Interactive effects of social adversity and respiratory sinus arrhythmia activity on reactive and proactive aggression

WEI ZHANGa AND YU GAOb
aDepartment of Psychology, The Graduate Center, City University of New York, New York, New York, USA
bDepartment of Psychology, Brooklyn College, City University of New York, Brooklyn, New York, USA

Abstract
Abnormal parasympathetic nervous system (PNS)-related cardiac activity has been linked to aggression. However, little is known about how it interacts with psychosocial adversity in predisposing to reactive-proactive aggression. In the current study, 84 male and female college students self-reported reactive and proactive aggression, and were assessed for respiratory sinus arrhythmia (RSA), a measure of PNS-related cardiac activity, during rest and when they contemplated an emotion-evoking decision-making task. Regression analyses showed that (a) resting RSA was positively linked to reactive aggression in conditions of high social adversity, and (b) RSA reactivity was positively associated with reactive but negatively associated with proactive aggression, in conditions of low social adversity. Main effects were not found for psychophysiological functioning or psychosocial adversity, suggesting the importance of their interaction. Findings support a biosocial basis for aggression and add additional support for the distinctions between reactive and proactive aggression.

Descriptors: Respiratory sinus arrhythmia, Social adversity, Aggression

Aggression constitutes a problem of significant clinical and social concern, and increasing evidence suggests that neurobiological mechanisms are important in explaining individual differences in antisocial and aggressive behaviors (Patrick, 2008; Raine, 2002). In order to obtain a more holistic picture of the problem, recent studies have examined the interactions between biological and social variables that affect the risk of antisocial behaviors (Raine, 2002; Wilson & Scarp, 2012). The aim of the current study was to test the hypothesis that parasympathetic nervous system (PNS)-related cardiac activity would interact with social adversity in predisposing to both reactive and proactive types of aggression.

Vagal Activity and Aggression
Vagal tone, as indexed by respiratory sinus arrhythmia (RSA) or high frequency heart rate variability, refers to the influence of PNS on cardiac activity. It reflects the variability of heart rate across the respiration cycle in stable or typical levels of arousal due to the influence of the vagus nerve on the sinoatrial node (Beauchaine, 2001; Grossman, van Beek, & Wientjes, 1990). Higher vagal tone has been posited to relate to a better ability to regulate emotions, focusing of attention, and adaption to the environment (Gyrak & Ayduk, 2008; Marcovitch et al., 2010), whereas lower vagal tone is related to more behavioral problems (Beauchaine, 2001; Porges, Doussard-Rosevelt, & Maiti, 1994). For example, studies have shown that, compared to matched controls, children with externalizing behaviors had lower vagal tone (Beauchaine, Gatzke-Kopp, & Mead, 2007; Calkins & Dedmon, 2000). However, given that vagal tone is negatively associated with resting heart rate, and that lower resting heart rate is robustly related to antisocial behaviors (Ortiz & Raine, 2004), some studies suggested that vagal tone should be positively linked to externalizing behavioral problems (Dietrich et al., 2007; Scarpa, Fikretoglu, & Luscher, 2000). For example, Dietrich et al. (2007) found that 10- to 13-year-old children who had higher vagal tone and lower heart rate exhibited more externalizing problems. It has been argued that a predominance of parasympathetic (i.e., vagal) over sympathetic activity or excessive vagal sensitivity indicates a passive vagal coping response to stress, which in turn may contribute to both low heart rate and more antisocial behaviors (Raine & Venables, 1984; Venables, 1988). Finally, some studies have failed to show a direct link between vagal tone and externalizing behaviors (Calkins, Graziano, & Keane, 2007; El-Sheikh, Harger, & Whitson, 2001; El-Sheikh & Whitson, 2006).

