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Developmental Trajectories of Delinquency Symptoms in Childhood: The Role of Marital Conflict and Autonomic Nervous System Activity

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Abstract

Trajectories of delinquency symptoms across middle and late childhood were examined through latent growth modeling, with a focus on the role of interactions among parental marital conflict, child sex, and multiple indices (baseline, reactivity) of either parasympathetic nervous system (PNS) activity, indexed by respiratory sinus arrhythmia (RSA), or sympathetic nervous system (SNS) activity, indexed by skin conductance level (SCL) as predictors of growth. At T1, 128 girls and 123 boys (Mean age 8.23 yrs $\pm$.73) and their parents participated. The sample was comprised of 64% European-American (EA) and 36% African-American (AA) children. Families participated in 2nd and 3rd waves of data collection with a one-year lag between each wave. Interactions among marital conflict, sex, baseline RSA, and RSA reactivity from baseline to a frustrating lab task were significant predictors of growth in delinquent behavior from age 8 to age 10, with overall patterns indicating increasing symptoms for boys who live in high conflict homes and have an RSA response profile comprised of lower RSA during the baseline and RSA augmentation (increase from baseline to the frustrating task). Furthermore, increases in delinquency symptoms over time were observed for children from high conflict homes with an SCL profile characterized by higher baseline levels and lower reactivity (less pronounced SCL increases from baseline) to the frustrating task. Findings highlight the importance of contemporaneous assessments of resting and reactivity levels when examining relations between the environment, physiological functioning, and psychopathology. Results are discussed in the context of biology by environment interactions as relevant to the development of psychopathology.

Keywords

respiratory sinus arrhythmia; skin conductance level; developmental trajectories; externalizing behavior problems; delinquency

There is considerable evidence suggesting that the study of biology by environment interactions is important for understanding developmental psychopathology processes (Beauchaine, Neuhas, Brenner, & Gatzke-Kopp, 2008; Curtis & Cicchetti, 2003). Although

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parental marital conflict is associated with a wide range of adjustment problems in children, physiological functioning and regulation are important moderators in this connection (El-Sheikh et al., 2009). Autonomic nervous system (ANS) activity across the parasympathetic (PNS) and sympathetic (SNS) branches has functioned as a moderator of risk for children's externalizing behaviors in the context of exposure to marital conflict. Although findings from such studies have been instrumental in highlighting the role of PNS (El-Sheikh & Whitson, 2006) and SNS (El-Sheikh, 2005a; El-Sheikh, Keller, & Erath, 2007) indices as vulnerability and protective factors against externalizing problems otherwise associated with children's exposure to interparental marital conflict, significant gaps in knowledge remain and are discussed next.

Although physiological responses to stressors occur in the context of basal levels of arousal, contemporaneous assessments of multiple parameters of physiological activity within a single ANS system (PNS or SNS) in relation to children's adjustment are scarce. Furthermore, no published study has investigated interactions between marital conflict and multiple indices of either PNS or SNS activity (referred to as within-physiological system functioning) to predict children's adaptation. Addressing this gap in the literature, we investigated children's delinquency symptoms as predicted by interactions between parental marital conflict, basal levels, and reactivity levels of either PNS or SNS indices.

There is strong support for investigating within-system physiological functioning in the development of psychopathology (Beauchaine, 2001; Hinnant & El-Sheikh, 2009). Such within-system investigations include assessments of basal levels of activity in one system (e.g., PNS) in conjunction with another parameter of activity within that same system (e.g., PNS indices of reactivity to stressors). Lower levels of basal PNS activity combined with a strong PNS stress response (i.e., decrease in PNS influence) are thought to constitute a pattern of PNS activity that results in physiological and emotional dysregulation (Beauchaine, 2001). Conversely, lower levels of basal SNS activity (e.g., as indexed by skin conductance) and a weak SNS stress response to challenges is thought to constitute a pattern of SNS functioning that is indicative of poor impulse control and disinhibition (Beauchaine, 2001). Some evidence suggests that there are important sex differences in how ANS activity is related to externalizing behaviors, with relations being more robust for boys and suggestive of a pattern of autonomic under-arousal (Beauchaine, Hong, & Marsh, 2008; Calkins & Dedmon, 2000; Isen et al., 2010). Thus, investigations of developmental trajectories as predicted by ANS functioning may show important differences based on sex (Beauchaine, 2009).

Although the importance of longitudinal studies has been emphasized as a method of understanding the etiology and varying courses of psychopathology (Cicchetti & Rogosch, 1996; Curran & Hussong, 2003), there are few studies focused on examining interactions between environmental characteristics and individual differences in children's physiological responses in defining risk and resilience to the development of children's externalizing behaviors (Steinberg & Avenevoli, 2000). Consistent with developmental psychopathology approaches (Degnan, Calkins, Keane, & Hill-Soderlund, 2008; Moffitt, 1993; Sroufe & Rutter, 1984), assessments of individual differences in biology by environment interactions in the prediction of trajectories of externalizing behavior are more likely to elucidate the multiple longitudinal patterns of delinquency symptoms than are single time point investigations. In particular, there are few studies focused on interactions between marital conflict and ANS activity in the prediction of trajectories of externalizing behaviors (Cummings, El-Sheikh, Kouros, & Buckhalt, 2009), yet these types of investigations are imperative for understanding which children are most at risk for developing and maintaining psychopathology. A greater understanding of how patterns of within-PNS or within-SNS functioning may create vulnerabilities to or protection from the negative influences of

destructive marital conflict may help to explicate the multiple developmental trajectories in numerous domains of function, including externalizing behaviors and delinquency. We addressed this issue through examinations of the development of children's delinquency symptoms at ages 8, 9, and 10 years as predicted by interactions between marital conflict and ANS activity.

In synthesizing these multiple propositions from diverse areas of inquiry such as developmental psychopathology, biopsychology, and family studies, it becomes apparent that the best explication of developmental trajectories of delinquency symptoms may include characteristics of the environment, individual differences in biology, sex differences, and their possible interactions. Our main objective in this study was to examine trajectories of delinquency symptoms in middle childhood as predicted by interactions between parental marital conflict, child sex, and either (a) PNS activity, indexed by interactions between basal levels of respiratory sinus arrhythmia (RSA-B) and RSA reactivity (RSA-R) to a lab challenge, or (b) SNS activity, indexed by interactions between basal levels of skin conductance (SCL-B) and SCL reactivity (SCL-R) to a lab challenge.

Marital Conflict

A large body of literature has documented direct relations between children's exposure to destructive marital conflict and adjustment problems (Kitzmann, Gaylord, Holt, & Kenny, 2003). More recent research in this area has focused on understanding the underlying processes by which marital conflict is related to psychopathology (Cummings & Davies, 2010). Physiological activity, both at rest and in response to stress, has been implicated as an important risk or protective factor in relations between destructive marital conflict and externalizing problems (Cummings et al., 2009; El-Sheikh et al., 2009). Indeed, a greater understanding of interactions between marital conflict and children's physiological responses is pivotal for elucidating the multiple developmental pathways to adaptive and maladaptive behavior (Cicchetti & Rogosch, 1996; Steinberg & Avenevoli, 2000), identifying which children are at greater risk for maladaptation in the context of marital conflict (El-Sheikh et al., 2009), and is a necessary step in targeting intervention and prevention efforts (Beauchaine et al., 2008; Curtis & Cicchetti, 2003).

