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Developmental trajectories of skin conductance level in middle childhood: Sex, race, and externalizing behavior problems as predictors of growth

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ABSTRACT

We examined trajectories of skin conductance level (SCL) during baselines and two tasks across middle and late childhood through growth modeling. We also assessed the role of individual differences including child sex, race, and externalizing behavior problems (delinquency, anger, and aggression) in defining these trajectories. At T1, 128 girls and 123 boys (Mean age 8.23 yrs; SD = 0.73) participated; 64% were European–American and 36% were African–American. Families participated in 2nd and 3rd study waves with a one-year lag between each wave. Mothers and children reported on child externalizing problems. Addressing notable gaps in knowledge, findings demonstrate varying trajectories of SCL over time based on the child's behavior problems, race, and sex, and are of importance for a better understanding of developmental psychopathology processes.

Electrodermal activity has been incorporated in numerous studies with the objective of elucidating markers of psychophysiological functioning and children's developmental psychopathology processes. Skin conductance level (SCL) during resting conditions or baselines, SCL responding to stimuli or laboratory challenges and tasks (task SCL), and calculated change or difference scores from baseline levels to task levels are markers of the activity of the sympathetic nervous system (SNS), and have been associated with symptoms of developmental psychopathology. Despite a rapidly increasing knowledge base regarding relations between the SNS and externalizing problems (e.g., Beauchaine et al., 2008; Lorber, 2004), and the development of biopsychosocial models that attempt to explain these relations (Beauchaine, 2001; Raine, 2002), relatively little is known about developmental trajectories of SCL in children. Furthermore, whether and how individual differences shape trajectories of either baseline SCL or task SCL in childhood remain open scientific questions. Our primary study aim was to address these notable gaps in knowledge, by examining the developmental trajectories of baseline SCL and task SCL across middle and late childhood through latent growth modeling. Additionally, we assessed the role of individual differences including child sex, race, and externalizing behavior problems (antisocial behavior, defiance, anger, and aggression) in defining trajectories of growth for baseline SCL and task SCL, and examined whether these characteristics interact to predict different developmental SCL trajectories.

A primary function of the SNS is to facilitate the mobilization of an individual's resources for "fight or flight" behavior and functioning (see Beauchaine, 2001; Boucsein, 1992). Effects of increased SNS activity include pupil dilation and increased sensory acuity to facilitate assessment and engagement with the environment, increased blood pressure and heart rate to facilitate movement, and increased perspiration. Notably, increased sweat gland activity in response to stress is controlled by the SNS (in comparison to the parasympathetic) branch of the autonomic nervous system (ANS). Baseline SCL and task SCL are considered to be valid measures of SNS functioning (Boucsein, 1992).

Several conceptual formulations have posited hypotheses regarding the relation between SNS functioning and externalizing symptoms and their development over time. Fearlessness and sensation seeking have been proposed as two key characteristics linking SNS functioning and externalizing behavior, delinquency, and psychopathy (e.g., Raine, 1993, 2002). Beauchaine (2001) and Beauchaine et al. (2007) integrated elements of the Polyvagal theory (Porges, 2007) and a theory of motivation for approach, avoidance, and inhibition (Gray, 1987a,b; Gray and McNaughton, 2000; McNaughton and Corr, 2004) to construct a more nuanced view of the psychophysiology of developmental psychopathology. Specifically, they hypothesized that externalizing behaviors are related hierarchically to ANS functioning, and that they may be

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predicted by unique patterns of psychophysiological functioning that include low levels of inhibition and low sensitivity to punishment (i.e., a tendency not to avoid punishment through active or passive inhibition). This lack of inhibition and insensitivity to punishment cues is thought to stem from low levels of functioning in the Behavioral Inhibition System (BIS), a hypothetical construct proposed to a key role in inhibiting prepotent behavior (Gray and McNaughton, 2000). Low levels of BIS functioning may translate into aggressive and externalizing problem behavior through the failure to constrain impulses, and failures in instrumental learning that would extinguish behavior under threat of punishment or reward withdrawal. Conversely, inhibited behavior and anxiety are related to high levels of BIS activity as assessed behaviorally (Amodio et al., 2007; Newman et al., 1997) and physiologically via SCL (Fowles et al., 2000; Hofmann and Kim, 2006), though non-significant results have also been found (Arnett and Newman, 2000).

Negative relations between SCL and aggression or externalizing behaviors have been reported in many studies (see Boucsein, 1992; Fowles, 1993; Quay, 1993). For example, aggressive individuals exhibit lower SCL, and findings are particularly robust when comparing SCL differences in individuals with undersocialized aggressive conduct disorder and controls (Quay, 1993). Studies with clinical samples of individuals with externalizing problems (e.g., criminals, psychopaths), conducted mostly with adult and adolescent males, are supportive of a negative association between externalizing problems and baseline SCL cross-sectionally (Gatzke-Kopp et al., 2002) and longitudinally (van Bokhoven et al., 2005). Supporting a specific link between SCL and psychopathy characterizing undersocialized aggression, juvenile delinquent adolescent males high on psychopathy (i.e., callous-unemotional traits) have shown lower SCL reactivity to provocation, regardless of their levels of aggression (Munoz et al., 2008) as well as lower levels of anticipatory SC responding to signaled unpleasant noise burst stimuli (Fung et al., 2005). Similar findings appear to extend to community samples, especially in adults (Sylvers et al., 2008). These findings are consistent with meta-analytic results indicating that externalizing behavior problems, especially psychopathy, are characterized by lower basal SCL and decreased SCL reactivity in adolescents and adults (Lorber, 2004).

