

## Associations Between Resting Heart Rate and Antisocial Behavior

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### Abstract

Studies testing the relationship between autonomic nervous system function as indexed by low resting heart rate and antisocial behavior have found that low resting heart rate is positively correlated with a wide range of antisocial behavior measures. The aim of this review was to assess the influence of heart rate (HR) level and HR variability (HRV) on the relationship between behavioral variables such as community violence (CV) exposure with proactive and reactive aggression. The explanations can be organized around two main causal mechanisms. In the first, low autonomic arousal (low resting heart rate) is a marker for psychological states that lead to increased antisocial behavior. In the second, physiological characteristics cause both low autonomic arousal (low resting heart rate) and increased antisocial behavior. In respect of hypotheses, we discuss these results in the context of the 'fearlessness' and 'sensation seeking' hypotheses. Our results offer an initial suggestion that biological characteristics are related to constructs that play central roles in behavioral actions. The results supported the suggestion that there is an association between cognitive function and HR/HRV.

**Keywords:** Resting Heart Rate, Antisocial, Behavior

### Introduction

Recent research has found that biological variables contribute to the development of antisocial and aggressive behavior in children. In particular, low autonomic arousal, especially in the form of low resting heart rate, is significantly associated with antisocial behavior in both children and adults (1). The linkage between biological characteristics and explanatory variables central to criminological theories is supported by recent reports. The previous studies often found that biological characteristics are robust predictors of crime, there is little reason to suspect that these characteristics have a large direct effect on behavior (2). Alternatively, these characteristics likely contribute to dispositions or broad behavioral tendencies, which interact with key features of the environment to increase the likelihood of crime and deviance. Low resting heart rate is well suited for an initial effort to link biological characteristics to key explanatory variables in criminological theory (3). In a meta-analysis of 40 studies testing the association between low resting heart rate and antisocial behavior, Ortiz and Raine (2004) found that "low resting heart rate appears to be the best-replicated biological correlate to date of antisocial and aggressive behavior in children and

adolescents" (1). Studies testing the relationship between autonomic nervous system function as indexed by low resting heart rate and antisocial behavior have found that low resting heart rate is positively correlated with a wide range of antisocial behavior measures. These different types of measures include clinical diagnoses, observational measures, self-report measures, and actuarial measures (4).

Farrington (1997) found low resting heart rate at age 18 was predictive of a conviction for violence before the age of 25, while controlling for impulsivity, employment, physical characteristics, parent criminality, and IQ (5). Cauffman, Steinberg, and Piquero (2005) show that low resting heart rate distinguished residents in the California Youth Authority from high schools students, net of controls for demographic characteristics, parental education, frontal lobe functioning, and future orientation (6). Armstrong, Keller, Franklin and MacMillan (2009) found low resting heart rate predicted serious and violent antisocial behavior in multivariate models also including measures of self-control, delinquent peers, parental attachment, and demographic characteristics (7).

The aim of this review was to assess such biosocial interactions in relation to aggression in a community sample of children. Specifically, we examined the influence of heart rate (HR) level and HR variability (HRV) on the relationship between behavioral variables such as community violence (CV) exposure with proactive and reactive aggression.

### Roles of Autonomic Nervous System

A link between resting low resting heart rate and perceptions regarding the certainty and severity of sanction is implied in speculation that a tendency towards fearlessness may mediate the connection between low resting heart rate and antisocial behavior. If those with low resting heart rate are less fearful of the consequences of their actions they may tend to underestimate the certainty and severity of sanction, leading to an increased tendency to engage in crime and delinquency (8).

Heart rate is a common and easily accessible measure of autonomic nervous system function. The autonomic nervous system has two major subdivisions: the parasympathetic nervous system and the sympathetic nervous systems. Relative increases in parasympathetic nervous system activity are associated with decreases in heart rate, while relative increases in sympathetic nervous system activity are associated with increases in heart rate (9).

Autonomic nervous system activity is influenced by the central autonomic network (CAN), which is comprised of cortical, limbic, and midbrain structures. Cortical structures in the CAN include the medial prefrontal cortex and the orbitofrontal cortex (6). Limbic structures include the cingulate cortex, the insular cortex, the amygdala and the hypothalamus. Midbrain structures include the parabrachial complex, nucleus of the solitary tract, and the rostral and caudal ventrolateral medulla. Output from the CAN flows through the parasympathetic and sympathetic nervous systems (10). These systems influence heart rate through input to the sino-atrial node, which serves as the heart's pacemaker, generating electrical impulses that facilitate heart contraction. Parasympathetic input to the sino-atrial node is conveyed by the tenth cranial or 'vagus' nerve and originates in the dorsal motor nucleus and the nucleus ambiguus in

the brain stem. Sympathetic influences originate in the rostral ventrolateral medulla and are conveyed to the sino-atrial node through the stellate ganglia by way of the intermediolateral column of the spinal cord (11).

In the autonomic nervous system, efferent neurons carry information away from the CAN and afferent neurons that carry information toward the central autonomic network (CAN). Afferent neurons allow that autonomic arousal (or underarousal) may have a direct influence on emotion and cognition, and by extension, behavior. Feedback from these neurons returns to the insular cortex (IC) and other higher cortical structures, where central representations of bodily states are thought to influence emotion and cognition (12).