Autonomic Function

Vagal tone and vagal reactivity in response to challenges are two indices of PNS functioning. Baseline vagal tone is an index of the PNS at rest while vagal reactivity refers to increases or decreases in cardiac output by vagal pathways to facilitate physiological regulation and responding to environmental stressors (see Berntson, Cacioppo, & Grossman, 2007; Grossman & Taylor, 2007; and Porges, 2007 for more detail). Vagal tone typically decreases during engagements with the environment that require coping with stressors, a process referred to as vagal suppression (Porges, 2007). The influence of the myelinated vagus nerve on the heart is operationalized through the assessment of respiratory sinus arrhythmia (RSA), which reflects rhythmic fluctuations in heart rate that occur with spontaneous breathing (Porges, 1995). RSA, which was used in the current study, is a valid measure of vagal tone and PNS function (Grossman & Taylor, 2007). While we utilize RSA as an index of PNS activity in this study, it is acknowledged that the PNS exerts antagonistic influences on numerous organs and systems in the body. While RSA, is perhaps the most commonly used measure of PNS activity in children, other non-invasive measures for use with humans also exist (e.g., pupillary response; Steinhauer, Siegle, Condray, & Pless, 2004).

High resting RSA has been related to positive emotionality (Oveis et al., 2009) and is also thought of as a trait index of the potential to cope with stressors (Beauchaine, 2001; Porges,

Doussard-Roosevelt, Portales, & Suess, 1994; Vasilev, Crowell, Beauchaine, Mead, & Gatzke-Kopp, 2009). RSA reactivity is thought of as a state-like physiological response to a stressor that promotes self regulation and coping (e.g., Calkins, 1997; Gentzler, Santucci, Kovacs, & Fox, 2009). In this paper, we use RSA reactivity to refer to increases (augmentation; a possibly maladaptive response to stress indicating lack of engagement) or decreases (suppression; a normative, adaptive response to stress) in RSA from resting to challenge conditions.

Basal RSA and RSA reactivity function as moderators of children's externalizing problems in the context of higher levels of parental marital conflict. For example, for children exposed to elevated levels of marital conflict, higher levels of basal RSA or RSA suppression in response to environmental challenges have functioned as protective factors against externalizing problems in cross-sectional (El-Sheikh, Harger, & Whitson, 2001; Katz & Gottman, 1995) and longitudinal investigations (El-Sheikh & Whitson, 2006; Katz & Gottman, 1997; Leary & Katz, 2004). Consistent with the Polyvagal Theory (Porges, 2007), higher levels of basal RSA or RSA suppression incur protection against environmental stress by promoting physiological and emotion regulation in children.

SNS indices have also functioned as moderators of the association between parental marital conflict and externalizing behaviors in children. We use SCL as one index of SNS activity in this study; while this is commonly practiced in the literature we acknowledge the utility of other SNS activity indices (e.g., pre-ejection period in the heart, Berntson, Lozano, Chen, & Cacioppo, 2004). In studies examining links between SNS activity and externalizing behaviors, the Behavioral Inhibition System (BIS) has been a subject of much attention. The BIS is a heuristic system responsible for the inhibition of prepotent behavior (Gray & McNaughton, 2000; Fowles, Kochanska, & Murray, 2000). BIS functioning is indexed physiologically with SCL and changes in SCL in response to challenges, or SCL reactivity (Beauchaine, 2001; Fowles, 1988), which are governed by the activity of sweat glands that are innervated by the SNS branch of the ANS (Boucsein, 1992). BIS underarousal and resulting disinhibition are thought to be a characteristic of children with persistent externalizing problems (Beauchaine, 2001; Fowles, 1988; Gatzke-Kopp, Raine, Loeber, Stouthamer-Loeber, & Steinhauer, 2002; Lorber, 2004; Posthumus, Bocker, Raaijmakers, Van Engleland, & Matthys, 2009; Quay, 1993). Furthermore, some research has indicated that the relation between SCL underarousal and conduct problems are stronger for boys (Beauchaine et al., 2008; Isen et al., 2010).

According to the principal of equifinality, however, there are multiple pathways to the development of externalizing problems and these pathways may be differentially driven by interactions across biological and environmental systems. For example, in comparison to girls with lower SCL-R to stressors, stronger relations between exposure to marital conflict and externalizing problems were evident for girls with higher levels of SCL reactivity (El-Sheikh, 2005a). In a follow-up longitudinal study with the same sample, El-Sheikh, Keller, and Erath (2007) reported that marital conflict predicted increased externalizing problems among boys with lower SCL reactivity (but not higher SCL reactivity) and among girls with lower or higher SCL reactivity over two years. Thus, although not conclusive, evidence provides initial support of SNS activity functioning as a moderator of externalizing difficulties for children residing in homes characterized by higher levels of marital conflict.

Interactions *within* physiological systems (i.e., either PNS or SNS) and in the context of parental marital conflict were investigated in this study, and constitute a new step of inquiry in the literature. It is possible that researchers are missing a key piece of information when basal levels of physiological activity in one ANS system are examined independently from reactivity levels within the same system. Similarly, when reactivity levels are examined

within an ANS system, researchers typically control for basal levels of physiological activity within that system in accord with the law of initial values. The law of initial values states that the direction of a physiological response to stimuli depends upon the initial level of function (Wilder, 1967). This principle is expressed in the associations between resting and stress levels of ANS activity; individuals with higher basal RSA, for example, tend to show greater RSA suppression in response to stressors (El-Sheikh, 2005b). However, resting and reactivity levels of either RSA (Calkins & Keane, 2004; El-Sheikh, 2005b) or SCL (El-Sheikh, 2007) are usually only modestly to moderately associated, indicating that each parameter may provide unique information about PNS or SNS activity. A focus on both basal levels of activity along with responding to stressors has the potential to further understanding of the role of physiological functioning in developmental psychopathology (Beauchaine, 2001; Hinnant & El-Sheikh, 2009). In other words, it may not be only the starting point (i.e., basal levels) or the end point (i.e., stress levels) of ANS function that is important for understanding adaptive ANS function, but a combination of both.

Research with clinical populations indicates that children and adolescents with externalizing disorders have lower basal RSA than control children but exhibit similar mean levels of RSA suppression to stress (Beauchaine, Gatzke-Kopp, & Mead, 2007) and this may hold especially for boys (Beauchaine et al., 2008). Thus, children with clinical levels of externalizing problems may become physiologically dysregulated more quickly and easily as low initial levels of RSA are suppressed even further by stress. Some research with community samples also supports the relation between externalizing problems and lower basal RSA (Calkins & Dedmon, 2000), though null results have been reported (Calkins, Graziano, & Keane, 2007). In contrast to findings with clinical populations however, research with community samples has most typically found that lower RSA suppression (or RSA augmentation) to stressors is associated with externalizing problems (Boyce et al., 2001; Calkins et al., 2007). Importantly, longitudinal findings with a community sample suggest that children with *both* lower basal RSA and lower RSA suppression (i.e., an unusually weak stress response) have an increased risk of developing later externalizing problems (Hinnant & El-Sheikh, 2009). Although the relations are untested, interactions between resting and reactivity levels within the SNS may also be important. Lower basal SCL in conjunction with lower SCL reactivity, for example, may indicate an unusual level of disinhibition characteristic of delinquency.

