate subsequent aggressive behavior that threatens socio-emotional functioning and increases risk for poor developmental outcomes.

Relational aggression, which includes purposeful acts of exclusion, gossiping, and manipulation of social status, is common in girls (Crick & Grotpeter, 1995; Prinstein et al., 2001) and features prominently in studies of HAB and aggression in girls. Interestingly, physical and relational aggression can both have either reactive or proactive functions (Marsee et al., 2014). Although hostile attributions of intent promote both physical and relational aggression (Martinelli et al., 2018), the nature of an ambiguous social situation may differentially evoke physical versus relational aggression. For example, *instrumental* provocations (e.g., a child breaking a belonging of another child) may evoke physical aggression whereas *relational* provocations (e.g., a child overhearing peers talk about a party they were not invited to) could specifically elicit relational aggression (Crick, 1995; Crick et al., 2002). Taken together, whereas HAB may similarly confer risk across physical and relational aggression, innovations will follow from assessment strategies for HAB that properly attend to *both* forms of social provocation, especially in the context of sex differences in aggression and emotional processing.

Despite their shared relevance for threat processing and associations with conduct problems, FEL and HAB are typically tested individually (rather than concurrently) or with paradigms that do not isolate their specific associations with conduct problems. Previous studies used facial expression stimuli to assess hostile interpretations/attributions of intent but did not separate encoding from interpretive processes (Schönenberg & Jusyte, 2014; Schultz et al., 2004; Stoddard et al., 2016). Other studies separately assessed encoding processes and HAB, but focused on other components of encoding (e.g., attention to hostile or non-hostile cues) rather than FEL deficits (Horsley et al., 2010). When FEL and HAB were evaluated, they were treated independently rather than sequentially (Guy et al., 2017). Collectively, these designs prevent inferences about how specific social information processes relate to aggression. Given that accurate encoding is necessary for subsequent social information processes, inaccurate FEL, particularly for ambiguously threatening faces, may predict aggression through HAB. Alternatively, given that HAB involves interpretation of social cues beyond facial expressions, HAB may also operate independently of aberrant FEL to predict conduct problems. In addition to clarifying the social cognitive mechanisms implicated in hostile, aggressive conduct problems, identification of a sequential association between these aberrant processes could yield new opportunities for identification and intervention, which are urgently needed for girls in particular.

Although aberrant social cognition is implicated in aggression in boys and girls (Martinelli et al., 2018), it may be especially important for the development of aggression in girls. Social interaction and close relationships are particularly valued by girls, reflected in sex differences in friendship characteristics and values, which are influenced and reinforced by differential socialization of boys and girls (Block, 1983; Cross & Madson, 1997). Friendships in girls are more interpersonally engaged and relational than in boys, as evidenced by their value for dyadic friendships, focus on connection-oriented goals with peers, and increased empathy. Boys, on the other hand, adopt more dominance and status-related goals, with periodic aggression being contingently reinforced among male peers, especially when goals are achieved (Rose & Rudolph, 2006). Thus, male aggression may be diversely modeled and/or reinforced (e.g., observation of male role models, male-dominated aggressive sports), whereas aberrant social cognition may be particularly consequential for aggression in girls. Alternatively, biased social information processing may increase girls' distress and impairment: given cultural values for girls' relationships (i.e., prioritizing cooperation and intimacy), understanding an ambiguous social situation, as well as the aggressive response that may follow, may be especially distressing for girls (Crick, 1995). Finally, girls with threat-biased interaction styles and aggressive tendencies are more impaired than boys with similar profiles, reflecting significant deviation from sex-specific norms (Robins & Price, 1991; Rose & Rudolph, 2006). Taken together, there is strong theoretical and empirical evidence that social information processing patterns, including deficits, are a compelling risk factor for aggression and related maladjustment in girls.

Trait negative emotionality, the propensity to experience negative affective states (e.g., anger, sadness, frustration), is a causal factor for diverse forms of psychopathology across the lifespan including youth (Compas et al., 2004; Eisenberg et al., 2009; Hankin et al., 2017) and adulthood (Khan et al., 2005b; Lahey et al., 2017). It uniquely predicted conduct problems (Harmon-Jones, 2003; Martel, 2009), particularly reactive aggression (Vitaro, Barker, et al., 2006; Wilkowski & Robinson, 2008). When manifested as trait anger and anxiety, negative emotionality is implicated in threat sensitivity (Derryberry & Rothbart, 1997; Lonigan et al., 2004; Mogg & Bradley, 1998; van Honk, Tuiten, Van Den Hout, et al., 2001), including hypersensitivity to social threat (E. Fox et al., 2002; van Honk, Tuiten, de Haan, et al., 2001). During potentially threatening interactions, dispositional negative emotionality may predict threat-biased social information processes via situational anger or anxiety and increased arousal (Schultz et al., 2010; Verona et al., 2002). In addition to well-established reciprocal effects between emotion and cognition (Damasio, 1994; Forgas, 2008; LeDoux, 1989), situational negative emotionality may specifically affect threat-biased social information processing (Crick & Dodge, 1994; Harper et al., 2010; Lemerise & Arsenio, 2016). Although trait negative emotionality reliably predicts reactive aggression and affects threat sensitivity, its association with specific social information processes has received surprisingly little attention, particularly in girls (de Castro et al., 2002; Helseth et al., 2015). While evidence for sex differences in dispositional negative emotionality in children is mixed (Else-Quest et al., 2006), women report higher levels of neuroticism, a personality construct with developmental origins in negative emotionality, than men, (Costa et al., 2001; Muris & Ollendick, 2005; Schmitt et al., 2008). Should negative emotionality predict threat-biased social information processes such as FEL and/or HAB, sequential testing of these constructs (see Figure 1.1) may elucidate a causal chain that would likely facilitate needed innovations in intervention.

Aims & Hypotheses: Study I

To review, although negative emotionality, inaccurate FEL, and HAB are each associated with conduct problems, especially those of an aggressive nature, informative sequential associations have not been investigated, particularly in girls. Furthermore, although theoretical and empirical evidence suggests that these correlates may be particularly relevant for reactive aggression, previous studies often failed to differentiate key dimensions of conduct problems and aggression (e.g., reactive versus proactive aggression, physical versus relational aggression). In this study, we aimed to test (1) sequential associations (i.e., a "chain reaction" effect) with respect to heightened negative emotionality, inaccurate FEL, elevated HAB, and two dimensions of reactive aggression (relational and physical) in a sample of pre-adolescent girls; and (2) differential associations between negative emotionality, inaccurate FEL, and elevated HAB with proactive relational aggression, proactive physical aggression, general aggressive behavior, and rule-breaking behavior compared to the two dimensions of reactive aggression.

We hypothesized that (1a) negative emotionality, inaccurate FEL, and elevated HAB would each be positively associated with youth reactive relational and reactive physical aggression; (1b) negative emotionality would be positively associated with youth reactive relational and reactive physical aggression through inaccurate FEL; (1c) negative emotionality would be positively associated with youth reactive relational and reactive physical aggression through elevated HAB; (1d) inaccurate FEL would be positively associated with youth reactive relational and reactive physical aggression through elevated HAB; and (1e) negative emotionality would be positively associated with youth reactive relational and reactive physical aggression through inaccurate FEL and elevated HAB when FEL and HAB are positioned as sequential mediators. Additionally, we hypothesized that (2a) associations with negative emotionality, inaccurate FEL, and elevated HAB would be attenuated (i.e., reduced effect size) for proactive relational aggression, proactive physical aggression, general aggressive behavior, and rule-breaking behavior relative to reactive relational and reactive physical aggression.

Methods

Participants

Participants consisted of 52 girls between the ages of 6 and 11 years old (*M* = 8.13, *SD* = 1.68) and their families who participated in the Developmental Research on Emotion and Mental Health in Girls (DREAMING) Study. Participants and their families came from diverse racial and ethnic backgrounds (38.5% Caucasian for participants), exemplifying the diversity of metropolitan Los Angeles, where the study was conducted. Due to mandatory stoppage of in-person research during the COVID-19 pandemic, data collection occurred during two periods: between January 2019 and March 2020 (N = 44) and between May and August 2022 (N = 8). Table 1.1 presents additional demographic information for the sample. There were no significant differences in participants' demographics depending on data collection period. Inclusion criteria consisted of girls between the ages of 6 and 11 years old, English fluency in both parent and child, and no serious medical or developmental diagnoses that would prevent full study participation. Families were recruited diversely to enhance generalizability, including targeted recruitment to ensure sufficient negative emotionality (e.g., irritability, frustration, anger), but without regard to a specific diagnostic taxon.

Participants were recruited using several strategies and multiple sources: flyers were distributed to and posted at local community organizations (e.g., recreation centers, libraries) and medical (e.g., pediatric, dental) clinics. Recruitment materials were also posted at local schools and mental health service providers as well as printed in family-focused publications. Lab members were involved in multiple recruitment events, including the principal investigator giving presentations at different organizations (e.g., schools) and graduate students distributing information at community resource fairs.

Procedures

Families first completed a telephone screener to determine eligibility. At the laboratory visit, parents provided written consent and youth provided assent. Consent was also obtained to mail parallel rating scales to the child's primary teacher. Parents completed some rating scales online prior to the lab visit, but all measures and tasks for this study were completed during the in-person assessment, which consisted of (1) standardized tests of child and parent cognitive ability and academic achievement, (2) computerized tasks of emotion processing (e.g., fear learning), (3) observational measures of parent-child interaction, and (4) multi-method/informant (e.g., structured diagnostic interviews, rating scales, youth self-report and teacher-rated) measures of children's socio-emotional and behavioral functioning. Psychophysiological measures (i.e., heart rate, respiration rate, and electrodermal activity) were collected from both parents and youth during some computerized tasks and observational measures not featured in Study I. Families received $100 for their participation as well as a psychoeducational report that summarized findings. All procedures were approved by the UCLA Institutional Review Board. Data collection procedures were identical between the two data collection periods, with the only exception being children, parents, and research staff being required to wear masks during the research visit to minimize spread of illness during the 2022 data collection period.

Measures

Trait Negative Emotionality

The Child and Adolescent Dispositions Scale (CADS; Lahey et al., 2010) is a parent-rated interview assessing three dimensions of temperament causally associated with child psychopathology: Negative Emotionality, Prosociality, and Daring. Parents rated 50 items (e.g., "Does your child get upset easily?") using a 1-4 scale (1 = *not at all*, 2 = *just a little,* 3 = *pretty* *much*, 4 = *very much*). Crucially, the CADS features language completely free of clear synonyms or antonyms of psychopathology, which inflates associations, and has shown strong predictive validity and sensitivity to genetic influences. (Class et al., 2019; Waldman et al., 2011).

Face Emotion Labeling

The Penn Emotion Recognition Test (ER-40), a behavioral, computer-based task, assessed accuracy in face emotion labeling (Gur et al., 2001). Participants viewed 40 images of human faces (20 male faces, 20 female faces) expressing happiness, sadness, anger, fear, or no emotion. For each trial, participants selected one of five answer choices: happy, sad, anger, fear, or no emotion. This task has been used to assess FEL deficits in clinical samples (e.g., emotional and behavioral problems, developmental delays, early psychosis symptoms) and school-based samples of youth (Dickson et al., 2014; Roddy et al., 2012; Schenkel et al., 2007). Participants completed the approximately 5-minute task while sitting with an examiner in a quiet room in front of a desktop computer. Given that sensitivity to threat and biases toward expressions of anger were associated with youth aggression (Mellentin et al., 2015), the FEL accuracy variable was calculated based on false positive ratings of anger. In this sample, scores for this count variable ranged from 0 to 4.

Hostile Attribution Bias

HAB was also assessed using a computer-based task, which included a series of six video-based vignettes depicting ambiguous social interactions in pre-adolescent girls. All interactions involved a potential provocation that was ambiguous in nature. Each video was followed by the examiner asking questions to evaluate participants' intent attributions, emotional reactions, and behavioral responses. Participants reported their attribution of the provocation (i.e., whether the provocateur was being mean, nice, or neither), how they would feel if they were in the position of the character who was harmed, and what they would do if they were the character who was harmed. Vignettes were created specifically for this study, adapting previously standardized HAB assessments by improving ethnic diversity, including specifically same-sex female interactions, and enhancing audio and visual quality of the original vignettes (Dodge et al., 1995b; Lansford et al., 2010; Weiss et al., 1992). Three additional vignettes involving frustrating situations with adults (e.g., parents, teachers) were administered, but only six were used in the present study to focus specifically on peer interactions. The HAB task was presented using E-prime (3.2.1) on a desktop computer. The total HAB score was calculated by adding the number of vignettes (out of six) involving the detection of a “mean” intention. Thus, scores range naturally from 0 to 6, which was evident in this sample.

Youth Aggression and Conduct Problems

The parent-report version of the Peer Conflict Scale (PCS; Marsee & Frick, 2007), previously validated in separate community and clinical samples of youth, assessed the form and function of aggressive behavior. The 40-item scale includes Reactive Relational Aggression (e.g., “If others make me mad, I tell their secrets”), Reactive Physical Aggression (e.g., “When someone hurts me, I end up getting into a fight”), Proactive Relational Aggression (e.g., “I gossip about others to become popular”), and Proactive Physical Aggression (e.g., “I start fights to get what I want”) subscales. All items were rated on a 0-3 scale (0 = *not true at all*, 1 = *somewhat true*, 2 = *very true*, 3 = *definitely true*). In this sample, the range of subscale scores was as follows: 0 to 14 for Reactive Relational Aggression, 0 to 22 for Reactive Physical Aggression, 0 to 9 for Proactive Relational Aggression, and 0 to 11 for Proactive Physical Aggression. These ranges approximated previous all-female samples (e.g., 0 to 22, 1 to 27, 0 to 18, and 0 to 17, respectively; Marsee & Frick, 2007). Analyses prioritized the Reactive

Relational Aggression and Reactive Physical Aggression subscales for Aim 1 and also tested the Proactive Relational Aggression and Proactive Physical Aggression subscales for Aim 2. All subscales were calculated using sum scores.

The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) is a widely-used, parent-report rating scale that consists of 113 items and produces multiple scales of internalizing and externalizing problems. Analyses for the present study utilized the Aggressive Behavior subscale (e.g., items spanning teasing others, having a hot temper, and physically attacking others) and the Rule-Breaking Behavior subscale (e.g., items spanning breaking rules at home/school, stealing from others, and swearing). Parents rated each behavior (past six months) on a 0-2 scale (0 = *not true*, 1 = *somewhat or sometimes true*, or 2 = *very true or often true*). Analyses for the present study utilized raw scores for both subscales. In addition to providing a measure of aggressive and rule-breaking behavior, the CBCL enabled thorough assessment of the sample's clinical characteristics, as they provide strong norms to adequately characterize normative, elevated, and clinically significant problem behavior. See Table 1.2 for a summary of all measures in Study I.

