Interactions between Empathy and Resting Heart Rate in Early Adolescence Predict Violent Behavior in Late Adolescence and Early Adulthood

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Abstract

Background: Although resting heart rate (RHR) and empathy are independently and negatively associated with violent behavior, relatively little is known about the interplay between these psychophysiological and temperament-related risk factors. **Methods:** Using a sample of 160 low-income, racially-diverse men followed prospectively from infancy through early adulthood, the current study examined whether RHR and empathy during early adolescence independently and interactively predict violent behavior and related correlates in late adolescence and early adulthood. **Results:** Controlling for child ethnicity, family income, and child antisocial behavior at age 12, empathy inversely predicted moral disengagement and juvenile petitions for violent crimes, while RHR was unrelated to all measures of violent behavior. Interactive effects were also evident such that among men with *lower* but not higher levels of RHR, lower empathy predicted increased violent behavior, as indexed by juvenile arrests for violent offenses, peer-reported violent behavior at age 17, self-reported moral disengagement at age 17, and self-reported violent behavior at age 20. **Conclusion:** Implications for prevention and intervention are considered. Specifically, targeting empathic skills among individuals at risk for violent behavior because of specific psychophysiological profiles may lead to more impactful interventions.

Keywords: antisocial behavior; psychophysiology; resting heart rate; violence

Antisocial behavior (AB) is reliably associated with numerous indicators of maladjustment in adulthood, including homelessness and low educational and occupational attainment (Fergusson, Horwood, & Ridder, 2005). Rooted in Patterson's and Moffitt's developmental taxonomy of AB (Moffitt, 1993; Patterson et al., 1991), conduct problems with an early or childhood onset typically appear before ages 10 to 14 years and precede a trajectory of life-course persistent AB associated with significant individual impairment and societal burden (Frick & Nigg, 2012; Offord, Boyle, & Racine, 1991). Research suggests that untreated, early-starting conduct problems may escalate to serious violence in adolescence and early adulthood (Frick & Nigg, 2012), with early starters accounting for approximately three-fourths of violent crimes (Offord et al., 1991). The primary aim of the current study is to examine the interplay of two established risk factors of AB representing different domains of influence that have previously been examined in isolation: children's low empathy and low resting heart rate (RHR).

Decades of research on AB have elucidated a plethora of risk factors, with a preponderance of studies focused on social-contextual influences. In addition to established contextual risk factors, such as harsh parenting and deviant peer affiliation, biological vulnerabilities independently contribute to the development of both childhood- and adolescent-onset AB (Fairchild, Van Goozen, Calder, & Goodyer, 2013; Fairchild, van Goozen, Stollery, & Goodyer, 2008). Although we know less about the biological underpinnings of AB than its social-contextual influences, established biomarkers of AB include atypical neural reactivity to threat, reward, and punishment (e.g., Blair, 2010), candidate gene polymorphisms that interact with adversity (e.g., Galán et al., 2016), and physiological indicators of atypical sympathetic and parasympathetic nervous system activity (Fairchild et al., 2013). One biomarker of AB that is ripe for further empirical investigation is low resting heart rate (RHR).

Resting Heart Rate and Antisocial Behavior

Low RHR is one of the most consistently replicated biological correlates of AB across development, with evidence indicating it is specific to AB (Latvala, Kuja-Halkola, Almqvist, Larsson, & Lichtenstein, 2015; Raine, 2002). Indeed, meta-analytic findings demonstrate a robust negative association between RHR and AB, with medium effect sizes ranging from .38 to .56 (Lorber, 2004; Ortiz & Raine, 2004). While Ortiz and Raine (2004) limited their meta-analysis to child and adolescent samples, Portnoy and Farrington's (2015) recent meta-analysis of 114 reports demonstrated that age did not moderate the association between RHR and AB, implicating low RHR as a robust predictor of AB from early childhood through adolescence and early adulthood, albeit with a small effect size (d = -.20). A prospective study of a Brazilian birth cohort demonstrated moderately-sized correlations in men's RHR from ages 15 to 18 years, and men's RHR levels at ages 11, 15, and 18 were each negatively associated with self-reported AB and official records of violent and non-violent crimes at age 18 (Murray et al., 2016). These findings suggest strong continuity in low RHR across early development which may explain its putative links with chronic AB. This negative association between RHR and AB has also been found to replicate across cultures, genders, longitudinal and cross-sectional designs, and remains after accounting for potential confounds, such as body size, physical activity, and socioeconomic status (SES; Latvala et al., 2015; Murray et al., 2016; Portnoy & Farrington, 2015; Raine, 2002). While RHR has been linked to various forms of AB, meta-analytic findings suggest a stronger association with violent than non-violent AB (Portnoy & Farrington, 2015). Moreover, few studies have examined prospective associations between RHR and violence while accounting for youths' earlier AB (Baker et al., 2009), which limits inferences of their temporal associations.

There are several theoretical explanations for the association between RHR and AB.