Although underarousal across baseline and task SCL has been associated with externalizing problems in many studies with adults and adolescents, the literature has been less consistent with children (Lorber, 2004; Scarpa and Raine, 1997). For example, lower levels of baseline SCL have been reported in clinically diagnosed children with conduct disorder or comorbid conduct disorder and attention deficit hyperactivity (Blair, 1999; Crowell et al., 2006; Herpertz et al., 2005; Snoek et al., 2004; van Goozen et al., 2000). Non-significant or sex dependent results have also been reported (Beauchaine et al., 2008).

It is not clear why the literature linking SCL with externalizing problems is more consistent with adults than children. It is plausible that SCL may develop into a marker of problem aggression or delinquency over time, or aggression and delinquency may become more differentiated and develop into more distinct subtypes as development progresses. In the present study, we address several of these possibilities by examining developmental trajectories of SCL over time as predicted by externalizing problems. In doing so, we use multiple assessments of basal SCL and SCL responses during two laboratory tasks. Furthermore, we examine developmental trajectories of SCL in relation to specific measures of externalizing behavior problems (early delinquency and anger/aggression).

Despite the conceptual and empirical interest in links between SNS functioning and developmental psychopathology processes, relatively little work has charted the development of this system in childhood. Examining continuity, stability, and variability in change are important aspects of understanding a developmental process (Bornstein and Suess, 2000). Furthermore, if SCL functioning is to be used as a correlate and predictor of developmental psychopathology, a better understanding of electrodermal responses in childhood is warranted. Next, we present findings pertinent to stability and continuity of SCL in childhood, and individual and group differences (child sex, race, and behavior problems) associated with SCL.

Basal SCL is moderately to highly stable in adults (see Boucsein, 1992). A few studies have explicitly examined continuity and stability of SCL functioning in childhood. Continuity refers to group level (i.e., mean) change over time while stability refers to consistency in individual rank over time (Bornstein and Suess, 2000). Early work with children aged 6–11 suggests that younger children have higher levels of SCL reactivity than their older counterparts (Janes et al., 1976). A study with 3-year-olds classified children into various groups based on SCL, skin conductance response amplitude, latency, and half recovery time (Venables, 1978). Results indicated that children predominantly fell into the same groups over 18 months. However, there was no clear demonstration of stability in SCL. More recently, El-Sheikh (2007) examined continuity and stability of baseline SCL longitudinally with children aged 9 and 11 years, and found that baseline SCL decreased significantly over the two-year period. Furthermore, in the same study, moderate stability in children's baseline SCL over two years was observed. Other studies comparing children by age group failed to find mean differences in their SCL reactivity (Morrow et al., 1969; Venables and Mitchell, 1996).

Sex-related effects in baseline SCL and SCL reactivity to challenges have been reported. Among children who ranged in age between 7 and 14 years, girls showed greater SCL reactivity than boys, especially during the viewing of emotionally unpleasant pictures (McManis et al., 2001). In a study with 6–13 year-olds, girls had higher baseline SCL than boys, whereas no sex-related effects were reported for SCL reactivity to lab challenges (El-Sheikh, 2007). Generally, the adult literature indicates higher levels of tonic electrodermal activity in women in comparison to men (Boucsein, 1992); disparate findings have also been reported (Venables and Mitchell, 1996).

Racial differences in baseline SCL have long been acknowledged and are thought to be due primarily to the inverse relation between the number of sweat glands and darker skin pigmentation (Boucsein, 1992). For example, European–American (EA) children have higher basal SCL (Gatzke-Kopp et al., 2002) and SCL reactivity than African–American children (AA; Janes et al., 1976; Janes et al., 1978). However, few studies have examined the role of race in the stability, continuity, and trajectories of SCL. In one study, AA children ranging in age between 6 and 13 years exhibited lower levels of SCL reactivity to a star-tracing task and listening to a conflict challenge in comparison to their EA counterparts (El-Sheikh et al., 2007). However, there were no significant differences in baseline SCL based on race in this study. In the same investigation, EA children exhibited lower levels of SCL reactivity at age 9 in comparison to age 11. However, no significant differences in SCL reactivity were evident for AA children over time.

Given the inconsistencies in the literature between SCL and externalizing behaviors with children, we proffered no hypotheses in our assessment of relations between these variables over the course of development. Because SCL tends to decrease with age (El-Sheikh, 2007), we predicted negative slopes of SCL over development. Whether the negative slopes would reflect a steeper decline over development for children higher versus lower in delinquency and anger/aggression was an open scientific question, which we probed. Given sex-related and racial differences in research