The Current Study

The primary purpose and novel contribution of this study is the assessment of trajectories of delinquency in the context of interactions between marital conflict, child sex, and basal and reactivity levels within indices of either the PNS or SNS. From a process perspective, destructive marital conflict is associated with higher levels of children's externalizing problems, but some children are clearly more vulnerable than others (Cummings et al., 2009). Maladaptive ANS functioning, both at rest and in response to stress (i.e., lower resting PNS or SNS levels or a lower PNS or SNS stress response), appear to have exacerbating negative effects. Potentially, adaptive ANS function in the face of destructive marital conflict may be protective through the promotion of problem-solving and conflict resolution strategies while maladaptive ANS function may pose risk by making avoidant, angry, or impulsive responses to parental marital conflict more likely. Patterns of physiological, cognitive, and behavioral responding learned and evoked in these conflictual situations are thought to carry over to multiple domains of children's lives, including developmental processes leading to varying trajectories of externalizing behaviors and delinquency.

Based on findings supportive of interactions between resting and reactivity levels of RSA in the prediction of children's externalizing behaviors (Hinnant & El-Sheikh, 2009), we

expected that children with lower basal RSA and lower RSA suppression (or increased RSA augmentation) would be at risk for developing increases in delinquency symptoms over time. Moreover, we expected that this would be especially true in the context of higher marital conflict. We also tested interactions with sex to determine if relations between marital conflict, RSA, and delinquency were different for boys and girls. No studies have tested interactions among basal SCL and SCL reactivity, but consistent with Beauchaine's (2001) conceptualization, we hypothesized that a combination of lower basal SCL and lower SCL reactivity in children would pose risk for delinquency, especially for boys. Consistent with other investigations involving a single index of SCL (baseline or reactivity) and family conflict (El-Sheikh et al., 2007; Erath, El-Sheikh, & Cummings, 2009), we expected that in the context of higher marital conflict, children with lower basal SCL in conjunction with lower SCL reactivity would evidence the greatest increases in delinquency symptoms over time. Finally, in this study we also control for possible confounds [i.e., race, SES, and body mass index (BMI)] that have been related to indexes of ANS function (El-Sheikh, 2005, 2007) or delinquency (Dodge, Pettit, & Bates, 1994).

Method

Participants

The current study consisted of three waves of data (T1, T2, T3). At age 8 (T1), participants were 123 boys and 128 girls (M age = 8.23, SD = 0.73) and their parents. Recruitment was conducted through three elementary school systems in rural and semi-rural Alabama. Parents were either married (88%) or had been living together for an extended amount of time. Average duration of cohabitation in the sample was 10 years (SD = 5.67 years); a minimum of two years was required for study participation to ensure some stability in family functioning. Because of miscommunication, 10 participating families (4%) had been living together for less than two years (M = 1.09 years, SD = .28). The majority of children lived with both biological parents (73%), whereas 27% lived in reconstituted families mostly with a mother and step-father or boyfriend. Furthermore, 23% of mothers and 22% of fathers had been previously married. To reduce potential confounds, children diagnosed with ADHD, a learning disability, or mental retardation were not eligible for participation. Letters inviting families to participate were sent home with children via their schools, and interested families contacted our lab; of those who met our inclusion/exclusion criteria, 37% participated, 18% declined participation, and 45% wanted to participate but did not because cell sizes pertinent to child sex, SES level, or ethnicity had been filled.

Families spanned a wide range of SES levels (Hollingshead, 1975), and the median family income was in the \$35,000 to \$50,000 range. The majority of parents had completed high school (76%) or college (45%). The sample was comprised of 64% European-American and 36% African-American families, which mirrors the demographics of the surrounding community. We oversampled to include European- and African-American families across a wide range of SES. In relation to SES representation among African- and European-American families, respectively, 32% and 21% were in either Level 1 or 2 (semiskilled workers), 38% and 32% were in Level 3 (skilled workers), and 30% and 47% were in either Level 4 or 5 (Professionals) based on Hollingshead (1975) criteria. The majority of children were classified as prepubertal (M = 1.39, SD = .33) based on mothers' reports on the Pubertal Development Scale (Petersen, Crockett, Richards, & Boxer, 1988). Children's height and weight were measured in the lab to compute BMI, based on criteria posted by Must, Dallal, and Dietz (1991).

Approximately one year following the first wave of data collection (M = 12.84 months; SD = 2.06 months between T1 and T2), 216 children (105 boys) and their families participated in a second wave of data collection at age 9 (86% retention rate; children's M age = 9.31, SD

= .79). Approximately one year after T2 ($M = 11.34$ months, $SD = 1.62$ months between T2 and T3), 189 children and their families returned for a third wave of data collection at age 10 (85% retention rate from T2; children's M age = 10.28, $SD = 0.99$). Reasons for attrition included moving out of the study area, declining to participate due to busy schedules, and failing to respond to phone and letter requests to participate. It is frequently noted that attrition is associated with lower SES (Farrington, Gallagher, Morley, St Ledger, & West, 1990), and thus our retention rates exceeded the 80% criteria for adequate-follow up frequently cited in the literature (e.g., Desmond, Maddux, Johnson, & Confer, 1995).

Procedures and Measures

Procedures and measures were identical during all three waves of data collection unless otherwise noted. Parents and children visited our university research laboratory. Each parent completed questionnaires in separate lab rooms, and each child completed his or her questionnaires via verbal interview with a research assistant in a separate room from parents. This study is based on a component of a larger longitudinal investigation and only pertinent procedures are discussed.

Children's physiological responses (i.e., RSA and SCL) were measured in the context of a cognitive challenge, namely a star-tracing task.¹ During the psychophysiological assessment session, electrodes were attached to the child's fingers, chest, and sides, and a bellows belt was placed around the child's chest while a parent was present. Then, the researcher left the room and a 6-minute adaptation period occurred. Children completed a star-tracing task that lasted for 3 minutes during which they traced a star on a piece of paper using the mirror as a guide (Lafayette Instrument Company, Mirror Tracer). This task was directly preceded by a 3-minute baseline assessment (these procedures are described in more detail in El-Sheikh et al., 2009). The star-tracing task is a well-established stressor (Feldman et al., 1999), and children's physiological responses during this task have been associated with family risk and child functioning (El-Sheikh, Keller, & Erath, 2007).

RSA data acquisition and reduction—Following standard guidelines (Berntson et al., 1997), RSA was assessed by placing one electrocardiography (ECG) electrode on the center of the child's chest to ground the signal while two electrodes were placed on each rib cage about 10 to 15 cm below the armpits. A pneumatic bellows was also placed around the child's chest and fastened with a beaded chain to measure respiratory changes (chest expansion and compression during breathing). A pressure transducer with a bandpass of DC to 4,000 Hz was used with the bellows to ensure no phase or time shifts were introduced in the measurement of respiration. A custom bioamplifier from SA Instruments (San Diego, CA) was used during data collection and the signal was digitized with the Snap-Master Data Acquisition System (HEM Corporation, Southfield, MI) at a sampling rate of 1,000 readings per second. To examine ECG, the bioamplifier was set for bandpass filtering with half power cutoff frequencies of .1 and 1,000 Hz, and the signal was amplified with a gain of 500. The ECG signal was processed using the Interbeat Interval (IBI) Analysis System from James Long Company (Caroga Lake, NY).

