Low Resting Heart Rate and Antisocial Behavior: A Brief Review of Evidence and Preliminary Results From a New Test
Todd A. Armstrong, Shawn Keller, Travis W. Franklin and Scott N. Macmillan
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LOW RESTING HEART RATE AND ANTISOCIAL BEHAVIOR

A Brief Review of Evidence and Preliminary Results From a New Test

TODD A. ARMSTRONG
SHAWN KELLER
TRAVIS W. FRANKLIN
SCOTT N. MACMILLAN

Sam Houston State University

Despite a large body of research demonstrating a clear and consistent relationship between resting heart rate and antisocial behavior, little is understood about the relative influence on antisocial behavior of resting heart rate and other constructs central to criminological theories. Here, the authors offer an initial effort to bridge this gap in the literature by testing the relationship between resting heart rate and a measure of antisocial behavior net of attachment to parents, self-control, peer delinquency, and potential physiological confounds. Results from ANOVA show that those with low resting heart rates have significantly higher rates of severe antisocial behavior and aggressive antisocial behavior net of physiological confounds. Results from multivariate regression models show that low resting heart rate has a statistically significant relationship with severe antisocial behavior and aggressive behavior in models controlling for attachment to parents, self-control, peer delinquency, and physiological confounds.

Keywords: heart rate; crime; delinquency

Recently, scholars within the field of criminology have issued a call for increased attention to the biological causes and correlates of crime, delinquency, and other antisocial behaviors (DeLisi, Wright, Vaughn, & Beaver, 2009; Wright et al., 2008). Here, we begin an effort to answer that call with preliminary results from a test of the relationship between low resting heart rate and antisocial behavior. These results are based on a sample of undergraduate students from an introductory criminology course. In the near future, we will extend our data collection efforts to incarcerated offenders. This expanded data collection will include both self-report and official measures of crime and delinquency.

Our broader data collection efforts are intended to gather information that will contribute to our understanding of the neuroanatomical correlates of crime, including resting heart rate. Here, we are interested in the extent to which the relationship between low resting heart rate and antisocial behavior is mediated by the correlates of crime that play an important role in criminological theory. Earlier work has found that resting heart rate predicted...
convictions for violence despite controls for impulsivity, employment, physical characteristics, parent criminality, and IQ (Farrington, 1997); other work has found resting heart rate distinguished offenders incarcerated in the California Youth Authority (CYA) from high school students net of controls for demographic characteristics, parental education, frontal lobe functioning, and future orientation (Cauffman, Steinberg, & Piquero, 2005).

In the preliminary results presented here, we first assess the relationship between resting heart rate and different measures of antisocial behavior among our sample of undergraduate students. We then explore the extent to which the relationship between low resting heart rate and antisocial behavior is mediated by measures of constructs that play a central role in traditional criminological theories. Our analysis extends the literature by incorporating measures of attachment to parents, self-control, and peers’ delinquency.

RESTING HEART RATE AND ANTISOCIAL BEHAVIOR

There is substantial literature linking resting heart rate and antisocial behavior. On the basis of a meta-analysis of 45 independent effect sizes from 40 studies, Ortiz and Raine (2004) concluded that “low resting heart rate appears to be the best-replicated biological correlate to date of antisocial and aggressive behavior in children and adolescents” (p. 154). The average effect size in the Ortiz and Raine meta-analysis was .44. In earlier work, Raine (1996) found that studies relying on noninstitutionalized and nonpsychopathic populations yielded an average effect size of .85. According to the guidelines developed by Cohen (1988), an average effect size of .44 would be regarded as moderate, and .85 would be classified as large.

In a recent discussion of the literature on the relationship between autonomic arousal and the development of aggressive and antisocial behavior, Raine (2002) concludes that (a) the relationship between low resting heart rate and aggressive and antisocial behavior is not artifactual (i.e., a function of height, weight, physical development) and (b) low resting heart rate is an independent predictor of violence. He also notes that the relationship between low resting heart rate and aggressive and antisocial behavior has been confirmed in prospective designs (Rutter, Giller, & Hagell, 1998, p. 161). The robust nature of the low resting heart rate–antisocial behavior relationship is further underscored by the Ortiz and Raine (2004) meta-analysis referenced earlier. This meta-analysis found that both the characteristics of the individuals in the studies and the methodological characteristics of the studies included in the analysis failed to moderate the relationship between low resting heart rate and antisocial behavior.