Data Analytic Plan

Path Analysis

To test sequential associations between the constructs of interest (i.e., a "chain reaction" effect, see Figure 1.1), path analysis modeling, a special case of structural equation modeling that utilizes only observed variables, was employed. Compared to multiple regression, path analysis tests complex models with several independent and dependent variables, avoiding multiple tests that incur Type I error (Tomarken & Waller, 2005). This approach enabled testing of indirect effects and other relationships between variables that serve as sequential predictors. Specifically, the models tested the following hypothesized paths: (1) the effect of CADS Negative Emotionality on FEL; (2) the effect of FEL on HAB, controlling for CADS Negative Emotionality; (3) the effect of HAB on aggression, controlling for CADS Negative Emotionality and FEL; (4) the effect of CADS Negative Emotionality on aggression, controlling for FEL and HAB; (5) the effect of CADS Negative Emotionality on HAB, controlling for FEL; and (6) the effect of FEL on aggression, controlling for CADS Negative Emotionality and HAB. Additionally, the following indirect effects were tested: (1) the indirect effect of CADS Negative Emotionality on aggression through FEL and HAB; (2) the indirect effect of CADS Negative Emotionality on aggression through FEL; (3) the indirect effect of CADS Negative Emotionality on aggression through HAB; and (4) the indirect effect of FEL on aggression through HAB. In addition to calculating regression-based path coefficients, the models produced point estimates and 95% bias-corrected confidence intervals for the individual paths and indirect effects. Confidence intervals, which were produced using 5,000 bootstrap simulations, enable assumption of statistical significance when the interval excludes zero. Relative to traditional mediation techniques, bootstrapped confidence intervals for indirect effects have greater statistical power (Zhao et al., 2010) and are also robust to non-normal data (Preacher & Hayes, 2008). Finally, to improve directional inferences derived from cross-sectional data, the test of the indirect effect was repeated but with the outcome (i.e., conduct problem variable) and two mediators (i.e., FEL and HAB) reversed.

Separate models were fit for each conduct problem variable to test predictions for that specific variable. Analyses for Aim 1 considered PCS Reactive Relational Aggression and PCS Reactive Physical Aggression as the final outcomes in the path models. Analyses for Aim 2 considered four highly similar models with each of the following outcome variables: PCS

Proactive Relational Aggression, PCS Proactive Physical Aggression, CBCL Aggressive Behavior, and CBCL Rule-Breaking Behavior. Effect sizes calculated using the completely standardized indirect effect (ab_{cs}, also referred to as the index of mediation; Preacher & Kelley, 2011), enabled comparisons of the strength of effects between models. Because guidelines for small, medium, and large effects have not been established for the completely standardized indirect effect (Miočević et al., 2018), standard guidelines for Cohen's *d* effect sizes were used (0.1 for small, 0.3 for medium, and 0.5 for large effects; Cohen, 1988). The standardized regression coefficients for individual paths were also examined to assess effect size and interpreted based on these benchmarks.

Statistical Power

The sample size for this study, and the accompanying statistical power, is modest for detecting main effects. Although statistical significance (i.e., *p*-values, bootstrapped confidence intervals) were considered when evaluating the effects produced by the path model, effect size measures that are independent of sample size were prioritized. We examined standardized path coefficients for individual paths and ab_{cs} for indirect effects within the path model.

Results

Descriptive Analyses

Descriptive statistics for study variables are presented in Table 1.3. No differences were evident between participants recruited in the pre-pandemic data collection period versus the 2022 data collection period. Intercorrelations between study variables were examined prior to fitting path models and are presented in Table 1.4. Figure 1.2 depicts the percentage of sample participants whose score on CBCL subscales fell within the borderline clinical or clinical ranges. Based on the CBCL norms, which are adjusted for children's age and sex, approximately 7% of children score in these ranges. The frequency of elevated scores was greater than would be expected for the following subscales: Anxious/Depressed, Withdrawn/Depressed, Aggressive Behavior, and Rule-Breaking Behavior.

Aim 1 tested predictions of PCS Reactive Relational Aggression and PCS Reactive Physical Aggression via sequential mediation. To compare these path models with those for PCS Proactive Relational Aggression, Proactive Physical Aggression, CBCL Aggressive Behavior, and CBCL Rule-Breaking Behavior for Aim 2, parallel path models testing predictions of each of these variables were employed.

Specific Paths Within Models

Mplus Version 8.3 (Muthén & Muthén, 2017) was used to fit all path models (see Figure 1.1). Prior to examining indirect effects to assess for possible mediation, individual paths within each model were examined. Table 1.5 presents standardized regression coefficients for each path within each model, controlling for the other predictors in the model. Based on these effects, CADS Negative Emotionality was not significantly associated with FEL or HAB in any model. Standardized regression coefficients for these effects revealed zero or small, negative effects for all models. CADS Negative Emotionality was significantly associated with conduct problem variables across all six models, with positive, medium-sized effects and one large effect in the case of the model predicting CBCL Aggressive Behavior (*ß* = 0.68, $p < .001$). FEL was significantly associated with HAB in all six models, with positive, medium-sized effects. FEL was marginally significantly and positively associated with PCS Reactive Physical Aggression (*ß* = 0.28, $p = .07$); effects for other conduct problem variables were non-significant with small effect sizes. HAB was significantly and positively associated with PCS Reactive Relational

Aggression ($ß = 0.30$, $p < .05$) and with CBCL Aggressive Behavior ($ß = 0.26$, $p < .05$); effects for other conduct problem variables were non-significant with zero or small effect sizes.

Indirect Effects

To evaluate for possible single or sequential mediation in each path model, p values and ab_{cs} values (i.e., standardized coefficients for completely standardized indirect effects) for each indirect effect of interest were examined. In addition to evaluating effects based on statistical significance, effect sizes were prioritized given sample size considerations. The following four indirect effects were examined for each model: CADS Negative Emotionality predicting the conduct problem variable through both FEL and HAB, CADS Negative Emotionality predicting the conduct problem variable through FEL, CADS Negative Emotionality predicting the conduct problem variable through HAB, and FEL predicting the conduct problem variable through HAB. Completely standardized indirect effects are presented in Table 1.6. Two completely standardized indirect effects were statistically significant or marginally significant, suggestive of FEL being associated with PCS Reactive Relational Aggression through HAB ($ab_{cs} = 0.11$, $p = .05$, 95% CI [0.02, 0.25]) and FEL being associated with CBCL Aggressive Behavior through HAB ($ab_{cs} = 0.10$, $p = .06$, 95% CI [0.00, 0.22]). These two completely standardized indirect effects yielded the largest effect sizes across all models. Although established guidelines for small, medium, and large completely standardized indirect effect sizes do not yet exist, interpretation of these values based on previously suggested conventions suggest that they are both small effects. All other completely standardized indirect effects across models were non-significant with effect sizes below the suggested cutoff for small effects. The path models with PCS Reactive Relational Aggression and CBCL Aggressive Behavior as the final outcomes are depicted in Figure 1.3 and Figure 1.4, respectively.

Testing Models With Reverse Mediation Effect

To assess directionality of effects seen within cross-sectional data, the two path models with statistically significant or marginally significant indirect effects were tested with reverse ordering of the variables of interest. The indirect effects for FEL predicting PCS Reactive Relational Aggression and CBCL Aggressive Behavior through HAB were both evaluated with reverse models, specifically, the conduct problem behavior variable predicting FEL through HAB. The completely standardized indirect effect for the PCS Reactive Relational Aggression model suggested a marginal, small effect (ab_{cs} = 0.11, p = .09, 95% CI [0.01, 0.23]), and the statistic for the CBCL Aggressive Behavior model suggested a non-significant, negligent effect (i.e., below the suggested cutoff for small effects; ab_{cs} = 0.05, p = .34, 95% CI [-0.05, 0.15]). Comparison of these reverse models and the original models cannot confirm directionality of effects, particularly for the PCS Reactive Relational Aggression model.

Discussion

To review, Study I evaluated socio-emotional correlates of aggressive behavior in girls by testing sequential associations between heightened negative emotionality, inaccurate FEL, elevated HAB, and multiple dimensions of aggression and conduct problems in a sample of 52 ethnically diverse, pre-adolescent (age 6 to 11 years) girls. Given that reactive aggression in particular is associated with threat sensitivity and perceptions of social harm (Carver & Harmon-Jones, 2009; Verona & Bresin, 2015), we tested individual and sequential associations predicting reactive relational aggression and reactive physical aggression. As predicted in Hypothesis 1a, negative emotionality was positively associated with both types of aggressive behavior, and elevated HAB was positively associated with reactive relational aggression. Inaccurate FEL also had a marginally significant positive association with reactive physical aggression. Of the four hypothesized indirect effects outlined in Hypotheses 1b, 1c, 1d, and 1e, inaccurate FEL was associated with reactive relational aggression through HAB. Other hypothesized indirect effects through inaccurate FEL and/or elevated HAB were non-significant, however.

Our second aim was to test these sequential associations as predictors of other dimensions of conduct problems and to compare the strength of associations. Interestingly, negative emotionality was similarly associated with all dimensions of conduct problems tested, the strongest association appearing for a general measure of aggression. The model testing general aggressive behavior also suggested that HAB was positively associated with general aggression, and inaccurate FEL was marginally associated with general aggression through HAB. Furthermore, the indirect effects in these two models from FEL to reactive relational/general aggression through HAB produced the largest indirect effect sizes. Counter to hypothesis 2a, these results highlight the significance of general aggressive behavior in the models, in addition to the expected results for reactive relational aggression.

As mentioned, tests of individual paths, which statistically controlled for other predictors in the path model, yielded the following results: negative emotionality was positively associated with all conduct problem variables, HAB was positively associated with reactive relational and general aggression, and FEL had a marginal positive association with reactive physical aggression. In addition, two other patterns emerged: first, contrary to the hypothesized sequential model, negative emotionality was unrelated to either FEL or HAB; second, as expected, FEL was positively associated with HAB with a medium-sized effect.

There are several possible explanations for the null relationships between negative emotionality with FEL and HAB. First, trait negative emotionality was hypothesized to associate with FEL and HAB given the centrality of emotion and physiological arousal on cognitive processes (Damasio, 1994; Forgas, 2008; Schultz et al., 2010). Because children who are high in negative emotionality are especially emotionally reactive and sensitive to threat (Lengua & Long, 2002), they experience more frequent negative emotional states that bias their social cognitions. However, given the "situational" nature of this analogue task (i.e., a brief, lab-based activity that mimics a real-life scenario), it may not have sufficiently elicited individual differences in negative emotionality relative to naturalistic social interactions in day-to-day life. Alternative approaches, such as mood induction procedures, may better estimate the range of effects attributable to negative emotionality. Indeed, previous studies found that individual differences in cognitive biases, including social information processing biases, were evident after emotion induction tasks (de Castro et al., 2003; Hubbard et al., 2016). While trait-level individual differences may still influence an individual's typical cognitive patterns, circumstances that deliberately evoke negative emotional states may strengthen their influence on cognitive processing.

Alternatively, trait negative emotionality is multidimensional, suggesting that specific facets may be more powerfully associated with social information processes. For example, trait anger specifically affected cognitive processes (Quan et al., 2022; Wilkowski & Robinson, 2008, 2010); potentially "competing" dimensions of trait negative emotionality, such as propensity toward sadness or anxiety, may obscure the influence of anger on social cognition (Shiner & Caspi, 2003). For example, propensity toward irritability accounted for the association between biases toward hostile social interpretations and depressive tendencies (Marks et al., 2021), suggesting that trait anger may be responsible for social cognitive biases in emotional and behavioral problems that are associated with negative emotionality. In another study, van Honk, Tuiten, Van Den Hout, and colleagues (2001) found that differences in attentional processing of threatening stimuli differed between high trait anger and high trait anxious individuals, possibly due to anxious individuals being more motivated to control/change their emotional responses or negative cognitions in response to threatening information. Although neuroticism/negative emotionality is a shared predictor of diverse markers of emotional and behavioral maladjustment, trait anger may relate more specifically to hypothesized linkages with threat-biased social information processing, underscoring the urgency of rigorous measurement strategies.

Despite null associations with negative emotionality, inaccurate FEL and elevated HAB were positively associated with general aggression, reactive relational aggression, and reactive physical aggression. Contrary to hypotheses, the breadth of behaviors included in the general aggression measure (e.g., argumentative, destroying property, having a short temper, bullying) may have strengthened the association with HAB by capturing a wide range of behavior and severity of aggressive tendencies (i.e., increased sensitivity of the measure). Given previous work demonstrating the role of encoding and interpretation biases in the propensity toward reactive aggression in particular, positive predictions of the reactive aggression measures were aligned with hypotheses. However, the specific associations between HAB with reactive relational aggression and FEL with reactive physical aggression were unexpected.

One possible explanation for the association between HAB and reactive aggression of a relational nature may be the design of the HAB task. Although the video-based vignettes of ambiguous peer interactions depicted a range of different social situations, four of the six vignettes depicted relational or verbal provocations, with the remaining two vignettes depicting physical provocations. Given that a systematic review suggested distinct associations between relational versus physical aggression and their respective attribution biases (Martinelli et al., 2018), this relational/social focus in the HAB task may have strengthened associations with reactive relational aggression versus reactive physical aggression. In addition, the same systematic literature review found that the physical HAB-physical aggression association might be stronger in male samples than female samples (Martinelli et al., 2018), which may help explain why reactive physical aggression was unrelated to HAB in this all-female sample.

The positive association between inaccurate FEL and reactive physical aggression is not surprising given that much of the existing work examining face emotion labeling and aggression, particularly a bias toward perceiving anger, has focused on physical aggression. In adults, higher perceptual sensitivity to subtle cues of facial anger was associated with physical aggression (Wilkowski & Robinson, 2012), as were false positive angry attributions (Taylor & Jose, 2014). Similar patterns were found in children: misspecifications of facial expressions were positively associated with concurrent overt aggressive behaviors (Acland et al., 2021). Given that perpetration of relational aggression requires a certain level of social awareness (Andreou, 2006), it may require early social information processes, (e.g., encoding of information) to be intact, while distortions in later processes (e.g., interpretation of information) may precipitate relational aggression. In other words, some children who struggle to accurately label facial expressions may be prone to physical aggression while lacking social attunement to effectively engage in relational aggression.

