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Brain activity, low self-control, and delinquency: An fMRI study of at-risk adolescents

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ABSTRACT

Purpose: A vast literature finds that low self-control is associated with a myriad of antisocial behaviors. Consequently, increasing attention has focused on the causes of low self-control. While criminologists have directed significant attention to studying its social causes, fewer studies have considered its neural bases.
Methods: We add to this nascent body of research by using data collected on an at-risk sample of adolescents participating in the ongoing Michigan Longitudinal Study. We examine the functioning of prefrontal and limbic regions of the brain during failed inhibitory control, assessed using the go/no-go task and functional magnetic resonance imaging, in relation to low self-control and self-reported delinquency.
Results: Results indicate that greater activation localized in the anterior cingulate cortex (ACC) during failed inhibitory control is negatively associated with low self-control. Moreover, the association between ACC activity and later delinquency is mediated through low self-control.
Conclusions: Findings of this study demonstrate the utility of integrating neuroscientific and criminological perspectives on the causes of antisocial behavior. Concluding remarks address the theoretical and policy implications of the findings, as well as directions for future research.

1. Introduction

Since the publication of *A General Theory of Crime* (Gottfredson & Hirschi, 1990), low self-control has been at the center of criminological research on the causes of delinquency and crime, and a multitude of studies find a positive association between low self-control and various antisocial behaviors (e.g., Burt, Sweeten, & Simons, 2014; Hay & Meldrum, 2015; Vazsonyi, Mikuška, & Kelley, 2017; Wright, Caspi, Moffitt, & Silva, 1999). Given this, scholars have increasingly focused attention on the causes of low self-control. In this regard, criminologists have thoroughly scrutinized its social causes, including parenting practices (e.g., Beaver, Ferguson, & Lynn-Whaley, 2010; Botchkovar, Marshall, Rocque, & Posick, 2015; Hay & Forrest, 2006; Vazsonyi & Huang, 2010; Wright & Beaver, 2005), peer associations (e.g., Burt, Simons, & Simons, 2006; Meldrum & Hay, 2012; Meldrum, Young, & Weerman, 2012), school environments (e.g., Burt et al., 2006; Turner, Piquero, & Pratt, 2005), and neighborhood contexts (e.g., Gibson, Sullivan, Jones, & Piquero, 2010; Jones, 2017; Pratt, Turner, & Piquero, 2004; Teasdale & Silver, 2009).

While much attention has been directed at the social causes of low self-control, other researchers have started to shed light on its neurobiological and neuropsychological underpinnings (e.g., Beaver, DeLisi, Vaughn, & Wright, 2010; Beaver, Wright, & DeLisi, 2007; Cauffman, Steinberg, & Piquero, 2005; DeLisi, 2014; Jackson & Beaver, 2013; Ratchford & Beaver, 2009). This work parallels research taking place within the neurosciences highlighting the importance of a concept closely related to self-control—inhibitory control—for understanding patterns of antisocial behavior (e.g., Feil et al., 2010; Luijten et al., 2014). Taken together, these lines of research call attention to a neglected aspect of Gottfredson and Hirschi's (1990) theory by providing evidence for a neurobiological substrate to self-control. To date, however, criminologists have generally examined neural influences on self-control by employing data derived from neuropsychological tests (e.g., Early Screening Inventory; Peabody Picture Vocabulary Test; Tower of London) rather than more proximate measurements of neural activity (but see Yancey, Venables, Hicks, & Patrick, 2013). Thus, additional research based on the measurement of brain activity via neuroimaging

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techniques (e.g., functional magnetic resonance imaging [fMRI]) can augment the existing criminological literature and further inform ongoing discussion regarding the neural underpinnings of self-control.

In a similar manner, the field of criminology has generally approached the study of the neurobiological bases of delinquency and crime by relying on indirect indicators of neural activity (e.g., Cauffman et al., 2005; Moffitt, Lynam, & Silva, 1994). And, while the relevance of research based on the use of neuroimaging data for the study of criminal behavior has been *discussed* within criminological journals (e.g., Bufkin & Luttrell, 2005), studies based on the *use* of neuroimaging data are virtually absent from the criminological literature. This, despite the fact that meta-analytic research assessing the association between structural and functional brain abnormalities and antisocial behavior has already been produced in other disciplines (see Yang & Raine, 2009). Given these facts, coupled with the increased interest in the neurobiological underpinnings of low self-control, it would seem important for criminologists to seek out collaborations with other scholars, particularly neuroscientists, to develop a more comprehensive understanding of the neural underpinnings of antisocial behavior.

Accordingly, the current study utilizes fMRI and survey data to examine two issues. First, we investigate whether activity localized in regions of the brain known to be associated with failed inhibitory control, including the insula, dorsolateral prefrontal cortex (dlPFC), and anterior cingulate cortex (ACC), is prospectively associated with variation in self-control during early adolescence. Second, we assess whether low self-control mediates the association between brain activity and later delinquent behavior. In the following section, we discuss theory and research on the causes of low self-control, including the growing discourse concerning its neurobiological underpinnings. Following this, research on failed inhibitory control and error monitoring, and the brain regions associated with failed inhibitory control and antisocial behavior, is discussed. After addressing the goals of the current study and presenting our hypotheses, we describe the prospective data used and present the results of our analyses.