Research has found that low resting heart rate is associated with a number of different measures of antisocial behavior. These measures include clinical diagnoses of different types of antisocial behavior, including conduct disorder, oppositional defiant disorder, and disruptive behavior disorder (Maliphant, Hume, & Furnham, 1990; van Goozen et al., 1998; van Goozen, Mattys, Cohen-Kettenis, Buitelaar, & van Engeland, 2000). Studies have also used observational measures of aggression and antisocial behavior (Kindlon et al., 1995; Rogeness, Cepeda, Macedo, Fischer, & Harris, 1990; Slobodskaya, Roifman, & Krivoschekov, 1999; Zahn-Waxler, Cole, Welsh, & Fox, 1995), self-report measures of aggression and antisocial behavior (Scarpa & Ollendick, 2003), and actuarial measures of aggression and antisocial behavior based on commonly used psychological assessments,
such as the Child Behavior Checklist (Raine, Venables, & Mednick, 1997). Other work has used official measures of crime, including convictions for serious offenses (Raine, Venables, & Willams, 1990, 1995), convictions for violence (Farrington, 1997), and officially recorded delinquency (Wadsworth, 1976). Although the overwhelming majority of published studies finds evidence for the relationship between resting heart rate and antisocial behavior, some studies have failed to find such a relationship (Pine et al., 1998; Van Hulle, Corley, Zahn-Waxler, Kagan, & Hewitt, 2000).

EXPLAINING THE RELATIONSHIP BETWEEN RESTING HEART RATE AND ANTISOCIAL BEHAVIOR

Early speculation on the nature of the relationship between resting heart rate and antisocial behavior focused on dispositional traits that coexist with resting heart rate (Raine, 2002). These traits include fearlessness and sensation seeking. The sensation-seeking explanation of the relationship between low resting heart rate and antisocial behavior assumes that the low levels of arousal indicated by a low resting heart rate are an unpleasant psychological state. To increase arousal levels, individuals seek out stimulating activities, such as antisocial behavior (Eysenck, 1997; Quay, 1965; Raine, Reynolds, Venables, & Mednick, 1997). This speculation finds indirect support in research showing that low resting heart rate is related to stimulation seeking at 3 years of age and aggressive behavior at age 11 (Raine, Venables, et al., 1997; Scarpa, Raine, Venables, & Mednick, 1997).

The possibility that the link between low resting heart rate and antisocial behavior is explained by fearlessness is based on the suggestion that those with low resting heart rates are less fearful and therefore experience antisocial behavior differently. Fearlessness, as an explanation of the relationship between low resting heart rate and antisocial behavior, receives support from studies finding that low resting heart rate is related to fearlessness and a lack of behavioral inhibition during childhood (Kagan, 1994; Scarpa, Raine, Venables, & Mednick, 1997). Other work has shown that individuals in extremely risky occupations, including bomb disposal experts and those who have been decorated for bravery in war, have particularly low resting heart rates (Cox, Hallam, O’Connor, & Rachman, 1983; O’Connor, Hallam, & Rachman, 1985).

Recently, Raine (2002) suggested that the relationship between low resting heart rate and antisocial behavior may be related to reduced functioning in the right hemisphere of the brain. Raine’s (2002) suggestion is consistent with contemporary explanations of variability in heart rate function. These explanations describe heart rate, and other measures of cardiac activity, as a function of an integrated system with direct effects through the parasympathetic and sympathetic nervous systems and indirect effects from distinct anatomical structures in the brain, including the amygdala, prefrontal cortex, cingulate cortex, and hypothalamus (Critchley et al., 2003; Foster, Drago, Ferguson, & Harrison, 2008; Lane et al., 2009; Porges, 2007; Thayer et al., 2009; Thayer & Lane, 2000).