Fearlessness theory has garnered support in developmental literature on temperament and is most relevant to the current study (Ortiz & Raine, 2004; Raine, 2002). Although fearlessness and low RHR are not synonymous constructs, research suggests that reduced autonomic arousal underpins a fearless temperament in infancy and early childhood (e.g., Fowles, Kochanska, & Murray, 2000). According to *fearlessness theory*, a low RHR reflects low levels of fear and anxiety, and thus a temperament characterized by low reactivity and/or arousal; fearless children, in turn, may be less sensitive to punishment and others' attempts to help them internalize norms, which could disrupt children's fear conditioning and moral development (e.g., conscience) and increase their subsequent risk for chronic AB (Frick et al., 2003). Indeed, a study with the current sample demonstrated that fearlessness distinguished toddler-age boys who showed chronic conduct problems in early and middle childhood from boys with low or decreasing conduct problems (Shaw, Gilliom, Ingoldsby, & Nagin, 2003). Therefore, children with a low RHR may be temperamentally fearless (i.e., low in autonomic arousal) and at increased risk for AB.

Stimulation-seeking theory, on the other hand, posits that antisocial individuals generally experience low autonomic arousal, causing them to seek stimulation through antisocial acts to increase their arousal to satisfactory or pleasant levels. Sijtsema et al. (2010), using a sample of Dutch youth, provide empirical support for the theory, demonstrating that lower heart rate at age 11 is associated with more sensation seeking, which in turn is related to greater rule-breaking at age 16. Similarly, in a US sample of 16-year-old boys, Portnoy et al. (2014) found impulsive sensation seeking mediated a concurrent association between heart rate and aggression. Thus, both *fearlessness theory and stimulation-seeking theory* have received empirical support and offer complementary rather than mutually exclusive perspectives on the association between RHR and AB (Raine, 2002).

Empathy, Antisocial Behavior, and Resting Heart Rate

In addition to low RHR, callous-unemotional (CU) traits and empathy are biologically-based temperamental attributes that are consistently been linked with AB and demonstrate moderate to high heritability (Knafo et al., 2008; Zahn-Waxler et al., 2001). CU traits are characterized by shallow emotions and a lack of empathy and guilt (Frick, 2009). Although a distinct construct, a lack of empathy is critical to the conceptualization of CU traits and is defined as an inability to reason about others' affective states and to experience emotions that are consistent with those states (Eisenberg & Fabes, 1990). In a meta-analysis of 35 studies, Jolliffe and Farrington (2004) identified a negative relationship between offending and empathy, with a moderate mean effect size of -.28. Additionally, in the current sample of low-income men, low empathy at age 12 was associated with higher levels of self-reported AB at ages 16 and 17 (Hyde, Shaw, & Moilanen, 2010). Although some children with early-onset AB may only show transitory problems, children who show AB *and* CU traits have demonstrated more severe, stable, and violent patterns of AB from middle childhood through adolescence and early adulthood (Fontaine et al., 2011; McMahon et al., 2010). However, recent research with the current sample found CU traits in adolescence were not more common among men with early- vs. late-starting AB, although the authors noted a caveat of measuring CU traits in late rather than early adolescence (Hyde, Burt, Shaw, Donnellan, & Forbes, 2015). By simultaneously examining the independent contributions of empathy, AB, and RHR in early adolescence on violent behavior in late adolescence *and* early adulthood, we can examine the interplay of two biologically-influenced child attributes underlying men's chronic perpetration of violence.

Although RHR and empathy have been independently implicated in the development of AB, little is known about whether their covariation and/or interaction predict AB in adolescence

and adulthood. There is evidence of stability in both RHR (Murray et al., 2016) and CU traits during adolescence (Blair, 2010). Although empathy is sometimes considered an ability or trait, it is also recognized to be situation-specific and a product of the interaction between state and trait influences (Cuff et al., 2016). Therefore, low empathy may only predispose youths to violence when coupled with low RHR. Such an interaction would be consistent with *fearlessness theory's* supposition that low RHR can promote children's social learning to aggress, particularly if anxiety and fear do not deter them from hurting others (Ortiz & Raine, 2004). After all, youth who lack empathy may be unable or unwilling to reason about and experience others' emotional states, which would be more likely to lead to aggression when compounded by low physiological arousal.

Frick et al. (2003) argue that children with conduct problems and CU traits may have temperaments characterized by low emotional reactivity to aversive stimuli and physiological underreactivity in the sympathetic nervous system. However, De Wied et al. (2012) found, despite significant group differences in resting respiratory sinus arrhythmia, that RHR did not distinguish adolescents with disruptive behavior disorders and high CU traits from adolescents with disruptive behavior disorders and low CU traits or from age-matched healthy controls. Thus, the relationship between RHR and empathy remains inconclusive and additional research is needed to evaluate their covariation and interaction in relation to the progression of violence, particularly when accounting for AB in early adolescence and potential cognitive mechanisms.

Moral disengagement, a cognitive mechanism by which people justify and commit immoral actions (Bandura, Barbaranelli, Caprara, & Pastorell, 1996), was shown at age 15 in the current sample to mediate negative effects of empathy at age 12 on AB at ages 16 and 17 (Hyde et al., 2010). Examining independent and interactive contributions of empathy and RHR in early

adolescence in relation to moral disengagement and violent behavior in late adolescence and early adulthood would extend established research among these variables in the current sample. Specifically, adolescent boys' low empathy may only lead to moral disengagement and subsequent violent behavior for those with low RHR. The combination of limited empathic concern for others and reduced visceral arousal may predispose youths to justify AB in morally ambiguous situations, thus contributing to violence that persists into adulthood.

