2009

THE ROLE OF EXECUTIVE DYSFUNCTION IN PREDICTING FREQUENCY AND SEVERITY OF VIOLENCE

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(Spine title: Predicting Frequency and Severity of Violence)

(Thesis format: Monograph)

by

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Graduate Program in Psychology

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

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Abstract

The adverse consequences of violence on society are tremendous. The proportion of offenders incarcerated for violent offences is large, and the cost of keeping these offenders incarcerated is startling. Understanding and treating the causal underpinnings of violent crime is of the utmost importance for individuals and society as a whole. Several factors have been identified as potential contributors to violent crime, including cognitive deficits in executive functioning (Hoaken, Allaby, & Earle, 2007). To investigate this further, 77 offenders from Fenbrook Institution, a federal facility, were tested on a battery of executive functioning measures. Offenders were found to have broad and pervasive dysfunction in their executive abilities. In addition, specific scores from the battery were found to predict the frequency and severity of past violent offending. This speaks to the possibility of a new type of correctional rehabilitation program, one that focuses on the rehabilitation of basic executive functions.

KEYWORDS: executive functioning; Delis-Kaplan Executive Function System; violence; severity of violence; frequency of violence; aggression; multivariate analysis of covariance; Poisson regression; binary logistic regression.

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List of Abbreviations

Abbreviation	Variable Name
$CWIT_{I\text{-}CN}$	Colour-Word Interference Test - Inhibition Condition minus Colour Naming. Scaled Score
$CWIT_{ICE}$	Colour-Word Interference Test - Inhibition Condition Corrected Errors. Cumulative Percentile Rank
$CWIT_{IUE}$	Colour-Word Interference Test - Inhibition Condition Uncorrected Errors. Cumulative Percentile Rank
$CWIT_{I/S\text{-}CN}$	Colour-Word Interference Test - Inhibition/Switching Condition minus Colour Naming. Scaled Score
$CWIT_{I/S\text{-}R}$	Colour-Word Interference Test - Inhibition/Switching Condition minus Reading. Scaled Score
$CWIT_{I/SCE}$	Colour-Word Interference Test - Inhibition/Switching Condition Corrected Errors. Cumulative Percentile Rank
$CWIT_{I/SUE}$	Colour-Word Interference Test - Inhibition/Switching Condition Uncorrected Errors. Cumulative Percentile Rank
FreqVO	Frequency of Violent Offending
KBIT Composite	Kaufman Brief Intelligence Test - Composite Standard Score
SevVO	Severe Violent Offending
ST_{CCS}	Sorting Test - Confirmed Correct Sorts. Scaled Score
ST_{FSDS}	Sorting Test - Free Sorting Description Score. Scaled Score
ST_{SRDS}	Sorting Test - Sort Recognition Description Score. Scaled Score
ST_{PR}	Sorting Test - Perceptual Rules. Scaled Score
ST_{VR}	Sorting Test - Verbal Rules. Scaled Score
ST_{ID}	Sorting Test - Incorrect Descriptions. Scaled Score
ST_{OAD}	Sorting Test - Overly Abstract Descriptions. Cumulative Percentile Rank
ST_{PSA}	Sorting Test - Percent Sorting Accuracy. Scaled Score
TT_{MAR}	Tower Test - Move Accuracy Ratio. Scaled Score
TT_{MFMT}	Tower Test - Mean First Move Time. Scaled Score
TT_{TAS}	Tower Test - Total Achievement Score. Scaled Score
$VF_{LF\text{-}TC}$	Verbal Fluency - Letter Fluency - Total Correct. Scaled Score
$VF_{CF\text{-}TC}$	Verbal Fluency- Category Fluency - Total Correct. Scaled Score
$VF_{CS\text{-}TC}$	Verbal Fluency - Category Switching - Total Correct. Scaled Score
$VF_{CS\text{-}SA}$	Verbal Fluency - Category Switching - Switching Accuracy. Scaled Score
VF_{RE}	Verbal Fluency - Repetition Errors. Scaled Score

The Role of Executive Dysfunction in Predicting Frequency and Severity of Violence

Aggression and violence have profound social, legal, and political effects. The victims of violent crime can lose valuable possessions, their health or ability to work, and sometimes their lives (WHO, 2002). In Canada in 2005, 15 271 incarcerated adult offenders (70% of all incarcerated offenders) had been charged with violent offences (e.g., homicides, attempted murders, sexual offences, abductions, and robbery offences causing bodily harm: Public Safety and Emergency Preparedness Canada, 2005). Contrary to what some believe, violent crime rates have stayed relatively stable over the years, with rates of 973 charges in 1990, 1009 in 1995, 984 in 2000, and 943 charges in 2005 (incidents reported per 100,000 population). It has recently been estimated to cost approximately $87, 919 per year to keep an offender in a penitentiary (Public Safety and Emergency Preparedness Canada, 2005). Clearly, violence results in significant financial consequences for society. Researchers urgently need to understand predisposing factors of violence in order to develop preventative strategies for individuals who are at risk, and to develop rehabilitation programs for individuals who are already violent. The objective of this thesis is to determine whether specific variables can predict the frequency and severity of violent offending, providing targets for more specialized prevention and rehabilitations programs for perpetrators of violence.

Aggression and violence are terms often used interchangeably; however, though similar, these terms are not synonymous. In the literature *aggression* is mainly an empirical term used by researchers investigating individuals in the community. *Violenc*e is mainly a forensic term used by researchers investigating incarcerated offenders. The focus of this thesis is on the behaviour of incarcerated offenders, as such, I will primarily refer to violence throughout the text. I will retain the original terminology (i.e., aggression or violence) when reviewing the existing literature in order to express the nature of the behaviour referred to in the original publications.

A number of researchers define aggression differently. An early definition put forth by Buss (1961) defines aggression as "a response that delivers noxious stimuli to another organism" (p. 1). In an extension of this definition Baron and Richardson (1994) stated that aggression is "any form of behaviour directed toward the goal of harming or injuring another being who is motivated to avoid such treatment" (p. 7). The inability of researchers to agree on a definition of aggression has led to confusion in its measurement. The present study does not directly measure aggression, and so no particular definition was adopted. As is the case with aggression, the term violence has a variety of proposed definitions, but the present study will define violence as behaviour involving an intentional act of physical aggression against another individual that is likely to cause physical injury (Meloy, 2006). Although the definition of violence is narrower than that of aggression, it is not necessarily a homogenous construct. However, for the purpose of this study it will be defined as such (Anderson & Bushman, 2002; Bushman & Anderson, 2001).

Historically, researchers have worked at identifying psychosocial risk factors in childhood that are related to an increased likelihood of aggression and violence later in life. In a review of the literature, Kashani, Jones, Bumby, and Thomas (1999) identified a number of variables that were related to an increased likelihood of aggressive behaviour in youth. For example, difficult temperament during infancy and early initiation of delinquency in a child's life were both related to an increased likelihood of aggression later in life. Physiological correlates such as low resting heart rates, low serotonin activity in the central nervous system, low cortisol, high testosterone, perinatal difficulties, and minor physical abnormalities were also identified. Family variables related to delinquency were found to include family history of criminality or substance abuse, family management problems, parental attitudes towards aggression, parental failure to reinforce prosocial behaviours, modeling of aggressive behaviours, insufficient monitoring, and intrafamilial violence. School variables identified included strict and inflexible classroom rules, frequent disciplinary problems at school, teacher hostility, lack of classroom management, and overcrowded schools. Peer variables that were correlated with aggression later in life included poor peer relations and affiliation with deviant peers. Finally, Kashani and colleagues identified several community factors to be related to aggression: availability of firearms, drugs, and alcohol; repeated exposure to violence in the media; neighbourhoods low in socioeconomic status; low sense of community; and high rates of community violence. A number of researchers have identified similar variables since the time of Kashani et al.'s review (e.g., Brook et al., 2003; Flannery, Hussey, & Jefferis, 2005; Raine, 2002a).

A more recent approach to better understanding violent behaviour has involved the assessment of cognitive variables. Rather than looking for environmental variables, researchers have begun to examine individual cognitive abilities to see whether there is a pattern of functioning characteristic of those who are aggressive or violent. The rationale for evaluating the relationship between cognitive variables and violent behaviour comes from research examining brain anomalies in aggressive and violent individuals (Marsh &

Martinovich, 2006). Before the cognitive variables can be discussed, a more general review of the brain-violence relationship is needed.

Human behaviour is no doubt governed by a variety of factors, both cumulative and interactive. Factors such as genetics, early experiences, mental disorders, acquired brain injury, and situational occurrences no doubt combine and interact to influence behaviour. It follows then that violent human behaviour must also result from a variety of variables, one of which being neurological abnormalities. Although brain anomalies may be present in only some of those who offend, the brain governs behaviour, and so aspects of brain structure and function relevant to violent behaviour deserve consideration. As a result, a great deal of research has been dedicated to examining traumatic brain injury and brain abnormalities in offender populations.

Research has repeatedly shown that acquired brain injury is much more prevalent in incarcerated populations than in the general public. The incidence of mild brain injury in the general public of North America varies from a low of 0.1% to a high of 0.6% depending on the data collection method (Cassidy et al., 2004). However, much higher rates have been reported in forensic populations. For example, higher rates (ranging from 29% to 100%) have been reported in samples of death row inmates, medium and maximum security offenders, offenders in a county jail, and violent men from the community (Barfield & Leathem, 1998; Lewis, Pincus, Feldman, Jackson, & Bard, 1986; Marsh & Martinovich, 2006; Martell, 1992; Sarapata, Herrmann, Johnson, & Aycock, 1998; Slaughter, Fann, & Ehde, 2003; Templer et al., 1992). In addition, Marsh and Martinovich reported that males with traumatic brain injury were impaired on measures of cognitive functioning when compared to the males without this injury. Despite these findings, the research is unclear on whether violent offenders are more likely to have incurred a traumatic brain injury than are non-violent offenders.

A specific area of the brain that has received a great deal of attention in the forensic literature is the frontal lobe, with research suggesting that the functional capacity of this area may in part influence the likelihood that an individual will act aggressively. In a review of neuropsychological studies looking at the relationship between violence and frontal lobe dysfunction, Kandel and Freed (1989) concluded that an association between this sort of dysfunction and violent criminal behaviour was weak at best. This claim has been challenged, with a number of subsequent studies finding abnormal frontal EEG activity in men who scored high on a self-report measure of physical aggression (Finn, Ramsey, & Earleywine, 2000) and in individuals with violent hallucinations and assaultive behaviour (Fornazzari, Farcnik, Smith, Heasman, & Ichise, 1992). Bernat, Hall, Steffan, and Patrick (2007) found that while being monitored by an EEG, individuals who had been convicted of violent offenses exhibited abnormal patterns of brain activity while engaging in a task requiring them to ignore frequent non-target stimuli and respond to infrequent target stimuli compared to individuals who had committed non-violent crimes. These authors interpreted the finding as indicating that unique neurobiological processes may be involved in these violent behaviours. Similarly, Blake, Pincus, and Buckner (1995) examined 31 individuals who had committed murder and found that 65% displayed physical signs of frontal dysfunction. These signs included snout, suck and grasp reflexes, abnormal smooth pursuit eye movements, paratonia, and reciprocal hand movement errors.[1]

Structural and functional imaging techniques are another way in which potential abnormalities have been examined in violent individuals. Studies utilizing these techniques have found similar results to the aforementioned studies, indicating that aggressive individuals display abnormalities of the frontal lobes and decreased frontal functioning. In a review of this literature, Brower and Price (2001) concluded that there was indeed a strong association between reduced prefrontal cortical size and activity and increased aggression. After reviewing studies employing neuropsychological, neurological, EEG, and neuroimaging techniques to examine the relationship between aggression and frontal lobe dysfunction, Brower and Price posited that there was an association between a loss of control over aggression and frontal lobe dysfunction. Although these findings are impressive, it should be pointed out that the mere presence of abnormalities does not establish whether or how these deficits contribute to violent behaviour, and none of the research available at the time of the review demonstrated a causal relationship.

