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Unique relations of age and delinquency with cognitive control☆

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A B S T R A C T

Context processing has significant empirical support as an explanation of age- and psychopathology-related deficiencies in cognitive control. We examined whether context processing generalizes to younger individuals who are in trouble with the law. We tested whether age and delinquency might have unique relations to context processing skills in four samples of male participants: adolescent offenders (n = 43), control adolescents (n = 33), young adult offenders (n = 40), and control young adults (n = 31). We used a modified Stroop task to measure context processing (i.e., attention, memory, and response inhibition). Task performance was superior for older participants in conditions most demanding of context processing skills. Adolescent offenders and control adolescents showed difficulties engaging selective attention to filter out irrelevant information, even after controlling for the effects of age. Control adolescents made the most errors in the condition most demanding of context processing, whereas the other three samples showed slower processing but fewer errors in context processing.

Optimal decision-making requires an ability to override habitual, non-optimal behavioral tendencies. Whether people can engage the extra mental resources required to inhibit these behaviors depends on several factors, including their age and the complexity of the situation. While habitual behaviors may allow people to obtain satisfaction in the short-term, most long-term goals require the thoughtful coordination of behaviors over time. Given the rash nature of many criminal acts, it is possible that cognitive control (i.e., the ability to inhibit inappropriate automatic responses in favor of executing appropriate, non-automatic responses) may be related to whether an individual chooses to engage in antisocial behaviors.

Many empirical investigations have examined age and antisocial behavior as factors related to cognitive control, but they have not examined both factors jointly. Independent empirical support for the role of each exists, although the exact way that these factors relate to cognitive control is not always consistent. In the current article, we review findings on the relations between age and cognitive control, followed by findings on the relations between delinquency and cognitive control. We then propose that a model from the cognitive neuroscience literature (Context processing; Cohen, Barch, Carter, & Servan-Schreiber, 1999) may enhance our understanding of the relations among age, delinquency, and cognitive control. We cross-sectionally test this model in four samples: control adolescents, adolescent offenders, control young adults, and young adult offenders.

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Age and cognitive control

A wealth of neurobiological evidence indicates that the human brain undergoes significant changes through adolescence (e.g., Spear, 2000). Prolific alterations occur within an expansive circuitry among brain structures, particularly within the prefrontal cortex (PFC) and its connections with other brain regions (e.g., Casey, Galvan, & Hare, 2005; Casey, Giedd, & Thomas, 2000; Giedd, 2004, pp. 77–85, 2008). Longitudinal research suggests that these interconnections are refined during adolescence, as evidenced by decreases in gray matter volume (Gogtay et al., 2004), and increases in white matter volume (Reiss, Abrams, Singer, Ross, & Denckla, 1996). Expanded white matter improves the speed (Casey, Tottenham, Liston, & Durston, 2005; Luna & Sweeney, 2004) and regulation (Fields & Stevens-Graham, 2002) of information being transmitted among brain regions. The cumulative effect of these neurobiological changes is a more focused, efficient, and modulated brain circuitry that continues to be modified through adolescence and beyond (Adleman et al., 2002; Gogtay et al., 2004; Sowell, Dells, Stiles, & Jernigan, 2001).

Refinements within the young brain coincide with improvements in cognitive control abilities, especially in response inhibition skills. Research has shown that localization and restriction of brain activity in the PFC increased with age and were associated with faster (Durston et al., 2002; Tamm, Menon, & Reiss, 2002) and more accurate (Durston et al., 2002) response inhibition skills. Brain imaging studies have also found that the band size of tract connections between the PFC and other brain structures (i.e., the striatum) narrow with age, and that narrower connectivity is related to faster and more accurate response inhibition skills (Liston et al., 2006). Maturation of white matter in the frontal lobe, but not the temporal lobe, corresponds to a specific improvement in working memory, demonstrating the correspondence between the development of brain structures and the development of cognitive control skills (Nagy, Westerberg, & Klingberg, 2004). Nuanced functional reorganization and activation of PFC circuitries occur in the developing adolescent brain and coincide with improvements in advanced cognitive control skills such as response inhibition (Luna & Sweeney, 2004).

Delinquency and cognitive control

The evidence drawn from normative samples of children and adolescents clearly indicates that brain developments occurring with age correspond to improvements in cognitive control. The evidence drawn from adolescents who engage in antisocial behaviors is more limited and less clear. Some studies have shown significant relations between delinquency and cognitive impairments in memory (Raine et al., 2005), response inhibition (Iselin & DeCoster, 2009; Toupin, Déry, Pauzé, Mercier, & Fortin, 2000), mental flexibility/set shifting (Kim, Kim, & Kwon, 2001; Lueger & Gill, 1990; Moffitt & Henry, 1989; Olvera, Semrud-Clikeman, Pliszka, & O'Donnell, 2005; Toupin et al., 2000), and sustained attention (Lueger & Gill, 1990; Moffitt & Henry, 1989; Toupin et al., 2000). However, other studies have found no relations between delinquency and similar cognitive skills (e.g., Déry, Toupin, Pauzé, Mercier, & Fortin, 1999; Herba, Tranah, Rubia, & Yule, 2006; Kim et al., 2001; Toupin et al., 2000). Some research has even found that delinquency was related to better response inhibition skills (Carroll, Hemingway, Bower, Houghton, & Durkin, 2006). Making claims about whether antisocial adolescents have normal or impaired cognitive control is difficult because of this diversity in findings.

One reason the relation between delinquency and cognitive control may vary between studies is that researchers have commonly examined cognitive control skills broadly and as independent processes. Studies often use tasks that measure one specific cognitive control skill, such as working memory processes, in isolation of other cognitive control processes (e.g., response inhibition). It is likely that more nuanced and integrative cognitive processes are developing through adolescence. For instance, Luna and Sweeney (2004) propose that it is the organization and integration of cognitive control skills, rather than the simple attainment of these skills, that occurs in adolescence. Psychopathology may therefore be marked by a failure to completely integrate existing cognitive control skills rather than by a complete absence of these skills (Luna & Sweeney, 2004). Moffitt (1993) theorized similarly regarding the cognitive control abilities of adolescents who engage in antisocial behaviors, noting that their neuropsychological anomalies are likely diffuse and subtle, unlike the clear neuropsychological impairments of children with autism or developmental delays. Subtle differences in cognitive abilities between delinquent and control adolescents may go unnoticed on measures of basic cognitive control. Tasks requiring the recruitment and integration of multiple cognitive control skills may be more sensitive to subtle neuropsychological differences, should they exist.

Context processing: attention, memory, response inhibition

Attention, memory, and response inhibition are the three skills comprising cognitive control (Fuster, 1980, 1985). Although investigators acknowledge that one skill rarely functions in isolation, many research paradigms target one skill using specialized tasks and measures of performance. Cohen and colleagues (e.g., Braver & Cohen, 2001; Cohen et al., 1999; Cohen & Servan-Schreiber, 1992) have examined the integration of all three elements of cognitive control in their model of context processing. Context processing comprises the abilities to attend to cues indicating appropriate future responses, to actively retain these cues in memory, and to use these cues to inhibit more dominant but inaccurate responses so that less dominant but accurate responses can be executed. Individuals with good context processing skills create internal representations of task-relevant information and maintain these representations over periods of delay, relying on this information to determine appropriate behavioral responses at later points in time (Cohen et al., 1999). Context information can be provided as task instructions or task stimuli that indicate the correct response to future decision-making situations (Cohen et al., 1999).