The current study extends previous research by examining direct and interactive effects of RHR and empathy during early adolescence in relation to violent behavior in late adolescence and early adulthood in a sample of low-income men followed prospectively from infancy. Violence-related antisocial outcomes (i.e., juvenile arrests for violent offenses, self-reported AB, peer-reported AB, moral disengagement) were examined in separate analytic models to assess the breadth of associations between RHR, empathy, and AB. We hypothesized that while controlling for pre-existing differences in AB at age 12, which falls within the age-window used to define early- or childhood-onset AB (Frick & Nigg, 2012): (1) Lower levels of empathy would be associated with higher levels of violent behavior in late adolescence and early adulthood; (2) RHR would also be negatively related to violent behavior; and (3) Low RHR would amplify the negative association between empathy and violent behavior.

Methods

Participants

Participants initially included 310 infant boys and their primary caregivers who were recruited in 1991 from Women, Infants, and Children Nutritional Supplement Program clinics in the Pittsburgh metropolitan area (Shaw et al., 2003). The sample was restricted to low-income boys to increase the probability of later AB. At the time of recruitment, boys were between 6 and

17 months old, and the initial assessment for most occurred when they were 18 months old. The initial sample of target children was 53% European American, 36% African American, 5% biracial, and 6% from other ethnicities (e.g., Asian American, Hispanic). At the study's outset, the mean per capita income was $2892 per year and the mean Hollingshead SES score was 24.5, which is indicative of a working class sample (Hollingshead, 1975).

Retention rates have been consistently high throughout two decades of data collection, with some data available for 275 families (89%) at the age 12 assessment, 272 families (87%) at age 17, and 258 families (83%) at age 20. Analyses in the present paper were derived from a smaller sample of boys with RHR data at age 12 (n = 160). The 160 boys who had complete data and were included in the primary analyses did not differ from those excluded (e.g., because of attrition, refusal to collect psychophysiological data, or unusable RHR data because of equipment failure or excessive noise interfering with R-wave detection) in terms of multiple indicators of SES at 18 months or study variables included in the current analyses.

Procedure

Assessments were conducted in families' homes and/or laboratory settings with mothers and their participating child at ages 1.5, 2, 3.5, 5, 5.5, 6, 8, 10, 11, 12, 15, 17, 20, and 22 years old, with additional phone- or internet-based assessments at ages 16, 18, 21, and 23. The assessments providing data for the present study occurred at ages 12, 17, and 20 years, and during these visits, parents and target children completed questionnaires regarding socio-demographic characteristics and child behavior. In addition, RHR was measured at the age 12 assessment. All participants provided consent and all procedures received Institutional Review Board approval at the University of Pittsburgh.

Measures

Empathy. The 48-item Children and Adolescent Disposition Scale (Lahey et al., 2008)

was administered to youth at the age 12 assessment to assess dispositional dimensions that contribute to the development of conduct disorder. The 10-item empathy/prosociality scale was used to assess empathy, including aspects of CU traits. Youth rated how much each statement describes them during the last 12 months using a four-point Likert scale, with sample items including "Do you feel badly for other children your age when they get hurt?" and "Do you care about other children's feelings?" Items were averaged to create a total empathy score ($\alpha = 0.83$).

Resting Heart Rate. Resting heart rate was assessed at the age 12 assessment using the 3992/2-ER Biolog system, which provides ambulatory recording of electrocardiograph (ECG) sampled at 1000 Hz and respiration sampled at 5 Hz. Electrodes were placed on boys' right and left shoulders, as well on the left abdomen near the bottom of the ribs. Resting heart rate (beats/min) was measured continuously during a five-minute baseline period when boys were reading a magazine. Data were processed via the program for spectral analysis of point events (PSPAT) after manually correcting for artifact R-wave occurrences or movement artifacts in the ECG signals (Weber, Molenaar, & van der Molen, 1991). Data were processed in 60 second epochs, and five 60 second epochs were averaged to compute a mean RHR for each participant. Of the 160 boys who provided psychophysiological data during the age 12 assessments, 29 reported taking medications known to influence heart rate. Although two boys were prescribed Clonidine, which decreases heart rate, most boys were on medications that increase heart rate, such as Adderall or Ritalin.[1]

Juvenile Violent Petitions. After receiving written permission from primary caregivers

[1] Follow-up analyses indicated that the results reported herein did not change as a result of including medication status as a covariate.

(*n* = 272; 87% of the initial recruitment sample), juvenile court records of arrests were obtained from local county offices on an annual basis when youth were between 15 and 18 years of age. The number of violent petitions (equivalent to the number of charges for violent crimes) against each boy was summed, creating a continuous measure of contact with the legal system. The following crimes were categorized as violent petitions because of their harm or potential to cause harm to others: homicide and attempted homicide, forcible rape, indecent and sexual assault, aggravated assault, robbery, weapons possession, and arson (Sitnick et al., 2017). Of the 160 participants included in the present sample, 51 (32%) had at least one court petition and 24 (15%) had at least one petition for a violent crime. Two men (1%) had a petition for homicide, attempted homicide, or rape. As the number of violent petitions had a positively skewed distribution (skewness = 2.73, kurtosis = 7.09), a logarithmic transformation (log10) was applied to this variable after adding a constant of one to all values.