Given the results for individual paths in the models, particularly the significant associations between FEL and HAB, HAB and reactive relational aggression, and HAB and general aggressive behavior, tests of sequential associations yielded unsurprising results. Two of the sequential associations had statistically significant or marginally significant indirect effects: aligned with hypotheses, FEL was positively associated with reactive relational aggression through HAB, and FEL was positively associated with general aggressive behavior through

HAB. These two indirect effects also had the largest effect sizes of all those tested. Trait negative emotionality was notably not included in these sequential associations, which is also unsurprising given the nonsignificant relationships with the two social information processes. Although proposed as a sequential, four-part model, the individual paths described in the previous section suggest two components of the model: positive associations between negative emotionality and conduct problems, and the positive association between FEL and HAB. While FEL and HAB were related to some conduct problem dimensions, their lack of association with negative emotionality affected the strength of sequential associations within the model as hypothesized.

Of note, given that all data were cross-sectional and one of the "reverse" models produced a small, marginal indirect effect, directionality of effects in the reactive relational aggression model cannot be reliably discerned. Specifically, these results suggest that, in addition to inaccurate FEL and elevated HAB influencing reactive relational aggression, these aggressive behaviors may also influence FEL and HAB (Quan et al., 2019). Given that aggressive responses to ambiguous provocations may be reinforced if the provocateur responds with further aggression, aggressive behavior could reinforce threat-biased social information processes over time (Dodge et al., 2015). However, given the wealth of theoretical (Crick & Dodge, 1994) and empirical (Martinelli et al., 2018) evidence suggesting that biased social information processing predicts aggressive behavior, we continue to interpret these results as evidence for a sequential model testing prediction of aggressive behavior.

This study demonstrated a number of strengths, including intensive evaluation of social cognitive processes and separable dimensions of conduct problems in a sample of ethnically diverse pre-adolescent girls, a population subject to notable gaps in existing literature on developmental correlates and precursors to externalizing problems. Despite its strengths, the limitations of this study are worth discussion. First, all data were cross-sectional, preventing strong inferences about directionality of predictive effects within the sequential model. Future work would benefit from stretching data collection across multiple time points to differentiate predictors from correlates or consequences of aggressive behavior. Second, the sample size for this study may have precluded identification of statistically significant effects, particularly indirect effects. Re-testing of these models with larger samples can inform whether the effects produced in this study hold true when questions about sufficient statistical power are eliminated. Relatedly, although analyses were planned with intention to prioritize effect size measures over statistical significance due to sample size considerations, a Bonferroni correction could be applied when interpreting *p*-values to account for the multiple models considered across different conduct problem variables. Given that six models were interpreted, the corrected alpha value would be .008. All models and effects that were significant at the .05 level are still presented given that these models were planned to be considered within two overarching aims/hypotheses (Ludbrook, 1998), as well as the prioritization of effect size measures.

Third, all measures of trait negative emotionality and conduct problems were based on parent report. Gathering additional reports of these constructs spanning multiple informants (e.g., teachers, peer nominations) would be informative for future studies, particularly given that behavioral problems may manifest differently in different settings. Finally, although no group differences in study variables were observed between the participants recruited prior to and after the COVID-19 pandemic, it is possible that these two groups differ in an unanticipated manner that could affect the presence or strength of associations within the path models. Future studies should replicate these findings in other samples of pre-adolescent girls, ideally with multiple time points extending into adolescence to enable early identification of risk factors for adolescent behavioral problems.

Table 1.1

Demographic Information for DREAMING Study

	Percentage of Sample	Test for Differences Between Data Collection Periods
Race:		$\chi^2(5) = 2.89$, $p = .72$
Caucasian	38.5%	
African American/Black	5.8%	
Asian	17.3%	
Mixed	36.5%	
Other	1.9%	
Ethnicity:		$\chi^2(1) = 1.42$, $p = .23$
Hispanic	21.2%	
Non-Hispanic	78.8%	
Parent Education:		$\chi^2(2) = 1.47$, $p = .48$
Some college or post high school	7.7%	
College graduate	34.6%	
Advanced graduate or professional degree	57.5%	
Age:		
$M = 8.13$, $SD = 1.68$		$t(49) = -0.69$, $p = .49$

Note. Data collection periods included January 2019 to March 2020 (N = 44) and May to August 2022 (N = 8).

Table 1.2

Summary of Study Measures

Construct	Measure	Measure Type	Measure Description
Negative Emotionality	Child and Adolescent Dispositions Scale – Negative Emotionality subscale	Parent-rated interview	Assesses three dimensions of temperament: negative emotionality, prosociality, and daring.
Face Emotion Labeling	Penn Emotion Recognition Test (ER-40) – False Positive Angry Ratings	Computer task	Presents 40 images of human faces, participants label the emotion expressed as happy, sad, anger, fear, or no emotion.
Hostile Attribution Bias	Hostile Attribution Bias Task – Total Number of Hostile Ratings	Computer task	Presents six video-based vignettes depicting ambiguous social interactions.
Aggression	Peer Conflict Scale – Reactive Relational, Reactive Physical, Proactive Relational, and Proactive Physical Aggression subscales	Parent-report rating scale	Assesses the form (i.e., physical versus relational) and function (i.e., reactive versus proactive) of aggressive behavior.
Aggressive Behavior and Rule-Breaking Behavior	Child Behavior Checklist – Aggressive Behavior and Rule-Breaking Behavior subscales	Parent-report rating scale	Assesses diverse emotional and behavioral problems.

Table 1.3

Descriptive Information for Study Variables

	M (SD)	Test for Differences Between Data Collection Periods
CADS Negative Emotionality	26.14 (5.38)	$t(49) = 1.23$ $p = .22$
FEL False Positive Angry Responses	0.46 (0.93)	$t(39) = 0.72$ $p = .47$
HAB Total Score	2.94 (1.28)	$t(48) = -0.14$ $p = .89$
PCS Reactive Relational Aggression	1.63 (2.92)	$t(46) = -0.09$ $p = .93$
PCS Reactive Physical Aggression	1.88 (3.85)	$t(46) = 0.54$ $p = .59$
PCS Proactive Relational Aggression	1.23 (2.15)	$t(46) = 0.11$ $p = .91$
PCS Proactive Physical Aggression	0.71 (1.88)	$t(46) = 0.64$ $p = .53$
CBCL Aggressive Behavior	4.76 (5.10)	$t(48) = 0.10$ $p = .92$
CBCL Rule-Breaking Behavior	1.64 (2.12)	$t(48) = 0.67$ $p = .51$

Table 1.4

Intercorrelations Between Study Variables

	CADS Negative Emotionality	FEL False Positive Angry Ratings	HAB Total Score	PCS Reactive Relational Aggression	PCS Reactive Physical Aggression	PCS Proactive Relational Aggression	PCS Proactive Physical Aggression	CBCL Aggressive Behavior	CBCL Rule-Breaking Behavior
CADS Negative Emotionality	-	-.104	-.210	.228	.387**	.332*	.310*	.625**	.395**
FEL False Positive Angry Ratings	-.104	-	.360*	.225	.271	.327*	.154	.099	.243
HAB Total Score	-.210	.360*	-	.282	.078	.071	.092	.138	.121
PCS Reactive Relational Aggression	.228	.225	.282	-	.520**	.745**	.547**	.376**	.305*
PCS Reactive Physical Aggression	.387**	.271	.078	.520**	-	.743**	.893**	.734**	.709**
PCS Proactive Relational Aggression	.332*	.327*	.071	.745**	.743**	-	.777**	.595**	.657**
PCS Proactive Physical Aggression	.310*	.154	.092	.547**	.893**	.777**	-	.711**	.719**
CBCL Aggressive Behavior	.625**	.099	.138	.376**	.734**	.595**	.711**	-	.740**
CBCL Rule-Breaking Behavior	.395**	.243	.121	.305*	.709**	.657**	.719**	.740**	-

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

Table 1.5

Standardized Coefficients for Individual Paths for Each Conduct Problem Model

	CP Outcome Variable					
	PCS RR	PCS RP	PCS PR	PCS PP	CBCL AB	CBCL RBB
CADS NE Predicting FEL						
β	-0.091	-0.103	-0.093	-0.097	-0.099	-0.109
SE	0.175	0.173	0.175	0.175	0.172	0.169
[95% CI]	[-0.42, 0.25]	[-0.42, 0.24]	[-0.42, 0.25]	[-0.42, 0.25]	[-0.41, 0.25]	[-0.41, 0.24]
CADS NE Predicting HAB						
β	-0.175	-0.170	-0.174	-0.173	-0.174	-0.167
SE	0.122	0.121	0.121	0.122	0.121	0.122
[95% CI]	[-0.42, 0.06]	[-0.41, 0.07]	[-0.41, 0.06]	[-0.41, 0.06]	[-0.42, 0.06]	[-0.41, 0.07]
CADS NE Predicting CP						
β	0.309*	0.426***	0.363**	0.348**	0.681***	0.433***
SE	0.125	0.104	0.132	0.120	0.075	0.119
[95% CI]	[0.06, 0.54]	[0.23, 0.64]	[0.09, 0.61]	[0.10, 0.58]	[0.54, 0.84]	[0.18, 0.65]
FEL Predicting HAB						
β	0.380***	0.384**	0.379***	0.374***	0.382***	0.371***
SE	0.098	0.099	0.100	0.100	0.102	0.102
[95% CI]	[0.18, 0.57]	[0.18, 0.57]	[0.17, 0.57]	[0.17, 0.57]	[0.19, 0.58]	[0.17, 0.57]
FEL Predicting CP						
β	0.143	0.279†	0.347	0.124	0.089	0.262
SE	0.195	0.151	0.228	0.175	0.125	0.173
[95% CI]	[-0.22, 0.56]	[-0.02, 0.63]	[-0.17, 0.68]	[-0.22, 0.56]	[-0.20, 0.30]	[-0.14, 0.56]
HAB Predicting CP						
β	0.299*	0.063	0.012	0.127	0.259*	0.072
SE	0.120	0.135	0.141	0.150	0.130	0.146
[95% CI]	[0.06, 0.54]	[-0.22, 0.34]	[-0.23, 0.31]	[-0.15, 0.44]	[0.00, 0.52]	[-0.18, 0.38]

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Note. CADS NE = CADS Negative Emotionality. FEL = face emotion labeling score. HAB = hostile attribution bias score. CP = score for conduct problems variable. PCS RR = PCS Reactive Relational Aggression. PCS RP = PCS Reactive Physical Aggression. PCS PR = PCS Proactive Relational Aggression. PCS PP = PCS Proactive Physical Aggression. CBCL AB = CBCL Aggressive Behavior. CBCL RBB = CBCL Rule-Breaking Behavior. CI = confidence interval.

Table 1.6

Completely Standardized Indirect Effects for Each Conduct Problem Model

	CP Outcome Variable					
	PCS RR	PCS RP	PCS PR	PCS PP	CBCL AB	CBCL RBB
CADS NE to FEL to HAB to CP						
ab_{cs}	-0.01	-0.002	0.000	-0.005	-0.01	-0.003
SE	0.026	0.013	0.013	0.017	0.022	0.015
[95% CI]	[-0.08, 0.03]	[-0.04, 0.02]	[-0.04, 0.02]	[-0.05, 0.02]	[-0.06, 0.02]	[-0.04, 0.02]
CADS NE to FEL to CP						
ab_{cs}	-0.013	-0.029	-0.032	-0.012	-0.009	-0.029
SE	0.043	0.053	0.060	0.039	0.027	0.048
[95% CI]	[-0.07, 0.11]	[-0.13, 0.09]	[-0.12, 0.13]	[-0.08, 0.08]	[-0.07, 0.05]	[-0.10, 0.10]
CADS NE to HAB to CP						
ab_{cs}	-0.052	-0.011	-0.002	-0.022	-0.045	-0.012
SE	0.044	0.032	0.031	0.039	0.043	0.036
[95% CI]	[-0.15, 0.02]	[-0.09, 0.05]	[-0.09, 0.04]	[-0.13, 0.03]	[-0.15, 0.02]	[-0.12, 0.02]
FEL to HAB to CP						
ab_{cs}	$0.114^{\dagger}$	0.024	0.005	0.047	$0.099^{\dagger}$	0.027
SE	0.058	0.055	0.056	0.061	0.053	0.027
[95% CI]	[0.02, 0.25]	[-0.09, 0.13]	[-0.11, 0.12]	[-0.06, 0.19]	[0.00, 0.22]	[-0.08, 0.16]

† $p < .10$

Note. CADS NE = CADS Negative Emotionality. FEL = face emotion labeling score. HAB = hostile attribution bias score. CP = score for conduct problems variable. PCS RR = PCS Reactive Relational Aggression. PCS RP = PCS Reactive Physical Aggression. PCS PR = PCS Proactive Relational Aggression. PCS PP = PCS Proactive Physical Aggression. CBCL AB = CBCL Aggressive Behavior. CBCL RBB = CBCL Rule-Breaking Behavior. CI = confidence interval.