In a more recent review of neuroimaging studies (Bufkin & Luttrell, 2005) revealed similar patterns in the literature. These authors concluded that prefrontal dysfunction and temporal lobe dysfunction (particularly left sided medial-temporal) were associated with violence and aggression. Although aggression and violence cannot be reduced down to brain function, it is important to integrate this information into an understanding of the variables that are related to an increased likelihood of aggressive

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[1] Snout, suck, and grasp reflexes are "primitive" reflexes that are normal in infants, present in a small number of healthy individuals, and occur in a larger number of patients with frontal dysfunction. *Paratonia* is the reduced ability of a muscle to stretch and can be induced by frontal lobe dysfunction.

and violent behaviour. A number of researchers have suggested that the relationship between these brain anomalies and violent behaviour may be mediated by an inability to use one's executive abilities, or executive functioning (Bufkin & Luttrell, 2005; Marsh & Martinovich, 2006).

Overview of the Concept of Executive Functioning

The concept of executive functioning is frequently discussed in the literature; however, a widely accepted definition has not yet been generated. Despite the popularity of the construct, there are still many contrasting views surrounding the true nature of executive abilities. Some of the current knowledge of executive functioning will be reviewed here, and a number of the conflicting views will be presented.

Early executive functioning research was stimulated by neuropsychological patients with frontal lobe damage like the well-known case-study Phineas Gage, who displayed severe behavioural changes as a result from the damage to this area of the brain. These patients exhibited difficulty controlling or regulating their behaviour and as a result they were very much impaired in their daily living. Although these individuals continued to perform well on other cognitive tasks and on tests of intelligence (Shallice & Burgess, 1991), they displayed deficits on tests thought to examine the abilities of the frontal lobes. This early research led neuropsychologists to believe that the frontal lobes of the brain may be partially responsible for executive functions.

Baddely and Hitch (1974) first described the concept of executive functioning as a "central executive." Lezak (1983) conceptualized executive functioning as being made up of four abilities: goal formation, planning, goal-directed behaviours, and effective performance. These abilities were thought of as high-level cognitive functions that needed to be intact in order for an individual to display appropriate, socially desirable behaviour. More recently Lezak, Howieson, and Loring (2004) expanded this conceptualization, discussing the abilities required to be successful at each of these previously mentioned components. Self-regulation, behaviour initiation, flexibility in thinking, and working memory were a few of the abilities discussed. There is currently no agreement on the definition of executive functioning, or on its possible subcomponents. For example Borkowsky and Burke (1996) broke executive functions into three separate abilities: task analysis, strategy control, and strategy monitoring. Alternatively, Delis, Kaplan, and Kramer (2001) conceptualized this construct as including flexibility of thinking, verbal fluency, initiation, inhibition, problem-solving, planning, impulse control, concept formation, and abstract thinking. Banich (2004), on the other hand, described executive functioning as the purposeful and coordinated organization of behaviour that reflects the success of the strategies employed. The point is this: there is no universally accepted definition for executive functioning.

Although there is no agreed upon definition, one point of agreement is that one's executive abilities allow him or her to shift mindsets quickly in a constantly changing environment. That is, executive abilities allow individuals to adapt to novel and diverse situations while simultaneously inhibiting inappropriate behaviours. This will be the conceptual definition of executive functioning adopted by the present study. These abilities enable individuals to make a plan, put it into effect, and keep on the task at hand until it is complete. Executive abilities are essential for success in school, in work, and in every day living as they mediate the ability to organize thoughts in a goal directed way. The ability to act in a moral and ethical way also requires intact executive abilities

(Ardila & Surloff, 2004). Though it is difficult to compare different investigations of executive functioning when the definitions are so numerous and diverse, it has been established that this construct is complex and important to human adaptive behaviour.

Theory: Unitary versus multiple constructs. A fundamental question that remains unanswered in the executive functioning literature surrounds whether this construct is better conceptualized as unitary, with all executive functions reflecting the same underlying ability, or whether it is nonunitary, with each component reflecting a distinct process. This question was first raised by Teuber (1972) and has not yet been entirely answered. Currently, there seems to be evidence to support both sides of the argument.

Duncan, Johnson, Swales, and Freer (1997) explored this issue by examining the relationship between different measures of executive functioning in a sample of 90 head-injured patients. Weak correlations were found between the tests of executive functioning. Duncan et al. suggested that these results emphasized "diversity rather than unity" (p. 722), meaning that there was no apparent global deficit contributing to performance on tests of executive functioning. Conversely, in a second experiment, Duncan and colleagues identified two common elements between all of the tests of executive functioning: fluid intelligence (i.e., Spearman *g*) and goal neglect. The results of the second experiment lend support for the argument that executive abilities share a similar underlying construct. A number of other researchers believe that a unifying central factor underlies executive functions (e.g., De Frias, Dixon, & Strauss, 2006; Parkin & Java, 1999).

Alternatively, Godefroy, Cabaret, Petit-Chenal, Pruvo, and Rousseaux (1999) rejected the existence of a unifying construct. Instead these authors suggested that "executive functions depend on multiple separable control processes" (p.1). These authors discovered selective deficits with double dissociations, finding that certain patients with frontal lobe injuries performed well on some measure of executive functioning though others did not. Consistent with these findings, a number of studies have found a similar pattern of low intercorrelations between different tasks of executive functioning (i.e., *r*s of less than .40) that seem to suggest executive functioning may not be a unitary construct (e.g., Lehto, 1996; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Salthouse Atkinson, & Berish, 2003).

Taken together, the research to date suggests that a simple dichotomy does not suffice. Both sides of this debate need to be seriously considered when trying to define executive functioning. So though the executive system can be useful in attempting to understand aspects of human behaviour, particularly aggressive and violent behaviour, there is not yet agreement on what exactly executive functioning includes, therefore the literature needs to be interpreted with caution.[2]

Developmental perspectives of executive functioning. Research on the development of executive functions has proposed that these abilities begin to develop around the end of the first year of life and continue to develop into late adolescence (Séguin & Zelazo, 2005). The sequential improvement of executive abilities throughout childhood coincides with the growth and development of the frontal lobes (Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001). Similarly, the decline in executive

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[2] Although I do not take a side in this debate, in the following thesis I will take the approach that executive functioning is made up of a variety of components. This approach is in accordance with the conceptualization of executive functioning by Delis et al. (2001) as I am using the Delis-Kaplan Executive Function System to quantify executive functioning. This is also in accordance with much of the literature investigating executive functioning and violence, which will be reviewed shortly. I am in no way suggesting that a central factor underlying these components does not exist, but rather that I do not attempt to measure it.

functions at the other end of the life span has been associated with anatomical changes in the brain during normal aging (Jurado & Rosselli, 2007). It seems that the development of executive abilities follows an inverted U-shaped curve when considered across the lifespan. Zelazo, Craik, and Booth (2004) examined age-related changes in executive functioning across the lifespan using a number of common measures and confirmed this curvilinear pattern in functioning, with young children and older adults being the most impaired. Age-related changes in executive functioning are not well understood and they are at times contradictory.

In examining the developmental trajectories of different executive components Huizinga, Dolan, and Van der Molan (2006) found that most abilities reached an adult level between the ages 11 and 15; however, some continued to develop until age 21. Ettenhofer, Hambrick, and Abeles (2006) examined the stability of executive functioning over time and found that executive abilities were stable within a normal aging population. The research suggests that once an individual reaches the age of 18 (i.e., the age of majority), his or her executive abilities should have almost completely matured, and these abilities should remain relatively stable until late adulthood.

Neural substrates of executive functioning. As briefly mentioned above, early research led scientists to believe that executive abilities were controlled by the frontal lobes. There are now a number of neural correlates of executive functioning that have been proposed. Innovative imaging techniques have allowed researchers to view how the brain functions while individuals engage in tasks of executive functioning. It was initially believed that all of the frontal lobes were involved (and only the frontal lobes); however, it is now accepted that executive functions are associated with a variety of regions including not only the frontal lobes (Stuss & Alexander, 2000; Stuss, et al. 2002), but also a broad cerebral network encompassing subcortical structures and thalamic pathways (Koechlin, Corrado, Pietrini, & Grafman, 2000; Monchi, Petrides, Strafella, Worsley, & Doyon, 2006).

Based on decades of research with patients who had incurred focal frontal lesions Stuss et al. (2002) suggested an anatomical and functional cognitive architecture of the frontal lobes. Monitoring behaviour was found to be regulated by the right dorsolateral frontal area, and the left dorsolateral area was involved in verbal processing. Both the right and left dorsolateral frontal areas, as well as the superior medial frontal lobe, were activated in tasks that required cognitive switching, and the inferior medial frontal area seemed to mediate certain aspects of inhibitory processes of behaviour. It should be pointed out that approaches that focus on the localization of executive abilities solely within the frontal lobe have often been criticized in favor of a perspective that emphasizes connectivity between the frontal regions and more posterior and subcortical brain areas (Jurado & Rosseli, 2007).

Royall and colleagues (2002) focused on three circuits, identified as originating in the frontal lobes and as sending projections to basal ganglia and the thalamus, for their implication on performance on tests of executive functioning. The dorsolateral prefrontal circuit was implicated in functions of planning, goal selection, set-shifting, working memory, and self-monitoring; the lateral orbitofrontal circuit was involved in risk assessment and the inhibition of inappropriate behavioural responses; and finally, the anterior cingulate circuit was associated with monitoring behaviour and self-correcting errors.

More recently, Elderkin-Thompson, Ballmaier, Hellemann, Pham, and Kumar (2008) examined the associations between tests of executive functioning and MRIs of the prefrontal cortex in 23 healthy elderly individuals in an attempt to see whether specific abilities correlated with volumes of specific prefrontal regions. After controlling for age, it was discovered that larger anterior cingulate volumes were associated with better performance during response inhibition tasks, and larger gyrus rectus volumes were associated with better performance on inductive reasoning tasks. Larger orbitofrontal volumes were actually associated with lower verbal and nonverbal generative output. Perhaps the most interesting aspect of these findings was that the volume of each individual subregion contributed uniquely to a specific task or tasks, and this contribution occurred after controlling for the other two subregions. These results provide helpful information in terms of the neural correlates of executive functioning, and also provide support for the argument that executive functioning is in fact a collection of unique abilities.