Violent Behavior. At ages 17 and 20, participants completed the 62-item Self-Report of Delinquency Questionnaire (SRD; Elliott, Huizinga, & Ageton, 1985), rating the frequency of their AB during the past year on a 3-point scale (1 = *never* and 3 = *more often*). Peers also rated the frequency of the target child's violent behavior using the SRD at the age 17 assessment. For the present study, boys' overall delinquency scores included 11 items that describe aggressive or violent acts, such as "Have you physically hurt or threatened to hurt someone to get them to have sex with you?" Items were summed for each informant and resulting scales showed adequate internal consistency (self-report: $\alpha = .70$ at age 17 and $\alpha = .78$ at age 20; peer-report: $\alpha = .96$).

Moral Disengagement. At age 17, participants rated their proneness to moral disengagement using the 32-item Mechanisms of Moral Disengagement Scale (MDS; Bandura et al., 1996). Participants rated how much they agreed with each statement using a 3-point scale (1

= *disagree* and 3 = *agree*). A sample item includes "It is alright to beat someone who bad mouths your family." Previous research suggests a one-factor solution of moral disengagement and such findings hold across samples of various ethnic and SES backgrounds (Bandura et al., 1996). Thus, MDS scores were derived by taking the mean of scores from all 32 statements ($\alpha = .92$).

Covariates. A single dummy code was used to indicate child ethnicity: 0 = Caucasian, 1 = non-Caucasian. Youth-report of AB on a shorter version of the SRD at age 12 (adapted from Elliot et al., 1985) was also included as a covariate to account for pre-existing differences in AB.[2] Finally, family household income at age 12 was included as a covariate to ensure that the main and interactive effects of empathy and RHR not be confounded with family SES.

Data Analysis Plan

After calculating descriptive statistics for study variables, analyses proceeded from univariate correlations in SPSS to structural equation modeling (SEM) in *MPlus* 7.2 to test for interactions between empathy and RHR in relation to multiple indicators of AB and their correlates (i.e., moral disengagement) in late adolescence and early adulthood. To reduce concerns of multicollinearity, RHR and empathy were centered prior to creating interaction terms in SPSS. Subsequent analyses were then conducted in *MPlus* using SEM, which simultaneously estimates all associations among variables, accommodates missing data with maximum likelihood with robust standard errors, and addresses non-normality of outcome variables (Kline, 2005).

Significant interactions were probed by conducting simple slope analyses one standard

[2] We used the total score reflecting AB at home and in school for the current analyses. When we partitioned the total score according to setting, school- but not home-based AB was significantly correlated with subsequent violent behavior. However, the overall pattern of regression findings reported herein remained intact when using only school-based AB.

deviation above and below the mean for RHR. To better reflect the multifaceted nature of violent behavior and based on our interest in examining convergence in findings between late adolescence and early adulthood, we examined violence-related outcomes in independent analyses rather than combining measures across time and indices of violent AB into a single latent construct.

Results

Table 1 presents descriptive statistics as well bivariate correlations among study variables. Although the SRD does not have *t*-score conversions or clinical-cut offs, the mean violent SRD scores of 10.69 at age 17 and 11.91 at age 20 indicate that many men endorsed engaging in violent forms of AB in late adolescence and early adulthood. Child ethnicity was unrelated to empathy and RHR at age 12, but was significantly correlated with violent petitions and youth report of violent behavior at age 17. Specifically, non-Caucasians demonstrated higher levels of AB across multiple methods of data collection. Unexpectedly, youth empathy was unrelated to RHR, youth report of AB, and peer report of AB, but as hypothesized, empathy was negatively correlated with violent court petitions and moral disengagement. Contrary to predictions, RHR at age 12 was unrelated to all study variables.

Resting Heart Rate x Empathy to Juvenile Violent Petitions

After testing univariate relations between empathy, RHR, and violent behavior, we then examined the hypothesis that associations between men's empathy and violent court petitions would be moderated by RHR. We simultaneously estimated the effects of child ethnicity, family income, and child AB at age 12 as covariates, the main effects of empathy and RHR, and the interaction between empathy and RHR. As indicated in Table 2, in addition to finding that lower levels of empathy were linked to having more petitions for violent crimes, a significant

interaction was evident between empathy and RHR. Consistent with study hypotheses, simple slope analyses indicated that among men with a *lower* RHR, lower empathy was significantly associated with more court petitions, $t(159) = -2.98$, $p < .01$, but not for men with a higher RHR, $t(159) = -.34$, *ns* (Figure 1).

Resting Heart Rate x Empathy to Self-Report of Violent Behavior (17 and 20 years)

When the same model was re-computed substituting juvenile violent petitions for youth report of violence at 17 and 20 years, while no significant interaction was evident between RHR and empathy in predicting violent behavior at age 17, RHR significantly moderated the association between empathy and self-report of violence at age 20. Consistent with study hypotheses, for men with a *lower* RHR, lower empathy predicted greater violence at age 20, $t(158) = -2.14$, $p < .05$, but was unrelated to violent behavior at age 20 among men with a higher RHR, $t(158) = .95$, *ns* (Figure 2).