Empirical findings concerning vagal reactivity to challenges in relation to aggression are also mixed. In general, vagal tone is expected to decrease (i.e., vagal suppression) in order to facilitate increases in heart rate in response to the stressors in the
environment (Porges, 1991). This process reflects both the ability to maintain the internal homeostatic balance and the capacity of emotional functioning during self-regulation (Calkins, 1997). Less vagal suppression (i.e., lower vagal reactivity) may reflect inactive engagement and ineffective coping with stressors, and has been linked to a number of psychopathologies defined by emotion dysregulation (Beauchaine, 2001; Porges, 2007) and behavior problems (Boyle et al., 2001; Calkins & Dedmon, 2000; Katz, 2007). For example, Boyle et al. (2001) found that lower vagal reactivity to the laboratory challenge was linked to more externalizing behaviors in a group of 6- and 7-year-old children. Similarly, Calkins and Dedmon (2000) reported that 2-year-old children at the high-risk level of externalizing problems exhibited significantly and consistently lower vagal reactivity during a variety of challenging tasks than the children at low risk. In contrast, some studies have found lower vagal reactivity to be linked to fewer externalizing problems and better behavioral self-regulation (Crowell et al., 2006; Hastings et al., 2008). Finally, many researchers have failed to find significant associations between vagal reactivity and conduct problems, externalizing behavioral problems, or aggression (Beauchaine et al., 2007; Dietrich et al., 2007; Gordis, Feres, Olezeski, Rabkin, & Trickett, 2010).

### Moderating Effect of Psychosocial Factors

The mixed findings of previous research on the relations between vagal activity (including both vagal tone and vagal reactivity to challenges) and aggression may be partly due to the fact that the associations are moderated by social factors, such as family adversity, history of abuse, and maternal rejection (see Raine, 2002, for a review). For example, in a sample of young adults, Scarpa, Romero, Fikretoglu, Bowser, and Wilson (1999) found that vagal tone was positively associated with aggression, but only among those without a history of being victims of violence. Obradovíc, Bush, Stamperdahl, Adler, and Boyle (2010) found that in 5- to 6-year-old children, maladaptive behavior was highest among those who had excessive vagal reactivity and high social adversity. Furthermore, some studies have found that more vagal reactivity, indicating better emotional regulation and coping skills in response to stressors, could protect against maladaptive outcomes from social risk factors including marital conflict and peer rejection in children (El-Sheikh et al., 2001; El-Sheikh & Whitson, 2006; Katz & Gottman, 1995; Whitson & El-Sheikh, 2003). Taken together, evidence suggests that both biological and social factors contribute to the probability of an antisocial outcome, and that it is important to study both factors in order to yield a more comprehensive understanding of aggression.

### Vagal Activity, and Reactive and Proactive Aggression

Another possible reason for the mixed findings regarding the links between vagal activity and aggression may be that there are distinct psychophysiological profiles regarding subtypes of aggressive behaviors. Two subtypes of aggression, reactive and proactive aggression, although highly correlated (e.g., Dodge & Coie, 1987; Raine et al., 2006), tend to have distinctive psychological and physiological correlates. Reactive aggression is characterized by irritable and hostile responses to provocation or frustration, and is linked to anxiety, impulsivity, and abnormality in information processing and emotion dysregulation (Dodge, 1991; Raine et al., 2006; Shields & Cicchetti, 2001). In contrast, proactive aggression is instrumental, predatory, and goal oriented with little evidence of arousal, and is linked to psychopathic personality and serious violence (Dodge, 1991; Raine et al., 2006). Researchers have found reactive aggression to be negatively related to vagal tone (Scarpa, Haden, & Tanaka, 2010; Xu, Raine, Yu, & Krieg, 2014), whereas proactive aggression to be positively associated with vagal tone (Scarpa et al., 2010; van Voorhees & Scarpa, 2002). Lower vagal tone seen in individuals with higher reactive aggression may indicate emotion dysregulation that is associated with trait hostility and anxiety disorders (see Beauchaine et al., 2007), whereas higher vagal tone observed in those with higher proactive aggression may reflect a higher degree of self-regulation and insensitivity to negative emotions (Fabes & Eisenberg, 1997; Scarpa & Raine, 1997).