Many of the anatomical structures implicated in the control of heart rate are also related to variation in violent and antisocial behavior. For example, reviews of brain imaging research and recent studies find that violent offenders, and those prone to aggression, show global dysfunction in the prefrontal cortex and specific dysfunction in anatomical structures within the prefrontal cortex, including the orbitofrontal cortex and the dorsolateral prefrontal cortex (Brower & Price, 2001; Bufkin & Luttrell, 2005; Glenn & Raine, 2008;
Raine & Yang, 2006; Volavka, 1999; Yang et al., 2005). Substantial research also suggests that the amygdala alone, and in conjunction with the orbitofrontal cortex, plays an important role in the explanation of aggression, violence, and psychopathy (Blair, 2004, 2008; Coccaro, McCloskey, Fitzgerald, & Phan, 2007; Davidson, Putnam, & Larson, 2000; Glenn & Raine, 2008; Kiehl, 2006; Lee, Chan, & Raine, 2008; Marsh et al., 2008; Raine & Yang, 2006).

Given that heart rate is the output of a complex system, it seems reasonable to suggest that dysfunction in the parts of this system may result in both abnormal heart rate and antisocial behavior. However, structures within the right hemisphere may be particularly important for an understanding of the low resting heart rate–antisocial behavior relationship (Raine, 2002). The right hemisphere is the dominant hemisphere for the control of heart rate, and decreased right hemisphere functioning is associated with decreased heart rate (Ahern et al., 2001; Oppenheimer, 2006; Yokoyama, Jennings, Ackles, Hood, & Boller, 1987; Zamrini et al., 1990).

Beyond its influence on heart rate, the right hemisphere also appears to have a particularly strong relationship with aggressive and violent behavior (Day & Wong, 1996; Drake, Pakalnis, Brown, & Hietter, 1988; Evans & Park, 1997; George et al., 2004; Hucker et al., 1988; Kiehl et al., 2004; Narayan et al., 2007; Raine et al., 2001). Right hemisphere dysfunction is also linked to impulsivity, aggression, and violence among men with schizophrenia (Hoptman et al., 2002, 2005; Kumari et al., 2006). There is also some suggestion that the relationship between hemispheric dysfunction and behavior may be gendered. Research has shown that unilateral right hemisphere damage tends to result in more severe emotional and behavioral impairments in males, whereas unilateral left hemisphere damage appears to be more important in females (Anderson, Barrash, Bechara, & Tranel, 2006; Tranel, Bechara, & Denburg, 2002; Tranel, Damasio, Denburg, & Bechara, 2005). Similarly, the volume of the right anterior cingulated cortex is correlated with aggression and defiance in boys but not in girls (Boes, Tranel, Anderson, & Nopoulos, 2008).

HEART RATE, ANTISOCIAL BEHAVIOR, AND OTHER CORRELATES OF CRIME

Tests of the relationship between resting heart rate and antisocial behavior typically create groups based on antisocial behavior. Authors then use ANOVA to compare the mean resting heart rate of the two groups (Kindlon et al., 1995; Maliphant et al., 1990; Maliphant, Watkins, & Davies, 2003; Moffitt & Caspi, 2001; Raine et al., 1990; Raine, Venables, et al., 1997; Slobodskaya et al., 1999; van Goozen, et al., 1998, 2000; Wadsworth, 1976; Zahn-Waxler et al., 1995). Studies of this nature are often sensitive to the possibility that the relationship between low resting heart rate and antisocial behavior is partly explained by confounding variables, including, height, weight, gender, and race. In many studies, these variables, and others, are included in ANCOVAs, with groups defined according to antisocial behavior showing statistically significant differences in heart rate despite the inclusion of controls for these potential confounds.

Raine, Reynolds, et al. (1997) reviewed the limited research exploring the influence of socioeconomic status on the relationship between low resting heart rate and antisocial behavior and found that the relationship between resting heart rate and antisocial behavior is stronger in areas of high socioeconomic status (SES). This phenomenon is described as the “benign homes effect,” whereby in low-SES areas, the relationship between low resting heart rate and antisocial behavior may be overwhelmed by the influence of environmental
factors that are predictive of crime and delinquency. In contrast, the relationship between resting heart rate and antisocial behavior is clarified when environmental influences support conforming behavior. It is worthwhile to note that evidence on the benign homes effect is inconsistent. Farrington (1997) finds that the association between resting heart rate and teacher ratings of aggressive behavior is stronger among boys from low-SES families.