The rhythmic fluctuations in heart rate that are accompanied by phases of the respiratory cycle were used to calculate RSA (Grossman, Karemaker, & Wieling, 1991). RSA was determined by the peak-to-valley method and all the units were in seconds. This methodology has been validated as a way of quantifying RSA (Bernston et al., 1997) and is

¹An argument task (socioemotional stressor) was also administered as part of the procedure (see El-Sheik et al., 2009, for details). No significant results were found in the prediction of final levels or change in delinquency from physiological responses to the argument task. To conserve space, those results are omitted and physiological responses to the argument are not considered further in the current report.

highly correlated with changes in RSA derived from surgical blockades and spectrally derived measures of RSA (Galles, Miller, Cohn, & Fox, 2002). The peak-to-valley method can also determine RSA reactivity (RSA-R) during brief periods (Berntson et al., 1997). Inspiration and expiration onset was determined by a respiration signal. RSA was computed by using the difference in IBI readings from inspiration to expiration onset.

SCL data acquisition—SCL and SCL-R (change in SCL between baseline to the challenge tasks) were measured by attaching two Ag-AgCl skin conductance electrodes (filled with BioGel, an isotonic NaCl electrolyte gel) to the volar surfaces of the distal phalanges of the first and second digits of the child's nondominant hand (Scerbo, Freedman, Raine, Dawson, & Venebles, 1992). Double-sided adhesive collars with a 1-cm hole were placed on each finger to control the area of gel contact. A constant sinusoidal (AC) voltage (0.5 V rms) was used. SCL was measured at a rate of 1,000 readings per second and was computed using the James Long Company Software. The signals were digitized and amplified using a 16 channel A/D converter (i.e., bio amplifier Model MME-4; James Long Co., Caroga Lake, NY). Both baseline SCL and SCL-R are expressed in microSiemens (μS).

Marital conflict—Mothers and fathers reported on their partners' verbal and physical aggression within the past year, using the Conflict Tactics Scale (CTS2; Straus, Hamby, Boney-McCoy, & Sugarman, 1996). The CTS2 is frequently used and has well-established reliability and validity (Straus et al., 1996). The internal consistency of the CTS2 in this study was .88 for mothers and .92 for fathers. Overall, 28.5% of families reported physical marital aggression within the last year based on at least one partner's reports; 16% reported injury resulting from such aggression. Mothers' and fathers' reports of spouse's averaged verbal and physical aggression in the marital relationship had means of 4.10 ($SD = 4.44$) and 3.42 ($SD = 3.43$), respectively, reflective of an average of about 6 to 10 aggressive acts within the past year and a wide range of marital conflict in the sample. Mother and father reports were positively related ($r = .36, p < .001$).

Children's Perceptions of Interparental Conflict Scale (CPIC; Grych, Seid, & Fincham, 1992) was completed by children via interview. The 19-item Destructive Conflict scale was used. The scale assesses child perceptions of the frequency, intensity, and resolution of marital conflict, and higher scores are indicative of frequent and intense conflict that is not well-resolved. The CPIC has demonstrated good internal consistency, test-retest reliability, and is considered appropriate for school-aged children (Grych et al., 1992). Internal consistency for the CPIC in this study was .82. Children reported a wide range of parental marital conflict ($M = 13.67, SD = 7.03$). Children's reports of marital conflict on the CPIC were significantly correlated with both mother and father reports of such conflict on the CTS ($r = .27, p < .001$ for both mother and father report).

To reduce the likelihood of Type 1 error and the number of analyses, parent reports on the CTS and child reports on the CPIC were fit in a principal component analysis (PCA) to derive a factor capturing children's and parents' shared perceptions of marital conflict. Kraemer et al. (2003) have described how reports from different individuals with different perspectives can be filtered into components that primarily capture "trait" or shared variance, and unique components that can be interpreted as context or perspective factors. As can be seen in Table 1, the application of PCA to child and parent reports of marital conflict was consistent with a component accounting for a large portion of shared variability in reports of marital conflict (Factor 1; all having positive loadings), a component accounting for less variance that may represent a unique parent perspective (Factor 2; mother and father factor loadings are negative while the child loading is positive), and a third component that may reflect a unique mother perspective or shared father-child perspective (Factor 3). The shared variance (Factor 1) between mother, father, and child

reports of marital conflict were output as scores and used in all substantive analyses. This shared variance marital conflict factor score is hereafter simply referred to as marital conflict.

Children's delinquency and ADH symptoms—Both mothers and fathers reported on children's externalizing behaviors using the Personality Inventory for Children-II (PIC2; Lachar & Gruber, 2001). The PIC2 has demonstrated discriminant and construct validity, interrater reliability, and test-retest reliability (Lachar & Gruber, 2001; Wirt, Lachar, Klinedinst, & Seat, 1990). We examined children's symptoms on the Delinquency scale, which consists of 47 items that assess antisocial behavior, dyscontrol, and noncompliance. At ages 8, 9, and 10, reliabilities for the delinquency scale raw scores were .80, .90, and .98, respectively. At age 8, 17 children (6%) had scores in the borderline or clinical range ($T \geq 60$). At ages 9 and 10, 14 (6%) and 12 (6%) of children, respectively, had scores in the borderline or clinical range. To predict delinquency outcomes while controlling the potential confounds of ADH symptoms, initial levels of the latter were controlled in analyses.² The ADH scale consists of 21 items (e.g., child often forgets things, has problems waiting, jumps from one activity to another). At age 8, the reliability for the ADH raw score subscale was .80.

Data Analytic Strategy

Latent growth analyses were conducted to examine the developmental trajectories of delinquency symptoms in children from age 8 to age 10, and to predict variability in the intercept and slope of delinquency symptoms. AMOS 17 was used in conducting these analyses. There were three time points (ages 8, 9, and 10); thus, latent growth was only modeled as linear change (Singer & Willett, 2003). Because we were interested in predicting both change over time (slope) and final levels (age 10) of delinquency symptoms, the intercept was set at age 10 and time was coded as -2 , -1 , and 0 at ages 8, 9, and 10, respectively (Biesanz, Papadakis, Deeb-Sousa, Bollen, & Curran, 2004).

Because the PIC2 T scores are age and gender corrected, raw scores were used to assess growth of delinquency symptoms as is commonly recommended (Singer & Willett, 2003). Unfortunately, this precluded the use of the established clinical risk cutoff values (i.e., T scores) as comparisons in the growth models. As a rough comparison, however, Lachar and Gruber (2001) reported a mean delinquency raw score of 6.44 for their standardization (i.e., normative) sample of over 2,000 children, adolescents, and young adults and a mean delinquency raw score of 16.48 for their referred (i.e., clinical) sample of approximately 1,500 children, adolescents, and young adults. Children's SES, race³, BMI, and initial Attention Deficit-Hyperactivity (ADH) symptoms were included as covariates; the latter was controlled to provide estimates of delinquency and its growth independent of the hyperactivity and attentional issues that characterize ADH symptoms. The RSA and SCL baseline values immediately preceding the star-tracing task were used. The physiological reactivity variables, RSA-R and SCL-R, were created by subtracting baseline values from scores during the star-tracing task. Thus, higher or positive values for RSA-R and SCL-R

²In initial analyses, we examined children's symptoms on the Attention Deficit-Hyperactivity (ADH) subscale, which consists of 21 items (e.g., child often forgets things, has problems waiting, jumps from one activity to another). Akin to our delinquency symptoms analyses, we examined the unconditional and conditional growth and final levels of ADH symptoms, controlling for initial delinquency symptoms, at ages 8 through 10. Unconditional growth demonstrated significant declines in ADH symptoms over time and significant variability in both the intercept (age 10 levels) and slope. Within-system interactions among marital conflict, child sex, RSA, and SCL, controlling for initial delinquency symptoms, were not predictive of the intercept or slope (i.e., change over time) of ADH symptoms in either conditional growth model. Thus, findings were limited to trajectories and final levels delinquency.