Relatively little is known about the associations between vagal reactivity and reactive-proactive aggression. Despite the paucity of research on this topic, there are at least two reasons to suspect that proactive and reactive aggression should be negatively and positively, respectively, associated with vagal reactivity. First, theoretical writings have often described reactive aggression as “hot-headed” and proactive aggression as “cold-blooded” (Dodge, 1991). This terminology suggests that reactive but not proactive aggression should be characterized by increased physiological reactivity. Similarly, Scarpa and Raine (1997, 2003) hypothesized that an overaroused autonomous nervous system was linked to reactive aggression, whereas autonomic underarousal was linked to proactive aggression. Consistent with this proposition, research has indicated that proactive aggression was associated with reduced skin conductance responses to conditioned punishment (Bobadilla, Wampler, & Taylor, 2012; Gao, Tuvblad, Schell, Baker, & Raine, 2015), whereas reactive aggression was linked to increased heart rate reactivity during a provocation (Pitts, 1997) and higher skin conductance reactivity in response to a frustration challenge (Hubbard et al., 2002). It is therefore conceivable that proactive and reactive aggression would be differentially associated with vagal reactivity. Second, research has linked proactive rather than reactive aggression with psychopathic traits (Cima & Raine, 2009; Frick, Cornell, Barry, Bodin, & Dane, 2003; Raine et al., 2006). Since individuals with psychopathic traits lack guilt and empathy, and since lower vagal reactivity has been associated with lower empathetic concern and lower levels of helping behavior (Gill & Calkins, 2003; Liew et al., 2011), it is predicted that proactive (but not reactive) aggression would be negatively associated with vagal reactivity.

### Current Study

The primary objective of this study was to determine whether there is a biosocial interaction for aggression, by examining the moderating roles of social adversity in the relationships between vagal activity and both reactive and proactive aggression. To our knowledge, to date only two studies have examined the vagal activity biosocial interaction in relation to these two subtypes of aggression. In a group of 7- to 13-year-old children, Scarpa, Tanaka, and Haden (2008) found that community violence exposure was related to higher reactive aggression only in those with higher vagal tone. Murray-Close and Rellini (2012) found that proactive relational aggression was negatively associated with vagal reactivity to a stress interview in women with a sexual abuse history. However, no research has examined the biosocial interaction effects on the two subtypes of aggression using both vagal tone and vagal reactivity.

This study seeks to address this research gap in a group of male and female college students. Based on theories and prior literature,
it was hypothesized that (a) reactive and proactive aggression would be negatively and positively, respectively, associated with resting RSA; and (b) reactive aggression would be positively associated with RSA reactivity, whereas proactive aggression would be negatively linked to RSA reactivity in an emotion-provoking decision-making task. Given that relatively little is known about the nature of the vagal activity biosocial interaction effect in relation to reactive-proactive aggression, we explored the moderating effect of social adversity on the above associations.

Method

Participants

Eighty-four undergraduate students (27 males and 57 females; mean age = 21.85 years, SD = 6.67) from an urban college participated for course research credit. The ethnicity breakdown of the sample was as follows: Caucasians 34%, Black 20%, Hispanic 10%, Asian 26%, and mixed/other 10%. Participants were tested individually in a research laboratory. After providing informed consent, each participant responded to 15 dilemmas (see below for details) while their psychophysiological activities were recorded. They were then asked to complete a series of self-report questionnaires including demographic information and reactive and proactive aggression. This study was approved by the university’s Institutional Review Board.

Measures

Reactive and proactive aggression. The Reactive-Proactive Aggression Questionnaire (RPQ; Raine et al., 2006) was used to assess the two types of aggression. RPQ includes 11 items assessing reactive aggression (e.g., “Yelled at others when they have annoyed you”) and 12 items assessing proactive aggression (e.g., “Had fights with others to show who was on top”). For each item, participants rated the frequency of occurrence on a scale of 0 (never), 1 (sometimes), or 2 (often). Scores for each subscale were calculated by summing the scores across items, with higher scores indicating higher levels of reactive aggression (possible range is 0 to 22) or proactive aggression (possible range is 0 to 24). Previous studies have documented that the two subtypes of aggression are positively correlated, with the correlation coefficient ranging from .67 to .83 (Dodge & Coie, 1987; Poulin & Boivin, 2000; Price & Dodge, 1989; Raine et al., 2006). Consistent with prior literature, reactive aggression was significantly associated with proactive aggression (r = .49, p < .001) for reactive aggression: M = 9.50, SD = 4.03, range = 0–21; for proactive aggression: M = 2.30, SD = 1.90, range = 0–7) in our sample. The internal reliability was .78 and .71 for reactive and proactive aggression, respectively.