2. Literature review

2.1. Theory and research on the causes of low self-control

Gottfredson and Hirschi's (1990) theory of low self-control, articulated in *A General Theory of Crime*, proposes that individual-level delinquency and crime can be explained by a lack of self-control. In articulating the concept of low self-control, they state that people who are low in self-control will tend to "pursue short-term gratification without consideration of the long-term consequences of their acts" (1990:177). Further, they state that individuals who are low in self-control will "tend to be impulsive, insensitive, physical (as opposed to mental), risk-taking, short-sighted, and nonverbal, and they will tend therefore to engage in criminal and analogous acts" (1990:90). In support of this claim, a large body of research finds that various indicators of low self-control are associated with a wide range of antisocial and deviant behaviors (for meta-analytic reviews see Pratt & Cullen, 2000; Vazsonyi et al., 2017; see also de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). In addition, research finds that low self-control is associated with a variety of negative life outcomes, including criminal victimization, poor health, and financial difficulties (e.g., Hay & Meldrum, 2015; Moffitt et al., 2011; Pratt, Turanovic, Fox, & Wright, 2014).

This evidence calls attention to the need to determine the causes of low self-control. In this regard Gottfredson and Hirschi (1990) place socialization, particularly parental socialization, at the center of the development of self-control. Specifically, they emphasize the importance of parental monitoring of the child's behavior and the use of effective disciplinary practices when a child misbehaves (1990:97). To the extent that a child is not effectively socialized, deficits in self-control are theorized to be the result. Prompted by this argument, a large number of studies have examined whether parenting practices account for variation in self-control, with many studies providing evidence supporting Gottfredson and Hirschi's claims (e.g., Botchkovar et al., 2015; Burt et al., 2006; Cullen, Unnever, Wright, & Beaver, 2008; Finkenauer, Engels, & Baumeister, 2005; Hay, 2001; Hay & Forrest, 2006; Meldrum, Young, & Lehmann, 2015; Perrone, Sullivan, Pratt, & Margaryan, 2004; Vazsonyi & Huang, 2010).

Yet, other studies find that parental socialization has a modest effect on the development of self-control (e.g., Vera & Moon, 2013), particularly once child-driven effects and genetic effects are taken into account (Beaver et al., 2010; Cecil, Barker, Jaffee, & Viding, 2012; Wright & Beaver, 2005; Wright, Beaver, Delisi, & Vaughn, 2008). Furthermore, studies which have found evidence supporting the link between parental socialization and self-control indicate that parental socialization accounts for a small portion of the variation in child and adolescent self-control (see for example Botchkovar et al., 2015; Perrone et al., 2004). These facts have led researchers to examine additional sources of socialization for instilling self-control, including the school context (e.g., Burt et al., 2006; Turner et al., 2005), peer groups (e.g., Burt et al., 2006; Meldrum & Hay, 2012; Meldrum, Young, & Weerman, 2012), and neighborhood environments (e.g., Gibson et al., 2010; Pratt et al., 2004; Teasdale & Silver, 2009). Many of these studies indicate that such sources incrementally add to our understanding of the causes of low self-control above and beyond parenting practices.

While most criminologists have sought to uncover the varied social causes of low self-control, others have started investigating its neural, biological, and genetic underpinnings. This represents a significant departure from the view proffered by Gottfredson and Hirschi (1990) that low self-control is a consequence of failed socialization. Specifically, Gottfredson and Hirschi (1990) are silent with regard to the role of the brain in explaining low self-control and generally reject the role of biological and genetic factors (1990:61–63), going so far as to state that genetic contributions to explaining antisocial behavior (and presumably low self-control) are "near zero" (1990:60). In contrast to this position, a growing number of studies support the contention that a neurobiological substrate also contributes to the variation in low self-control. First, research indicates that self-control is heritable (e.g., Beaver et al., 2009; Boisvert, Wright, Knopik, & Vaske, 2012; Connolly & Beaver, 2014). Second, a number of studies find that early-in-life factors such as birth complications (e.g., Beaver & Wright, 2005) and fetal exposure to neuroteratogens during pregnancy (e.g., Meldrum & Barnes, 2016; Minnes et al., 2016; Turner, Livecchi, Beaver, & Booth, 2011) are detrimental to the development of self-control.

Most pertinent to our current focus, a growing number of criminologists have directed attention to the potential importance of brain functioning in accounting for between-person differences in self-control (e.g., Beaver et al., 2007; DeLisi, 2014; Jackson & Beaver, 2013). Beaver et al. (2007) in particular contend that self-control should be viewed as an executive function of the frontal lobes of the brain (see also Barkley, 1997). The host of executive functions carried out by the brain include many things which overlap with Gottfredson and Hirschi's (1990) view of self-control, including planning, decision-making, sustaining attention, and inhibiting inappropriate or impulsive behavior (e.g., Ishikawa & Raine, 2003; Moffitt, 1990). To test the relationship between brain functioning and self-control, criminological studies have primarily made use of data derived from neuropsychological tests. Supporting the view that there is a neural basis to self-control, multiple studies report a positive association between neuropsychological deficits and low self-control (e.g., Cauffman et al., 2005; Jackson & Beaver, 2013; Ratchford & Beaver, 2009). Related strands of research also provide evidence that neuropsychological deficits are associated with broad measures of antisocial behavior (e.g., Beaver, Vaughn, DeLisi, Barnes, & Boutwell, 2012; Jackson, 2017; Jackson & Beaver, 2016; Jackson & Newsome, 2016; Vaske, Newsome, & Boisvert, 2013).

It is important to point out, however, that such studies rely on the indirect measurement of brain functioning. Thus, an important step in moving this area of research forward is to investigate the association