Isolated studies have used multivariate regression to test the relationship between low resting heart rate and criminality. These are particularly important for the current work, as they include variables measuring constructs that play a major role in contemporary criminological theories. Farrington (1997) found that low resting heart rate at age 18 was predictive of a conviction for violence before the age of 25, while controlling for a number of characteristics, including impulsivity, employment, physical characteristics, parent criminality, and IQ. Cauffman et al. (2005) used logistic regression to assess the characteristics that distinguished a group of offenders incarcerated in the CYA from a group of high school students in northern California. Low resting heart rate predicted membership in the CYA group net of demographic characteristics, parental education, frontal lobe functioning, and future orientation.

SUMMARY AND THE CURRENT STUDY

In sum, the relationship between low resting heart rate and criminality is not entirely mediated by measures of other causes and correlates of crime. However, the extent to which the low resting heart rate–antisocial behavior relationship is influenced by other variables important to criminological theory bears further exploration. Absent from the tests discussed earlier are constructs central to criminological theories that are demonstrably related to crime. In the current work, we extend research on the relationship between resting heart rate and antisocial behavior by testing this relationship while accounting for potential physiological confounds and the influence of attachment to school, self-control, and delinquent peers. In our analysis, we first test differences in self-reported antisocial behavior across groups defined by resting heart rate. Next, we use multivariate regression models to test the relationship between low resting heart rate and our self-report measure of antisocial behavior while controlling for physiological confounds, attachment to parents, a self-control scale, and delinquent peers.

METHOD

PARTICIPANTS

Data were collected from 105 students in a large introductory criminology and criminal justice class at Sam Houston State University. Research has shown that the relationship between resting heart rate and antisocial behavior is strongest in studies relying on noninstitutionalized and nonpsychopathic populations (Raine, 1996). Other work has found a relationship between resting heart rate and antisocial behavior in young adults (Farrington, 1997; Raine et al., 1990, 1995; Scarpa & Ollendick, 2003). The sample was 55.2% (n = 58) male and had an average age of 21.43 years (SD = 5.70). Approximately 16.2% (n = 17) of the sample were African American, 4.8% (n = 5) were Asian, 54.3% (n = 57) were Caucasian, 1% (n = 1) were Hawaiian or Pacific Islander, and 23.8% (n = 25) were Hispanic.
MEASUREMENT PROCEDURE

Data collection included the measurement of resting heart rate and a self-report survey. The self-report survey was administered to students during the regularly scheduled class period. Students had their heart rate measured within 3 weeks of the administration of the survey. Heart rate measurement was taken with a CONTEC CMS 50D finger pulse oximeter. Respondents were seated in a comfortable chair at a desk in an office and were asked to relax. Heart rate was measured after respondents had been seated and again after 5 minutes had elapsed.

Preliminary data analyses demonstrated that the first heart rate measurement had a stronger relationship with self-reported antisocial behavior. All subsequent analyses are based on the first heart rate measurement.

HEART RATE GROUPS

To divide the sample into groups with meaningfully different heart rates, a technique used by Raine, Venables, et al. (1997) was employed. The sample was divided into three different heart rate groups—low, average, and high—by creating cutoff points at one standard deviation above and below the mean heart rate. This resulted in a low-heart-rate group consisting of individuals with a resting heart rate of 66 or fewer beats per minute ($n = 13$), an average-heart-rate group consisting of individuals with a resting heart rate ranging from 67 to 94 beats per minute ($n = 70$), and a high-heart-rate group consisting of individuals with a resting heart rate of 95 or more beats per minute ($n = 18$).

SURVEY MEASURES

The self-report survey included measures of antisocial behavior, delinquent peers, and attachment to parents that were based on measures included in the National Youth Survey (Elliott, Huizinga, & Ageton, 1985). Self-control was measured with the 24-item Self-Control Scale developed by Grasmick, Tittle, Bursick, & Arnklev (1993), the most commonly used self-control measure in criminology. The survey also measured respondent demographic characteristics and physiological characteristics that may influence resting heart rate. Demographic measures were age, gender, and race. Questions addressing physiological characteristics influencing resting heart rate included those regarding respondent height and weight and three items measuring exercise.