³We also examined whether children's race or SES served as moderators by testing models in which sex interactions were replaced with race or SES. No evidence was found for interactions between race or SES and marital conflict, RSA, or SCL in predicting delinquency.

indicate increases over baseline (i.e., augmentation or activation). Similarly, lower or negative values indicate decreases from baseline (i.e., suppression or inhibition). Because the terms higher RSA-R and lower RSA-R can be confusing, we also refer to them specifically as RSA augmentation and RSA suppression, respectively, in this text. In accordance with the law of initial values, all predictive models included both baseline and reactivity. In these models, interaction terms were allowed to correlate with one another and their constituent variables. Correlated variables, shown in Table 2, were also allowed to covary in the models. All continuous predictor variables were mean centered and categorical variables were coded as 0 or 1 to facilitate interpretation and minimize multicollinearity in interaction terms (Aiken & West, 1991). Outlier data points (± 4 SD) were removed from the data file prior to data analysis.

The primary objective of the current study was to test the interactions among marital conflict, child sex, and either RSA (both resting and reactivity levels) or SCL (both resting and reactivity levels) as predictors of growth and final levels of delinquency symptoms. Two conditional growth models for delinquency were fit to assess the hypothesized interactions among study variables (one with the RSA variables and one with the SCL variables). To facilitate interpretation, simple slopes for interactions were plotted at ± 1 SD and their significance was tested (Aiken & West, 1991; Preacher, Curran, & Bauer, 2006). Importantly, these simple slopes are predicted trajectories for prototypical children (Curran, Bauer, & Willoughby, 2004; Willett, Singer, & Martin, 1998). For example, a significant three-way interaction between marital conflict, RSA-B, and RSA-R on the slope of delinquency would be represented by plotting trajectories of delinquency over time for children with a given set of parameters (e.g., $+1$ SD on marital conflict, -1 SD on RSA-B, and $+1$ SD on RSA-R) and testing whether these slopes are significantly different from zero.

Results

Missing Data

The default missing data procedure in AMOS, Full Information Maximum Likelihood (FIML) estimation, was used to account for missing data. FIML assumes that data are Missing Completely At Random (MCAR) or Missing At Random (MAR) (Acocck, 2005). Using the missing value analysis function in SPSS 17, patterns of missingness in the data were evaluated with these considerations in mind, paying special attention to variables that are known to be related to missingness (e.g., SES, race, children's initial ADH symptomology). At age 8, 251 children had data on delinquency symptoms; at age 9, 216 (86%) children had data on delinquency symptoms; at age 10, 189 (75%) children had data on this outcome. Attrition was not related to SES, race, or initial ADH symptoms. Additionally, Little's MCAR test indicated that missing delinquency data over time was not related to itself (i.e., families who dropped out of the study did not have children with higher levels of delinquency at age 8), $\chi^2(6) = 2.71, p = .84$. The only pattern of missingness was marginal and indicated that children missing data on delinquency symptoms at age 10 had higher SCL-R to the star tracing task at age 8, $t(89) = -1.7, p = .09$. Including SCL-R in the substantive analyses corrects for any errors in parameter estimates that may result from this one pattern of missingness (Widaman, 2006).

Preliminary Analyses

Descriptive statistics and correlations among all study variables are presented in Table 2. The star tracing task elicited significant mean changes in RSA from baseline, dependent samples $t(235) = 5.74, p < .001$, and in SCL from baseline, dependent samples $t(231) = 16.86, p < .001$. The normative, or average, responses to the task were RSA decreases or

suppression (69% of participants) and SCL increases (93% of participants). RSA-B was negatively and moderately ($r = -.36$) related to RSA-R, indicating that children with higher baseline RSA tended to show greater RSA decreases in response to the task (i.e., suppression). SCL-B and SCL-R were positively and moderately related ($r = .33$); higher SCL-B was related to greater SCL increases to the task.

Delinquency and ADHD symptoms were highly correlated both within and across time. Higher marital conflict was positively related to delinquency symptoms at age 9. RSA and SCL were not directly associated with delinquency and ADHD symptoms with one exception; higher RSA-R (RSA augmentation in response to the star tracing task) was related to higher delinquency symptoms at age 10.

Unconditional Growth of Delinquency

An unconditional growth model was fit to explore the developmental trajectories of children's delinquency symptoms across three years (Table 3). Fit indexes for the unconditional model were acceptable. On average, delinquency symptoms did not show significant change over time, but significant variability was detected in both the intercept (end point; age 10) and slope. This meant that some children were showing increases in delinquency over time, others were exhibiting decreases over time, and that children were widely distributed in their final levels of delinquency symptoms. Significant variability in the intercept and slope indicated that this variability could be accounted for by adding predictors to the models.

Conditional Growth of Delinquency

Our theoretical conditional growth model is presented in Figure 1. Fit indexes for the two conditional growth models (one for RSA measures and the second for SCL measures) were good to excellent. RMSEA values were .035 and .042, respectively. Changes in R^2 and total model R^2 are presented in Tables 4 and 5. In both models, initial (age 8) ADHD symptoms were positively related to age 10 (intercept) delinquency symptoms (children with higher ADHD symptoms at age 8 had higher delinquency symptoms at age 10) and negatively related to the slope of delinquency symptoms (children with higher initial ADHD symptoms showed more steeply decreasing delinquency symptoms over time). No other covariate "main" effects showed consistent prediction in the models.

Marital conflict x RSA-B x RSA-R—Full results can be found in Table 3. Marital conflict was positively related to children's final levels of delinquency symptoms. A number of significant two-way interactions were found on both the intercept and slope, but these were subsumed under the three-way interactions. The first of the four three-way interactions (marital conflict x RSA-B x RSA-R) was marginally significant ($p = .07$). Plotting this interaction revealed that at lower levels of marital conflict, children showed no change or significant declines in delinquency symptoms over time (Figure 2A). At higher levels of marital conflict, most children also showed no significant increases with one exception (Figure 2B). Children with lower RSA-B and higher RSA-R (augmentation or RSA increases in response to the star tracing task) showed significant increases in delinquency over time. The significant three-way interaction among marital conflict, RSA-B, and sex indicated that boys with lower RSA-B who experienced higher levels of marital conflict showed increasing levels of delinquency symptoms over time (Figures 3A and 3B).

Similarly, the significant three-way interaction among marital conflict, RSA-R, and sex indicated that boys with higher RSA-R (augmentation) in response to the frustrating task who experienced higher levels of marital conflict showed an increasing trajectory of delinquency symptoms (Figures 4A and 4B). Finally, the significant three-way interaction

among RSA-B, RSA-R, and sex showed that boys with lower RSA-B and higher RSA-R had an increasing trajectory of delinquency symptoms (Figure 5A and 5B). The four-way interaction was not significant. In total, the two- and three-way interactions accounted for approximately 15% of the variance in the intercept of delinquency symptoms and nearly 30% of the variance in the slope. The total model accounted for 44% of the variance in age 10 delinquency symptoms and 50% of the variance in the slope.