Figure 1.1

Proposed Sequential Associations Between Negative Emotionality, Inaccurate FEL, HAB, and Aggression

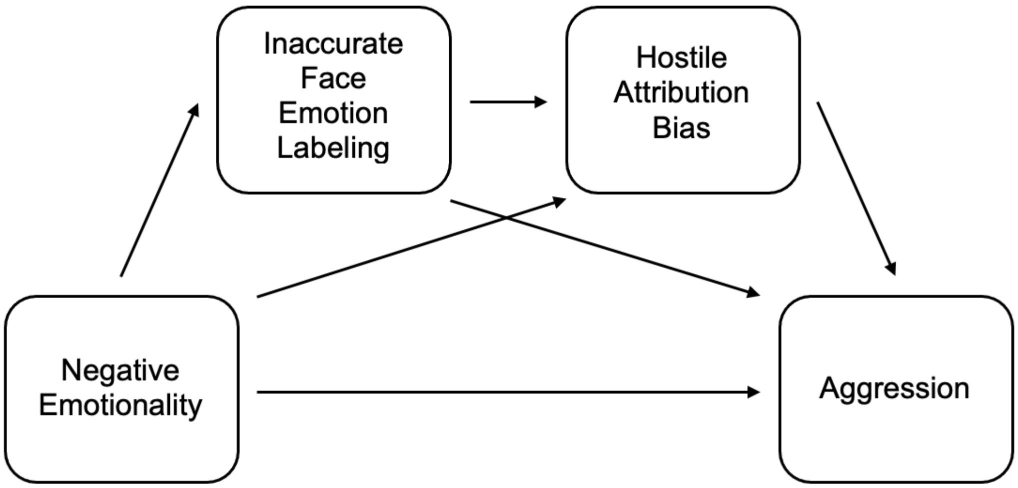
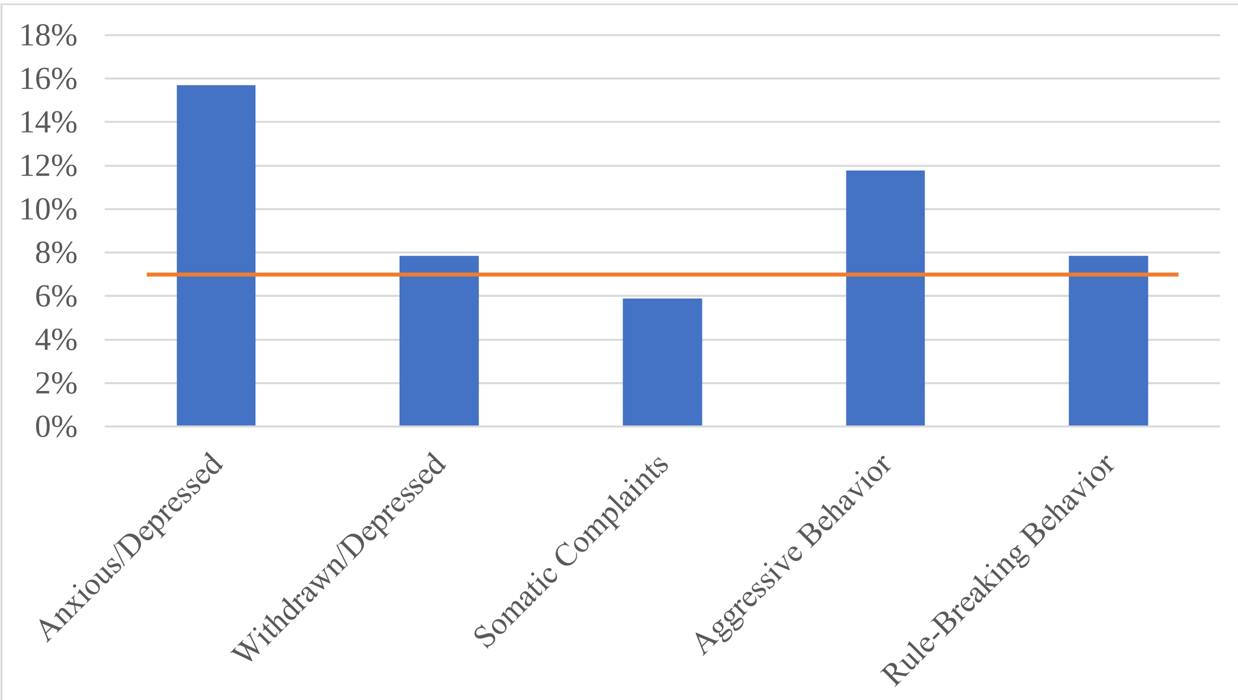


Figure 1.2

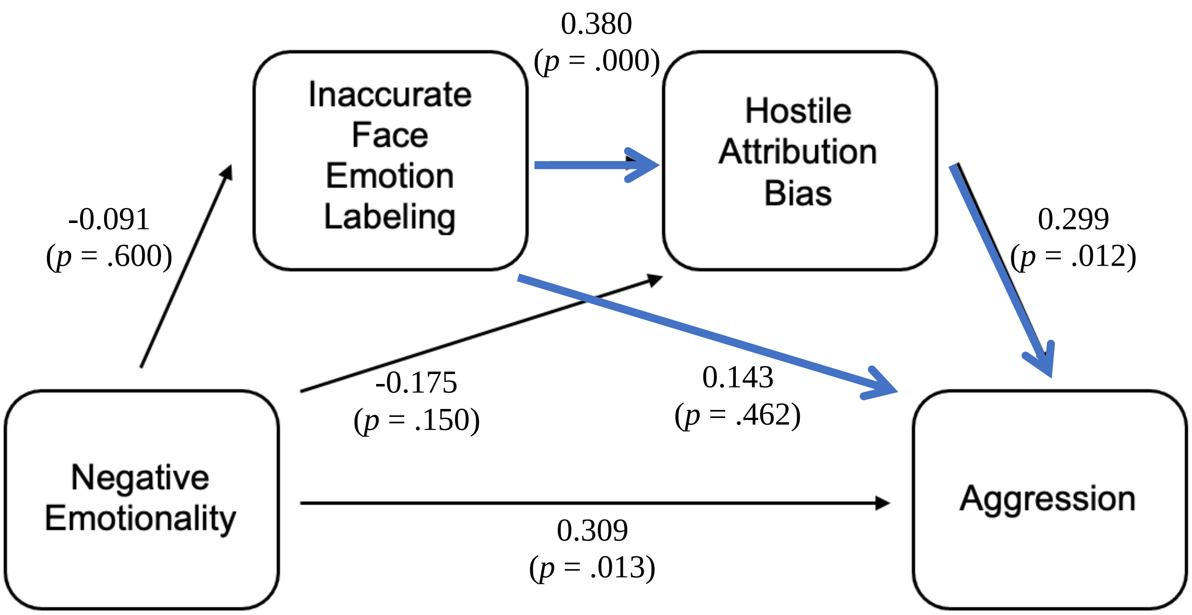
Percentage of Participants With Borderline Clinical or Clinical Elevations on CBCL Narrowband Scales



Note: Horizontal line represents proportion of sample expected to have borderline clinical or clinical elevations on CBCL Narrowband Scales.

Figure 1.3

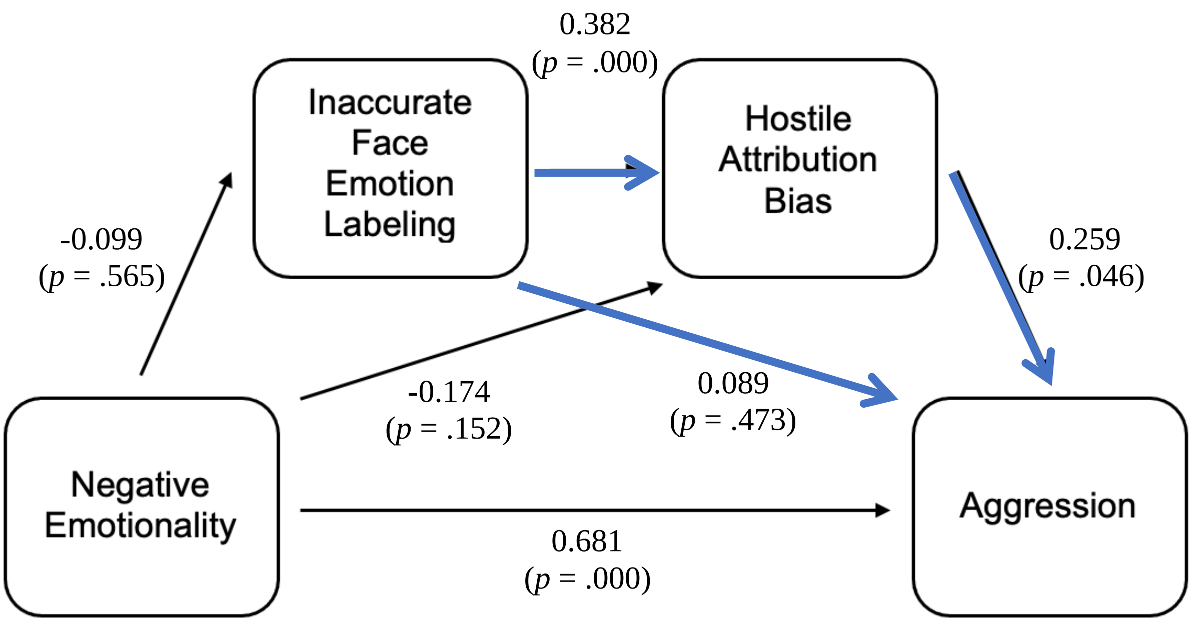
Path Model Depicting Indirect Effect of FEL on PCS Reactive Relational Aggression Through HAB



Indirect effect: ab_{cs} = 0.114, p = .05, 95% CI [0.02, 0.25]

Figure 1.4

Path Model Depicting Indirect Effect of FEL on CBCL Aggressive Behavior Through HAB



Indirect effect: ab_{cs} = 0.099, p = .06, 95% CI [0.00, 0.22]

Study II: Association of Respiratory Sinus Arrhythmia With Aggressive Behavior in Girls

Amidst distressing evidence on the increasing burden of psychopathology nationally and globally (Twenge et al., 2019; Whiteford et al., 2013), innovative approaches are necessary to improve traction on these considerable problems, including identifying potential intervention targets. Whereas the taxonomy of psychopathology has traditionally been organized around discrete, categorical diagnoses ascertained through observed symptoms, the National Institute of Mental Health Research Domain Criteria (RDoC) prioritizes dimensional approaches across multiple units and levels of analysis (Insel, 2014; Kozak & Cuthbert, 2016). In particular, biomarkers (e.g., genetics, neural circuitry, physiological signals), conceptualized as connections between psychological and biological phenomena, are well-positioned to detect specific pathogenic processes relative to imprecise observed symptoms (G. A. Miller et al., 2016). To identify novel intervention targets informed by transdiagnostic constructs and their underlying mechanisms, RDoC holds great promise for innovations in prevention and treatment of psychopathology.

Within RDoC's negative valence systems domain, "acute threat" usefully frames threat processing for youth aggression. The acute threat system includes physiological and behavioral responses to protect against perceived danger; while some contingent responses to threat are adaptive, hypersensitivity to threat may precipitate aberrations including increased arousal and inappropriate behavioral responses (e.g., reactive aggression, retreat). In addition to companion psychobiological factors (e.g., pathways between the medial prefrontal cortex and amygdala, cortisol reactivity), the autonomic nervous system significantly mediates detection of and response to threat (Bosch et al., 2009; Öhman, 2005). Autonomic biomarkers (e.g., heart rate variability, skin conductance) both at rest (i.e., baseline) and in response to emotion evocation are diversely associated with both internalizing and conduct problems (Beauchaine & Thayer, 2015; Lorber, 2004; McTeague & Lang, 2012). Under conditions of perceived threat, the sympathetic nervous system provides excitatory signals whereas the parasympathetic nervous system withdraws inhibitory signals. Together, these signals support diverse responses to threat (i.e., fight-or-flight response) by increasing blood flow and oxygen to the muscles, decreasing blood supply to the extremities, and improving efficiency of respiration. When the threat is removed, these processes are reversed to initiate restorative processes (e.g., decreasing heart rate, stimulating digestion) and promote physiological homeostasis (Hamill & Shapiro, 2011). While the sympathetic and parasympathetic nervous systems often operate antagonistically, processes may become uncoupled or even co-active/co-inhibitory due to environmental demands, emotional states, or aberrant physiological responding to stress (Zisner & Beauchaine, 2016). Such aberrations are believed to be crucial for understanding risk processes that connect individual differences in psychophysiology to psychopathology (Beauchaine, 2001; Beauchaine et al., 2007; Thayer & Lane, 2000).

Individual differences in respiratory sinus arrhythmia (RSA) are transdiagnostically and diversely associated with psychopathology (Beauchaine, 2015b; Beauchaine et al., 2019). RSA reflects cardiac vagal tone, which refers to parasympathetic nervous system influences controlled by efferent connections from the brainstem to the heart (Beauchaine, 2001; Porges, 1995). RSA measures the changes in heart rate variability that are specifically associated with respiration (i.e., parasympathetic mechanisms slowing heart rate during exhalation and increasing heart rate during inhalation; Zisner & Beauchaine, 2016). Individual differences in baseline RSA and RSA withdrawal (i.e., reductions in RSA, also referred to as RSA reactivity) are diversely associated with psychological functioning (e.g., emotional processing, attention; Beauchaine et al., 2007;

Porges, 1986, 2009). Illustrating its transdiagnostic utility, low baseline RSA and/or excessive RSA withdrawal during emotion evocation have been observed among individuals with internalizing and externalizing problems, including anxiety/phobia, callousness, conduct disorder, depression, non-suicidal self-injury, panic disorder, and trait hostility (Beauchaine, 2015b). RSA is viewed as a marker of self-regulatory processes (e.g., emotion regulation, regulation of physiological arousal), which are disrupted in most emotional and behavioral problems (Beauchaine, 2015b; Graziano et al., 2007; Koenig et al., 2016; Thayer et al., 2012). Excessive RSA withdrawal was associated with dysregulation in response to threat, particularly in individuals prone to aggression, anger, or anxiety (Beauchaine et al., 2019; Chalmers et al., 2014; Porges, 2007). Given that components of autonomic reactivity change throughout the lifespan and are sensitive to sex differences, clinical correlates and mechanisms of risk may show similar divergent associations across development and biological sex (Beauchaine et al., 2008; El-Sheikh et al., 2010; Zisner & Beauchaine, 2016).

With respect to aggression and conduct problems in boys, across childhood and adolescence, RSA withdrawal is most consistently positively associated with youth conduct problems (Beauchaine et al., 2019; Fanti et al., 2019). In boys, baseline RSA is inversely associated with aggression (particularly reactive aggression), but RSA in girls has received less attention, and studies that do consider girls often ignore key distinctions between types of aggression (e.g., reactive, relational), leading to inconsistent findings (El-Sheikh & Hinnant, 2011; Hinnant & El-Sheikh, 2013; Lorber, 2004; Thomson & Centifanti, 2018). Additionally, studies of psychophysiology must attend to specific developmental periods, particularly given dynamic changes (e.g., brain maturation, hormonal changes) secondary to pubertal onset; key socio-biological correlates differ between boys and girls and, including sex differences in autonomic functioning (Kajantie & Phillips, 2006). For example, sex differences in gonadal hormones, which emerge with puberty, affect psychophysiological reactivity to threat or stress (Ordaz & Luna, 2012). Empirical reviews suggest that thorough examination of sex-specific processes and sex differences in psychophysiology during specific developmental periods (e.g., childhood) may clarify the interplay between autonomic functioning and other aspects of development (e.g., social development; Murray-Close, 2013).