Social adversity. Following prior literature (Fung, Raine, & Gao, 2009; Gao, Raine, Chan, Venables, & Mednick, 2010; Raine, Yaral- lian, Reynolds, Venables, & Mednick, 2002), a social adversity score (i.e., a multiple environmental risk score, Sameroff, Seifer, Baldwin, & Baldwin, 1993) was created by adding one point for each of the following 10 variables: divorced parents (single parent family, remarriage, or living with guardians other than parents), foster home, public housing, welfare food stamps, parent ever arrested (either parent has been arrested at least once), parents physically ill, parents mentally ill, crowded home (five or more family members per house bedroom), teenager mother (aged 19 years or younger when child was born), and large family (having five or more siblings by age 3 years). All items were scored either 0 (no) or 1 (yes), with a higher total score indicating higher social adversity. In the current sample, the mean of the social adversity index was 1.68 (SD = 1.39, range = 0–5) and the median was 1.0.

Psychophysiological Data Acquisition and Reduction

All electrocardiogram and respiration data were collected continuously at 1000 Hz using a Biopac system (MP150-BIOPAC Systems Inc., Goleta, CA) during a 2-min rest (Rest 1), an approximately 15-min decision-making task (see below for details), and a final 2-min rest period at the end (Rest 2). During both rest periods, participants were asked to sit still and relax. Electrocardiogram was recorded using ECG100C amplifier with two prejelled Ag-AgCl disposable vinyl electrodes placed at a modified Lead II configuration. Respiration was assessed using RSP100C amplifier by putting a respiration belt around the abdomen of the subject at the point of complete exhalation.

Decision-making task. A total of 15 dilemmas (five neutral, five moral-impersonal, and five moral-personal scenarios) selected from a previously published set (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Koenigs et al., 2007) were presented in a random order. Neutral dilemmas involved no harm, and a typical neutral/nonmoral dilemma posed questions such as whether or not to travel by bus or by train under certain time constraints. Impersonal moral dilemmas involved less emotional violation or committed no direct harm, and a typical impersonal moral dilemma asked questions such as whether to flip a switch to let noxious fumes flow from a room with three people into a room with one person. Personal moral dilemmas involved strong emotional violation and direct harm, and questions included killing an injured crew member to save other members’ life, or bringing one’s own child to a fatal experiment to avoid having all children die. Each dilemma was individually presented on a computer screen for 45 s, and then a question was presented in the form of “Would you . . . ?” or “Would you . . . ?” Participants had no time limit to answer “yes” or “no” to the hypothetical questions by pressing one of the two buttons on the response pad (mean response time = 7.31 s, SD = 3.92 s). The next dilemma was then presented 15 s after the response. For more details about the task, see Gao and Tang (2013).

Psychophysiological measures. All physiological data were analyzed offline with AcqKnowledge 4.2 software (BIOPAC Inc.). RSA was derived from the ECG100C amplifier with a band-pass filter of 35 Hz and 1.0 Hz and the RSP100C respiration amplifier with a band-pass filter of 1.0 Hz and 0.05 Hz. Recorded electrocardiogram signal was visually inspected for artifacts, and then converted to R-R intervals using the AcqKnowledge automated modified Pan-Tompkins QRS detector. The AcqKnowledge automated function for RSA analysis was utilized. This software followed the well-validated peak-valley method (Grossman et al., 1990), in which RSA was computed in milliseconds as the difference between the minimum and the maximum R-R intervals during respiration. Higher values reflect greater vagal activity while lower values indicate lower vagal activity (Gruber, Harvey, & Johnson, 2009).