Marital conflict x SCL-B x SCL-R—Full results can be found in Table 5. Higher SCL-B was associated with higher delinquency symptoms at age 10. Only one two-way interaction was marginally significant. A marginally significant three-way interaction among marital conflict, SCL-B, and SCL-R ($p = .08$) on the slope indicated that at lower levels of marital conflict, most children showed nonsignificant declines in delinquency with the exception that children who had higher SCL-B in combination with lower SCL-R, showed a significant decline in delinquency symptoms over time (Figure 6A). Conversely, at higher levels of marital conflict, all children showed no significant change in delinquency symptoms over time with the exception that children with higher SCL-B in conjunction with lower SCL-R exhibited significant increases in delinquency symptoms over development (Figure 6B). The diverging trajectories at higher and lower marital conflict for children with higher SCL-B in conjunction with lower SCL-R are notable.

A significant three-way interaction among marital conflict, SCL-B, and sex indicated that children (both boys and girls) with higher SCL-B who experienced higher marital conflict showed the highest overall levels of delinquency symptoms, though none of the slopes were significantly different from zero (Figures 7A and 7B). In total, two- and three-way interactions accounted for 4% of the variance in age 10 delinquency symptoms and 12% of the variance in the slope. Again, the four-way interaction was not significant. The full model accounted for 33% of the variance in delinquency symptoms at age 10 and 34% of the variance in the slope.

Discussion

We examined interactions among marital conflict, sex, and patterns of children's RSA or SCL functioning (i.e., baseline and reactivity levels) as predictors of delinquent behavior from age 8 through age 10 in a relatively large and diverse community sample. Baseline and reactivity levels of both RSA and SCL were considered because each of these variables has been identified as a moderator of links between marital conflict and children's adjustment (e.g., El-Sheikh et al., 2001; El-Sheikh & Whitson, 2006; Katz & Gottman, 1995; 1997), and because the status of physiological systems depends on both their starting points and the degree to which they change in response to stress (Beauchaine, 2001; Hinnant & El-Sheikh, 2009).

PNS Patterns and Delinquent Behavior

In analyses that included indices of PNS activity, results consistently demonstrated elevated risk for increasing delinquent behavior among boys (but not girls) with lower RSA and higher RSA-R (augmentation), particularly in the context of higher marital conflict. These findings are consistent with evidence for higher rates of delinquent behavior among boys compared to girls (Stanger, Achenbach, & Verhulst, 1997), and suggest that boys are more susceptible to delinquent behavior in the context of the family and physiological risk factors under investigation. Given that internalizing problems increase in girls in adolescence (Hankin & Abramson, 2001), future research should consider whether the same profile of marital conflict and RSA activity would predict increases in internalizing behavior among girls. In contrast to higher RSA-R (i.e., augmentation), lower RSA-R (i.e., RSA suppression)

appeared to operate as a protective factor, predicting declines in delinquent behavior, even in the context of elevated marital conflict.

Findings that involved RSA and RSA-R are consistent with several related lines of investigation. Lower RSA-B and higher RSA-R (augmentation) each has been linked with externalizing behavior problems in community samples (Calkins & Keane, 2004; Calkins et al., 2007; Graziano et al., 2007; Katz, 2007). One prior study with an independent sample has shown that children with lower RSA-B in conjunction with higher RSA-R (augmentation) in response to lab challenges have higher levels of externalizing behavior than children with any other combination of RSA-B and RSA reactivity/regulation (Hinnant & El-Sheikh, 2009). In addition, several studies have shown that the association between marital conflict and externalizing behavior is exacerbated among children with lower RSA-B or higher RSA-R (augmentation), or attenuated among children with higher RSA-B or lower RSA-R (increased suppression) to challenges (El-Sheikh et al., 2001; El-Sheikh & Whitson, 2006; Katz & Gottman, 1995; 1997). The risk conferred by lower RSA-B has been explained on the basis of evidence that lower vagal tone may be a marker of poorer emotional regulation or dysfunction of the social engagement system (e.g., Beauchaine, 2001; Porges, 2007). Higher RSA-R (augmentation) in response to stressors also may be an indicator of emotional dysregulation, in contrast to the efficient and incremental coping associated with increased RSA suppression, which increases metabolic output to promote engagement with environmental demands (Porges, 2007).

The present study is the first, however, to examine interactions among marital conflict, RSA-B, and RSA-R. Analyses not only accounted for RSA-B, but also tested the hypothesis that RSA-B and RSA-R are conditional upon one another as moderators of marital conflict and predictors of externalizing behavior. The Polyvagal Theory suggests that higher RSA-B and increased RSA suppression to stressors support (or reflect) positive social engagement and regulated responses to stress, respectively (Porges, 2007). According to Porges' theory, both higher RSA-B and lower RSA-R (i.e., suppression) stem from adaptive neural circuitry (i.e., the ventral vagal complex) that promotes calm physiological states, in part, via myelinated vagal fibers that have an inhibitory influence on the cardiac pacemaker. Adaptive functioning of the ventral vagal complex also supports social engagement behaviors, in part, via overlap with neural networks that regulate muscles involved in facial orienting and expression, hearing, and speaking. RSA suppression is also viewed as an appropriate response to stress, yielding rapid and incremental increases in metabolic output (e.g. heart rate increase; Porges, 2007).

Children with lower RSA-B may experience less positive interactions with socializing agents who can discourage aggressive and noncompliant behavior (e.g., parents, teacher, peers), and children with higher RSA-R (augmentation) may react to interpersonal stress situations in a passive or dysregulated manner. One maladaptive physiological response (i.e., lower RSA-B or increased RSA augmentation) appears to exacerbate the negative effects of the other. Difficulties with calm social engagement and controlled stress responses may be further exacerbated when children are exposed to high levels of marital conflict, contributing to delinquent behavior problems. Potentially, maladaptive RSA levels are reflected in avoidant or angry responses to parents in the context of marital conflict, rather than problem-solving or engagement with parents that may be protective and facilitated by more adaptive RSA levels (especially RSA suppression to challenges). Of course, we can only speculate here about the psychological or behavioral responses that link physiological responses with externalizing behaviors in the context of marital conflict.

It is important to note that some research suggests that lower RSA-B accompanied by lower RSA-R (increased suppression) would be linked to externalizing behavior because this

response pattern would presumably result in especially high physiological arousal that may promote aggression (Beauchaine, 2001). At least two features of the present study may explain why lower RSA-B in conjunction with lower RSA-R (increased suppression) did not predict externalizing behavior in our study. First, much of the research linking lower RSA-R (increased suppression) with externalizing behaviors involves children or adolescents with clinical diagnoses. Second, control for ADHD symptoms in the present study may have limited the association between lower RSA-R (increased suppression) and the externalizing construct, to the extent that very low RSA-R would contribute to dysregulated behaviors related to ADHD symptoms. Perhaps moderate levels of RSA withdrawal are optimal, whereas excessive withdrawal contributes to responses of panic or aggression (Beauchaine, 2001).

SNS Patterns and Delinquent Behavior

In analyses that included indices of SNS activity, interactions did not emerge as consistently as they did for RSA, but suggested that the combination of higher SCL-B and lower SCL-R may confer risk for delinquent behavior among children exposed to higher levels of marital conflict. Several studies have reported that children who exhibit relatively low SCL-R have elevated levels of externalizing behavior in the context of family stress, compared to children who exhibit relatively high SCL-R (Erath et al., 2009; Shannon, Beauchaine, Brenner, Neuhaus, & Gatzke-Kopp, 2007), yet exceptions to this pattern exist (e.g., Cummings, El-Sheikh, Kouros, & Keller, 2007; El-Sheikh, 2005a). Furthermore, other evidence suggests that the vulnerability function of higher or lower SCL-R depends on child gender (El-Sheikh et al., 2007). One possibility is that lower SCL-R reflects insensitivity to threatening situations (Gao, Raine, Venables, Dawson, & Mednick, 2010; Beauchaine, 2001; Fowles et al., 2000; Raine, 2002), such that children with lower SCL-R may be less likely to experience internalizing (i.e., sad, anxious) reactions in the context of marital conflict, but more likely to develop aggressive patterns of social information processing (e.g., hostile encoding and attributions) and to learn negative or coercive social problem-solving strategies. Indeed, underaroused children, whose attention is unimpeded by high arousal, may experience optimal physiological conditions for learning aggressive behaviors from their parents in the context of destructive marital conflict (Hoffman, 1983; 1994).