Resting Heart Rate x Empathy to Peer-Report of AB (17 years)

We then examined the hypothesis that the association between men's empathy and peer report of target youth's AB at age 17 would be moderated by RHR. Consistent with previous models, RHR interacted with empathy to predict peer report of AB at age 17. Follow-up simple slope analyses indicated that empathy was significantly associated with greater peer-report of AB at *lower*, $t(140) = -2.48$, $p < .05$, but not higher levels of RHR, $t(140) = 1.45$, *ns*.

Resting Heart Rate x Empathy to Moral Disengagement (17 years)

Our final model tested the interaction between RHR and empathy in relation to youth report of moral disengagement at age 17. Consistent with hypotheses and other results, RHR moderated the association between empathy and moral disengagement, such that among men with *lower* RHR, lower empathy was significantly associated with greater moral disengagement,

$t(158) = -3.19$, $p < .01$. Empathy was unrelated to moral disengagement among men with higher RHR, $t(159) = -0.06$, *ns*.

Discussion

The current investigation provided partial evidence of both direct and interactive effects of RHR and empathy in early adolescence on young men's violent behavior in late adolescence and early adulthood. In support of our first hypothesis postulating direct effects, lower levels of empathy at age 12 were associated with more juvenile petitions for violent offenses and greater moral disengagement at age 17. Empathy was unrelated to other indicators of violent behavior, including peer-reports at age 17 and self-reports at ages 17 and 20. Contrary to our second hypothesis, RHR was unrelated to violent behavior in late adolescence and early adulthood. However, although RHR was unrelated to empathy in early adolescence and later antisocial outcomes (contrary to *fearlessness theory*), consistent with our third hypothesis, RHR and empathy interacted to robustly predict violent behavior and its correlates in late adolescence and early adulthood. Notably, findings held while accounting for child race, family SES, and pre-existing differences in AB in early adolescence, highlighting their unique interactive effects above and beyond other child- and family-level risk factors. Additionally, statistical interactions were evident across multiple informants and methods of data collection (i.e., juvenile court data, peer ratings, self-report), thus reducing concerns our findings are spurious or due to chance.

Resting Heart Rate and Violent Behavior

The lack of an association between RHR in early adolescence and violent behavior in late adolescence and early adulthood is inconsistent with the extensive body of literature implicating low RHR as one of the most robust biological correlates of AB across development (Raine, 2002). Notably, our sample size was smaller than in other studies (e.g., Latvala et al., 2015;

Murray et al., 2016), which may have contributed to insufficient power to detect a significant correlation between RHR and violent behavior. Alternatively, although purely speculative, our inability to replicate this relationship could be explained by the "social push" hypothesis. According to this perspective, psychophysiological risk factors such as RHR are more strongly associated with AB among youth from affluent social classes. As explained by Raine (2002), for antisocial youth from disadvantaged families, "the link between AB and biological risk factors will be weaker…because the social causes of crime camouflage the biological contribution" (p. 314). The social push hypothesis may be more appropriately characterized as a bioecological form of GxE, which proposes that genetic influences have the most explanatory power in low risk environments but become masked in the context of environmental adversity (e.g., Bronfenbrenner, & Ceci, 1994; Burt, Klahr, Neale, & Klump, 2013). Although we accounted for SES in our current analyses, all participants were recruited from WIC nutrition supplement centers and therefore faced financial hardships. However, it is possible that a direct effect of RHR on violent behavior would have been evident in a higher SES sample of youth living in an advantaged environment in which biological influences are more strongly expressed.

Interaction between Resting Heart Rate and Empathy in Predicting Violent Behavior

According to Cuff and colleagues (2016), empathy is a multi-faceted phenomenon that encompasses cognitive *and* affective components. While cognitive empathy involves an intellectual understanding of others' feelings, affective empathy represents the ability to experience emotions concordant with another's affective state. Research suggests that among typically developing children, vicarious affective responsiveness may precede and scaffold the development of cognitive empathy (e.g., O'Brien et al., 2011). However, despite the developmental link between affective and cognitive empathy among normative populations, for

children with CU traits, the development of cognitive empathy does not appear contingent upon affective perspective-taking. Despite deficits in affective empathy (e.g., Anastassiou-Hadjicharalambous & Warden, 2008), children with CU traits appear to possess relatively intact cognitive perspective-taking skills. In fact, some evidence suggests that these children actually outperform their typically developing peers on tasks involving deception and manipulation, skills that require an ability to discern the emotional and mental states of others (Jones et al., 2010).

Notably, within the CU literature, affective empathy is typically defined on the basis of physiological arousal whereas cognitive empathy is measured through self-report of how one would react to another's distress (Cuff et al., 2016; Vachon, Lynam, & Johnson, 2014). Thus, while the Children and Adolescent Disposition Scale (Lahey et al., 2008) measured young men's earlier cognitive empathy in the present study, it is possible that their RHR, other than indicating autonomic arousal, reflected the extent to which they could experience affective empathy. In a study supporting *fearlessness theory*, when presented with scenarios of criminal offending, young adults with low RHR perceived reduced risks of arrest and conviction and anticipated less guilt and shame but only for a morally ambiguous assault scenario (Armstrong & Boutwell, 2012). These findings suggest low RHR is associated with diminished expectancy of punitive consequences and negative affect as deterrents to perpetrating violence when it may be justifiable.