Resting RSA was computed as the average RSA values during the last minute of the two rest periods. To calculate RSA reactivity, RSA activity was first derived during the 45-s period when each dilemma was presented on the monitor, and raw RSA values during neutral, impersonal moral, and personal moral dilemmas were
averaged across the five dilemmas within each category. The internal reliability of raw RSA values for these three types of dilemmas was .92, .93, and .94, respectively (.97 for the 10 moral dilemmas combined). RSA reactivity measures were then computed as the residual scores by regressing the RSA values during impersonal or personal moral dilemmas on those for the neutral dilemmas. Standardized residual scores were used in the current study given that they have been suggested to provide more meaningful information about whether an individual’s reactivity is higher or lower than the predicted value established by a particular sample’s regression line and the baseline value (Burt & Obradović, 2013; Obradović et al., 2010). In addition, using RSA activity during neutral dilemmas as a task-specific baseline could control for the task demands that are not of interest to the current study (Burt & Obradović, 2013; Bush, Alkon, Obradović, Stamperdahl, & Boyce, 2011). Higher RSA reactivity, indexed by negative residual values, meant greater vagal suppression during the moral challenges than was expected based on the sample’s regression line and the neutral baseline value. Lower RSA reactivity, indexed by positive residual values, corresponded to less vagal suppression or even RSA augmentation to the moral challenges than expected. RSA reactivity to impersonal and personal moral dilemmas was combined in the following analyses, since the two types did not produce different results.

Statistical Analyses

Independent samples t tests were conducted to compare males and females on psychophysiological and psychosocial variables. Hierarchical multiple regression analyses were conducted, and all variables were standardized before the analyses. The same set of analyses was conducted for reactive and proactive aggression separately. In each regression model, the nonfocal form of aggression was entered in the first step to control for its effect. In the second step, main effects of resting RSA, RSA reactivity, and social adversity were tested for their status as risk factors. In the third step, the interaction terms (i.e., Resting RSA × RSA Reactivity, Resting RSA × Social Adversity, and RSA Reactivity × Social Adversity) were entered.

Table 1. Correlations Among Study Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reactive aggression</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>2. Proactive aggression*</td>
<td>.49**</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>3. Resting RSA</td>
<td>.27*</td>
<td>.24*</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4. RSA-neutral</td>
<td>.24*</td>
<td>.20</td>
<td>.88**</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5. RSA-moral</td>
<td>.21</td>
<td>.19</td>
<td>.88**</td>
<td>.96**</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6. RSA reactivity</td>
<td>−.09</td>
<td>−.01</td>
<td>.11</td>
<td>.01</td>
<td>.28*</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>7. Social adversity*</td>
<td>.13</td>
<td>.07</td>
<td>.01</td>
<td>.05</td>
<td>.02</td>
<td>−.08</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>9.50</td>
<td>1.74</td>
<td>74.75</td>
<td>78.37</td>
<td>77.00</td>
<td>0.00</td>
<td>1.58</td>
</tr>
<tr>
<td>SD</td>
<td>4.03</td>
<td>0.53</td>
<td>30.90</td>
<td>32.51</td>
<td>30.70</td>
<td>1.00</td>
<td>0.42</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.25</td>
<td>0.15</td>
<td>0.44</td>
<td>0.53</td>
<td>0.45</td>
<td>0.10</td>
<td>0.26</td>
</tr>
</tbody>
</table>

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

Vagal Activity, Aggression, and Social Adversity

Reactive aggression. Collinearity diagnostic tests were first conducted to ensure that our regression analyses were not affected by multicollinearity (i.e., tolerance > .10 and variance inflation factor < 10; Tabachnick & Fidell, 2013). In our sample, tolerance values were larger than 0.72, and the variance inflation factors were found to be well within the acceptable range (< 1.39), indicating that all predictors could be simultaneously entered into the regression models. We also examined the residuals scatter plots to ensure that the assumption of linearity and normality were not violated for all the regression models (Tabachnick & Fidell, 2013).