Somewhat surprisingly, growth in delinquent behavior was observed among children with higher (rather than lower) SCL-B, but only when they also exhibited lower SCL-R and were exposed to relatively high levels of marital conflict. In contrast, research has generally linked high SCL-B with anxiety and low SCL-B with impulsivity and aggression, especially in samples with older children and adults (Beauchaine, 2001; Lorber, 2004). Interestingly, however, El-Sheikh, Keiley, and Hinnant (2010) found that with the present sample, externalizing behavior was associated with declining skin conductance levels from age 8 to age 10, suggesting a potential developmental change in the risk for externalizing behavior associated with higher or lower baseline SCL. As noted, the present study is the first to consider interactions among marital conflict and both baseline and reactivity levels of skin conductance. It will be important to consider whether future research replicates the heightened risk for increasing delinquent behavior among children who are exposed to marital conflict and exhibit both relatively high SCL-B and relatively low SCL-R.

Limitations and Conclusions

Several limitations of the present study inform directions for future research. While we used raw scores for delinquency because they are the preferred scores to use when examining developmental trajectories, this may not allow for direct comparisons to scores used to indicate clinical risk (i.e., *T* scores). As noted earlier, however, Lachar & Gruber (2001) reported an average delinquency raw score of 16.48 for clinically referred children in their

sample, which is higher than that observed in our community sample. Another metric may be informative: the highest predicted levels of delinquency in this sample were approximately one SD above the average. Thus, the children with the steepest increases in delinquency were, on average, not likely to present clinical levels of problems, yet their trajectories and final levels of delinquency would likely be troubling to parents. The community nature of the sample thus limits the generalizability of the findings; it is possible that different mechanisms of environmental and physiological risk and resilience operate in clinical populations.

We measured patterns of physiological functioning that operated as protective or vulnerability factors, but not the behavioral or psychological stress responses linked with these physiological responses. Investigations of voluntary stress responses would illuminate the mechanisms by which physiological responses increase risk or provide protection. We examined delinquent behaviors via parental reports as the outcome variable. It will be important to extend the current line of investigation on interactions among environmental stress and within-system physiological parameters to other measures and subtypes of externalizing behavior and to other outcomes, such as internalizing problems and peer problems. Given limits of statistical power, we did not examine interactions among baseline and reactivity levels across both the PNS and SNS in the same model (rather, we focused on within-single-system interactions), but recent research has demonstrated important effects of cross-system interactions (e.g., El-Sheikh, Erath, Buckhalt, Granger, & Mize, 2008; El-Sheikh et al., 2009). Other relevant complexities include non-linear physiological effects and physiological recovery from stress. An important direction for future research is to implement or develop analytic strategies that allow tests of more complex, multivariate interactions. It also was not feasible to examine all predictors and their interactions at multiple time points in the current report; however, it would be informative to know whether changes in marital conflict and ANS functioning paralleled changes in delinquent behavior.

Despite these limitations, the present study advances the existing literature by demonstrating that the association linking marital conflict with increasing delinquent behavior in childhood is conditional upon sex and both RSA and SCL functioning, which are themselves contingent upon both baseline and reactivity levels. The results highlight the importance of contemporaneous assessment of multiple indices of the activity of physiological systems in conjunction with familial stressors towards an explication of developmental psychopathology processes. In the majority of growth models in the literature, variance is predicted frequently for the intercepts but not for the slopes, with the assumption that operative factors associated with different levels of behavior found at the intercept have occurred prior to that time (Keiley, Martin, Liu, & Dolbin-MacNab, 2005). However, our two final fitted models indicated that a large proportion of the variance was predicted in the intercepts and slopes of delinquency symptoms. This suggests that we are targeting important variables and developmental periods, and capturing critical changes in children's delinquency symptoms during middle and late childhood.

Results provide further empirical evidence for a tenet of developmental psychopathology – the need to consider interactions among multiple risk and protective factors at both individual and environmental levels to understand normal and abnormal child development. Importantly, we examined indices of physiological functioning that may be responsive to intervention themselves (e.g., Rain, Venables, Dalais, Mellinger, Reynolds, & Mednick, 2001), and that increasingly have been linked to behavioral and emotional processes that are responsive to intervention. Thus, the present study advances basic research on variability in the risk associated with marital conflict, and lays further foundation for research on risk and protective factors with more applied implications.

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Figure 1.
The theoretical conditional growth model for delinquency symptoms.

Figure 2.

Figures 2A and 2B. Interaction between marital conflict, RSA-B, and RSA-R in response to star-tracing in predicting growth of delinquency symptoms.

Figure 3. Figures 3A and 3B. Interaction between marital conflict, RSA-B, and sex in predicting growth of delinquency symptoms.

Figure 4. Figures 4A and 4B. Interaction between marital conflict, RSA-R in response to star-tracing, and sex in predicting growth of delinquency symptoms.

Figure 5. Figures 5A and 5B. Interaction between RSA-B, and RSA-R in response to star-tracing, and sex in predicting growth of delinquency symptoms.

Figure 6.

Figures 6A and 6B. Interaction between marital conflict, SCL-B, and SCL-R in response to star-tracing in predicting growth of delinquency symptoms.

Figure 7. Figures 7A and 7B. Interaction between marital conflict, SCL-B, and sex in predicting growth of delinquency symptoms.

Table 1

Principal Component Analysis of Mother, Father, and Child Reported Marital Conflict

Marital Conflict Reporter	Factor 1: Shared	Factor 2: Parent	Factor 3: Mother
	Factor Weight	Factor Weight	Factor Weight
Mother	.73	-.16	-.67
Father	.71	-.52	.48
Child	.69	.69	.21
Variance attributable to factor	50.26%	25.58%	24.16%

Table 2

Estimated Means, Standard Deviations, and Correlations (N = 260)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Sex	--												
2. Ethnicity	-.04	--											
3. SES	.04	-.24**	--										
4. Body Mass Index	-.09	.13	-.05	--									
5. Marital Conflict	.09	.06	-.12	-.01	--								
6. RSA-B (baseline)	-.01	.24**	-.14*	.05	.22**	--							
7. RSA-R (reactivity)	.06	-.09	-.09	-.12~	-.12	-.36**	--						
8. SCL-B (baseline)	.18**	-.40**	.09	.12~	.01	-.06	-.07	--					
9. SCL-R (reactivity)	-.09	-.13	-.04	-.04	.01	.00	-.07	.33**	--				
10. ADH age 8	.20**	-.06	-.08	-.18**	.07	-.01	.04	.09	-.04	--			
11. DLQ age 8	.05	.06	-.16*	-.20**	.14*	.07	-.03	.08	.02	.75**	--		
12. DLQ age 9	.13	.02	-.16*	-.20**	.17*	-.07	.07	.12	-.04	.59**	.75**	--	
13. DLQ age 10	.08	-.03	-.13	-.09	.09	-.07	.09	.08	.04	.50**	.60**	.81**	--
Mean	-	-	0.00	19.08	0.00	.15	-.02	7.46	1.24	4.72	4.78	4.96	4.50
SD	-	-	.83	3.88	.95	.08	.06	5.36	1.82	3.57	4.21	4.77	4.65

Note. Sex was coded 0 for females and 1 for males. Ethnicity was coded 0 for European Americans and 1 for African Americans. SES and Marital Conflict are standardized z scores.

