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Resting heart rate and antisocial behavior: An updated systematic review and meta-analysis

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ABSTRACT

Prior meta-analyses have concluded that low resting heart rate is associated with higher levels of antisocial behavior. These reviews, however, have had important limitations that preclude firm conclusions about both the relationship between resting heart rate and antisocial behavior and potential moderators of this association. The goal of the current article was to address these limitations by conducting an updated systematic review and meta-analysis of resting heart rate versus antisocial behavior that included both published and unpublished results. 114 reports and 115 independent effect sizes yielded a summary effect size of $d = -.20$ (SE = .039, $p < .001$) under the random effects model. Sex and study design (concurrent or longitudinal) did not moderate the relationship between resting heart rate and antisocial behavior. Age and number of covariates were also unassociated with effect size. This meta-analysis demonstrated that the relationship between low resting heart rate and antisocial behavior is highly replicable and applies to multiple types of antisocial behavior, including aggression and psychopathy. Findings confirm the importance of low resting heart rate as a robust biological correlate of antisocial behavior.

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1. Introduction

Antisocial and violent behavior are increasingly viewed as major public health concerns (Mercy, Rosenberg, Powell, Broome, & Roper, 1993; Shepherd & Farrington, 1993), which both impose a large financial cost to society (Scott, Knapp, Henderson, & Maughan, 2001) and are also associated with a host of other negative outcomes, including poor health (Piquero, Shepherd, Shepherd, & Farrington, 2011), increased risk of certain mental disorders (Marmorstein, 2007), and reduced overall life success (Farrington et al., 2006). In order to design effective, evidence-based interventions for antisocial and violent behavior, it is critical to identify risk factors for antisocial behavior that can be targets for potential change (Farrington, 2000). Biological researchers have contributed to this undertaking by identifying numerous biological correlates of antisocial behavior, including volumetric brain abnormalities (Yang & Raine, 2009), reduced autonomic nervous system activity (Lorber, 2004; Ortiz & Raine, 2004), and impaired executive functioning (Morgan & Lilienfeld, 2000). Of all biological factors, low resting heart rate has been suggested as the "best-replicated biological correlate of antisocial behavior in child and adolescent populations" (Ortiz & Raine, 2004, p. 159). Low heart rate has also been proposed as a putative biomarker, or objective index, of conduct disorder (Moffitt et al., 2008) and is listed in the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*, The American Psychiatric Association, 2013) as a physiological risk factor for conduct disorder.

Heart rate is a psychophysiological measure that is controlled by both the parasympathetic and sympathetic branches of the autonomic nervous system. Although the mechanism underlying the low heart rate-antisocial behavior relationship is not yet fully understood, low resting heart rate is hypothesized to be associated with increased levels of antisocial behavior, because low autonomic nervous system arousal may reflect a relative lack of fear, which could facilitate antisocial behavior (Raine, 1993, 2002a). Alternatively, reduced autonomic nervous system arousal could be an unpleasant physiological state, leading those with low resting heart rates to engage in stimulating behaviors, including antisocial behaviors, in order to increase their level of arousal to a more optimal level (Quay, 1965; Raine, 2002a).

In a series of narrative reviews, Raine (1993, 2002a) argued that (1) low resting heart rate characterizes antisocial behavior in both males and females, (2) the resting heart rate-antisocial behavior relationship is unlikely to be artifactual given that relationship holds up after controlling for a number of variables – including body size, IQ, physical activity, and socioeconomic status, (3) the resting heart rate-antisocial behavior relationship is confirmed in cross-sectional, as well as prospective longitudinal research, (4) low heart rate is more typical of young antisocials, and (5) low resting heart rate does not appear to characterize psychopaths. Since the publication of these reviews, researchers have continued to investigate the relationship between resting heart rate and antisocial behavior. Though some results have varied (e.g., Bimmel, van Ijzendoorn, Bakermans-Kranenburg, & Juffer, 2008; de Wied, van Boxtel, Posthumus, Goudena, & Matthys, 2009; Schneider, Nicolotti, & Delamater, 2002), numerous studies have found that low resting heart rate is related to higher levels of antisocial behavior (e.g., Armstrong, Keller, Franklin, & MacMillan, 2009; Baker et al., 2009; Cauffman, Steinberg, & Piquero, 2005). This more recent wave of research has confirmed several of Raine's (1993, 2002a) claims, but cast some doubt on others. For instance, some prospective research published since that time has reached mixed results. Sijtsema et al. (2010) found that low resting heart rate at age 11 years was related to antisocial behavior at age 16 years in males but not in females. Additionally, some studies have confirmed that there is not a relationship between resting heart rate and psychopathic traits (e.g., de Wied, van Boxtel, Matthys, & Meeus, 2012), while others have detected a significant association (e.g., Baker et al., 2009; Hansen, Johnsen, Thornton, Waage, & Thayer, 2007).