The role of the frontal lobes should not be undervalued, but it is now understood that executive abilities involve a variety of brain regions and a number of sub-cortical pathways. Anderson, Northam Hendy, and Wrenall (2001) suggested that the pattern of connectivity of the frontal lobes indicates that, although the prefrontal regions might coordinate behaviour, they depend on other areas for input. Efficient functioning relies on the quality of information received from other parts of the brain. Essentially, the entire brain is necessary for optimal performance on tasks of executive functioning. Therefore, the current view of the neural substrates underlying executive processes is that they likely involve links between frontal and posterior areas and subcortical and thalamic pathways (Jurado & Rosselli, 2007).

After discussing the neural correlates of executive functioning, it becomes apparent that there are similarities between the neural correlates of executive functions and the structural and functional abnormalities seen in the brains of individuals who engage in aggressive and violent behaviours. Given that 70% of incarcerated offenders have been convicted for violent behaviour (Public Safety and Emergency Preparedness Canada, 2005), it is of interest whether there is a relationship between executive functioning and violent behaviour.

The Relationship Between Executive Functioning and Criminality and Violence

It is difficult to discuss the relationship between executive functioning and violence when a widely accepted definition is unavailable for either. Years of research from a wide range of fields have suggested that impaired executive functioning plays an important role in the etiology of aggressive and violent behaviour (Barker et al., 2007; Broomhall, 2005; Giancola, 2004; Hoaken, Shaughnessy, & Pihl, 2003; Marsh & Martinovich, 2006; Raaijmakers et al., 2008; Séguin, Nagin, Assaad, & Tremblay, 2004; Séguin, Pihl, Harden Tremblay & Boulerice, 1995; Villemarette-Pittman, Stanford, & Greve, 2002). However, although a number of studies have examined the relationship between executive functioning and violence, it has not yet been consistently demonstrated which particular components of executive functioning are impaired in these individuals. Just as the definition of executive functioning is unclear, the relationship between this construct and violence is similarly ambiguous.

A large number of studies have examined the relationship between executive functioning and criminality, antisocial behaviour, aggression, and violence; however, each of these studies used a slightly different conceptual definition of executive functioning. In addition to the wide range of definitions used, a number of different measures were used to assess executive abilities. However, not all of these measures are thought to assess the same abilities or share the same psychometric properties. To complicate matters more, some researchers evaluate aggression and violence using self-report, and others examine criminal histories or directly observe behaviour. Some researchers only consider an offenders' index offence, and others take into account their complete criminal history.

Incarcerated individuals have been examined in an attempt to determine whether there is a relationship between criminality, in general, and deficits in executive functioning. In 2000, Morgan and Lilienfeld reviewed the literature to clarify the relationship between executive abilities and antisocial behaviours because, until then, many studies had produced equivocal conclusions. In their meta-analysis of 39 studies they found that individuals who took part in antisocial behaviours performed .62 standard deviations worse on measures of executive abilities than individuals who did not. This was the case despite controlling for age, sex, ethnicity, and intelligence.

In 2001, Bergeron and Valliant examined the relationship between executive functioning, personality, and cognition among offender and non-offender groups. Using three measures of executive functioning, it was found that adolescent (aged 16-18) and adult (aged 19-40) offenders could be differentiated from age matched controls on the basis of their performance on two of these measures. These individuals were also characterized by higher levels of impulsivity, aggression, immaturity, and tendencies to act out.

Valliant, Freeston, Pottier, and Kosmyna (2003) compared offenders who had committed multiple offences to offenders who had committed only one offence in order to see whether there were differences in their executive abilities. Valliant and colleagues found that individuals who had committed multiple offences were significantly more impaired on the Wisconsin Card Sorting Test than those who had only committed one crime. In light of these findings, it appears that there is a relationship between executive abilities and criminality, with more frequent criminal behaviour being related to greater executive dysfunction. Given that a large portion of incarcerated offenders have committed violent crimes, it follows that researchers would examine the relationship between executive functioning and violent and nonviolent offending separately.

Foster, Hillbrand, and Silverstein (1993) examined the usefulness of executive functioning measures in the prediction of frequency of aggressive behaviour and the severity of aggressive behaviour in male forensic patients who had committed violent crimes. They found that subjects who performed poorly on the executive measures exhibited a higher frequency and higher severity of aggression over a one-year observation period; however, frequency but not severity of aggression could be predicted from particular executive scores. Broomhall (2005) also examined executive deficits in groups of violent offenders. Using three subtests of the Delis-Kaplan Executive Function System (i.e., Verbal Fluency Test, Design Fluency Test, and the Colour-Word Interference Test) and the Iowa Gambling Task to assess executive functioning, Broomhall found that violent offenders were significantly impaired on tests of executive functioning, but he noted that "the results did not provide the depth of understanding required to inform adequate prediction of future dangerousness, assessment, or treatment of individuals who commit violent crime" (p. 379). These results suggest that further investigation of executive functioning deficits are needed in order to truly understand the underlying abilities that are impaired in offenders who are violent.

Greenfield and Valliant (2007) failed to find significant differences in performance between violent and non-violent offenders on measures of executive functioning. Executive functioning was evaluated with the Porteus Maze, a test that requires individuals to trace paths through mazes of varying complexities. Similarly, Hoaken, Allaby, and Earle (2007) found no difference between violent and nonviolent offenders on three tests of executive functioning. However, violent offenders and non-violent offenders as a group performed more poorly than the controls.

Apart from testing incarcerated offenders, some researchers have examined the executive abilities of aggressive individuals in the community. Villemarette-Pittman et al. (2002) investigated the differential contributions of language deficits and executive functioning to the aggression displayed by college students. Villemarette-Pittman et al.'s results indicated that executive dysfunction was a contributing factor in the development and persistence of hostile, aggressive, and antisocial behaviours displayed by the impulsive students. Results also suggested that individuals who displayed impulsive aggressive outbursts were not impaired in language processing in general, but rather, as the task demands increased so as to require more executive modulation, impairments in language abilities became apparent. The authors suggested that these impaired abilities could result in poor academic performance, less job success, and social dysfunction. Villemarette-Pittman and colleagues stated the following:

> Executive functioning deficits compromise the ability to interpret body language, the social meaning of facial expressions, and the prosodic elements of oral communications. This may lead to misinterpretations of threat or hostility in conflict situations, which may further weaken the ability to generate alternative socially adaptive behavioural responses and to execute a sequence of responses necessary to avoid aggressive or stressful situations. (p. 1542).

This explanation of how executive dysfunction could lead to aggression captures just how complex the construct of executive functioning is.

Hoaken and colleagues (2003) found that males and females who responded more aggressively to provocation performed more poorly on measures of executive abilities. In agreement with these findings, Giancola (2004) found that aggression was negatively related to executive functioning, even after controlling for non-executive abilities including memory, visuospatial functioning, spatial orientation, and intelligence. However, in contrast to Hoaken et al., Giancola found that this relationship was only significant for men. In addition to examining the relationship between executive functioning and aggression, Giancola identified a moderating influence of executive functioning on the alcohol-aggression relationship. That is, alcohol increased aggression only in men with lower executive abilities. Giancola concluded that impaired executive functioning is related to aggressive behaviour and that executive abilities moderate the alcohol-aggression relationship in men.

Similarly, Séguin and colleagues (2004) found that poor performance on measures of working memory (a proposed component of executive functioning) was related to chronic elevated levels of physical aggression in adult males aged 18 to 22. Barker et al. (2007) examined the developmental trajectories of two types of antisocial behaviour and the associated neurocognitive deficits. Barker et al. found that frequency of physical violence was negatively related to executive functioning but that frequency of theft was positively related to executive functioning. These results suggest that executive dysfunction is not characteristic of criminality and antisocial behaviours, but more specifically physical aggression and violence.

In addition to adolescents and adults, research suggests that the relationship between aggression and executive dysfunction also exists in children. Séguin, et al., (1995) examined the cognitive and neuropsychological characteristics of physically aggressive boys. These authors found that boys who were physically aggressive displayed difficulties on the tests of executive functioning. Years later, Raaijmakers et al. (2008) examined executive functioning in four year old children who displayed aggressive behaviour. Using a variety of measures appropriate for children, the authors found that children who demonstrated aggressive behaviour were impaired in certain executive abilities, specifically inhibition, even after controlling for attention problems. Though research in this area is limited, it does seem to suggest that executive dysfunction is apparent in aggressive children. Perhaps for some children, these deficits are precursors for aggressive behaviour later in life.

It is beyond the scope of this thesis to fully review what factors contribute to the executive deficits observed in offender populations and in aggressive individuals, but a few possibilities will be mentioned. These deficits may be due to the higher incidence of traumatic brain injury in offender populations, to the structural and functional abnormalities observed in the brains of incarcerated offenders, or to differences in the development of executive abilities in early childhood. These ideas are explored more fully in the Discussion section of this thesis.

What can be taken from the above literature is that the relationship between executive functioning and violent behaviour is still somewhat unclear. Though it has been relatively well established that incarcerated individuals display deficits on measures of executive functioning, these deficits are not well understood, and the implications of these deficits on everyday behaviour are unclear.

The Present Study

It has been established that incarcerated offenders are characterized by executive dysfunction. Furthermore, there is some evidence to suggest that this dysfunction is more characteristic of individuals who are aggressive or who have committed violent acts and is worse in those who commit frequent violent acts. That being said, the executive deficits that have been identified are rather vague, and it is not well understood how these deficits translate into everyday behaviour. Violent crime is a serious problem in our society and variables that identify whether an individual is likely to be violent, how frequently they will be violent, and whether they are likely to be severely violent need to be uncovered. Identification of how (or whether) the components of executive functioning are able to predict the frequency and severity of violent behaviour would be of great value.

The first goal of the present study was to examine a sample of offenders to see whether global deficits in executive functioning were identified using measures with normative samples. More importantly, it was of interest whether these deficits would remain after controlling for age and intelligence, a detail that most research in the past has neglected to explore. These goals were accomplished by comparing the offenders to a control group, while keeping age and intelligence constant. The rationale for controlling age and intelligence will be more fully explored in the Discussion section of this thesis.

The next goal was to identify executive functioning scores that were able to predict the frequency of past violent offending. Furthermore, similar to Murrie, Cornell, Kaplan, McConville, and Levy-Elkon's (2004) distinction between violence and "more serious forms of violence, beyond the realm of common fist fighting" (p. 59), it was of interest whether executive functioning scores were able to predict the frequency of past severe violent offending. A severe violent offence being an act that results in lasting harm. The frequency of severe violent offending is likely a more reliable count than is the total number of violent offences because as Armstrong (2005) points out, measures of less serious crime that are based on official data are more prone to measurement error than measures of serious crime.