SES = Socioeconomic status; RSA = Respiratory Sinus Arrhythmia; SCL = Skin Conductance Level; ADH = Attention Deficit-Hyperactivity; DLQ = Delinquency.

RSA-R and SCL-R were coded such that baseline levels were subtracted from pertinent levels during the star tracing task. Thus, a positive reactivity number denotes an increase from baseline to the stressor.

* $p < .05$;

** $p < .01$.

Table 3
Parameter Estimates and Standard Errors for the Unconditional Growth Model of Delinquency Symptoms

Model	Intercept factor		Slope factor		RMSEA	CFI	χ^2	df	p
	Estimate	SE	Estimate	SE					
Delinquency	4.47** (21.85**)	.32 (2.15)	-.16 (3.70**)	.14 (.48)	.08	.99	5.63	3	.13

Note. In these models the intercept is set at the end of the most recent data collection, age 10. Average intercept and slope values and their standard errors are listed without parentheses. Variability estimates of the intercept and slope and their standard errors are given in parentheses.

*
 $p < .05$;
**
 $p < .01$.

Table 4

Parameter Estimates and Standard Errors for Conditional Growth Models of Delinquency Symptoms Predicted by Marital Conflict, RSA-B, RSA-R, and their interactions

Predictor	Delinquency					
	Intercept factor			Slope factor		
	B	SE	β	B	SE	β
<i>Demographics</i>						
						.035
Sex	-.034	.569	-.004	.374	.263	.126
Ethnicity	.755	.648	.080	-.298	.300	-.096
SES	-.381	.328	-.070	-.015	.151	-.009
Body Mass Index	-.063	.073	-.054	.037	.034	.096
<i>Main effects</i>						
						.172
ADH symptoms	.619	.077	.489**	-.124	.035	-.297**
Marital conflict (MC)	1.017	.519	.206*	.249	.240	.153
Basal RSA (RSA-B)	-.032	.054	-.053	-.009	.025	-.044
RSA reactivity (RSA-R)	.061	.107	.074	.046	.049	.171
Basal SCL (SCL-B)	.051	.057	.061	-.019	.026	-.067
SCL reactivity (SCL-R)	.182	.151	.073	.053	.070	.065
<i>2-way interactions</i>						
						.094
MC x RSA-B	.171	.089	.256 [†]	.112	.041	.525**
MC x RSA-R	.425	.148	.465**	.257	.068	.855**
MC x sex	-.092	.700	-.013	.121	.323	.053
RSA-B x RSA-R	.003	.006	.063	.001	.003	.079
RSA-B x sex	-.033	.082	-.035	-.038	.038	-.120
RSA-R x sex	.233	.132	.201 [†]	.112	.061	.293 [†]
<i>3-way interactions</i>						
						.195
						.092

Delinquency							
		Intercept factor		Slope factor		ΔR^2	
Predictor	B	SE	β	B	SE	β	
MC x RSA-B x RSA-R	-.017	.010	-.225 [†]	-.008	.005	-.330 [†]	
MC x RSA-B x sex	-.286	.113	-.311 ^{**}	-.141	.052	-.464 ^{**}	
MC x RSA-R x sex	-.326	.170	-.287 [*]	-.216	.078	-.575 ^{**}	
RSA-B x RSA-R x sex	-.030	.011	-.234 ^{**}	-.012	.005	-.289 [*]	
4-way interaction							.001
MC x RSA-B x RSA-R x sex	-.032	.022	-.258	-.004	.010	-.094	
Total R ²							.497

Note. B = unstandardized coefficient, SE = standard error, β = standardized coefficient. Sex was coded 0 for females and 1 for males. Ethnicity was coded 0 for European Americans and 1 for African Americans. SES and Marital Conflict are standardized z scores.

SES = Socioeconomic status; MC = Marital Conflict; RSA = Respiratory Sinus Arrhythmia; SCL = Skin Conductance Level; ADH = Attention Deficit-Hyperactivity.

RSA-R and SCL-R were coded such that baseline levels were subtracted from pertinent levels during the star tracing task. Thus, a positive reactivity number denotes an increase from baseline to the stressor.

[†] $p < .10$,
* $p < .05$;
** $p < .01$.

Table 5

Parameter Estimates and Standard Errors for Conditional Growth Models of Delinquency Symptoms Predicted by Marital Conflict, SCL-B, SCL-R, and their interactions

Predictor	Delinquency					
	Intercept factor			Slope factor		
	B	SE	β	B	SE	β
<i>Demographics</i>						.035
Sex	-.039	.570	-.004	.430	.266	.139
Ethnicity	.616	.650	.066	-.327	.303	-.100
SES	-.468	.349	-.087	-.060	.162	-.032
Body Mass Index	-.055	.075	-.048	.046	.035	.115
<i>Main effects</i>						.172
ADH symptoms	.571	.081	.456**	-.148	.038	-.338**
Marital conflict (MC)	.665	.552	.137	-.082	.257	-.048
Basal RSA (RSA-B)	-.048	.040	-.084	-.024	.019	-.120
RSA reactivity (RSA-R)	.046	.055	.058	.038	.026	.139
Basal SCL (SCL-B)	.196	.100	.225*	.032	.047	.106
SCL reactivity (SCL-R)	-.124	.223	-.050	-.053	.104	-.062
<i>2-way interactions</i>						.054
MC x SCL-B	-.081	.148	-.080	-.090	.069	-.251
MC x SCL-R	-.205	.323	-.072	-.252	.150	-.254 [†]
MC x sex	-.305	.737	-.045	.283	.343	.119
SCL-B x SCL-R	.030	.038	.078	.005	.018	.034
SCL-B x sex	-.182	.121	-.175	-.061	.056	-.169
SCL-R x sex	.169	.379	.040	.030	.177	.021
<i>3-way interactions</i>						.063
						.033

Delinquency						
Intercept factor			Slope factor		AR ²	
Predictor	B	SE	β	B	SE	β
MC x SCL-B x SCL-R	.081	.083	.135	.067	.039	.319 [†]
MC x SCL-B x sex	.285	.171	.226 [†]	.165	.080	.377*
MC x SCL-R x sex	.238	.430	.062	.238	.200	.180
SCL-B x SCL-R x sex	.013	.060	.022	.007	.028	.033
4-way interaction						.022
MC x SCL-B x SCL-R x Sex			-.064	.098	-.050	-.193
Total R ²						.343

Note. B = unstandardized coefficient, SE = standard error, β = standardized coefficient. Sex was coded 0 for females and 1 for males. Ethnicity was coded 0 for European Americans and 1 for African Americans. SES and Marital Conflict are standardized z scores.

SES = Socioeconomic status; RSA = Respiratory Sinus Arrhythmia; SCL = Skin Conductance Level; ADH = Attention Deficit-Hyperactivity.

RSA-R and SCL-R were coded such that baseline levels were subtracted from pertinent levels during the star tracing task. Thus, a positive reactivity number denotes an increase from baseline to the stressor.

[†] $p < .10$,
 * $p < .05$;
 *** $p < .01$.