In support of this interpretation, current findings suggest low levels of cognitive empathy confer an increased risk for violent behavior, particularly juvenile violent petitions and moral disengagement at age 17, which further elucidate associations reported by Hyde et al. (2010). Low RHR and cognitive empathy may signify limited affective empathy, and thus an increased tendency to justify AB. While the ability to cognitively understand another's emotional state may

help individuals to refrain from engaging in violent behavior, robust interactions between self-reported empathy and RHR underscore the importance of examining cognitive *and* affective empathy concurrently. Specifically, study findings suggest that although low cognitive empathy independently increases risk for violent behavior, this risk may be magnified when affective empathy is also limited. Thus, it is possible that boys with low levels of cognitive empathy and low RHR demonstrate the highest risk for perpetrating violence because of limitations in understanding and feeling others' emotions, as well as an increased justification of their AB. Moreover, evidence of a greater effect of the interaction between empathy and RHR on violent behavior compared to their independent effects may explain why a recent meta-analysis found a relatively weak, negative correlation between empathy and aggression (Vachon et al., 2014).

Limitations of this study include its focus on young, low-income men's individual characteristics that contribute to violent behavior. We were motivated to focus on physiological and temperament precursors of violent behavior given that social-contextual influences have received greater empirical attention. However, whereas our findings highlight the interaction of psychophysiological and temperament-related risk factors in men's perpetration of violence, future research would benefit from considering context to test a biopsychosocial model of AB. Our analyses accounted for child ethnicity, self-reported AB, and family household income measured concurrently with empathy and RHR at age 12, but not salient psychosocial stressors, such as community violence and harsh parenting. However, a recent study found that family income in early childhood and minority status distinguished violent juvenile offenders from non-offenders in this sample, while both maternal depression and neighborhood deprivation were unrelated to juvenile petitions (Sitnick et al., 2017). Thus, future studies can extend this work by examining the interplay of empathy and other temperament-related constructs, multiple markers

of autonomic activity, and concurrent parenting or peer influences to illustrate a biopsychosocial model of AB. Moreover, replication of our findings is needed to determine their generalizability to samples with boys *and* girls, greater racial-ethnic diversity, and a wider distribution of SES.

The present study is also limited by its assessment of RHR and empathy at a single time point. Although empathy has been conceptualized as an enduring disposition that is stable across time and contexts, albeit situational to a degree (Cuff et al., 2016; Knafo et al., 2008), little is known about the stability of RHR from early childhood to adulthood. Murray et al. (2016) reported stability in their measures of RHR in adolescence, but it remains unclear whether RHR assessed at other developmental periods (e.g., early childhood) also moderates the association between empathy and young men's violent behavior. Future research would benefit from the longitudinal assessment of both empathy and RHR in order to elucidate potential differences in vulnerability across developmental periods. Studies that examine typical and atypical trajectories of empathy development and psychophysiological functioning through childhood and adolescence in relation to growth in AB can inform our understanding of the causal pathways and interplay of cross-domain mechanisms involved in the onset and maintenance of violent behavior.

Clinical Implications and Future Directions

The current findings represent an important step toward understanding how psychophysiological and temperament characteristics interact to contribute to the development of violent behavior in late adolescence and early adulthood. Future research dedicated to identifying developmental precursors of empathy and RHR in early adolescence may elucidate their interactive effects on violence reported in this study. For example, early temperament attributes, such as low fearfulness, may contribute to low levels of empathy or reflect low RHR, and in

combination with these factors, contribute to chronic AB (Eme, 2009). Additionally, temperament-based deficits in negative emotional arousal can compromise fear learning or aversive conditioning, thereby limiting an individual's ability to learn through punishment how not to behave (Eme, 2009).

Empathy training is often a critical component of the treatment of aggressive and violent behavior, particularly among sexual offenders and perpetrators of domestic violence (Fruzzetti & Levensky, 2000; McGrath et al., 2010). It has also been included in bully and violence prevention curricula for elementary school students (Sahin, 2012). By increasing empathic concern and victim awareness, these programs seek to prevent initial perpetrations of violence and reduce rates of recidivism. Although research does not support the use of empathy training as a standalone treatment for violence (Day, Casey, & Gerace, 2010), the present findings suggest that targeting empathic abilities among individuals at risk for violent behavior due to specific psychophysiological profiles may lead to more robust intervention and prevention effects.

Key Points

- Using a prospective longitudinal design, the current study examines the interplay of empathy and resting heart rate in early adolescence in relation to men's violent behavior in late adolescence and early adulthood.
- Lower empathy at age 12 was associated with more juvenile petitions for violent offenses and greater moral disengagement at age 17.
- Resting heart rate was unrelated to all measures of violent behavior.
- Lower levels of empathy were significantly associated with greater violent behavior among men with *lower* but not higher levels of resting heart rate. This interaction was replicated in late adolescence *and* early adulthood and across multiple informants and methods of data collection.