Given transactional influences between physiological reactivity and psychological functioning, individual differences in regulation of physiological arousal are central to cognition, emotion, and social behavior. Poor physiological regulation may adversely affect cognitive processes central to decision-making and behavioral responses ranging from risk-taking behavior (Ditto et al., 2006; Porcelli & Delgado, 2009) to reward valuation (Sohn et al., 2015). Interpretive social information processing (e.g., assigning attributions of intent) may similarly covary with poor regulation of arousal states to predict reactive aggression (Anderson et al., 1995). Following an ambiguously threatening social provocation, induction of extreme arousal increased participants' retaliatory behaviors, even after alternative interpretations of the provocation were evaluated (Zillmann et al., 1975). Next, psychophysiological reactivity was positively correlated with hostile attributions, and both reactivity and hostile attributions were associated with increased aggression, suggesting that arousal and social information processes are plausibly associated with aggression in boys (Craven Williams et al., 2003). Given that excessive RSA withdrawal may reflect disrupted regulation when perceiving and responding to threat, particularly among individuals prone to aggression (Beauchaine et al., 2019), examining the association of excessive RSA withdrawal with attributional biases may be particularly informative. Indeed, among adult women, the combination of elevated RSA withdrawal and hostile attribution bias (HAB) predicted relational aggression (Murray-Close, 2011). Given that children and adolescents regulate affect less effectively than adults, and regulation of physiological reactivity in particular develops over time, social cognition in youth may be particularly sensitive to physiological processes (John & Gross, 2004; Pang & Beauchaine, 2013; Steinberg, 2007).

Despite its plausibility, little is known about “in vivo” psychophysiological reactivity in regard to girls’ conduct problems, particularly while interpreting social information. Whereas individual differences in psychophysiology during encoding processes, including electrodermal activity or heart rate reactivity while viewing or listening to social cues, are correlated with youth aggression (Blair, 1999; de Wied et al., 2009), few studies have considered the covariation of physiological arousal with interpretive aspects of social information processing in children; previous studies employed adolescents (Crozier et al., 2008) or additional mood induction components (Hubbard et al., 2016). This is problematic given that psychophysiological responses may be particularly important for interpretation (e.g., HAB), including how meaning is ascribed to ambiguous social stimuli and subsequent associations with social decision making.

Biomarkers designating disrupted regulation of physiological arousal plausibly connote vulnerability to aggression, particularly reactive aggression, after viewing and interpreting ambiguously threatening social stimuli. Specifically, excessive RSA withdrawal, which may be accentuated by low baseline RSA, may influence perceptions of threat during social interaction and thus potentiate aggressive responding (see Figure 2.1). Given that interpretation is central to the assessment of threat and danger, and that autonomic responses and cognition often operate bidirectionally (Porges, 2007), autonomic states may affect cognitive appraisal to signal threat and to potentiate aggressive behavior. Investigating individual differences in RSA, including initial values and reactivity while interpreting ambiguous social interactions, are positioned to inform etiological models of aggression in girls and accelerate innovations in intervention, which is particularly urgent given evidence of the increasing prevalence/burden of aggression in girls.

Aims & Hypotheses: Study II

Given that baseline RSA is inversely associated with aggression and conduct problems in boys and RSA withdrawal is positively associated with aggression in boys, RSA is a plausible biomarker of aggression in girls. To investigate the psychophysiological correlates of aggression in girls specifically, we tested (1) the association of individual differences in RSA assessed while interpreting ambiguous social interactions with reactive relational aggression and reactive physical aggression; and (2) differential associations between RSA and proactive relational aggression, proactive physical aggression, general aggressive behavior, and rule-breaking behavior. Specifically, we hypothesized that (1a) RSA withdrawal while interpreting ambiguous social interactions would be positively associated with both reactive relational aggression and reactive physical aggression; (1b) initial RSA values would be inversely associated with both reactive relational aggression and reactive physical aggression; and (2a) associations with RSA withdrawal and initial RSA values would be attenuated (i.e., reduced effect size, non-significant effects) for proactive relational aggression, proactive physical aggression, general aggressive behavior, and rule-breaking behavior relative to reactive relational aggression and reactive physical aggression.

Methods

Participants

Please see the Methods section in Study I and Table 2.1 for details about the DREAMING Study sample (pp. 22).

Procedures

Please see Methods Study I section for details (pp. 23).

Measures

Respiratory Sinus Arrhythmia

The signals required to monitor RSA were recorded during the HAB video task to estimate autonomic nervous system reactivity while interpreting ambiguous social interactions (please see Methods Study I for details about the task, pp. 24-25). A Biopac MP160 system (Biopac Systems, Goleta, CA) with accompanying AcqKnowledge 5.0.2 (Biopac) software continuously monitored signals for heart rate and respiration rate, both of which are necessary to calculate RSA. Heart rate was measured via a Wireless BioNomadix RSPEC-R electrocardiogram amplifier using a three-lead configuration, with Ag/AgCl electrodes placed on the right and left clavicles and on the left rib cage. Respiration rate was recorded using a RSP100C respiration amplifier and a respiration belt transducer that was secured around the participant's waist. Reactivity measurements were recorded throughout the HAB task, during which the participant watched the videos while sitting at a computer with an examiner and briefly answered questions about each one.

An additional measurement of RSA was collected outside of the HAB video task to approximate baseline RSA. During this 3.5-minute period, participants passively viewed the faces of two women with neutral facial expressions. Each woman's face was visible on the screen for four 5-second intervals, between which the screen was blank. It is important to note that this phase cannot be considered a true baseline period, as neutral facial expressions may evoke emotion. In the absence of a true baseline period in which no stimuli are shown, RSA values collected during this period were examined for secondary analyses, with the values collected during the HAB task being used for the primary analyses.

Youth Aggression and Conduct Problems

The parent-report Peer Conflict Scale (PCS; Marsee & Frick, 2007) was again used to assess children's Reactive Relational Aggression, Reactive Physical Aggression, Proactive Relational Aggression, and Proactive Physical Aggression (please see Methods Study I for details about the measure, pp. 25-26). Subscales were calculated using sum scores of individual items.

The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) was again used to assess Aggressive Behavior and Rule-Breaking Behavior (please see Methods Study I for details about the measure, pp. 26). Raw scores were used in all analyses.

Data Analytic Plan

Psychophysiological Data Procedures

RSA was calculated using spectral analysis, which decomposes the heart rate time series into component frequencies using fast-Fourier transformations or autoregressive techniques. With this method, specific frequency bands, such as high frequencies of HRV that estimate RSA (e.g., above 0.15 Hz in human adults), are extracted from the spectral density function (Beauchaine, 2001; Zisner & Beauchaine, 2016). All preprocessing and data analysis steps were completed using the AcqKnowledge 5.0.2 software, including the program's HRV spectral function.

Quality checking and cleaning procedures were applied to the heart rate signals prior to data analysis. Specifically, a band pass filter between 1-35 Hz was first applied to reduce drift and high-frequency noise in the ECG signal. Artifacts were then identified using visual inspection of the ECG signal and of the interpolated tachogram, which is generated by the AcqKnowledge program's HRV spectral function to locate R-R intervals. Once artifacts were identified, they were eliminated by smoothing noise between QRS peaks and amplifying peaks (i.e., adding a constant to improve detection of individual peaks by the HRV spectral function). Specific focus areas were defined within the task to mark six observation periods, each of which began at the time of video onset and ended 20 seconds following video end to capture any RSA withdrawal that could be attributed to the video stimulus.

To calculate RSA, the high-frequency component of HRV during each of these six observations was then extracted using the spectral analysis function within AcqKnowledge's HRV/RSA tool. Given that respiration rate decreases throughout childhood, frequency band parameters were adjusted for each participant based on the average respiration rate of children their age (Shader et al., 2018). Following calculation of RSA values, each participant had six RSA data points to be used to assess initial status and withdrawal throughout the task.

Multilevel Models

A multilevel model was employed to test the association of RSA withdrawal recorded during the child's viewing and interpreting of ambiguous social interactions with youth aggression. Multilevel modeling is a regression-based technique for nested data that uses separate regression equations for each level of nesting, enabling estimation of both within- and between-participant effects. When applied to psychophysiological data, multilevel modeling can model repeated measures as individual time points within each individual's testing session (Zisner & Beauchaine, 2016). A two-level model was used to evaluate initial RSA and withdrawal throughout the HAB task while testing whether individual differences in aggression account for variability in psychophysiological responses. At level 1, repeated observations were modeled for each participant with an intercept and a slope for each individual. The intercept represented the participant's initial RSA, and the slope quantified withdrawal during the task. At level 2, the effects of aggression were modeled to test for significant differences in initial RSA and RSA withdrawal depending on level of aggression.

Analyses for Aim 1 considered the relationship between RSA and PCS Reactive Relational Aggression and PCS Reactive Physical Aggression specifically. To compare these effects with those for PCS Proactive Relational Aggression, Proactive Physical Aggression, CBCL Aggressive Behavior, and CBCL Rule-Breaking Behavior for Aim 2, parallel multilevel models testing the effects of each of these variables were employed. If multiple models yielded significant effects, Cohen's f^2 would be used to compare effect sizes (Selya et al., 2012).

Statistical Power

To account for the repeated measures nature of the psychophysiological data when conducting the power analysis, the $n_{effective}$ approach was used prior to analyses and was revisited after completion of analyses to determine the corresponding single-level sample size for a multilevel design. First, the design effect was computed using the following formula: [design effect = 1+(n observations per subject-1) ρ], where ρ is the estimated intraclass correlation coefficient (ICC). Past research with similarly aged children provides an estimate of .45 for the ICC (Gatzke-Kopp & Ram, 2018), leading to a design effect of 3.25. G*Power 3.1 was used to calculate the necessary sample size for the proposed analyses, but with a single level instead of repeated measures. To detect a moderate effect ($f^2 = 0.15$) at the α=.05 level, a multiple regression model with two predictors requires a sample size of 68 to reach sufficient power (.80). The $n_{effective}$ was calculated using the following formula: [$n_{effective}$ = total sample size / design effect], which estimates a required sample size of at least 21 subjects for the proposed multilevel model. The actual sample size of 52 is sufficient for the proposed analyses.

Statistical power calculations were revisited after completion of analyses. Given that the actual ICC based on these data was .71, the required sample size would be smaller than initially estimated based on the ICC estimate from previous research with other samples. With the larger ICC, the $n_{effective}$ estimates a required sample size of at least 15 subjects for the proposed multilevel model.

Results

Descriptive Analyses

Table 2.1 summarizes descriptive statistics for study variables, including mean and standard deviation values for RSA. To inform specification of the level 2 submodel, exploratory OLS-fitted linear change trajectories for all participants were visually examined prior to fitting multilevel models. Examination of the trajectories depending on participants' levels of aggression enabled assessment of the utility of the selected conduct problem variables as possible predictors of variability in RSA initial values and RSA withdrawal. Figure 2.2 depicts participants' observed RSA trajectories separated by high versus low levels of aggression. Participants were separated into high and low groups using a mean split procedure for each specific conduct problem variable.

Model Building Procedure

All analyses were conducted using the SAS PROC MIXED procedure in SAS version 9.4. Restricted maximum likelihood (REML) estimation was used to fit all multilevel models (Goldstein, 1986). The Satterthwaite approximation for estimating degrees of freedom was used in all models (Gaylor & Hopper, 1969). Given the lack of theoretical rationale to constrain variances or covariances, all models specified unstructured covariance matrices. To aide in interpretation of changes in RSA across timepoints within the task, the timepoint variable used in all models was centered around zero. To assume linearity between the level 2 predictors and the outcome with the centered timepoint variable, all continuous level 2 predictor variables (i.e., conduct problem variables, covariates) and the outcome variable (i.e., RSA) were transformed by computing the square root of the original variable.

Fitting Unconditional Multilevel Models

Prior to fitting models with predictors of interest and with tests of fixed versus random effects, two unconditional models were fit to assess the amount of outcome variation across participants and time (Singer & Willett, 2003). The unconditional means model (i.e., the intercept-only model) partitioned and quantified outcome variation across people without regard to time, whereas the unconditional growth model considered differences across people *and* time. The results of fitting the unconditional models are presented in Table 2.2. In the unconditional means model, estimates of both covariance parameters were significant, suggesting that the average participant's RSA changed throughout the task, and that participants differed from one another in their RSA values ($\sigma^2 = 0.01$, $p < .001$; $T_{00} = 0.03$, $p < .001$). The unconditional means model also enabled computation of the ICC (ρ) which quantifies the proportion of the total outcome variation that is attributable to between-person differences and is also used in statistical power calculations. Based on this model's covariance parameters, the ICC for these data is .71.

In the unconditional growth model, two significant covariance parameters suggest non-zero variability in RSA initial values ($T_{00} = 0.03$, $p < .001$) and that there is within-person variation in RSA at level 1 ($\sigma^2 = 0.01$, $p < .001$). One non-significant covariance parameter (T_{11}

= 0.00, p = .27) reflected non-significant variability in RSA at level 2, suggesting that level 2 predictors may have a limited role in accounting for variance within the model.

Fitting Multilevel Models With Predictors

A separate model was fitted to test each conduct problem variable as a level 2 predictor of RSA initial values and/or RSA withdrawal throughout the task. Models for Aim 1 assessed the effects of PCS Reactive Relational Aggression and PCS Reactive Physical Aggression; models for Aim 2 assessed the other conduct problem variables, PCS Proactive Relational Aggression, Proactive Physical Aggression, CBCL Aggressive Behavior, and CBCL Rule-Breaking Behavior. The following structures were tested for each model: fixed versus random slope and/or intercept, and whether the conduct problem variable affected the growth parameters for slope and/or intercept.

Because psychophysiological responding, including HRV, respiration rate, and RSA, changes throughout development (Alkon et al., 2003; Beauchaine et al., 2008; Zisner & Beauchaine, 2016), participant age was included as a level 2 covariate in all models. Participant age and mean RSA value were also moderately inter-correlated (r = .30, p = .05), suggesting that age may be associated with RSA values and supporting the inclusion of age in the models. Age was not significantly correlated with any conduct problem variables.

To determine the best fitting random specification of the model for each conduct problem variable, models with fixed and random intercepts and slopes were fit and then compared to one another. Criteria for evaluating model fit were the AIC values for each model and the results of the deviance change tests when comparing two models. Across all conduct problem variables, the random intercept model fit best based on these two criteria. Since the level 2 conduct problem variable could affect either or both level 1 growth parameters (i.e., intercept and/or slope), the random intercept models with each of these three possible structures were fit, then compared using the same two model fit criteria. With one exception, the model structure that included the effect of the conduct problem variable on the intercept (but not the slope) fit best and was selected as the final model for each variable. The model testing the relationship between RSA and PCS Reactive Relational Aggression fit best when effect of the conduct problem variable on the slope was included, but the effect on the intercept was not. Table 2.3 displays the descriptions and equations for the model structures tested.