ANTISOCIAL BEHAVIOR, SEVERE ANTISOCIAL BEHAVIOR, AND AGGRESSION

Self-report antisocial behavior measures included items measuring violence and aggression, property crime, and drug and alcohol use. Respondents were asked to report how many times they engaged in various behaviors in the past year, ranging on a 9-point scale from never to 2 to 3 times a day. The self-report antisocial behavior items were used to construct three different scales measuring antisocial behavior: General Delinquency, Severe Antisocial Behavior, and Aggression. These separate scales were created in light of research showing heart rate is related to aggressive forms of antisocial behavior but not to nonaggressive antisocial behavior (Raine, Reynolds, et al., 1997) and research showing that heart rate is not related to a general measure of externalizing behavior (Pine et al., 1998).
**General delinquency.** The first scale is a broad measure of delinquency, including acts against people and property and both drinking and drug use. The resulting 18-item scale includes measures of verbal aggression (e.g., “Got into a verbal altercation with a stranger”), physical aggression (e.g., “Got into a fight,” “Deliberately injured spouse/partner”), and nonaggressive antisocial behavior (e.g., “Stole something worth more than $20,” “Got drunk”). Actual scale items are included in the appendix. The items included in the scale demonstrated good internal consistency (Cronbach’s $\alpha = .71$).

**Severe antisocial behavior.** The Severe Antisocial Behavior scale included a subset of nine items from the General Delinquency scale. These items measured different dimensions of aggression, including verbal aggression, physical aggression, and serious nonaggressive antisocial behaviors (e.g., “Stole something worth more than $50,” “Broke into a vehicle or building to steal something”). This subscale demonstrated less internal consistency than the broader General Delinquency scale (Cronbach’s $\alpha = .56$). Despite the lower internal consistency, each of the items was theoretically relevant, and interitem correlations indicated acceptable similarity among the items.

**Aggression.** The third scale is also a subset of items derived from the General Delinquency scale and is limited to measures of aggression and violence (e.g., “Got into a fight,” “Used force to get money or things from people,” “Purposefully damaged/destroyed property that does not belong to you,” “Attacked someone with the idea of seriously hurting or killing them”). The seven items included in this scale demonstrated acceptable internal consistency (Cronbach’s $\alpha = .62$).

**BIOLOGICAL AND DEMOGRAPHIC CONTROLS**

Consistent with prior research, several biological and demographic controls were included for analysis (see, e.g., Cauffman et al., 2005; Farrington, 1997; Raine, Venables, et al., 1997; Wadsworth, 1976).

**Body mass index (BMI).** BMI was calculated according to the Centers for Disease Control and Prevention (CDCP; 2009) guidelines and was based on the self-reported height and weight of the survey respondents. After it was calculated, the BMI measure was standardized for analysis.

**Physical fitness.** Physical fitness is captured on a 5-point scale (ranging from never to 10 or more) that assessed the frequency with which respondents engaged in mild, moderate, and vigorous exercise. To better account for the overall intensity of exercise, mild, moderate, and vigorous exercise was weighted by a factor of 1, 2, and 3, respectively. This allowed for the combining of different types and amounts of exercise into a single summed measure ranging from 0 to 24. The final measure was then standardized for analysis.

**Demographics.** Consistent with much of the prior criminological literature, controls for age, race-ethnicity, and gender were assessed. Age is measured in years and was captured at the time of the survey. Race-ethnicity is a dichotomous measure indicating whether the respondent was White (coded 1) or non-White (coded 0). Finally, gender is
a dichotomous variable indicating whether the respondent was male (coded 1) or female (coded 0).

**CONSTRUCTS FROM CRIMINOLOGICAL THEORY**

*Self-control.* Self control was measured with the Grasmick et al. (1993) Self-Control Scale. The scale includes 23 items assessing respondent’s impulsivity, preference for simple tasks, risk seeking, preference for physical activities, self-centeredness, and temper. A factor analysis of the scale items supported a single-factor solution, as indicated by the eigenvalues. Internal reliability for the 23-item scale was relatively strong (Cronbach’s $\alpha = .87$).

*Attachment.* A measure of attachment was constructed from four questions pertaining to parent attachment (e.g., “How important has your relationship with your parents been to you?” “How much warmth and affection do you get from your parents?”). The items created a summed scale range from 0 to 16 and demonstrated good internal consistency (Cronbach’s $\alpha = .88$).