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Table 1

Descriptive Statistics and Correlations among Study Variables

Variables	1	2	3	4	5	6	7	8	9
1. AB (youth-report; 12 years)	__								
2. Empathy (youth report; 12 years)	-.126	__							
3. Resting Heart Rate (12 years)	-.101	.092	__						
4. Juvenile Violent Petitions (15-18 years)	.006	-.182*	-.016	__					
5. Violent Behavior (youth-report; 17 years)	.147†	-.067	.051	.365**	__				
6. Violent Behavior (peer-report; 17 years)	.213*	-.058	-.013	.358**	.195*	__			
7. Violent Behavior (youth-report; 20 years)	.055	-.113	-.067	.156†	.361**	.225*	__		
8. Moral Disengagement (youth-report; 17 years)	.121	-.216**	-.110	.172*	.391**	.306**	.306**	__	
9. Child Race	.193*	.030	-.001	.241**	.411**	.082	.124	.126	__
M	.905	2.889	82.933	.069	10.690	7.721	11.9110	48.181	CA: *n* = 91 NC: *n* = 69
SD	1.624	0.572	12.413	0.167	1.484	3.457	1.999	9.384	
Range	9.000	2.780	78.926	.700	10.000	9.000	11.000	54.000	

Note. AB = antisocial behavior. Juvenile violent arrests have undergone a logarithmic transformation. Child Race: 0 = Caucasian (CA); 1 = Non-Caucasian (NC). †$p < .10$. *$p < .05$. **$p < .01$

Table 2

Path Coefficients in Model of Independent Variables Predicting Violent Behavior and Age-Related Correlates in Early Adulthood, While Accounting for Child Race, Family Income at Age 12, and Child AB at Age 12

Dependent Variable (DV)	Path	β	*SE*	Model R^2
1) Juvenile Violent Court Petitions (official court records; 15 to 18 years)	Child Race → DV		.084	.118
	Family Income → DV	-.113	.086	
	AB (12 years) → DV	-.073	.081	
	Empathy → DV	-.188*	.071	
	Resting Heart Rate → DV	-.058	.084	
	Empathy x Resting Heart Rate→ DV	.174*	.081	
2) Violent Behavior (self-report; 17 years)	Child Race → DV	.351**	.065	.161
	Family Income → DV	-.044	.069	
	AB (12 years) → DV	.088	.078	
	Empathy → DV	-.045	.070	
	Resting Heart Rate → DV	.078	.080	
	Empathy x Resting Heart Rate→ DV	-.067	.085	
3) Violent Behavior (peer-report; 17 years)	Child Race → DV	.047	.093	.096
	Family Income → DV	-.095	.079	
	AB (12 years) → DV	.174†	.098	
	Empathy → DV	-.032	.067	
	Resting Heart Rate→ DV	-.055	.075	
	Empathy x Resting Heart Rate→ DV	.201**	.059	
4) Violent Behavior (self-report; 20 years)	Child Race → DV	.079	.084	.093
	Family Income → DV	-.035	.069	
	AB (12 years) → DV	-.003	.072	
	Empathy → DV	-.121	.102	
	Resting Heart Rate→ DV	-.085	.107	
	Empathy x Resting Heart Rate→ DV	.272*	.136	
5) Moral Disengagement (self-report; 17 years)	Child Race → DV	.173†	.089	.125
	Family Income → DV	.010	.073	
	AB (12 years) → DV	.024	.074	
	Empathy → DV	-.223**	.079	
	Resting Heart Rate→ DV	-.120†	.064	
	Empathy x Resting Heart Rate→ DV	.183*	.086	

Note. Child Race: 0 = Caucasian; 1 = Non-Caucasian. Shaded cells denote significant paths. †$p < .10$. *$p < .05$. **$p < .01$.