Prior meta-analytic reviews of resting heart rate versus antisocial behavior have helped to clarify both the strength of the resting heart rate-antisocial behavior relationship, as well as potential moderators of this relationship, by applying rigorous methods to summarizing the existing literature (Lorber, 2004; Ortiz & Raine, 2004). However, these prior meta-analyses have had several important limitations that preclude firm conclusions about both the strength of the relationship between resting heart rate and antisocial behavior and potential moderating variables. The purpose of this article is to build upon the prior meta-analyses by conducting an updated systematic review and meta-analysis of resting heart rate versus antisocial behavior.

1.1. Prior meta-analyses

Ortiz and Raine (2004) conducted a systematic review and meta-analysis of resting heart rate versus antisocial behavior that included 40 reports, 45 independent effect sizes, and a total of 5,868 children and adolescents, yielding an overall effect size of $d = -0.44$ ($p < .0001$) for resting heart rate versus antisocial behavior. None of their hypothesized moderators – including age, gender, source of recruitment (community or clinical), study design (concurrent or prospective), source of behavioral data (parent, teacher, or self-report), or the method of measuring resting heart rate (sophisticated recording or simple recording) – significantly moderated the strength of the effect. Lorber (2004) conducted a similar meta-analysis of resting heart rate that included 40 reports and 46 independent effect sizes. Lorber (2004) reported significant effect sizes for studies of resting heart rate and aggression ($d = -.38$, $p < .05$) and conduct problems ($d = -.33$, $p < .05$), but not for studies of heart rate and psychopathy ($d = .06$, $p > .05$). Age did not significantly moderate the effect size in studies of conduct problems and was only marginally significant for studies of aggression ($p < .10$), with statistically significant effect sizes reported for studies of children ($d = -.51$, $p < .05$) and adults ($d = -.30$, $p < .05$), but not for adolescents ($d = -.15$, $p > .05$). However, there were only four studies in adolescent samples, precluding firm conclusions.

These existing meta-analyses have made several important contributions to our understanding of the resting heart rate-antisocial behavior relationship. For instance, Lorber (2004) usefully disaggregated effect sizes by antisocial behavior type, while Ortiz and Raine (2004) ruled out a number of important moderators of this relationship. However, there are a number of limitations of the existing meta-analyses that should be noted. These include the following: (1) Although Ortiz and Raine (2004) considered longitudinal versus concurrent study design as a moderating variable, their meta-analysis included only child and adolescent samples. Therefore, the length of the period between the measurement of resting heart rate and the assessment of antisocial behavior was necessarily limited. As Lorber's (2004) meta-analysis excluded prospective longitudinal research, it is unclear whether low resting heart rate will continue to be associated with antisocial behavior in longitudinal research that involves a longer follow-up period. (2) Lorber (2004) did not include an overall effect size for resting heart rate versus all types of antisocial behavior, making it more difficult to draw conclusions from the meta-analysis about the relationship between resting heart rate and antisocial behavior. (3) Ortiz and Raine (2004) did not differentiate studies on the basis of type of antisocial behavior. Lorber (2004) reported results by behavior type, but antisocial behavior type moderator analyses were conducted within age groups, resulting in analyses that included only a small number of studies. Therefore, more research is needed that addresses whether the resting heart rate-antisocial behavior relationship varies by antisocial behavior type. (4) Lorber (2004) did not record sex as a moderator. Although Ortiz and Raine (2004) found that sex did not moderate the resting heart rate-antisocial behavior relationship, their sample consisted only of child and adolescent samples. Therefore, it remains possible that sex moderates this relationship in studies that include adults. (5) Lorber (2004) coded eight effect sizes as $d = 0$ for studies where