*Peer behavior.* Peer delinquency is consistently one of the strongest correlates of individual delinquency (Warr, 2002). As such, a measure of peer behavior was employed that asked respondents about the number of their friends who have engaged in various antisocial behaviors and crimes (e.g., “Got into a fight,” “Stole something worth more than $20”). The resulting scale included 12 items and ranged from 0 to 60, with higher numbers indicating more deviant peer networks. Moreover, internal reliability for the scale was strong (Cronbach’s $\alpha = .89$).

**RESULTS**

**LOW RESTING HEART RATE AND BEHAVE SCALES**

In the first stage of analysis, a one-way ANOVA model was used to test differences in antisocial and aggressive behaviors across those with a low resting heart rate and those with a high resting heart rate. Results indicated that the low-resting-heart-rate group did not differ significantly from the high-resting-heart-rate group on any of the three behavioral scales included in the analysis. This finding is not entirely surprising, given the small number of respondents identified as having a low or high resting heart rate ($n = 31$).

To address this shortcoming, an additional analysis was conducted comparing respondents with low resting heart rates to the rest of the sample (those with average and high resting heart rates). The results indicated that respondents with low resting heart rates did not report significantly higher levels of general delinquency, although the mean differences were in the expected direction. Important differences did emerge, however, when examining levels of severe antisocial behavior and aggression. Participants with low resting heart rates reported significantly higher levels of both severe antisocial behavior and aggression. The differences are illustrated by Figure 1.

**BIOLOGICAL AND DEMOGRAPHIC CONTROLS**

The next stage of analysis takes into consideration the possibility that other biological and demographic factors might mediate the relationship between low resting heart rate and
the behavioral measures. To address this issue, ANCOVA models were estimated with age, race, gender, BMI, and physical fitness as covariates. After considering these covariates, the relationship between low resting heart rate and the general delinquency measure remained nonsignificant, $F(1, 91) = .098$, $p > .75$. Moreover, none of the covariates was significantly related to the dependent measure.

When each of the covariates was entered into the ANCOVA model examining severe antisocial behavior, the difference between heart rate groups reported in the earlier ANOVA model remained statistically significant. That is, even after controlling for these covariates, participants with low resting heart rates reported higher levels of severe antisocial behavior as compared with those participants with average or high resting heart rates, $F(1, 91) = 2.81$, $p < .10$. Although most of the covariates included in the model did not effect the outcome measure, gender did have a significant influence on severe antisocial behavior, $F(1, 91) = 4.36$, $p < .05$.

The final ANCOVA model estimated the effect of low resting heart rate on aggression after controlling for each of the covariates in the analysis. Findings similar to the previous ANCOVA model emerged. First, although most of the covariates were not significant, gender also demonstrated an effect on levels of aggression, $F(1, 91) = 4.04$, $p < .05$. Second, participants with a low resting heart rate reported higher levels of aggression as compared with those with average or high resting heart rates, $F(1, 91) = 3.47$, $p < .10$, demonstrating that this finding was not diminished by the covariates included in the model.
Thus far in the analysis, it appears that low resting heart rate is an important factor for understanding both severe antisocial behavior and aggression. The final stage of analysis used ordinary least squares (OLS) regression models to determine whether low resting heart rate is an important predictor of antisocial behaviors after important criminological constructs—namely, self-control, attachment, and peer associations—are controlled.

Table 1 presents the findings from the multivariate regression analyses. Collinearity diagnostics were examined for all OLS regression models; variance inflation factors ranged from 1.04 to 1.40, and tolerances were greater than .7, indicating that multicollinearity was not a concern. Results of the first model examining the general delinquency scale indicate that all three of the criminological constructs were statistically significant and relatively strong predictors. Participants who have lower levels of self-control and higher numbers of peers who engage in antisocial and criminal behavior reported increased levels of antisocial behavior. Consistent with findings from the previous ANCOVA model, low resting heart rate was not a significant predictor for the general measure of antisocial behavior.

The second model in Table 1 examined the effects of low resting heart rate as well as the criminological constructs on severe antisocial behavior. The results indicate that self-control and peer behavior continued to exert moderate to strong effects on the outcome; the effect of parental attachment was nonsignificant. Of particular interest to the current study is that the effect of low resting heart rate is statistically significant and in the theoretically expected direction. Even after controlling for important criminological constructs, participants with low resting heart rates engaged in higher levels of severe antisocial behavior as compared with those participants with average or high resting heart rates.