Although Foster et al. (1993) found that frequency but not severity of aggression could be predicted from particular executive scores, the present study will nonetheless examine the ability of executive functioning measures to predict the frequency and severity of violence rather than aggression. By addressing some methodological limitations of Foster et al.'s research, namely the statistical techniques used and the limited data collection period, there was an increased likelihood of identifying significant predictors. For the purpose of this study, violent offences were defined as those involving an intentional act of physical aggression against another individual that was likely to cause physical injury (Meloy, 2006). The coding scheme for severity of violence will be discussed in detail in the Methods section.

In order to assess executive functioning, four subtests from the Delis-Kaplan Executive Function System (D-KEFS) were chosen. The D-KEFS is a relatively new, innovative battery that was chosen because it was reasoned that the wide variety of scores available for each of the subtests would allow for a better understanding of offenders' specific executive deficits. In accordance with Delis et al. (2001), executive functioning was conceptualized as being made of the following components: flexibility of thinking, verbal fluency, initiation, inhibition, problem-solving, planning, impulse control, concept formation, and abstract thinking.

This study was primarily exploratory in nature, therefore no hypotheses were made about which specific executive functioning scores would be impaired or about which scores would predict offending. Specific hypotheses were not possible, in part because the D-KEFS battery has not yet been used to assess executive functioning in very many studies examining incarcerated offenders. It was hypothesized that offenders would evidence a significant pattern of executive dysfunction.

Violence was assessed using a continuous scale which took into account the frequency and severity of violent acts. Most research investigating executive abilities in offenders tends to be concentrated on the division of violent versus non-violent offenders. Contrary to this division, the present study examined and recorded each offender's entire adult criminal history by accessing the Offender Management System, thereby including all violent and non-violent offences and avoiding categorization all together. Violence severity was also considered because, though an offender with multiple murder charges and an individual with a single assault charge are both 'violent offenders', these individual are very different and warrant different classification. Regression analyses were conducted to assess whether particular executive abilities were predictive of frequency and severity of violence.

Method

Participants

The sample for the present study consisted of 80 adult male offenders from Fenbrook Institution, a federal prison in Gravenhurst, Ontario. Fenbrook is a medium security facility for offenders who have typically served a long sentence and for whom release or transfer to minimum security is likely imminent. Offenders serving in a Federal institution have received sentences of two years or greater and are therefore more likely to have committed violent offences than those incarcerated in Provincial institutions. Approximately 65% of the offenders recruited had served a sentence for a violence-related crime. Offenders who had committed either violent or non-violent crimes were allowed to participate in this study. The offenders ranged in age from 19 to 57 (M = 33.35, SD = 9.19).

The control group for the present study consisted of 30 male undergraduate students from the University of Western Ontario. Students were recruited from an undergraduate psychology subject pool and through posters placed around the university campus. The students ranged in age from 17 to 43 (M = 21.47, SD = 4.63).

Materials

Pre-assessment instruments. The presence of previous head injuries was assessed using a number of questions developed specifically for this study. Participants self-reported whether they had ever been knocked out, had a concussion, or incurred any other closed head injury. They also reported whether the injury had resulted in a loss of consciousness, a visit to the hospital, or any persisting problems (e.g., headaches, concentration problems, memory problems etc.). Head injury status was evaluated because as previously discussed, there is a large body of literature suggesting that incarcerated offenders have high rates of traumatic brain injury (Barfield, & Leathem, 1998; Lewis et al., 1986; Martell, 1992; Sarapata et al., 1998; Slaughter et al., 2003; Templer et al., 1992; Turkstra, Jones, & Toler, 2003) and demonstrating a relationship between head trauma and poor executive functioning (Bufkin & Luttrell, 2005; Hawkins & Trobst, 2000; Marsh & Martinovich, 2006).

Intelligence was measured using the Kaufman Brief Intelligence Test, Second Edition (KBIT-2), a quick and relatively thorough measure of verbal and nonverbal intelligence. This test can be administered in approximately 20 to 30 minutes and provides Verbal and Nonverbal Scores, plus a composite IQ. Test items were designed to be free of cultural and gender bias. The KBIT-2 was administered to ensure that any differences in executive functioning were not just a function of the samples' different levels of intelligence.

The KBIT-2 manual reports that internal consistency reliability estimates range from .86 to .96 on the Verbal Score, .78 to .93 on the Nonverbal Score, and .89 to .96 on the IQ composite. The KBIT-2 has been shown to have good construct validity by correlating (in the moderate to high range) with well-established tests of cognitive ability and academic achievement such as the Wechsler Abbreviated Scale of Intelligence, Wechsler Intelligence Scale for Children: Third Edition and Fourth Edition, Wechsler Adult Intelligence Scale: Third Edition, Wide Range Achievement Test: Third Edition, and the Kaufman Test of Educational Achievement: Second Edition. Likewise, validation studies have established that special populations (e.g., individuals with Mental Retardation, traumatic brain injury, or in gifted programs) differ from the normative sample in the expected direction (Kaufman & Kaufman, 1990, 2004).

Delis-Kaplan Executive Function System. As previously discussed, executive functioning is a broad and poorly understood construct. The following battery was selected to assess the relevant cognitive abilities thought to underlie the broad cognitive construct of executive functioning.

Executive abilities were assessed using the Delis-Kaplan Executive Function System (D-KEFS), a battery of nine tests that comprehensively assess the key components of executive functioning. In light of the available data on the psychometric properties of the D-KEFS, this battery is considered among the most valid means of assessing executive functioning (Baron, 2004; Homack, Lee, & Riccio, 2004).The D-KEFS subtests use a game-like format, and no corrective feedback is provided; this format is intended to reduce unproductive discouragement and frustration caused by repeated negative feedback during testing (Homack et al., 2004). Due to time constraints it was not possible to administer all nine subtests of the D-KEFS; however, because the D-KEFS subscales were designed to 'stand alone,' the psychometric properties of the administered subscales were not expected to change as a result of the incomplete administration. Four subtests thought to measure each of the executive abilities proposed by Delis et al. (2001) were selected for administration: the Tower Test, the Verbal Fluency Test, the Colour-Word Interference Test, and the Sorting Test.

For this study, raw scores for each of the D-KEFS subtests were transformed into age-adjusted standard scores (which ranged from 1 to 20; $M = 10$, $SD = 3$), based on available norms. For most scaled scores a higher score reflects a better performance. However, there a few scores for which both low and high scaled scores reflect different types of cognitive problems. These differences will be discussed in the relevant sections below. Another point that the reader needs to know to interpret the scores relates to the fact that when observed in the normative sample, some raw scores were limited in range. For instance, some types of errors are rare among normally functioning individuals but common in patients with certain types of brain damage. Therefore, to address the problem of a limited range of raw scores, the raw scores are converted into cumulative percentile ranks which are also corrected for age. The particular scores that are converted to cumulative percentile ranks will be identified where appropriate.

During the *Tower Test*, participants assemble a number of towers by moving disks of different sizes across three vertical pegs, as quickly as possible, and in the fewest number of moves. Participants are also required to follow a number of rules including moving only one disk at a time, using only one hand at a time, and finally never placing a larger disk on top of a smaller disk. Performance on the Tower Test reflects executive abilities including spatial planning, rule learning, inhibition of impulsive and perseverative responding, and the ability to establish and maintain the instructional set (Delis et al., 2001).

A Total Achievement Score (TT_{TAS}) was generated which is an indicator of overall test performance. Higher total achievement scores identify individuals who were able to minimize their number of moves and yet complete the towers within the allotted time frame. Normal performance on this score reflects intact spatial planning, rule learning, and inhibition. Participants' Mean First-Move Time (TT_{MFMT}) was used to identify problems with impulsivity or, alternatively, initiation. This particular score is unique in that high scores are suggestive of one cognitive problem (i.e., impulsivity), but low scores are indicative of another type of cognitive problem (i.e., initiation). Finally, the Move Accuracy Ratio (TT_{MAR}) was generated to assess the degree to which participants employed effective versus ineffective strategies while constructing their towers. Higher scores identified individuals who had built their towers in a number of moves close to the minimum possible number of moves.

The second subtest chosen, the *Verbal Fluency Test*, consists of three conditions: Letter Fluency, Category Fluency, and Category Switching. During the Letter Fluency condition, participants are asked to generate as many words as they can that start with a specific letter (i.e., *F*, *A*, and *S*). For Category Fluency, examinees are asked to list as many words as possible that belong to a particular semantic category (i.e., animals and boys' names). Finally, in the Category Switching condition, examinees are asked to generate words alternating between two different semantic categories (i.e., fruit and furniture). Each trial is timed, and the examinee is allowed 60 seconds to generate as many words as they can. In addition, while generating words, the participant simultaneously follows a number of rules (e.g., they cannot repeat the same word). This test measures participants' ability to generate words fluently in an effortful, phonemic format (Letter Fluency), from overlearned concepts (Category Fluency), and while simultaneously shifting between overlearned concepts (Category Switching; Delis et al., 2001).

A score for the total number of correct responses was generated for each of the three conditions (Letter Fluency: $VF_{LF\text{-}TC}$, Category Fluency: $VF_{CF\text{-}TC}$, and Category Switching: $VF_{CS\text{-}TC}$) and for the switching accuracy in the Category Switching condition ($VF_{CS\text{-}SA}$). Errors were analyzed in order to provide information about the nature of the participants' deficits. Specifically, frequent Repetition Errors (VF_{RE}) can be indicative of perseverative tendencies.

The third subtest, *Colour-Word Interference Test* (a task similar to the classic Stroop test) consists of four conditions. The first two conditions provide a baseline measure of the two basic skills that were required to complete the higher-level tasks: naming of colour patches and reading of colour-words. In the third condition, participants are shown a list of different colour words that are typed in incongruent colours of ink. Participants are required to speak aloud the ink colour while refraining from reading the written word (e.g., if the word appearing on the list is *blue* and it is printed in red ink, the correct response would be "red"). This condition measures inhibition, as participants must inhibit reading the words in order to name the dissonant ink colours in which those words are printed (Delis et al., 2001). The fourth condition requires the examinees to switch back and forth between naming the dissonant ink colours and reading the words. As such, this condition measures both inhibition and cognitive flexibility (Delis et al. 2001). Each of these conditions is timed, and errors are recorded.

The Colour-Word Interference Test provided a number of scores that were helpful in the evaluation of executive functioning. First, the Contrast Measure Scores (Inhibition minus Colour Naming: $CWIT_{I\text{-}CN}$, Inhibition/Switching minus Color Naming: $CWIT_{I/S\text{-}CN}$, and Inhibition/Switching minus Reading: $CWIT_{I/S\text{-}R}$) assessed participants' speed of completion of the higher level tasks while controlling for their fundamental cognitive skills (i.e., speed of reading and colour naming). Participants were required to respond as quickly as possible, therefore it was not uncommon for them to make errors. As such, the number of uncorrected errors made during the inhibition condition and the inhibition/switching condition were recorded ($CWIT_{IUE}$, $CWIT_{I/SUE}$), as were the corrected errors ($CWIT_{ICE}$, $CWIT_{I/SCE}$). These latter four scores were converted into cumulative percentile ranks.