Results of hierarchical regression analyses are summarized in Table 2. In Step 1, proactive aggression was significantly linked to reactive aggression ($β = .47, SE = .09, t = 4.94, p < .001$). After controlling for proactive aggression, no significant main effects were observed for resting RSA ($β = .12, SE = .10, t = 1.26, p = .214$), RSA reactivity ($β = −.06, SE = .10, t = −.54, p = .589$), or social adversity ($β = .14, SE = .09, t = 1.47, p = .147$). In Step 3, both the resting RSA × Social Adversity interaction ($β = .28, SE = .10, t = 3.00, p = .004$) and the RSA Reactivity × Social Adversity interaction ($β = .33, SE = .08, t = 3.43, p = .001$) were significant, but the interaction between resting RSA and RSA reactivity was nonsignificant ($β = −.11, SE = .08, t = −1.02, p = .310$). The overall regression model was significant, F(7,71) = 6.98, p < .001.

To further probe the significant two-way interactions, these effects were broken down by examining the effects of RSA measures on reactive aggression at high (+1 SD) and low (−1 SD) levels of social adversity (Aiken & West, 1991). Resting RSA was positively associated with reactive aggression at high ($β = .36, SE = .15, t = 2.38, p = .020$) but not low levels of social adversity ($β = −.19, SE = .14, t = −1.34, p = .186$, see Figure 1). Finally, higher RSA reactivity (indexed by negative residual values) was...
associated with higher reactive aggression at low (β = −.39, SE = .14, t = −2.69, p = .010) but not high levels of adversity (β = .11, SE = .09, t = 1.17, p = .247, see Figure 2).

Proactive aggression. After controlling for reactive aggression, no significant main effects were observed for resting RSA (β = −.12, SE = .11, t = 1.18, p = .243), RSA reactivity (β = −.08, SE = .12, t = −.98, p = .337), or social adversity (β = −.02, SE = .10, t = −.18, p = .862). In Step 3, the interactions between resting RSA and RSA reactivity (β = .16, SE = .09, t = 1.40, p = .166) and between resting RSA and social adversity (β = −.12, SE = .12, t = −1.16, p = .249) were nonsignificant. However, the interaction between RSA reactivity and social adversity was significant (β = −.24, SE = .10, t = −2.25, p = .027). The overall regression model was significant, F(7,71) = 4.81, p < .001.

Analysis of the simple effects of RSA reactivity on proactive aggression showed that lower RSA reactivity (indexed by positive residual values) was associated with higher proactive aggression at low (β = .32, SE = .15, t = 2.13, p = .036) but not high levels of social adversity (β = −.13, SE = .12, t = −1.03, p = .305). This interaction effect is illustrated in Figure 3.

Finally, regression analyses were conducted for aggression scores without controlling for the nonfocal aggression. Resting RSA was positively associated with both reactive and proactive aggression (for reactive aggression, β = .24, SE = .11, t = 2.23, p = .029; for proactive aggression, β = .26, SE = .12, t = 2.19, p = .032). No significant main effect was found for RSA reactivity when predicting reactive or proactive aggression. The interaction between resting RSA and social adversity was significant for reactive aggression (β = .30, SE = .11, t = 2.79, p = .007), with higher resting RSA linked to higher reactive aggression in the condition of high social adversity only (β = .50, SE = .16, t = 3.01, p = .004). The interaction between RSA reactivity and social adversity was also significant in predicting reactive aggression (β = .29, SE = .10, t = 2.62, p = .011), although follow-up analyses of the simple effects failed to find significant associations between RSA reactivity and reactive aggression at either high or low levels of social adversity.

Discussion

The primary goal of this study was to examine the PNS-related cardiac activity (e.g., RSA) biosocial interaction effect on reactive and proactive aggression. Findings support the biosocial perspective of aggression, and provide further support for a differentiation between reactive and proactive aggression.