The final model presented in Table 1 examined the effects of low resting heart rate and the criminological constructs on aggressive behavior. The results demonstrate that peer behavior is a significant predictor of aggressive antisocial behavior, in that participants with increased numbers of deviant or criminal peers reported higher levels of aggression. Self-control, however, does not emerge as a significant predictor in this model. On the other hand, low resting heart rate emerges once again as a significant predictor, net of important controls. More specifically, participants with low resting heart rates reported higher levels of aggressive antisocial behavior, and the strength of the relationship emerged more strongly than in the previous model examining severe antisocial behavior.
DISCUSSION

Here we have offered a preliminary analysis of data collected to extend research on the relationship between resting heart rate and antisocial behavior (Ortiz & Raine, 2004; Raine, 2002). To date, the strong majority of research on the relationship between resting heart rate and crime has relied on samples of children and adolescents. The relationship between resting heart rate and our self-report measures of antisocial behavior in our sample of young adults supports a modest but growing literature showing that the relationship between resting heart rate and antisocial behavior generalizes from children and adolescents to young adults (Farrington, 1997; Raine et al., 1990, 1995; Scarpa & Ollendick, 2003).

In the current analyses, we first compare the rates of self-reported antisocial behavior across those with low resting heart rate and all others while controlling for potential biological confounds. We found that those with low resting heart rates reported higher levels of severe antisocial behavior and aggressive behavior. The relationship between resting heart rate and antisocial behavior appears to be stronger when the measure of antisocial behavior indexes more serious acts, with the relationship between low resting heart rate and aggressive behavior measure being the strongest. This finding is consistent with earlier research showing that heart rate is related to aggressive forms of antisocial behavior but not to nonaggressive antisocial behavior (Raine et al., 1997).

In the multivariate models, resting heart rate is a statistically significant predictor of severe antisocial behavior and aggressive antisocial behavior, net of controls for attachment to parents, self-control, and peer delinquency. These results are consistent with earlier work using multivariate regression models to test the relationship between resting heart rate and crime, net of the influence of a host of other correlates of crime, including impulsivity, employment, physical characteristics, parent criminality, IQ, parental education, frontal lobe functioning, and future orientation (Farrington, 1997; Cauffman et al., 2005).

In the multivariate models included in our analysis, resting heart rate would remain a significant predictor of antisocial behavior, net of controls for some of the constructs that play an important role in criminological theories. It does, and our study joins a large and developing body of research finding that neuroanatomical characteristics, resting heart rate included, have a robust relationship with antisocial behavior (Ortiz & Raine, 2004; Raine, 2002). Despite this strength of evidence, criminological theorists seem largely uninterested in the relationship between resting heart rate and antisocial behavior, and major criminological theories remain silent on the biological correlates of crime or openly antagonistic to the possibility that biology may play an important part in the explanation of crime and delinquency (see Gottfredson & Hirschi, 1990, pp. 47-63).

This silence undermines the empirical validity of criminological theories. For a theory to have empirical validity, the theory must offer causal propositions that are consistent with “the facts.” We would argue that this is a necessary yet not sufficient cause. Although a theory does indeed have advantaged empirical validity to the extent that the causal propositions that it offers are consistent with empirical reality, so too does empirical validity vary with the extent to which the relevant facts are addressed. And although we offer a modest test, we would suggest that—given prior research—there is ample evidence that the relationship between biological characteristics and antisocial behavior represents fact (Glenn & Raine, 2008; Kim-Cohen et al., 2006, Moffitt, 2005; Ortiz & Raine, 2004; Rhee & Waldman, 2002; Walsh & Beaver, 2008).
At first blush, the argument that theorists need to attend to all major empirical realities may seem to place an undue burden on criminologists; however, it may be that this burden is a bit lighter than that faced by those positing theories of antisocial behavior from within other disciplines. Criminologists focus on a dependent variable rather than on a level of explanation. With this focus comes training in multiple research methods and the use of a variety of analytical techniques. In addition, criminologists are acquainted with processes working at the broad macrolevel and with causal influences in the immediate social level. As such, criminologists are well situated to offer an integrated explanation of behavior that attends to processes at the biological, peer, family, neighborhood, and broader socioeconomic levels, provided that research on the predictors of crime and delinquency can be evaluated on merit rather than method.