Finally, the *Sorting Test* consists of two conditions. In the Free Sorting condition, examinees are presented with an assortment of six cards, each of which display a stimulus word and possess various perceptual features. The examinee is asked to sort the cards into two groups, three cards per group, according to as many different categorization rules or concepts as possible. They are also asked to describe the concepts that they used to generate each sort. Each of the card sets can be grouped into a maximum of eight target sorts: Three sorts are based on verbal-semantic information from the stimulus words (e.g., parts of the body vs. clothing), and five sorts are based on visual-spatial features or patterns on the cards (e.g., blue vs. yellow). During the second condition, Sort Recognition, the examiner sorts the cards into two groups, three cards per group, according to the eight target sorts. Examinees are required to identify the correct categorization rule used by the examiner. Examinees' problem-solving abilities are scored on the basis of the accuracy of their sorting responses and the descriptions of the sorting concepts.

The Sorting Test assesses a number of important component processes of executive functioning, including (a) initiation of problem-solving behaviour, (b) concept formation skills, (c) modality-specific problem-solving skills (verbal versus perceptual), (d) the ability to explain the sorting concepts abstractly, (e) the ability to transfer sorting concepts into action, (f) the ability to inhibit previous sorting responses in favour of flexibility of behaviour, and (g) the ability to inhibit previous description responses in favour of flexibility of thinking (Delis et al., 2001).

Description Scores were generated for each of the two conditions (Free Sorting: ST_{FSDS} and Sort Recognition: ST_{SRDS}). These scores reflected the accuracy of the description responses and were sensitive to concept formation skills, flexibility of thinking, and problem solving skills. The frequencies of Incorrect Descriptions (ST_{ID}) were combined across the free sort and sort recognition conditions, with high frequencies indicating impairment in concept formation. Frequency of Confirmed Correct Sorts (ST_{CCS}) referred to the number of correct sorts generated during the free sorting condition for which a description that was at least partially correct was given. Frequent confirmed correct sorts suggest intact initiation and problem solving behaviour, an ability to transfer knowledge into action, and flexibility of responding. Participants' Percent Sorting Accuracy (ST_{PSA}) reflects the percentage of sorts generated in the free sorting condition that correspond to one of the eight target sorts. This score can help to identify the type of impairment. For example, participants who generated a low number of sorts but who had high accuracy may be have impaired initiation but adequate concept formations skills. Conversely, participants who generated a low number of sorts and also had poor accuracy may have deficits in both initiation and concept formation. As previously explained, target sorts could be made according to either perceptual rules or verbal rules, therefore the number of Perceptual Rules (ST_{PR}) correctly described in either condition, as well as the number of Verbal Rules (ST_{VR}) correctly described in either condition, were recorded separately in an attempt to examine modality specific problem solving skills. Overly

Abstract Descriptions (ST_{OAD}) were recorded as a high number of these (or a low cumulative percentile rank) may reflect limited expressive language abilities.

Psychometric properties. The D-KEFS has a large normative sample that is demographically and regionally matched with the United States population. Internal consistency reliabilities are generally quite high for composite scores on the Verbal Fluency Test (from .32 to .90) and Colour-Word Interference Test (.62 to .86), but somewhat lower for the Sorting and Tower Test (Delis et al., 2001). The test-retest reliability estimates of the D-KEFS, obtained based upon an average administration interval of 25 days, are impressive but variable across age groups. In addition, the D-KEFS technical manual (Delis et al., 2001) includes significant (however weak) correlations between the D-KEFS and other neuropsychological tests of executive functioning (e.g., the California Verbal Learning Test and the Wisconsin Card Sort Task). However, it is difficult to assess the construct validity of the D-KEFS when the construct that it purports to measure is ill-defined. Some have argued that the D-KEFS lacks evidence for its predictive validity, but given its recent publication, such studies may simply not have been conducted yet.

Strengths of the D-KEFS. The D-KEFS provides a number of solutions to commonly identified problems with the assessment of executive functioning. These solutions were part of the reason that the D-KEFS was an appealing battery for the present study. One problem when attempting to measure executive functioning is that of "task impurity" (Jurado & Rosselli, 2007). Often times, a task believed to be measuring executive functioning might, in reality, be triggering non-executive processes unrelated to the task. Tasks that tap into executive processes are generally very complex and stress many cognitive systems in addition to the executive. In order to establish whether the deficit presented by a participant is strictly one of the executive system, researchers must be able to identify all other non-executive contributions to the task (Jurado & Rosselli, 2007). To address this problem, many of the D-KEFS subtests measure fundamental cognitive abilities such as visual and spatial skills, basic linguistic and perceptual skills, and attention, in addition to the executive functioning abilities. Consequently, users of the D-KEFS are able to partial out the effects of basic cognitive abilities and attain values reflecting purer measures of executive functioning.

An additional limitation of other popular tests of executive abilities is that they provide only global summary scores of executive functioning instead of isolating and quantifying the specific features of executive functions (e.g., planning, reasoning, and problem solving; Jurado & Rossei, 2007). In comparison, error analyses and an application of a process approach may be considered a prominent strength of the D-KEFS: A concerted effort was made in the construction of this battery to detail potential error patterns, to document these patterns qualitatively, and to provide normative data for these variables in an attempt to delineate the abilities required during completion of a task (Baron, 2004). Rule violations, repetitions, and set losses are examples of qualitative errors routinely quantified by the D-KEFS. The availability of these scores enables researchers to identify the type and severity of executive dysfunction.

Procedure

Data collection with the offender sample was approved by the Office of Research Ethics (Appendix A) and by the Research Board at the Correctional Service of Canada (Appendix B). Offenders were informed about the study through an outdoor recruitment event whereby a peer counseling committee distributed ice cream while three researchers discussed the rationale for the study and testing procedures with the offenders. Appointments were arranged in advance and posted on a central communication board. Additional participants were recruited when they approached the researchers in the yard. Interested participants were accompanied by the researcher to a quiet testing area within the institution. Due to the flexibility provided to inmates in terms of scheduling, only seven participants required more than one testing session to complete the study.

At the time of the testing session, a thorough description of the study was provided in the form of a letter of information (see Appendix C) and a verbal discussion, subsequent to which remaining questions were addressed. The participant was also assessed on two additional criteria: Proficiency in English and normal or corrected-to-normal vision needed to be demonstrated for inclusion in this study. Only 3 of the 80 participants were excluded for failing to meet these criteria. Before the participant signed the informed consent (Appendix D), the voluntary nature of the study was made explicit, as was the fact that participation had no bearing on any subsequent correctional decisions. For offenders who wished, the consent form was read aloud by the experimenter. It was also explained to the offenders that a number of the tasks would be very difficult, and a number very simple. The researchers emphasized to the participants that their best effort must be made at all time regardless of the task. Finally, the researchers explained that they would not be providing any feedback to the offenders regarding whether responses were correct or incorrect. Feedback was withheld in order to avoid questioning about performance and to avoid affecting performance on later tests.

Subsequent to providing informed consent, participants responded to questions pertaining to past head trauma (Appendix E) and demographics. Upon completion, the participant was administered four measures of executive functioning, as well as the KBIT-2.[3] Order of task administration was partially counterbalanced, but complete counterbalancing was not possible due to the number of tests administered. Four conditions corresponding to unique orders of test administration were developed on the basis of the following rules: (a) a task never appeared in the same position in two different conditions, (b) each task occurred during the first half of administration in two of the conditions and in the second half of administration in the other two conditions, and (c) in no two conditions was an individual task followed by the same task.

Examiners encouraged participants to take breaks whenever they needed. Upon completion, participants were thanked and accompanied back to their unit. As prescribed by the Correctional Service of Canada, offenders were unable to receive compensation for participation. The overall time to complete the experiment for the offenders was approximately two to three hours. To prevent experimenter bias, no questions regarding current or past criminal activities were asked during the testing session

File Review

Only after an offender had completed the test battery was his file reviewed. Two primary researchers collaboratively reviewed offenders' complete adult criminal history through the Offender Management System. These researchers then went back over the first 20 files to ensure there had been no code drift. Files were reviewed to determine the frequency and severity of violent offending.

All of the adult violent offences were coded according to Cornell's (1996)

[3] A number of other measures were also administered, but these details are not reported here because they are outside the scope of the present study.

guidelines. That is, severity of violence was coded along a 6-point scale that had the following anchors: 1 (*assault without injury*), 2 (*minor injury*; e.g., bruises, minor medical treatment, attempted rape), 3 (*serious injury requiring substantial hospital treatment*; e.g., broken limb, rape, gunshot wound), 4 (*severe injury resulting in lasting impairment or life-threatening injury*), 5 (*homicide*), and finally 6 (*extreme homicide*; e.g., multiple killings, mutilation). Two dependent variables were then generated from these ratings. First, the total number of violent offences committed by each offender were summed. Therefore the first dependent variable was frequency of violent offending. Next, offences that had a severity of 4, 5, or 6 were summed for each offender and classified as severely violent offences. Therefore the second dependent variable was frequency of severe violent offending. Each of these severe offences was characterized by serious, lasting physical harm. Offences were summed across the offender's entire adult life (from the age of 18 and beyond).

In coding the violent offences, whenever there was evidence of a crime being a separate event it was coded as such, regardless of whether the events had the same conviction date. Whenever crimes were related (e.g., an assault and possession of an unregistered firearm), they were coded as a single crime and the details of the crime were coded based on the most serious offence. Whenever there were multiple crimes with the same conviction date and there was insufficient information to determine whether the crimes were related or unrelated to one another, they were coded as a single offence (with the most serious crime being coded).

Control Group

In addition to the 77 offenders included in this study, 30 undergraduate students were recruited to serve as a control group. This portion of the study was ethically approved by the Department of Psychology (Appendix F) at the University of Western Ontario. Students were recruited through a subject pool of first year undergraduate students in an introductory psychology course and through posters placed throughout the school (see Appendix G). Interested males were contacted by email, and scheduled for a testing session. The testing took place in a laboratory in the University of Western Ontario. At the time of testing, a thorough description of the study was provided through a letter of information (Appendix H) and a verbal discussion, and remaining questions addressed before the participant provided informed consent (Appendix I). Testing procedures identical to those used with the offenders were employed with the control group, the exception being that controls were given a debriefing form (Appendix J) and were compensated for their time with course credit or 20 dollars. The overall time to complete the experiment for the controls was approximately two hours.

Results

To analyze the data, I utilized the following data analytic approach: First, to compare the executive functioning of offenders to that of controls, a multivariate analysis of covariance (MANCOVA) was run with scores on the D-KEFS serving as the dependent variables and with age and intelligence (i.e., the composite score on the KBIT) serving as covariates. Second, using only the offender data, a series of Poisson regressions were conducted to identify predictors of frequency of violent offending. Finally, a series of binary logistic regressions were conducted to identify which D-KEFS scores predicted whether an offender had committed a severe violent offence. The rationale for these analyses is discussed below. Alpha levels were set at .05 for all analyses, and all analyses were conducted using Stata 10.1.