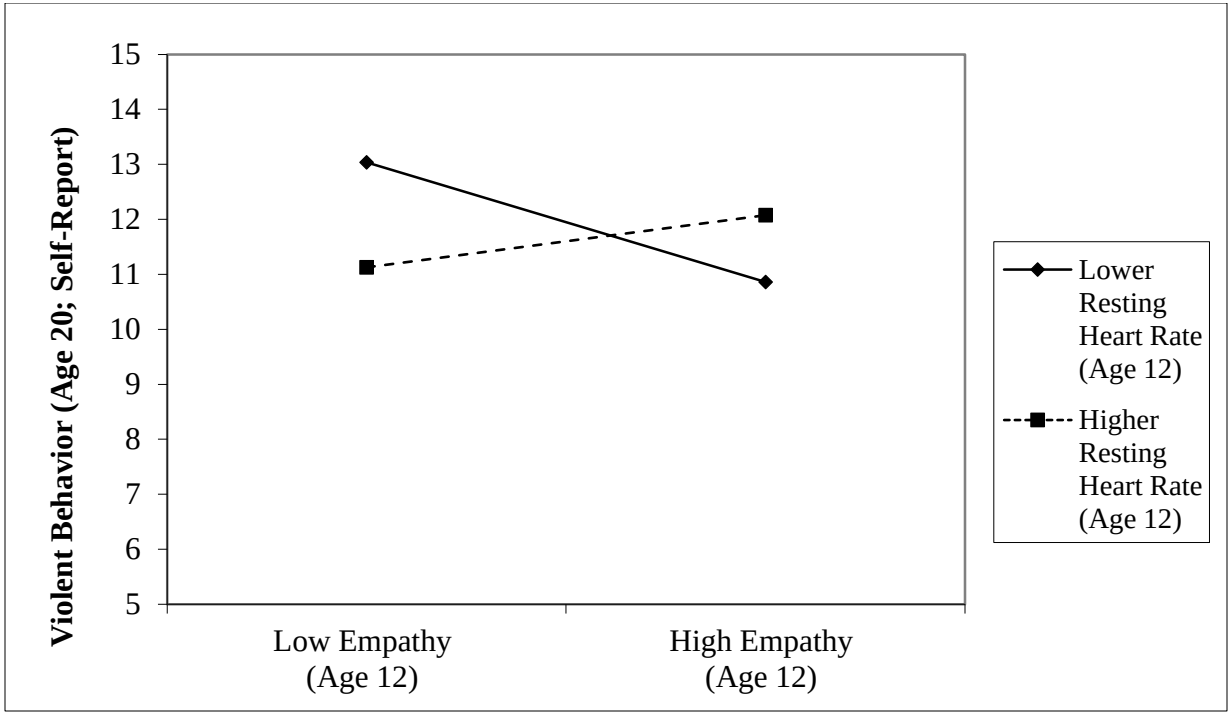

Figure 1. Association between empathy at age 12 and self-reported violent behavior at Age 20 for men with higher vs. lower resting heart rate (RHR) at age 12 (i.e., 1 SD above and below the mean RHR). Findings indicate that lower empathy predicts greater violence at age 20 for men with lower but not higher RHR.

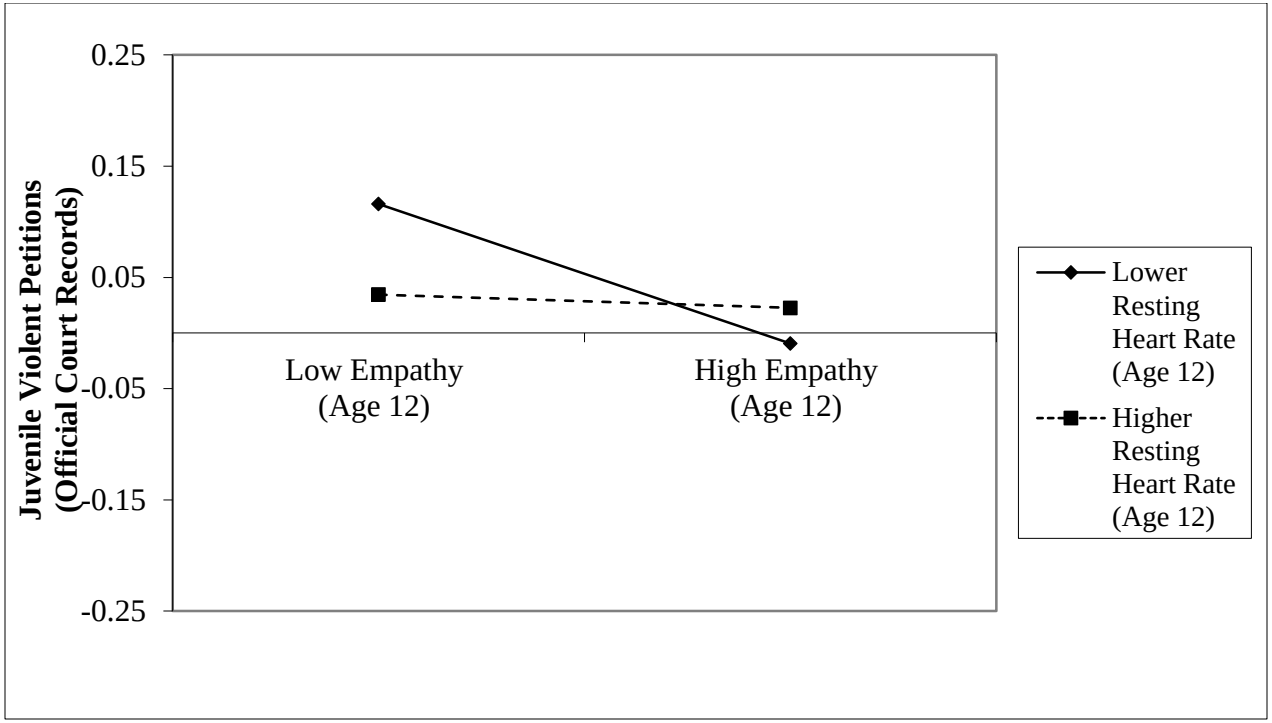

Figure 2. Association between empathy at age 12 and juvenile violent court petitions for men with higher vs. lower resting heart rate (RHR) at age 12 (i.e., 1 SD above and below the mean RHR). The juvenile violent petitions variable has undergone a logarithmic transformation. Findings indicate that lower empathy predicts more violent court petitions for men with lower but not higher RHR.