Results of Final Models

Table 2.4 presents the results of fitting the model testing each conduct problem variable. Examination of the fixed effects for RSA initial value, b_{0i}, revealed that all models had significant effects for g_{00} ($p < .001$), which estimates the grand mean of RSA values across all time points and individuals. The significant effect in each model indicates that average RSA of the average participant is non-zero. Examination of g_{01}, the fixed effect for the influence of the conduct problem variable on RSA initial value, revealed that this effect was non-significant for four of the five models that included this effect in its structure. This effect was significant ($p < .05$) in the model assessing the relationship between CBCL Rule-Breaking Behavior and RSA initial value, suggesting that CBCL Rule-Breaking scores were negatively associated with RSA initial value. Specifically, for every one unit increase in a participant's score, their RSA initial value decreased by 0.259 (the square root of 0.067). This model is depicted in Figure 2.3. The fixed effect for the influence of participant age on RSA initial value, g_{02}, was significant in three of the six models, suggesting that age was a significant predictor when the effects of PCS Reactive Relational Aggression, CBCL Aggressive Behavior, and CBCL Rule-Breaking Behavior on RSA initial value were tested.

Examination of the fixed effects for RSA rate of change (i.e., withdrawal), b_{1i}, revealed that all models had non-significant effects for g_{10}, the estimated rate of change in RSA throughout the task. Only one model estimated g_{11}, the fixed effect for the influence of the conduct problem variable on RSA rate of change. In this model, the fixed effect was significant ($p < .05$), indicating that, for every one unit increase in a participant's PCS Reactive Relational Aggression score, RSA rate of change decreased by 0.089 (the square root of 0.008). This multilevel model is depicted in Figure 2.4.

The statistically significant variance components also inform interpretation of the models. The within-person variance component, σ^2, is significant in all six models ($p < .001$), indicating that, as suggested by the unconditional growth model, within-person variation in RSA at level 1 remains. However, because no additional measurements beyond RSA were taken at different time points within the HAB task, there are no possible level 1 covariates to test in these models. Additionally, the initial status variance component, T_{00}, is also significant ($p < .001$), suggesting that potential explainable variation in initial status remains in the models.

Due to the total outcome variation being partitioned into multiple variance components, traditional R^2 values are not calculated for multilevel models (Kreft & de Leeuw, 1998; Snijders & Bosker, 1994). Alternative methods to estimate the proportion of outcome variation explained, or "pseudo" R^2 statistics, have been proposed. One strategy involves calculating the proportional reduction in level 2 residual variance following the addition of level 2 predictors. Each level 2 variance component has a pseudo R^2 statistic, which were compared to the variance components from the unconditional growth model. Pseudo R^2 statistics for each of the models are also included in Table 2.4.

Of note, a Bonferroni correction may be applied to account for the multiple models considered across different conduct problem variables. Given that six models were interpreted, the corrected alpha value would be .008. Based on this value, some of the previously described effects would not survive correction. All models and effects that were significant at the .05 level are still presented given that these six models were planned to be considered within two overarching aims/hypotheses assessing the differing effects of aggressive behavior dimensions on RSA (Ludbrook, 1998).

Secondary Analyses – Approximating Baseline RSA

In the absence of a true baseline period to collect resting RSA, signals collected during a 3.5-minute period outside of the HAB task were used as an approximate measure of baseline RSA. Participants' RSA values during this period were not significantly correlated with any of the conduct problem variables tested in the multilevel models. Pearson's *r* values depicting these non-significant associations are presented in Table 2.5.

Discussion

Study II examined the association of parasympathetic nervous system functioning, specifically individual differences in RSA, with aggression and conduct problems during social information processing in girls. The study goals were to assess individual differences in RSA initial values and RSA withdrawal (i.e., reductions in RSA in response to emotional stimuli, also referred to as RSA reactivity) while interpreting ambiguous social interactions and to compare associations with different dimensions of aggression and conduct problems. These goals were evaluated in a sample of 52 ethnically diverse, pre-adolescent girls (age 6 to 11 years) recruited for high trait negative emotionality, a group representing an understudied population in the aggressive behavior literature, particularly studies that investigate psychophysiological correlates of these behaviors (Lorber, 2004; Murray-Close, 2013). Given that RSA is associated with aberrant emotional reactivity and regulation (Beauchaine, 2015b; Butler et al., 2006; Frazier et al., 2004), both of which are implicated in reactive aggression and anger (Bookhout et al., 2017; Dane & Marini, 2014), the first Aim of Study II was to test associations between individual differences in RSA with reactive relational aggression and reactive physical aggression. Aligned with Hypothesis 1a, excessive RSA withdrawal throughout the task was associated with higher levels of reactive relational aggression. RSA withdrawal was not associated with reactive physical aggression. Contrary to Hypothesis 1b, neither reactive relational aggression nor reactive physical aggression were associated with RSA initial values.

The second Aim of Study II was to test differential associations between RSA with other dimensions of conduct problems, specifically proactive relational aggression, proactive physical aggression, general aggressive behavior, and rule-breaking behavior. Although we hypothesized that associations with these constructs would be weaker (i.e., reduced effect size, non-significant effects) relative to reactive relational aggression and reactive physical aggression, rule-breaking behavior was inversely associated with RSA initial values. Individual differences in RSA withdrawal and initial values were not associated with any other conduct problems tested.

Results implicate excessive RSA withdrawal in the propensity toward reactive relational aggression, which is aligned with previous findings for reactive aggression, most of which are from male or adult samples (Fanti et al., 2019). According to polyvagal theory (Porges, 1995, 2007), RSA withdrawal is a marker of decreasing vagal tone relative to baseline, thus increasing heart rate and activating the sympathetic nervous system. While moderate RSA withdrawal is an adaptive response in the face of challenge, excessive RSA withdrawal contributes to aberrant autonomic reactivity in situations involving possible threat. Excessive RSA withdrawal is broadly associated with deficits in emotion regulation (Beauchaine, 2015b), plausibly linking aggressive behavior of a reactive nature to heightened RSA withdrawal via deficits in regulating emotions such as anger and frustration (Beauchaine, 2015a). Conversely, high RSA is a marker of resilience and positive adjustment following adversity (McLaughlin et al., 2014), such as witnessing conflict/hostility between parents or experiencing parental depression (El-Sheikh et al., 2001; Shannon et al., 2007). Similar associations were found with adaptive social characteristics, including social competence, social engagement, and displays of empathy toward others (Eisenberg et al., 1995; Fabes et al., 1993; N. A. Fox & Field, 1989). Impairment in these domains may increase the likelihood of threatening interpretations of ambiguous or nuanced social situations, thus increasing propensity toward anger and subsequent reactive aggression, while also increasing risk for aggressive behaviors of a relational nature (i.e., behaviors that harm others' relationships or social standing). Through its negative influences on both emotion regulation and social functioning, girls' excessive RSA withdrawal during social situations exacerbates risk for hostile behaviors in response to perceived threats in one's environment, particularly behaviors with the intention of harming others' social success.

Despite evidence that RSA is associated with physical aggression in boys (Gatzke-Kopp et al., 2015), neither initial RSA values nor excessive RSA withdrawal were associated with reactive physical aggression. Two features of the sample may help contextualize this pattern: the inclusion of only pre-adolescent girls and the sample being a community sample enriched for negative emotionality. Relational aggression is consistently more common and normative among girls than physical aggression (Card et al., 2008; Lansford et al., 2012). Additionally, Sijtsema and colleagues (2011) found a complex association between RSA withdrawal and physical aggression in girls: excessive withdrawal was associated with girls' physical aggression, but only when girls were rejected by peers and were also highly sensitive to rejection. Interestingly, RSA augmentation (i.e., increasing RSA as opposed to RSA withdrawal) was marginally associated with physical aggression when girls were rejected by peers (but did not rate high on rejection sensitivity). These findings highlight the interactive roles of environment (e.g., experiences of rejection) and temperament (e.g., sensitivity to rejection) on RSA-behavior relationships in girls. Future studies should prioritize testing of moderators RSA in girls' aggressive behavior, such as temperamental differences in negative emotionality, social cognitive factors, and stressful life experiences.

Given inconsistent results depending on clinical versus community samples of youth, the current sample being enriched for negative emotionality and community-based may have delimited findings. For example, whereas studies of clinical samples typically suggest that excessive RSA withdrawal is associated with conduct problems, community samples have produced more inconsistent patterns, including inverse or null associations between RSA withdrawal and conduct problems (e.g., lower levels of withdrawal or even augmentation predicting these behaviors; El-Sheikh et al., 2009; Fortunato et al., 2013). The underlying mechanisms of RSA-behavior associations may be sensitive to elevations in key constructs and behaviors, thus complicating discernment of precise patterns of association across diverse samples (e.g., clinic-referred, treatment seeking, community-based). Use of diverse sample types spanning clinical, community, and at-risk populations in future studies may be necessary to clarify the precise mechanisms at play depending on the severity of behavioral problems.

Although not included in our hypotheses, the significant inverse association between rule-breaking behavior and RSA initial values can be interpreted in the context of previous work examining individual differences in baseline/resting RSA and conduct problems. Previous studies with boys/men suggest that low baseline RSA is associated with rule-breaking behavior (e.g., stealing, destroying property, lying, swearing; sometimes in combination other externalizing problems; (Beauchaine et al., 2007; de Wied et al., 2012; El-Sheikh & Hinnant, 2011; Thomson & Centifanti, 2018), which is etiologically distinct and separable from reactive aggression. For example, relative to reactive aggression, rule-breaking/delinquent behavior is generally more deliberate, covert, and calculated, as it is propelled by instrumental motivations (e.g., seeking power or control) or responses to distal threats (Olson et al., 2013). Symptoms of conduct disorder, which is marked by a persistent pattern of violating societal norms, rules, or the rights of others, overlap significantly with rule-breaking behavior, yet other features of conduct disorder aligning more with proactive, instrumental aggression (Tackett et al., 2005), further attesting to the heterogeneity of conduct problems.

Unlike aggressive behavior, rule-breaking behavior is associated with heightened impulsivity and sensation-seeking behavior rather than increased anger and poor self-regulation (Burt, 2012; Jensen et al., 2011; Kornienko et al., 2019). In boys, sensation-seeking and rule-breaking behaviors were both predicted by low resting heart rate, suggesting that psychophysiological responding may play an important role in this relationship (Sijtsema et al., 2010), with sensation-seeking potentially acting as a mediator between psychophysiology and behavior (Portnoy et al., 2014). A trait-like propensity toward boredom was also associated with both sensation-seeking/impulsivity and rule-breaking behaviors, highlighting the possible role of individual differences in temperament and biology for these particular conduct problem behaviors (Boylan et al., 2021; Watt & Vodanovich, 1992). Unique mechanisms may plausibly underlie RSA-behavior relationships for aggressive versus rule-breaking behavior: whereas reactive aggression is a response to perceived provocation in one’s environment and aberrant parasympathetic responding, rule-breaking behavior may result from under-arousal and attempts to raise autonomic arousal to a comfortable level via thrill-seeking behavior (Fagan et al., 2017; Scarpa & Raine, 2004). Speaking to the importance of assessing separable dimensions of aggression and conduct problems, lower initial or resting state RSA may be part of a risk process specific to rule-breaking and delinquent behaviors for pre-adolescent girls.

Rule-breaking behavior during childhood may also be considered a marker of severity of conduct problems. Theories of antisocial behavior postulate two trajectories of youth behavioral problems - individuals who fall into a life-course-persistent category marked by antisocial behaviors of varying forms throughout the lifespan, and others who engage in relatively normative antisocial behaviors that are limited to adolescence (Moffitt, 1993). The life-course-persistent trajectory is characterized by childhood-onset antisocial behavior, dispositional traits, neuropsychological deficits (e.g., low verbal IQ), and density of family risk factors (e.g., parent psychopathology) that interact with one's environment to promote these behaviors. In contrast, the adolescent-limited trajectory is influenced by peer affiliations, behaviors, and norms via social imitation and reinforcement of behavior. The latter is viewed more normatively, perhaps reflecting attempts to increase independence from authority figures and gain acceptance and respect from peers (e.g., social mimicry; see Moffitt et al., 2002 for a review). Less common than adolescent onset behaviors, persistent rule-breaking behaviors during childhood, as well as temperamental, physiological, or cognitive correlates of these behaviors, may act as warning signs for more severe conduct problems that may last into adulthood.

Indeed, empirical research suggests that childhood rule-breaking and delinquent behaviors are associated with worse outcomes in adulthood that span both internalizing problems and externalizing problems, even relative to childhood aggressive behaviors (Hofstra et al., 2002;

Reef et al., 2010). In girls, co-occurring delinquency and depression may create a particularly concerning combination of risk factors given evidence that these emotional and behavioral problems continue through adolescence and young adulthood (Keenan et al., 1999). The inverse association between initial RSA with rule-breaking behavior may be less indicative of the unique causes or functions of rule-breaking behavior and more meaningful for understanding neurobiological influences on severe, chronic conduct problems. Rule-breaking behaviors, particularly in girls of this age, are potential precursors or developmental antecedents to subsequent maladjustment; the role of initial or resting-state RSA in predicting elevations in these behaviors may be informative for both identification of at-risk youth and the development of possible mechanism-based interventions.

Given that the sample used in the present study was made up entirely of pre-adolescent girls who were recruited for high trait negative emotionality, results may reflect previous evidence of sex differences in parasympathetic nervous system activity. Women are often found to be more physiologically reactive to social stress than men, particularly during adolescence (Ordaz & Luna, 2012; Stroud et al., 2009). For RSA specifically, women typically have higher resting levels of RSA than men (Chambers & Allen, 2007). Evidence for sex differences in RSA withdrawal is mixed: some studies found greater withdrawal in women (Hughes & Stoney, 2000), others in men (Johnsen et al., 1995; Vial et al., 1992), and others with no differences (Hamilton & Alloy, 2016). Meta-analytic findings suggest that female adults exhibit increased RSA withdrawal relative to male adults (Beauchaine et al., 2019). Studies of male and female children with large enough sample sizes to assess for sex differences are relatively limited, and results are mixed. For example, for resting levels of RSA, one study found no sex differences (Thomson & Centifanti, 2018), whereas another found lower levels for boys than for girls, and that the association between low baseline RSA and conduct problems was significant for boys, but not for girls (Beauchaine et al., 2008). Hinnant and El-Sheikh (2013) found that RSA augmentation (i.e., increasing RSA rather than RSA withdrawal) in boys predicted membership in a high comorbid externalizing-internalizing trajectory, but high RSA withdrawal predicted girls' membership in this trajectory. These mixed findings highlight the multifaceted nature of the association between RSA and conduct problems, particularly when considering sex differences in pre-adolescent children, and the need for future studies assessing psychophysiological responding with careful attention to possible sex differences/similarities during this developmental period.