Rationale

The present study investigated the differences in performance on the D-KEFS between offenders and students using a MANCOVA. A MANCOVA analyzes multiple dependent variables in an analysis of variance (ANOVA) design as a set, while controlling for variables (Gardner & Tremblay, 2006). The rationale for using a MANCOVA over a series of ANOVA's was first to control Type I error if in fact the null hypothesis was true, second, to maximize the chances of detecting a true multivariate effect (if one in fact exists), and finally, to capitalize on the power associated with considering the set of dependent variables as a unit (Gardner & Tremblay, 2006). If a multivariate effect was detected then individual effects would be examined to determine which specific scores differed between offenders and controls. If however there was not a multivariate effect, then it would be accepted that offenders were not impaired in executive functioning.

The present study investigated the frequency of violent offences and severe violent offences that offenders had committed over the course of their adult lives. Therefore, the dependent variables of interest are count variables, meaning they reflect the occurrence of discrete events and they must take the form of non-negative integers (e.g., 0, 1, 2…). Count data present a challenge to researchers in the correctional and forensic fields; however, these challenges can be managed with statistical techniques designed specifically for this type of data (Hutchinson & Holtman, 2005; Walters, 2007). Although appropriate techniques are available, many researchers fail to use them. For example, after reviewing 154 empirical articles in crime psychology journals, Walters identified 43 (27.2%) studies that made use of count data. Not one of these studies utilized the appropriate statistical techniques for analyzing count data. Instead, these studies applied suboptimal strategies which could have resulted in inaccurate findings.

The problem in analyzing count data is that, as non-negative integers count data typically form a positively skewed heteroskedastic distribution (Walters, 2007). Given this non-normal distribution, three fundamental assumption of traditional (ordinary least-squares) regression are violated by count data. Walters asserts that the homoskedasticity assumption, or the assumption that the variance of the errors of prediction is constant for all values of the independent variable, is violated by wide variation in error variance between the observations in the count data set. The normality assumption, or the assumption that errors are normally distributed, is violated by the nonnegative integer character of count data. Finally, the linearity assumption is violated by the nonlinear nature of count data. However, the problem is not with the data, but rather with finding an appropriate model to fit data having these particular properties.

The benchmark model for fitting count data is the Poisson distribution, and the standard regression model for analyzing count data is the Poisson regression. Although linear regression is estimated by ordinary least-squares, the Poisson regression is estimated with maximum likelihood (Walters, 2007). The Poisson regression uses a log transformation which adjusts for the skewness and prevents the model from producing negative predicted values (Gardner, Mulvey, & Shaw, 1995).

Similar to ordinary least-squares regression, the Poisson model has its own set of assumptions. The Poisson distribution assumes independence. In other words, it holds that past events do not influence future events. Poisson regression also assumes that change in the dependent variable is fully modeled by the independent variables in the regression equation, a process known as population homogeneity. There is often additional heterogeneity between individuals in the population that is not accounted for by the predictors in the model. Population heterogeneity in turn results in a violation of the third assumption, that of equidispersion. Poisson regression assumes equidispersion, a condition in which the conditional mean and the conditional variance are roughly equivalent. Violation of this assumption occurs when the conditional mean exceeds the conditional variance (underdispersion) or when the conditional variance exceeds the conditional mean (overdispersion; Walters, 2007).[4]

Poisson regression assumes that the period of risk, also known as exposure, is the same for all observations. This assumption was violated in the present study considering that offenders were different ages and, consequently, had been at risk of committing adult offences for different periods of time. To control for non-uniform exposure times, the natural logorithm of years at risk of committing an adult offence was entered as a covariate in each of the regression analyses with its parameter fixed at 1.00. As a result of the inclusion of this variable, the outcome variable predicted in each analysis was the rate of log-offences per unit of exposure (i.e., per year of adult life) instead of simply the frequency of offences. A better estimate of time at risk would have been the actual time that an offender had spent in the community; however, this period was not easily calculated from the information available in the files. Furthermore, some offenders

[4] Psychology data are often overdispersed and so therefore better analyzed by a negative binomial model. An estimate of the dispersion parameter can be calculated through Stata which indicates whether a Poisson or negative binomial model is more appropriate. This statistic indicated that a Poisson model was most appropriate for the present data.

received convictions for illegal activity that occurred while incarcerated. Other researchers have used a similar estimate of time at risk (Walters, Frederick, & Schlauch, 2007).

Another factor that needs to be considered when deciding whether or not to use Poisson-class regression is whether the number of zero counts exceeds what the Poisson model can handle (Walters, 2007). Zero-inflated models for Poisson regression allow for an excessive number of observed zeroes (Ridout, Demétrio, & Hinde, 1998). First it must be determined whether or not this modification is necessary. Although zero was the most common number of violent offences it was difficult to see from a histogram whether the number of zeroes was 'excessive' (see Figure 1). Consequently a zero-inflated Poisson regression was conducted to test whether it provided a better fit than the standard model.

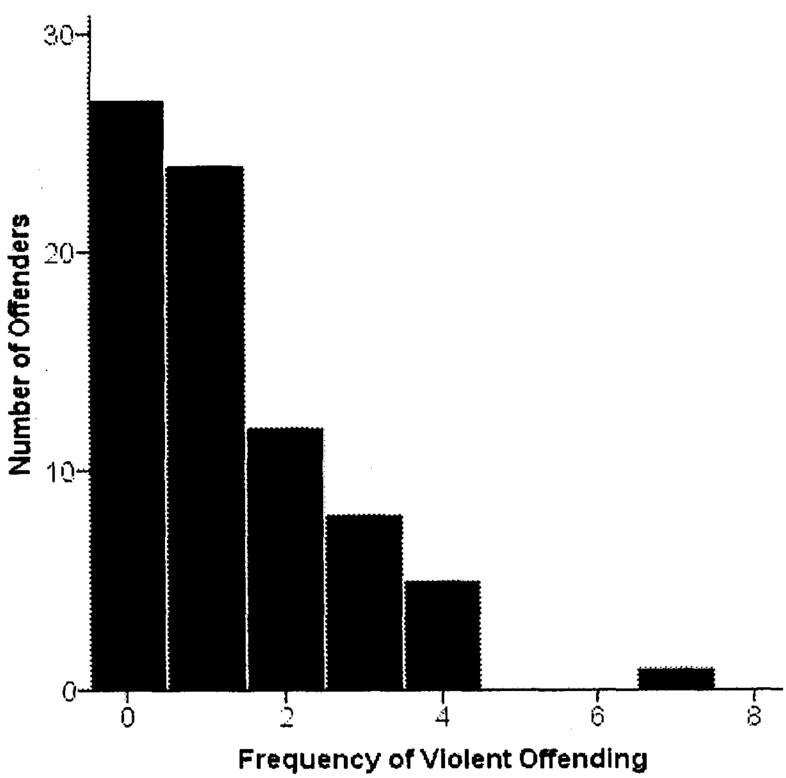

Figure 1. Frequency distribution of violent offending

The Vuong test, a product of the zero-inflated Poisson regression, compares the zero-inflated model to the standard model to determine which model is a better fit. The z-value was not significant when the outcome predicted was frequency of violent offending ($z = 0.63$, $p > .05$) meaning that the zero-inflated Poisson regression is not a better fit than the standard Poisson regression. As such, a standard model of Poisson regression was determined to be most appropriate for the present analyses.

Although the initial intent was to use Poisson regression to predict frequency of violence and frequency of severe violence, none of the offenders in the sample had committed more than one severe violent offence. Therefore, this dependent variable was dichotomous (i.e., either an offender had committed a severe violent offence or they had not). Consequently, binary logistic analyses were conducted to examine predictors of severe violent offending. This model allows researchers to predict the value of a binary variable from a set of explanatory variables. More precisely, logistic regression is used to model the probability of the occurrence of a binary outcome (i.e., history of severe violent offence vs. no history of severe violent offence).

Participants

One offender and three control participants were missing one or more data points due to either computer malfunction or colour-blindness.[5] In order to retain as much meaningful data as possible (i.e., to prevent listwise deletion of data that would have occurred in the MANCOVA), group mean (e.g., offenders or controls) were utilized to fill the missing data points. It is acknowledged that there are other strategies for dealing with missing data. I chose not to substitute population means because it was suspected

[5] Due to colour blindness, one offender's scores on the Colour-Word Interference Test were deemed invalid.

that there were differences between the offenders and the controls, and these differences would be masked by population means. Alternatively I could have utilized a regression equation to estimate the missing values; however, this method can artificially inflate correlations between variables and can result in an estimation value that is outside the possible range of values (Hair, Anderson, Tatham, & Black, 1998). As such, substitution with group means was determined to be the most appropriate technique for dealing with missing data for the current study.

Although many of the frequently collected demographic variables (e.g., socio-economic status) were not available for the group of incarcerated offenders, two demographic issues were of particular relevance to the current study. These were age and intelligence (as measured by the KBIT-2). An independent samples *t*-test revealed that offenders ($M = 33.35$, $SD = 9.19$) were significantly older than controls ($M = 21.47$, $SD = 4.63$), $t(1, 105) = 6.75$, $p < .001$. With respect to intelligence, offenders ($M = 90.23$, $SD = 11.83$) had significantly lower composite KBIT scores than the control group ($M = 108.97$, $SD = 13.71$), $t(1,105) = -7.03$, $p < .001$. Age and intelligence were consequently covaried in each subsequent analysis. See Table 1 for correlations between the D-KEFS scores and age and the KBIT scores.

Additionally, offenders were asked questions about traumatic brain injury and it was found that 68% of had incurred a head injury at some point in their life, 45% lost consciousness as a result of this injury, and 43% required hospitalization. Furthermore, 18% of offenders experienced lasting problems resulting from and continuing after the head injury (e.g., headaches, concentration problems, memory problems etc.).