APPENDIX
Scale Items

Antisocial Behavior/Severe Antisocial Behavior/Aggression

In the past year, how many times have you (never, once or twice, once every 2-3 months, once a month, once every 2-3 weeks, once a week, 2-3 times a week, once a day, or 2-3 times a day):

1. Purposely damaged or destroyed property that does not belong to you
2. Used marijuana
3. Used hard drugs (such as methamphetamines, heroin, cocaine, LSD)
4. Got into a verbal altercation with a stranger
5. Stole something worth less than $20
6. Hit or threatened to hit someone without any reason
7. Used alcohol
8. Broken into a vehicle or building to steal something
9. Gotten into a fight
10. Sold illegal drugs
11. Stole something worth more than $50
12. Gotten drunk
13. Sold or given alcohol to kids under 18
14. Pressured or forced someone to do more sexually that he/she wanted to do
15. Attacked someone with the idea of seriously hurting or killing them
16. Exceeded the speed limit by 10-20 mph
17. Used force to get money or things from people
18. Deliberately injured spouse/partner

General Delinquency = All 18 items
Antisocial Behavior = Items 1, 6, 8, 9, 11, 14, 15, 17, and 18
Violence and Aggression = Items 1, 6, 9, 14, 15, 17, and 18

Attachment to Parents

1. How important has your relationship with your parents been to you? (very important, pretty important, somewhat important, not too important, or not important at all)
2. How much warmth and affection do you get from your parents? (a great deal, quite a bit, some, not too much, or very little)
APPENDIX (continued)

3. How much support and encouragement have you received from your parents? (a great deal, quite a bit, some, not too much, or very little)

4. Overall, how satisfied have you been with your relationship with your parents? (very satisfied, somewhat satisfied, neither satisfied nor dissatisfied, somewhat dissatisfied, very dissatisfied)

Peer Behavior

Think of your friends in the past year. How many of your friends (all of them, most of them, some of them, very few of them, or none of them):

1. Were arrested
2. Were convicted
3. Used drugs
4. Stole something (less than $20)
5. Got drunk
6. Hit someone
7. Broke into a vehicle
8. Stole something (more than $20)
9. Pressured someone sexually
10. Sold drugs
11. Used force or threat of force to get money or things from other people
12. Purposely damaged or destroyed property that did not belong to them

Exercise

During a typical week, how many times do you do the following exercises for more than 25 minutes (never, 1-3, 4-6, 7-9, or 10 or more):

1. Mild exercise that requires minimal effort where you could easily sing while doing the activity: yoga, fishing, bowling, golf, leisure walking, etc.
2. Moderate exercise that is not exhausting where you could easily carry on a conversation while doing the activity: jogging, non-competitive sports, leisure dancing, leisure swimming, etc.
3. Vigorous exercise where you become winded or too out of breath to carry on a conversation while doing the activity: running, competitive sports games (soccer, football, basketball, etc.), energetic dancing, swimming laps, etc.

REFERENCES


Todd A. Armstrong is an associate professor in the College of Criminal Justice at Sam Houston State University. His current research interests include criminal careers, criminological theory, and biosocial influences on criminal behavior. His recent research has appeared in *Journal of Research on Crime and Delinquency*, *Justice Quarterly*, and *Crime & Delinquency*.

Shawn Keller is a doctoral student at Sam Houston State University in the College of Criminal Justice. His current interests include biological correlates of crime, neighborhood disadvantage, and mentally ill offenders.

Travis W. Franklin is currently an assistant professor in the College of Criminal Justice at Sam Houston State University. His research interests include the influence of race in criminal processing, biosocial influences on crime, prison violence, and factors that influence the fear of crime. His most recent research has appeared in the *Journal of Criminal Justice* and *Social Justice Research*.

Scott N. MacMillan is a doctoral student in the College of Criminal Justice at Sam Houston State University. His current interests include neurolaw-neuroethics and biolaw-bioethics, biological and psychological correlates of crime, and violent sex offender recidivism.