This study provides important preliminary evidence on the covariation of RSA with individual differences in pre-adolescent girls' behavioral problems, specifically, reactive relational aggression and rule-breaking behavior. Given the dearth of research on aggression and conduct problems in girls, particularly psychophysiological correlates of these behaviors, findings from this study fit in a notable gap evident in the literature. Despite its strengths, the following limitations should be noted. First, psychophysiological monitoring did not include a true baseline or resting state assessment, a specific component of RSA that is implicated in risk for psychopathology in previous studies. Although RSA initial values during the HAB task were collected and tested in the models as proxy measures of baseline RSA, they are not substitutions for resting state assessments, nor are the signals collected during the 3.5-minute period outside of the HAB task that were presented as secondary analyses. True resting state assessments demand a particular design to ensure validity, including 5- to 10-minute periods with minimal cognitive demands, sound, speech, or movement (Zisner & Beauchaine, 2016). Future studies will benefit from precisely designed baseline assessments to thoroughly assess resting state RSA in girls of this age group. Second, as mentioned, separate models tested associations with each dimension of conduct problems, suggesting that a Bonferroni correction could be applied, thus changing the significant/marginal effects found. Third, all measures of conduct problems were based on parent report. Given that behavioral problems often present differently across settings, use of multiple informants, such as teachers and peer nominations, should be included in future studies whenever possible. Lastly, participants between participants may have been present depending on whether families were recruited before or after the COVID-19 pandemic. Although no group differences in study variables were evident, these two groups may have differed in unanticipated ways that could affect the presence or magnitude of effects within the multilevel models.

Evolutionarily, the autonomic nervous system is critical to promoting survival by allocating resources to appropriately respond to threats in the environment, engaging in recovery processes following threat, and cooperating/connecting with others. Parasympathetic influences support recovery process to help restore homeostasis, and appropriate modulation of the parasympathetic nervous system is essential for adaptive responding to environmental threats and stress. Individual differences in vagal tone, reflected by RSA at rest and in response to emotional stimuli, are replicated risk factors for emotion dysregulation and related internalizing and externalizing problems, though relatively little is known about RSA and aggressive behavior in girls specifically. In our sample, excessive RSA withdrawal and low RSA initial values were unique risk factors for specific dimensions of conduct problems, highlighting the value of specificity in measurement when testing psychophysiology-behavior relationships. If replicated, particularly across multiple timepoints to assess causal relationships over time, they could inform targeted strategies to identify girls at risk for specific types of aggression and conduct problems.

Table 2.1

Descriptive Information for Study Variables

	M (SD)	Test for Differences Between Data Collection Periods
PCS Reactive Relational Aggression	1.63 (2.92)	$t(46) = -0.09$ $p = .93$
PCS Reactive Physical Aggression	1.88 (3.86)	$t(46) = 0.54$ $p = .59$
PCS Proactive Relational Aggression	1.23 (2.15)	$t(46) = 0.11$ $p = .91$
PCS Proactive Physical Aggression	0.71 (1.88)	$t(46) = 0.64$ $p = .53$
CBCL Aggressive Behavior	4.76 (5.10)	$t(48) = 0.10$ $p = .92$
CBCL Rule-Breaking Behavior	1.64 (2.12)	$t(48) = 0.67$ $p = .51$
RSA During HAB Task	5.76 (0.87)	$t(42) = -1.17$ $p = .25$
RSA Baseline Approximation During Neutral Faces Task	6.49 (0.97)	N/A

Note: Insufficient RSA values were available for the neutral faces task during the second data collection period, so a *t*-test was not conducted.

Table 2.2

Results of Fitting Unconditional Means and Unconditional Growth Models

		Parameter	Unconditional Means Model	Unconditional Growth Model
Fixed Effects				
Initial Status, b_{0i}	Intercept	g_{00} (SE)	2.391*** (0.027)	2.400*** (0.030)
Rate of Change, b_{1i}	Intercept	g_{10} (SE)	-	-0.003† (0.004)
Variance Components				
Level 1	Within-Person	σ^2 (SE)	0.013*** (0.001)	0.012*** (0.001)
Level 2	In Initial Status	T_{00} (SE)	0.031*** (0.007)	0.034*** (0.009)
	In Rate of Change	T_{11} (SE)	-	0.000 (0.000)
	Covariance	T_{01} (SE)	-	-0.001 (0.001)

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Table 2.3

Model Structures Compared for Each Conduct Problem Model

Model Structure		Equation
Unconditional Models	Means	$Y_{ti} = b_{0i} + e_{ti}$ $b_{0i} = g_{00} + u_{0i}$
	Growth	$Y_{ti} = b_{0i} + b_{1i}*\text{time}_{ij} + e_{ti}$ $b_{0i} = g_{00} + u_{0i}$ $b_{1i} = g_{10} + u_{1i}$
Random/Fixed Effects	Both Random Intercept and Random Slope	$Y_{ti} = b_{0i} + b_{1i}*\text{time}_{ij} + e_{ti}$ $b_{0i} = g_{00} + u_{0i}$ $b_{1i} = g_{10} + u_{1i}$
	Random Intercept Only	$Y_{ti} = b_{0i} + b_{1i}*\text{time}_{ij} + e_{ti}$ $b_{0i} = g_{00} + u_{0i}$ $b_{1i} = g_{10}$
	Random Slope Only	$Y_{ti} = b_{0i} + b_{1i}*\text{time}_{ij} + e_{ti}$ $b_{0i} = g_{00}$ $b_{1i} = g_{10} + u_{1i}$
Growth Parameters Affected by Aggression	Both Intercept and Slope	$Y_{ti} = b_{0i} + b_{1i}*\text{time}_{ij} + e_{ti}$ $b_{0i} = g_{00} + g_{01}*\text{agg}_{i} + u_{0i}$ $b_{1i} = g_{10} + g_{11}*\text{agg}_{i} + u_{1i}$
	Intercept Only	$Y_{ti} = b_{0i} + b_{1i}*\text{time}_{ij} + e_{ti}$ $b_{0i} = g_{00} + g_{01}*\text{agg}_{i} + u_{0i}$ $b_{1i} = g_{10} + u_{1i}$
	Slope Only	$Y_{ti} = b_{0i} + b_{1i}*\text{time}_{ij} + e_{ti}$ $b_{0i} = g_{00} + u_{0i}$ $b_{1i} = g_{10} + g_{11}*\text{agg}_{i} + u_{1i}$

Table 2.4

Best Fitting Multilevel Models for Each Conduct Problem Variable

			PCS RR	PCS RP	PCS PR	PCS PP	CBCL AB	CBCL RBB
Structure of Best-Fitting Model			Random intercept, CP affects slope	Random intercept, CP affects intercept	Random intercept, CP affects intercept	Random intercept, CP affects intercept	Random intercept, CP affects intercept	Random intercept, CP affects intercept
Fixed Effects								
Initial Status, b_{0i}	Intercept	g_{00} (SE)	1.831*** (0.281)	1.913*** (0.295)	1.845*** (0.289)	1.889*** (0.282)	1.716*** (0.267)	1.800*** (0.258)
	CP	g_{01} (SE)	-	-0.025 (0.024)	-0.013 (0.029)	-0.049 (0.034)	-0.024 (0.019)	-0.067* (0.028)
	Age	g_{02} (SE)	0.193* (0.095)	0.173 (0.098)	0.192 (0.097)	0.181 (0.095)	0.243** (0.090)	0.223* (0.086)
Rate of Change, b_{1i}	Intercept	g_{10} (SE)	-0.010† (0.005)	-0.004 (0.004)	-0.004 (0.004)	-0.004 (0.004)	-0.003 (0.004)	-0.003 (0.004)
	CP	g_{11} (SE)	0.008* (0.004)	-	-	-	-	-
Variance Components								
Level 1	Within-Person	σ^2 (SE)	0.013*** (0.001)	0.013*** (0.001)	0.013*** (0.001)	0.013*** (0.001)	0.013*** (0.001)	0.013*** (0.001)
Level 2	In Initial Status	T_{00} (SE)	0.027*** (0.007)	0.027*** (0.007)	0.028*** (0.007)	0.027*** (0.007)	0.024*** (0.006)	0.021*** (0.005)
	In Rate of Change	T_{11} (SE)	-	-	-	-	-	-
	Covariance	T_{01} (SE)	-	-	-	-	-	-
Model Fit Statistics								
AIC			-235.7	-236.4	-235.9	-238.1	-253.9	-258.5
Deviance Change Test			.063	.021	.024	.029	.001	.002
Proportion of Outcome Variation Explained								
Pseudo R^2			.199	.194	.174	.216	.307	.376

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Note: PCS RR = PCS Reactive Relational Aggression. PCS RP = PCS Reactive Physical Aggression. PCS PR = PCS Proactive Relational Aggression. PCS PP = PCS Proactive Physical

Aggression. CBCL AB = CBCL Aggressive Behavior. CBCL RBB = CBCL Rule-Breaking Behavior. CP = conduct problems variable.

Table 2.5

Exploratory Correlations Between RSA Baseline Approximation and Conduct Problem Variables

	RSA Baseline Approximation During Neutral Faces Task
CBCL Aggressive Behavior Score	*r* = -.273, *p* = .177
CBCL Rule-Breaking Score	*r* = -.081, *p* = .694
PCS Reactive Relational Score	*r* = .345, *p* = .092
PCS Reactive Physical Score	*r* = -.147, *p* = .484
PCS Proactive Relational Score	*r* = .166, *p* = .426
PCS Proactive Physical Score	*r* = -.080, *p* = .702