We hypothesized that reactive and proactive aggression would be positively and negatively, respectively, associated with RSA reactivity. Our findings are generally consistent with this hypothesis, with one important notion that these associations were found significant only at low levels of social adversity. These findings support the “social push” theory (Raine, 2002) that biological risk factors are more important in explaining antisocial behaviors where individuals lack the social risk factors that predispose them to the
sensitivity theory that an excess of vagal sensitivity leads to

Xu et al. (2014) found that higher vagal tone was associated

sion (Raine, Fung, Portnoy, Choy, & Spring, 2014). Similarly,

adversity in predicting higher reactive but not proactive aggres-

higher reactive, but not proac tive, aggression in children. A

and witnessing community violence were associated with

for example, Scarpa et al. (2008) found that higher vagal tone

result is partly consistent with some prior studies, which sug-

ory was negatively related to proactive relational aggression

autonomic nervous system reactivity (indexed by diastolic

vagal reactivity and proactive aggression are differentially associated with resting RSA

The findings of different associations between RSA reactivity

The two subtypes of aggression are in line with the prior study

Consequently, the negative association between vagal reactivity and proactive aggres-

may reflect a lack of concern for others when individuals con-

Proactive rather than reactive aggression is more strongly related to psychopathic personality, which is charac-

characterized by impaired moral socialization and conscience development (e.g., Blair, 2004; Frick & Morris, 2004). Consequently, the negative association between vagal reactivity and proactive aggression may reflect a lack of concern for others when individuals contemplate the moral dilemmas in the decision-making task. In contrast, higher reactive aggression may be characterized by a higher level of concern as reflected by excessive vagal reactivity. Taken together, our findings provide further evidence that reactive aggression (characterized by irritable and hostile response to provocation or frustration) is characterized by autonomic hyperarousal, whereas proactive aggression (instrumental, predatory, and goal-oriented) is characterized by underaroused PNS-related cardiac reactivity to challenges, especially in individuals from benign home backgrounds.

It was hypothesized that resting RSA would be negatively related to reactive aggression but positively related to proactive aggression. However, we found that resting RSA was positively associated with reactive aggression, and this association was only significant in conditions of high social adversity. This result is partly consistent with some prior studies, which suggest that PNS activity may be positively associated with disinhibited temperament (e.g., Kagan, 1989; Scarpa et al., 2008). For example, Scarpa et al. (2008) found that higher vagal tone and witnessing community violence were associated with higher reactive, but not proactive, aggression in children. A recent study showed that lower resting heart rate (usually associated with high resting RSA) interacted with higher social adversity in predicting higher reactive but not proactive aggression (Raine, Fung, Portnoy, Choy, & Spring, 2014). Similarly, Xu et al. (2014) found that higher vagal tone was associated with both lower heart rate and higher reactive aggression. Together with our data, these findings support the vagal sensitivity theory that an excess of vagal sensitivity leads to

antisocial behaviors. That is, when the influence of social adversity on the antisocial behavior is minimized, the links between biological risks and antisocial behavior can shine through (Raine, 2002).

The findings of different associations between RSA reactivity and the two subtypes of aggression are in line with the prior study by Murray-Close and Rellini (2012), who found that vagal reactivity was negatively related to proactive relational aggression whereas autonomic nervous system reactivity (indexed by diastolic blood pressure reactivity) was positively associated with reactive relational aggression. Proactive rather than reactive aggression is more strongly related to psychopathic personality, which is characterized by impaired moral socialization and conscience development (e.g., Blair, 2004; Frick & Morris, 2004). Consequently, the negative association between vagal reactivity and proactive aggression may reflect a lack of concern for others when individuals contemplate the moral dilemmas in the decision-making task. In contrast, higher reactive aggression may be characterized by a higher level of concern as reflected by excessive vagal reactivity. Taken together, our findings provide further evidence that reactive aggression (characterized by irritable and hostile response to provocation or frustration) is characterized by autonomic hyperarousal, whereas proactive aggression (instrumental, predatory, and goal-oriented) is characterized by underaroused PNS-related cardiac reactivity to challenges, especially in individuals from benign home backgrounds.