Table 1

Correlations Among the D-KEFS Scores, Age and the KBIT Scores

Variable	Age	KBIT Verbal	KBIT Non Verbal	KBIT Composite
1. TT_{MAR}	-.01	-.01	.02	.00
2. TT_{MFMT}	-.07	.13	.12	.15
3. TT_{TAS}	-.04	.15	.22	.20
4. $VF_{LF\text{-}TC}$	-.04	.45*	.22	.38*
5. $VF_{CF\text{-}TC}$	.02	.40*	.18	.32*
6. $VF_{CS\text{-}TC}$	.01	.34*	.20	.29*
7. $VF_{CS\text{-}SA}$	.00	.43*	.25*	.37*
8. VF_{RE}	.39*	.14	.03	.07
9. $CWIT_{I\text{-}CN}$	-.04	.12	.07	.09
10. $CWIT_{ICE}$	.30*	.20	.07	.16
11.$CWIT_{IUE}$	-.02	.24*	.33*	.32
12. $CWIT_{I/S\text{-}CN}$	.06	.22	-.01	.12
13. $CWIT_{I/S\text{-}R}$	.03	.25*	.08	.18
14. $CWIT_{I/SCE}$	.18	.22*	.03	.14
15. $CWIT_{I/SUE}$	-.05	.29*	.31*	.34*
16. ST_{CCS}	.08	.51*	.39*	.51*
17. ST_{FSDS}	.13	.59*	.41*	.56*
18. ST_{SRDS}	.15	.64*	.55*	.67*
19. ST_{PR}	.14	.63*	.52*	.64*
20. ST_{VR}	.05	.51*	.36*	.49*
21. ST_{ID}	-.14	.22	.28*	.28*
22. ST_{OAD}	.23*	.25*	.23*	.29*
23. ST_{PSA}	-.01	.02	.04	.04

Note. MAR = Move Accuracy Ratio, MFMT = Mean First Move Time, TAS = Total Achievement Score, LF-TC = Letter Fluency Total Correct, CF-TC = Category Fluency Total Correct, CS-TC = Category Switching Total Correct, CS-SA = Category Switching-Switching Accuracy, RE = Repetition Errors, I-CN = Inhibition minus Colour Naming, I/S-CN = Inhibition/Switching minus Colour Naming, I/S-R = Inhibition/Switching minus Reading, ICE = Inhibition Corrected Errors, I/SCE = Inhibition/Switching Corrected Errors, IUE = Inhibition Uncorrected Errors, I/SUE = Inhibition/Switching Uncorrected Errors, CCS = Confirmed Correct Sorts, FSDS = Free Sorting Description Score, SRDS = Sort Recognition Description Score, PSA = Percent Sorting Accuracy, ID = Incorrect Descriptions, OAD = Overly Abstract Descriptions, PR = Perceptual Rules, VR = Verbal Rules, KBIT = Kauffman Brief Intelligence Test.
$N = 77$
*$p < .05$

Means and standard deviations for scores on the D-KEFS are given in Tables 2 through 5. As can be seen from these Tables, offenders scored below the mean of the normative sample (*M* = 10, *SD* = 3) or cumulative percentile ranks on the many, but not all, of the scores from the D-KEFS tests, indicating a relative weakness in these areas compared to the general population.

Multivariate Analysis of Covariance

A MANCOVA was conducted in an attempt to determine whether offenders' performance on the D-KEFS was impaired relative to controls when controlling for age and intelligence. The multivariate effect indicated a significant difference between offenders and controls, Pillai's Trace = 0.53, $F(81,23) = 3.07$, $p < .001$, $\eta_p^2 = .47$; however, multivariate assumptions for homogeneity of variance were not met as indicated by Box's M test of equality of covariance matrices (Box's $M = 520.29$, $F(267,10029) = 1.27$, $p < .05$). Pillai's Trace was used instead of Wilks' λ since this is a more appropriate statistic when the homogeneity of variance assumption is violated (Tabachnick & Fidell, 2007). Because the multivariate statistic was significant, individual scores were examined. As seen in Tables 2 through 5, many of the D-KEFS scores were significantly different between the two groups, suggesting that offenders performed more poorly than controls on executive functioning measures even after controlling for age and intelligence.[6] The observed power for the significant analyses ranged from .57 to .97. The observed power for the analyses that were not significant ranged from .05 to .43.

[6] It should be noted that all scores from the D-KEFS that are significantly different between controls and offenders after covarying age and intelligence were also significant before covarying age and intelligence. The only difference was that more scores from the D-KEFS were significantly different between controls and offenders before controlling for these variables.

Findings from the Tower Test (see Table 2) suggested that offenders were significantly less accurate at moving the disks, employing less effective strategies in constructing the towers than were the controls. The Verbal Fluency Test did not provide any scores that were significantly different for offenders compared to controls (see Table 3). The Color-Word Interference Test provided a number of scores on which offenders performed more poorly than the controls (see Table 4). Offenders appeared to be impaired at inhibiting prepotent verbal responses and at thinking flexibly as evidenced by their slower speeds and increased number of errors on the Colour-Word Interference Test. Finally, a number of scores on the Card Sorting Test were significantly different for offenders compared to controls (see Table 5). Offenders were not as good at identifying correct target sorts on their own as were the controls. Offenders also had more difficulty describing both their own sorts and the sorts created by the experimenter than did controls. Taken together, offenders demonstrated impairments in transferring knowledge into action, initiation, problem solving, flexibility of thinking, and concept formation. When examining modality-specific problem solving skills it was found that the offenders were significantly more impaired than controls at identifying perceptual rules. A similar trend was seen for the identification of verbal rules. Finally, offenders gave significantly more overly abstract descriptions of their sorts and of the sorts generated by the experimenter, a pattern thought to reflect limited expressive language abilities.

Table 2

Offenders versus Controls on the Tower Test (TT) Covarying Age and Intelligence

	Group					
	Offender[a]		Control[b]		F	η_p^2
	M	SD	M	SD		
TT_{TAS}	10.10	2.14	10.90	2.56	0.01	.00
TT_{MFMT}	10.87	2.17	11.80	1.73	0.01	.00
TT_{MAR}	8.83	2.57	10.67	2.20	6.16*	.06

Note. D-KEFS scaled scores have a mean of 10, a standard deviation of 3, and a maximum of 20. TAS = Total Achievement Score, MFMT = Mean First Move Time, MAR = Move Accuracy Ratio. η_p^2 = effect size.

[a]N = 77, [b]N = 30.

*$p < .05$

Table 3

Offenders versus Controls on the Verbal Fluency (VF) Test Covarying Age and Intelligence

	Group					
	Offender[a]		Control[b]		F	η_p^2
	M	*SD*	*M*	*SD*		
$VF_{LF\text{-}TC}$	9.17	3.43	12.47	3.43	1.30	.01
$VF_{CF\text{-}TC}$	10.38	3.20	13.17	3.58	1.05	.01
$VF_{CS\text{-}TC}$	9.12	3.07	10.70	3.30	0.07	.001
$VF_{CS\text{-}SA}$	8.91	3.14	10.80	2.88	0.24	.002
VF_{RE}	8.75	3.12	10.63	1.96	0.02	.000

Note. D-KEFS scaled scores have a mean of 10, a standard deviation of 3, and a maximum of 20. LF-TC = Letter Fluency Total Correct, CF-TC = Category Fluency Total Correct, CS-TC = Category Switching Total Correct, CS-SA = Category Switching-Switching Accuracy, RE = Repetition Errors. η_p^2 = effect size. [a]N = 77, [b]N = 30.

Table 4

Offenders versus Controls on the Colour-Word Interference Test (CWIT) Covarying Age and Intelligence

	Group					
	Offender[a]		Control[b]		F	η_p^2
	M	*SD*	*M*	*SD*		
$CWIT_{I\text{-}CN}$	9.51	3.26	12.80	2.71	6.87*	.06
$CWIT_{I/S\text{-}CN}$	9.27	3.11	12.23	3.22	4.64*	.04
$CWIT_{I/S\text{-}R}$	9.17	3.12	11.00	3.04	0.57	.005
$CWIT_{ICE}$[c]	38.96	41.96	66.83	41.60	13.11**	.11
$CWIT_{I/SCE}$[c]	37.77	40.42	70.47	40.32	11.27**	.10
$CWIT_{IUE}$[c]	61.06	42.07	67.87	38.53	2.05	.02
$CWIT_{I/SUE}$[c]	51.44	38.69	81.87	37.05	3.22	.03

Note. [c] indicates a cumulative percentile rank, which is out of 100. All other scores are scaled scores which have a mean of 10, a standard deviation of 3, and a maximum of 20. I-CN = Inhibition minus Colour Naming, I/S-CN = Inhibition/Switching minus Colour Naming, I/S-R = Inhibition/Switching minus Reading, ICE = Inhibition Corrected Errors, I/SCE = Inhibition/Switching Corrected Errors, IUE = Inhibition Uncorrected Errors, I/SUE = Inhibition/Switching Uncorrected Errors. η_p^2 = effect size
[a]N = 77, [b]N = 30, *$p < .05$, **$p < .01$

Table 5

Offenders versus Controls on the Sorting Test (ST) Covarying Age and Intelligence

	Group					
	Offender[a]		Control[b]		F	η_p^2
	M	*SD*	*M*	*SD*		
ST_{CCS}	7.79	3.01	11.37	2.01	7.07*	.06
ST_{FSDS}	7.29	2.86	11.37	2.36	11.07*	.10
ST_{SRDS}	7.10	3.09	11.90	2.45	11.78**	.10
ST_{PSA}	10.32	2.57	10.70	1.84	0.003	.00
ST_{ID}	9.94	2.83	11.63	1.73	1.29	.00
ST_{OAD}[c]	53.40	42.20	97.43	14.06	15.42**	.13
ST_{PR}	6.97	3.61	12.20	2.25	11.84**	.10
ST_{VR}	7.05	2.96	10.63	2.95	3.12	.03

Note. [c] indicates a cumulative percentile rank, which is out of 100. All other scores are scaled scores which have a mean of 10, a standard deviation of 3, and a maximum of 20. CCS = Confirmed Correct Sorts, FSDS = Free Sorting Description Score, SRDS = Sort Recognition Description Score, PSA = Percent Sorting Accuracy, ID = Incorrect Descriptions, OAD = Overly Abstract Descriptions, PR = Perceptual Rules, VR = Verbal Rules. η_p^2 = effect size.

[a]N = 77, [b]N = 30

*$p < .05$, **$p < .01$

Regression Analyses

In order to determine which variables needed to be entered into the regression analyses, the partial correlation (see Tables 6 through 9) between each of the predictor variables and the two outcome variables (i.e., frequency of violent offending [FreqVO] and frequency of severe violent offending [SevVO]; explained on p. 35 of the Method), was computed, controlling for age and intelligence. This was a crude estimation because the assumptions underlying correlation analyses are similar to those underlying linear regression and, as mentioned above, the present data violated those assumptions. As such, it was concluded that an inclusive approach for entry into the regression model would be appropriate to ensure that all possible relationships between the predictors and outcome variables were fully explored. Therefore, predictor variables that were significantly related to the outcome variables with alpha set at .10 were included in the regression equations.

As can be seen from Tables 6 through 9, four variables met the criteria for entry into regression equations for FreqVO: $CWIT_{I/SCE}$, TT_{TAS}, ST_{PR}, and ST_{SRDS}. Seven variables met these criteria for entry into regression equations for SevVO: $CWIT_{I/S\text{-}CN}$, $CWIT_{I/SUE}$, ST_{PSA}, ST_{OAD}, TT_{MAR}, $VF_{CS\text{-}TC}$, and $VF_{CS\text{-}SA}$.

An explanation of how regression coefficients were interpreted needs to be provided before presenting the results. Briefly, because Poisson regression is "linear in the logarithm" (Coxe, West, Nixon, & Strauss, 2009), when all other variables are held constant, a 1-unit increase in a predictor results in an increase of the natural logarithm of

Table 6

Partial Correlations Between Tower Test (TT) Scores and Dependent Variables (Age and Intelligence Removed)

	Dependent Variable	
	SevVO	FreqVO
	r	*r*
TT_{TAS}	.16	-.23**
TT_{MFMT}	-.18	-.16
TT_{MAR}	.21*	-.14

Note. SevVO = Severe Violent Offending, FreqVO = Frequency of Violent Offending, TAS = Total Achievement Score, MFMT = Mean First Move Time, MAR = Move Accuracy Ratio

$df = 73$, $N = 77$.