Figure 2.1

Proposed Psychophysiological Correlates of Aggression

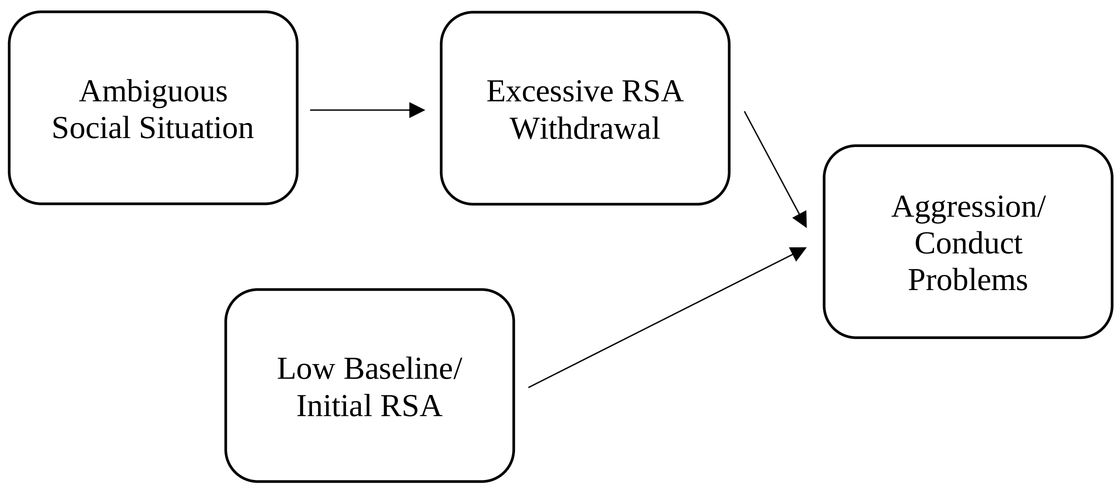


Figure 2.2

RSA Throughout HAB Task Separated by High Versus Low Conduct Problems

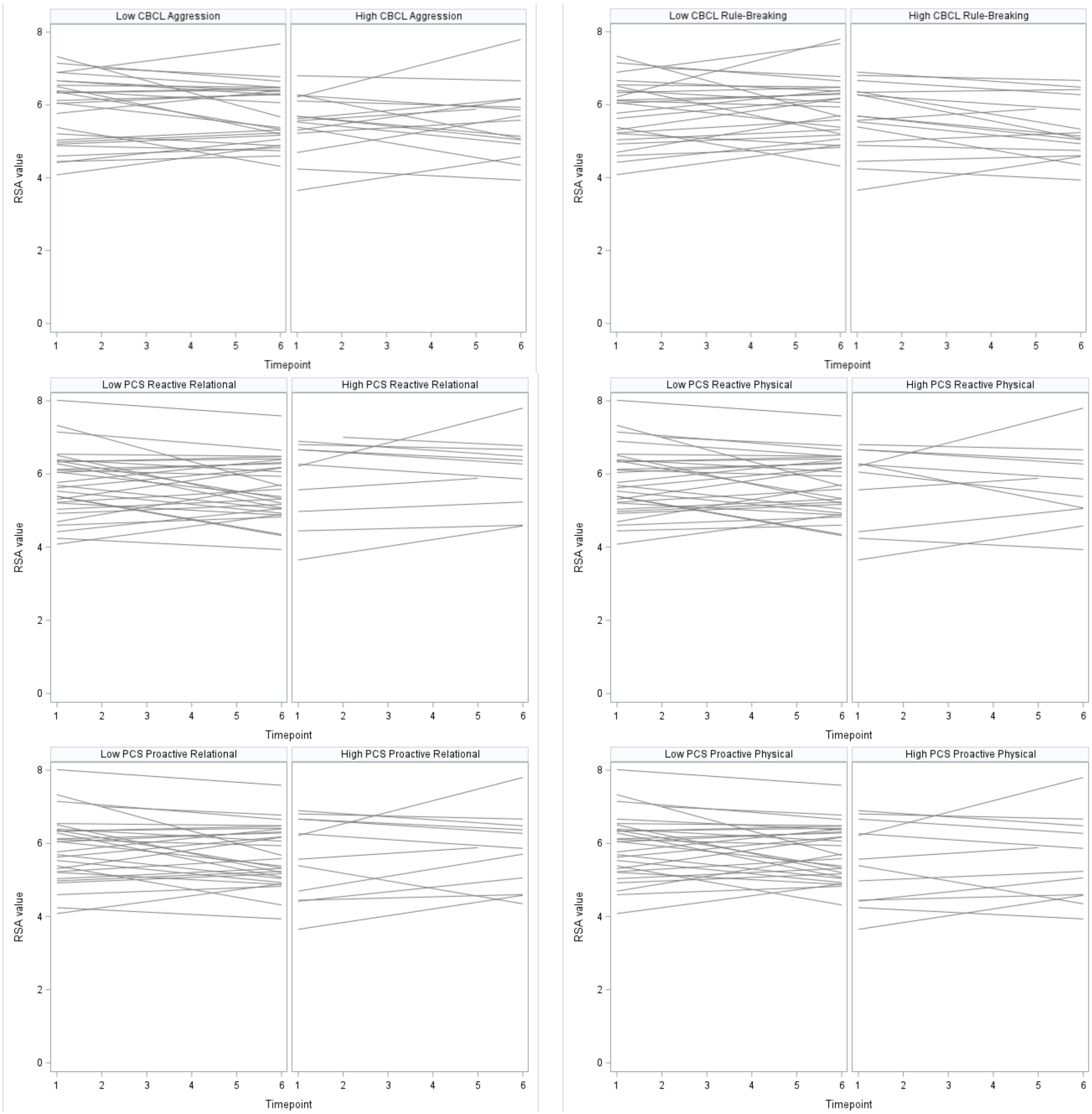
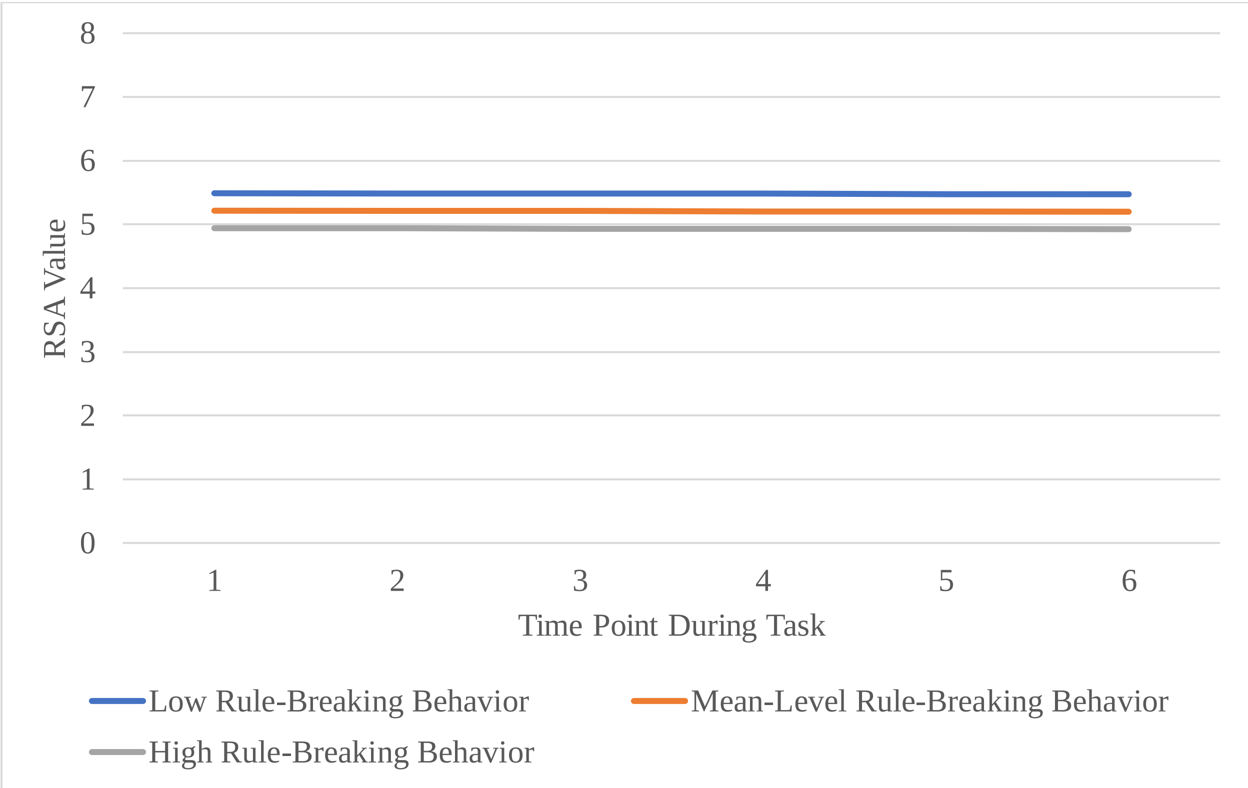


Figure 2.3

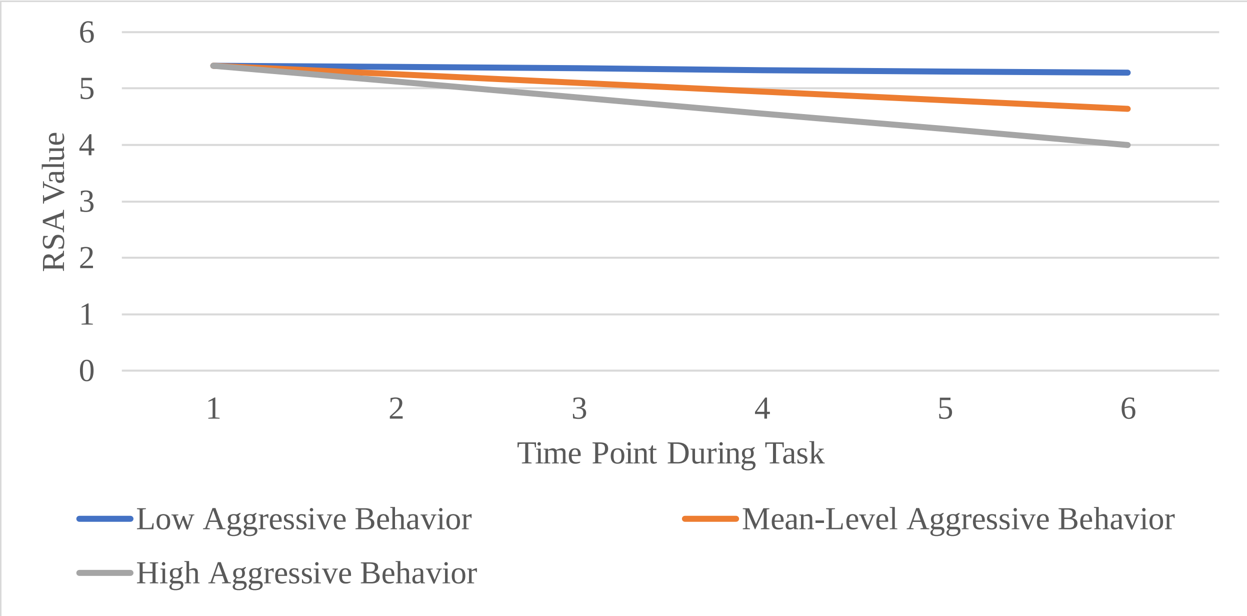
Predicted Trajectories of RSA Throughout HAB Task by Level of CBCL Rule-Breaking Behavior



Note: Low Aggressive Behavior 1/2 SD below mean, High Aggressive Behavior 1/2 SD above mean. Age set at mean value of 8.13 years.

Figure 2.4

Predicted Trajectories of RSA Throughout HAB Task by Level of PCS Reactive Relational Aggression



Note: Low Aggressive Behavior ½ SD below mean, High Aggressive Behavior ½ SD above mean. Age set at mean value of 8.13 years.

Conclusions

Recent national survey data reveal a mental health crisis among girls: 57% of girls experienced persistent feelings of sadness or hopelessness and 30% considered suicide in the last year, revealing alarming increases in frequency of these experiences relative to previous years (Centers for Disease Control and Prevention, 2023). These trends are in addition to girls' consistently high rates of being threatened or injured with a weapon at school (7%), avoiding school due to safety concerns (10%), and regular alcohol use (27%). While rates of mental health problems are concerning across genders, the differences between girls and boys are stark, with girls consistently faring worse than boys across emotional and behavioral problems and stressful experiences. Findings from population studies like these draw needed attention to the growing mental health crisis for girls, but they are agnostic about potential causal influences, predictors of severity and persistence of problems for individual people, and mechanisms that may serve as targets for both individual and group-level interventions. These data sound the alarm; investigations of risk factors and processes with rigorous methodologies and diverse, all-female samples are needed now more than ever.

Adding to the concern about girls' mental health, other data suggest that girls are engaged in proportionately more delinquency and criminal behavior relative to previous decades, as rates of these behaviors are declining faster for boys than for girls (Puzzanchera & Ehrmann, 2018; Silcox, 2019). Relatedly, despite several longstanding programs to prevent bullying, girls consistently report experiencing bullying both at school and online: surveys suggest that, for the last couple of decades, 17-29% of female students reported experiencing bullying at school, and 20-22% reported experiencing bullying online, rates that are consistently higher than parallel statistics in boys (Centers for Disease Control and Prevention, 2023; National Center for

Education Statistics, 2022). Given that both bullies and victims *both* experience poor mental health outcomes and widespread maladjustment (Kumpulainen et al., 2001; Wolke & Lereya, 2015), and that many children both bully others *and* are bullied themselves (Estévez et al., 2020; Whitney & Smith, 1993), these statistics escalate calls for concern.

Aggression and conduct problems in girls have long been understudied relative to the literature in boys. Because rates of behavioral problems are lower in girls relative to boys (Lahey et al., 2000), most existing theoretical and empirical work to date has focused on the development of these behaviors in boys. Even when sex differences in behavior are found and replicated (Archer, 2004), assumptions are often made that the risk factors and processes are the same across sexes without testing these ideas in girls. In the present studies, we sought to examine socio-emotional and psychophysiological correlates of several dimensions of aggressive behavior and conduct problems to elucidate the mechanisms that propel these behaviors in girls. Although some findings paralleled those seen in boys (e.g., social cognitive factors in some types of aggressive behaviors, associations between RSA and certain dimensions of aggression and conduct problems), key differences were also observed: most notably, the hypothesized associations with reactive physical aggression were not supported, despite these behaviors being associated with threat-biased social cognition and individual differences in RSA in boys. Reactive relational aggression, on the other hand, was associated with negative emotionality and social cognitive factors in a sequential manner and with RSA withdrawal in our preadolescent female sample. Additionally, general aggressive behavior and rule-breaking behavior were both associated with some of the correlates that were tested. This evidence can further refine models of psychopathology onset and development that are specific to girls, propelling novel strategies to predict who is most at risk and intervene upon behavioral problems at an early stage.

Despite girls' lower rates of aggression and conduct problems relative to boys, theoretical and empirical evidence suggest that they are often more severely impacted and experience worse functioning relative to boys with similar behavioral problems (Loeber & Keenan, 1994). This "gender paradox" may be evident for several conditions that affect male children more frequently than female children, leading to a phenomenon of "selective female affliction" (Elkins et al., 2011; Eme, 1992; Solomon et al., 2012). Central to this gender paradox is the idea of comorbidity – rates of comorbid psychopathology are consistently and substantially greater for girls than for boys, suggesting that girls with behavioral problems are at significant risk of experiencing concurrent or worsening emotional problems. Indeed, girls with conduct problems consistently have higher rates of depression than boys with conduct problems (Konrad et al., 2022). Relatedly, among preschool children with concurrent emotional and behavioral problems, only girls showed an increase in depression and anxiety during adolescence (in addition to the increased risk for adolescent conduct problems evident in both boys and girls), suggesting unique trajectories of comorbidities for girls (Zahn-Waxler et al., 2005). Although our sample did not include boys for comparison, and our studies did not assess for comorbid internalizing problems, notable rates of co-occurring clinical elevations in withdrawn-depressed, anxious-depressed, aggressive, and rule-breaking behaviors were evident in our sample (see Figure 1.2). Environmental, socialization, and biological factors all comprise possible female-specific pathways between girls' conduct problems and experiences of depression and anxiety (Zahn–Waxler et al., 2000). As rates of girls' mental health problems continue to rise, detection of and intervention upon early behavioral problems in girls can prevent both internalizing and externalizing problems from worsening in severity and chronicity, as well as the negative effects of bullying on victims' mental health. In addition to targeted treatments that address the complexity, severity, and frequency of girls' mental health problems, early intervention strategies that are tailored for the mechanisms of risk in girls are direly needed to improve the well-being of this generation.

Related to the concept of comorbid emotional and behavioral problems is the clinical importance of transdiagnostic risk factors. Although the present studies focused on socio-emotional and psychophysiological correlates of aggressive behavior, they have also been linked with other dimensions of psychopathology in past research. Trait negative emotionality is a risk factor for numerous types of psychopathology (Compas et al., 2004; Eisenberg et al., 2009; Hankin et al., 2017). Parasympathetic functioning is associated with a wide range of internalizing and externalizing problems (Beauchaine, 2015b), likely a product of emotion dysregulation being implicated in almost all types of mental health problems. Threat-biased social information processing in general and hostile attribution bias in particular are implicated in anxiety (Deschenes et al., 2015; Hayes et al., 2010; Jeon et al., 2013). We focused exclusively on conduct problems to test associations with a set of constructs that are rooted in theories of aggression, replicated in research with male samples, and plausible based on existing empirical work in girls. However, future studies should test whether these correlates are also implicated in internalizing problems for girls; if so, further tests can assess whether they predict comorbid emotional and behavioral problems, or if moderating factors influence which girls develop which problem types. Given their consistent negative influence on youth psychological adjustment, identification of transdiagnostic risk factors is highly impactful in the search for targets to intervene upon to improve mental health.

The findings from the present studies and previous literature point to several recommendations for future directions in the assessment of girls' aggressive behavior and related problems. First, more studies with all-female samples are needed to assess risk factors and processes specifically in girls, as well as sufficiently powered studies with combined male-female samples to test for sex differences versus sex similarities in developmental mechanisms. Prospective longitudinal designs, particularly with study timepoints beginning prior to adolescence, are crucial for testing whether individual differences in biology, cognition, socio-emotional functioning, and environment are correlates or predictive factors for girls' aggressive behavior. In addition, use of both community and clinical samples will enable future studies to assess a wide range of severity of behavioral problems, a particularly important venture given that the direction and strength of associations with risk factors may vary depending on sample type (Zisner & Beauchaine, 2016). Finally, given the clinical implications of comorbidity and transdiagnostic risk factors, thorough assessments of both emotional and behavioral problems, as well as shared symptoms that cut across specific diagnoses (e.g., irritability), are essential for elucidating risk factors and processes in girls.

Aggressive behavior in girls remains poorly understood, including how these problems relate to girls' maladjustment. Given the alarming rates of girls' mental health problems broadly, the lack of progress in reducing rates of girls' delinquency, and the risk for negative outcomes among girls with early behavioral problems, further investigation of girls' aggression and conduct problems is desperately needed. Girls' behavioral problems are meaningful contributors to the public health crisis surrounding girls' mental health, making them prime candidates for novel strategies for targeted early intervention and treatment. We hope that these studies will propel future research that can fill this alarming gap in the literature, enabling the development of innovative intervention approaches and ultimately reducing the burden of these behaviors for girls, their families, and society more broadly.

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