It was hypothesized that resting RSA would be negatively related to reactive aggression but positively related to proactive aggression. However, we found that resting RSA was positively associated with reactive aggression, and this association was only significant in conditions of high social adversity. This result is partly consistent with some prior studies, which suggest that PNS activity may be positively associated with disinhibited temperament (e.g., Kagan, 1989; Scarpa et al., 2008). For example, Scarpa et al. (2008) found that higher vagal tone and witnessing community violence were associated with higher reactive, but not proactive, aggression in children. A recent study showed that lower resting heart rate (usually associated with high resting RSA) interacted with higher social adversity in predicting higher reactive but not proactive aggression (Raine, Fung, Portnoy, Choy, & Spring, 2014). Similarly, Xu et al. (2014) found that higher vagal tone was associated with both lower heart rate and higher reactive aggression. Together with our data, these findings support the vagal sensitivity theory that an excess of vagal sensitivity leads to

low resting heart rate and reactive aggression in particular (Raine & Venables, 1984).

Initial correlational analyses showed that resting RSA was positively associated with both types of aggression. This is not surprising given that reactive and proactive aggression were highly correlated. This finding is also consistent with some prior studies (Dietrich et al., 2007; Scarpa et al., 2000), suggesting that excessive vagal activity may be associated with externalizing behavior regardless of subtypes of aggression (Raine & Venables, 1984; Venables, 1988). However, in the hierarchical regression analyses after the nonfocal aggression was controlled for, the resting RSA – aggression associations were no longer significant (see Table 2). Instead, both types of aggression were better accounted for by the biosocial interaction effects. These findings provide additional support for the notion that reactive and proactive aggression are related but different constructs, and contribute to the growing body of research documenting that vagal activity interacts with psychosocial factors in predicting antisocial behaviors (e.g., El-Sheikh et al., 2001; Murray-Close & Rellini, 2012).

It has been argued that there are meaningful differences in vagal reactivity for different types of tasks (Graziano & Derefinko, 2013) and that the type of task may moderate the relations between vagal reactivity and behavioral outcomes. For example, in children living in the context of high marital conflict, more externalizing behavior was associated with excessive vagal reactivity to a cognitive task, but with less vagal reactivity to an interpersonal task (Obрадовић, Bush, & Boyce, 2011). In the current study, participants were asked to answer questions related to hypothetical dilemmas in which both cognitive and emotional processes are involved. It has been argued that, when contemplating these moral dilemmas, the negative social-emotional response associated with the thought of killing someone competes with a more abstract, “cognitive” understanding that, in terms of lives saved/lost, one has nothing to lose (relative to the alternative) and much to gain by carrying out the horrific act (Greene, Nystrom, Engell, Darley, & Cohen, 2004). Brain imaging studies have supported this proposition by showing the engagement of brain areas associated with emotion and social cognition (including medial prefrontal cortex, posterior cingulate, and superior temporal sulcus/temperoparietal junction; Greene & Haidt, 2002; Greene et al., 2001) and abstract reasoning and cognitive control (including dorsolateral prefrontal cortex and anterior cingulate cortex; Greene et al., 2004) in these difficult moral dilemmas. RSA reactivity in response to these dilemmas may capture individual differences in the capacity to engage in situationally appropriate regulation of affect, which is necessary to facilitate utilitarian judgment (i.e., to maximize aggregate welfare; Haidt, 2001). It remains to be determined if the biosocial interactions seen in the current study can be observed in response to interpersonal or cognitive tasks.

Several limitations of the current study should be noted. First, sample size was modest. Nonetheless, both male and female participants were included, and the potential effect of sex was examined. Second, the aggression and social adversity measures were limited to self-report. Third, this is a cross-sectional study so a conclusion on the causal relationships cannot be drawn. A prospective longitudinal design including a larger sample size and multi-informant measures of aggressive behavior and social background should be considered in future studies to obtain a full picture of their relations.

In conclusion, findings from this study show that reactive and proactive aggression are differentially associated with resting RSA.
and RSA reactivity to an emotion-provoking decision-making task, and that the associations are moderated by social adversity. Findings highlight the importance of examining both PNS-related cardiac activity and social factors in understanding aggressive behavior, and provide further support for the distinctive etiology involved in reactive and proactive aggression.

References


*(Received May 17, 2014; Accepted June 15, 2015)*
This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.