HR variability (HRV) has also been implicated in antisocial behavior, but the direction of the relationship is unclear. HRV reflects the normal variation of intervals that occur between heart beats as a function of respiration. Whereas HR has both sympathetic and parasympathetic influences, HRV is mediated by the vagus nerve and controlled primarily by the parasympathetic branch of the autonomic nervous system (13). The parasympathetic nervous system helps to slow the heart, which creates more beat-to-beat variability in HR, and this variability is thought to reflect vagal tone. Because of its parasympathetic influence, high vagal tone is thought to reflect emotion regulation capacity in the sense of being able to self-soothe when experiencing a strong emotion; thus, it may reflect a protective factor that buffers children from adverse situations (14).

### Mechanisms and Hypotheses Linking Biological Variables and Behavior

These explanations can be organized around two main causal mechanisms. In the first, low autonomic arousal (low resting heart rate) is a marker for psychological states that lead to increased antisocial behavior. In the second, physiological characteristics cause both low autonomic arousal (low resting heart rate) and increased antisocial behavior. Psychological characteristics proposed as mediators between resting heart rate and antisocial behavior include sensation seeking and fearlessness (15). The sensation seeking explanation of the relationship

between low resting heart rate and antisocial behavior suggests that low resting heart rate is an indicator of low psychological arousal and this low arousal constitutes an unpleasant psychological state. Acts of antisocial behavior, including crime and delinquency, are then undertaken in an effort to increase arousal levels. Low resting heart rate may also indicate a decreased sensitivity to aversive consequence or fearlessness, which in turn leads to increased antisocial behavior (16). Physiological processes potentially mediating the relationship between resting heart rate and antisocial behavior include right hemisphere dysfunction, reduced noradrenergic functioning and increased vagal tone. While testable propositions are easily derived from the potential links between low resting heart rate and antisocial behavior, the extent to which the proposed links actually explain the relationship between the two is largely unexplored in the literature (17). In an important exception to this general trend, Sijtsema et al. (2010) found the relationship between resting heart rate and rule breaking was mediated by sensation seeking in adolescence. Further tests of the individual characteristics that mediate the relationship between low resting heart rate and antisocial behavior may serve to contribute to our understanding of this relationship and to situate it relative to the causal mechanisms offered by criminological theory (2).

In respect of hypotheses, first discuss these results in the context of the 'fearlessness' and 'sensation seeking' hypotheses regarding the relationship between resting heart rate and antisocial behavior. If we allow that tendency to attribute a lower likelihood of sanction is indeed a reasonable proxy for fearlessness, our results are consistent with suggestion that the relationship between low resting heart rate and antisocial behavior is explained by a tendency towards 'fearlessness' among those with low resting heart rate (18). We found that LRHR was associated with a significantly lower perceived chance of arrest for both theft and drunk driving. Those with LRHR also tended to anticipate a reduced chance of conviction for assault. While far from a definitive test, our results are inconsistent with the idea that a tendency towards sensation seeking explains the relationship between resting heart rate and antisocial behavior (19). This explanation suggests that those with low resting heart rate tend to engage in sensation seeking behavior to increase

an otherwise unpleasant state of underarousal. Personality theory has a history of research linking biological processes to certain dimensions of personality, and findings support the notion that such individual differences may predispose to violent behavior. HR under-arousal has been attributed to the personality trait of extraversion or stimulation-seeking; under-aroused individuals are thought to seek stimulation or reward to elevate their arousal (20). One component of extraversion is impulsivity, or acting without forethought. Reinforcement Sensitivity Theory proposes that impulsive individuals may be oversensitive to reward due to an overactive behavioral activation system (BAS) coupled with an underactive behavioral inhibition system (21). Consistent with the notion of stimulation-seeking, Mathias & Stanford (2003) found that men characterized by high (versus normal) levels of impulsivity showed reduced resting HR and increased HR reactivity to a challenge (15). Knyazev, Slobodskaya, & Wilson (2002) similarly found evidence for cortical and autonomic under-arousal in relation to high BAS. In addition to reward sensitivity, under-arousal may also reflect low levels of fear during mildly stressful situations. In such cases of reduced fear, individuals are less likely to inhibit their behaviors in risky situations or to learn from cues of punishment. Taken together, these findings suggest that low HR may relate to personality profiles that are high in fearlessness, sensation-seeking, risk-taking, or impulsivity. Such personalities may be channeled in socially appropriate ways (e.g., race car driving, sports, and recreational activities). Violence exposure, however, has the potential to socialize these personalities toward inappropriate aggressive behavior (22).

## Conclusions

Our results offer an initial suggestion that biological characteristics are related to constructs that play central roles in behavioral actions. The results supported the suggestion that there is an association between cognitive function and HR/HRV. Knowledge concerning the underlying organization of the psychopathic personality will help us to get a better understanding of this important condition and help us to develop appropriate intervention programs in the future.

## Conflicts of interest

Authors declare no conflict of interests.

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