$^{**}p < .05$, $^{*}p < .10$

Table 7

Partial Correlation Between Verbal Fluency (VF) Test Scores and the Dependent Variables (Age and Intelligence Removed)

	Dependent Variable	
	SevVO	FreqVO
	r	*r*
$VF_{LF\text{-}TC}$	-.04	-.12
$VF_{CF\text{-}TC}$	-.09	-.04
$VF_{CS\text{-}TC}$	-.24**	-.15
$VF_{CS\text{-}SA}$	-.21*	-.02
VF_{RE}	-.09	.07

Note. SevVO = Severe Violent Offending, FreqVO = Frequency of Violent Offending, LF-TC = Letter Fluency Total Correct, CF-TC = Category Fluency Total Correct, CS-TC = Category Switching Total Correct, CS-SA = Category Switching-Switching Accuracy, RE = Repetition Errors.

$df = 73$, $N = 77$

$^{**}p < .05$, $^{*}p < .10$

Table 8

Partial Correlations Between Colour-Word Interference Test (CWIT) Scores and the Dependent Variables (Age and Intelligence removed)

	Dependent Variable	
	SevVO	FreqVO
	r	*r*
$CWIT_{I\text{-}CN}$	-.04	.15
$CWIT_{I/S\text{-}CN}$	-.29**	.14
$CWIT_{I/S\text{-}R}$	-.16	.03
$CWIT_{ICE}$	.02	-.02
$CWIT_{I/SCE}$	-.08	.24*
$CWIT_{IUE}$	.08	-.01
$CWIT_{I/SUE}$	-.22*	.01

Note. SevVO = Severe Violent Offending, FreqVO = Frequency of Violent Offending, I-CN= Inhibition minus Colour Naming, I/S-CN = Inhibition/Switching minus Colour Naming, I/S-R = Inhibition/Switching minus Reading, ICE = Inhibition Corrected Errors, I/SCE = Inhibition/Switching Corrected Errors, IUE = Inhibition Uncorrected Errors, I/SUE = Inhibition/Switching Uncorrected Errors

$df = 73$, $N = 77$

$^{**}p < .05$, $^{*}p < .10$

Table 9

Partial Correlations Between Sorting Test (ST) Scores and the Dependent Variables (Age and Intelligence removed)

	Dependent Variable	
	SevVO	FreqVO
	r	*r*
ST_{CCS}	-.09	-.10
ST_{FSDS}	-.11	-.16
ST_{SRDS}	.14	-.22*
ST_{PSA}	-.30**	-.12
ST_{ID}	.09	-.14
ST_{OAD}	.33**	.08
ST_{VR}	.10	.06
ST_{PR}	.10	-.29**

Note. SevVO = Severe Violent Offending, FreqVO = Frequency of Violent Offending, CCS = Confirmed Correct Sorts, FSDS = Free Sorting Description Score, SRDS = Sort Recognition Description Score, PSA = Percent Sorting Accuracy, ID = Incorrect Descriptions, OAD = Overly Abstract Descriptions, PR = Perceptual Rules, VR = Verbal Rules.

$df = 73$, $N = 77$.

$^{**}p < .05$, $^{*}p < .10$

the predicted count that is equal to the value of the unstandardized regression coefficient (b). This interpretation is straightforward but has the disadvantage of interpreting the change in the unit of a transformation of the outcome (i.e., the natural logarithm of the predicted count). It is preferable to present how changes in the predictors are expected to affect the rates when an offset is included. As such, for the Poisson models, the exponentiated unstandardized regression coefficients (i.e., e^b) are presented in the Tables, which can be interpreted as incidence rate ratios. That is, for a 1-unit change in the predictor, the predicted rate is multiplied by e^b. Similarly, for the binary logistic model, exponentiating the regression coefficients produces an odds ratio. Odds ratios are interpreted as the change in the likelihood of an offender having committed a severe violent offence given a 1-unit change in the predictor.

First, Poisson regressions were performed to observe the influence of a number of D-KEFS scores on the overall frequency of violent offending. Table 10 shows the Likelihood Ratio chi-square ($LR\ \chi^2$), z values, incident rate ratios, and significance level for each predictor variable. The $LR\ \chi^2$ is the test statistic for the omnibus test that at least one predictor variable's regression coefficient is not equal to 0 in the model. If the $LR\ \chi^2$ is significant, there is justification for inspecting the coefficients on an individual basis to determine which coefficients are responsible for producing the significant omnibus test. Due to the exploratory nature of the research, each score was run in a separate regression analysis in order to see whether that particular variable was related to violent offending. In these analyses, age and intelligence served as covariates and time at risk was entered as an offset variable. Each of the predictors was statistically significant in the prediction of rate of offending. The exponentiation of the regression coefficient for ST_{SRDS}, $e^{-.09}$ =

Table 10

Individual Poisson Regressions Predicting Frequency of Violent Offending Covarying Age and Intelligence

Predictor	*LR* $\chi^2(3)$	z	Exp(β) [95% Conf. Interval]	Std. Error
$CWIT_{I/SCE}{}^{c}$	11.31*	2.12*	1.005[1.001 – 1.010]	.002
ST_{SRDS}	11.53**	-2.10*	.91 [.83 – .99]	.04
ST_{PR}	15.27**	-2.80*	.89 [.83 - .96]	.04
TT_{TAS}	9.86*	-1.72*	.92 [.84 - 1.01]	.04

Note. Age and intelligence served as covariates. Time at risk was entered as an offset variable. ^{c} indicates a cumulative percentile rank, which is out of 100. All other scores are scaled scores which have a mean of 10, a standard deviation of 3, and a maximum of 20. $CWIT_{I/SCE}$ = Colour-Word Interference Test Inhibition/Switching Corrected errors, ST_{SRDS} = Sorting Test Sort Recognition Description Score, ST_{PR} = Sorting Test Perceptual Rules, TT_{TAS} = Tower Test Total Achievement Score.
$N = 77$
$*p < .05$, $**p < .01$

.91, was the predicted multiplicative effect of a 1-unit change in ST_{SRDS} on the number of violent offences committed in one year. In other words, an offender with a ST_{SRDS} score of 7 was expected to have a rate of violent offending that was .91 times the rate of violent offending of an offender with a scaled score of 6. The expected rate change in violent offending for a one-unit change in $CWIT_{I/SCE}$ was 1.01. The expected rate change for a one-unit change in ST_{PR} was .89. Finally, the expected rate change in violent offending for a one-unit change in TT_{TAS} was .92. In other words, a higher scaled score or cumulative percentile rank on $CWIT_{I/SCE}$, ST_{SRDS}, ST_{PR}, or TT_{TAS} was related to a decreased rate of violent offences per year while age and intelligence were held constant.

Second, binary logistic regressions were used to predict whether an offender had committed a severe violent offence from scores from the D-KEFS. Table 11 shows the Wald χ^2, *z*-values, odds ratios, and significance level for each predictor variable. Wald χ^2 is the test statistic for the omnibus test that at least one predictor's odds ratio is not equal to 1 in the model (A score of 1 indicates that change in the predictor does not change the probability that an offender is in one group or the other). Once again, each predictor variable was run in a separate regression along with age and intelligence. The exponentiation of the regression coefficient for $CWIT_{I/S\text{-}CN}$, $e^{-.33} = .72$, was the predicted multiplicative effect of a 1-unit change in $CWIT_{I/S\text{-}CN}$ on the likelihood of having committed a severe violent offence (versus not committing a severe violent offence). In other words, an offender with a $CWIT_{I/S\text{-}CN}$ score of 6 was .72 times as likely to have committed a severe violent offence as an offender with a scaled score of 5. Similarly, it was found that for a one unit increase in ST_{PSA}, the odds of having committed a severe violent offence changed by a factor of .73. For a one unit increase in ST_{OAD}, the odds of committing a severe violent offence changed by a factor of 1.03. Finally, for a one unit increase in $VF_{CS\text{-}TC}$, the odds of committing a severe violent offence multiplied by a unit of .76.

Table 11

Individual Binary Logistic Regressions Predicting Severe Violent Offending Covarying Age and Intelligence

Predictor	Wald $\chi^2(3)$	z	Exp(β) [95% Conf. Interval]	Std. Error
$CWIT_{I/S-CN}$	8.94*	-2.42*	.72 [.54 – .94]	.10
$CWIT_{I/SUE}$[c]	6.81	-1.77	.98 [.96 – 1.00]	.01
ST_{PSA}	8.30*	-2.42*	.73 [.56 - .94]	.10
ST_{OAD}[c]	10.81*	2.50*	1.03 [1.00-1.06]	.01
TT_{MAR}	7.55	1.88	1.38 [.99-1.91]	.23
VF_{CS-TC}	8.12*	-2.08*	.76 [59 - .98]	.10
VF_{CS-SA}	7.11	-1.78	.81 [.64 – 1.00]	.10

Note. Age and intelligence served as covariates. [c] indicates a cumulative percentile rank, which is out of 100. All other scores are scaled scores which have a mean of 10, a standard deviation of 3, and a maximum of 20. $CWIT_{I/S-CN}$ = Colour-Word Interference Test Inhibition/Switching minus Colour Naming, $CWIT_{I/SUE}$ = Colour-Word Interference Test Inhibition/Switching Uncorrected Errors, ST_{PSA} = Sorting Test Percent Sorting Accuracy, ST_{OAD} = Sorting Test Overly Abstract Descriptions, TT_{MAR} = Tower Test Move Accuracy Ratio, VF_{CS-TC}= Verbal Fluency Category Switching Total Correct, VF_{CS-SA} = Verbal Fluency Category Switching-Switching Accuracy.

$N = 77$

$*p < .05$

In other words, four scores from the subtests of the D-KEFS were each related to whether an offender had committed a severe violent offence or not, over and above age and intelligence.[7]

Although it is important to interpret the odds ratios, it was equally important to examine how accurate the regression models were at correctly identifying offenders as those who had committed severe violent offences and those who had not. It was found that for each individual binary logistic regression (containing age, intelligence, and a significant predictor variable) 90% of offenders were correctly classified. One of the nine severe violent offenders was correctly classified, and all of 68 offenders who had not committed a severe violent offence were correctly classified. The sensitivity, or percentage of occurrences correctly predicted, was 11%. The specificity, or percentage of non-occurrences correctly predicted was 100%.

Because sensitivity was low, a binary logistic regression was run containing all of the significant predictors identified by the individual regressions. Table 12 displays the z-values, odds ratios, and significance level for each predictor variable within this regression. The Wald $\chi^2(6) = 14.71, p < .05$ indicated that at least one predicator variable's odds ratio was not equal to 1 in the model. Three of the scores were able to predict whether an offender had committed a severe violent offence over and above the ability of the other scores, age, and intelligence.

More importantly, it was found that the regression model's accuracy of correctly classifying offenders improved when all of the predictors were input simultaneously.

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[7] I would like to acknowledge that I have made no mention of power or effect size throughout the discussion of the regression analyses, however this was done intentionally. The regression analyses used in the present study are not completely developed in terms of the traditional types of testing that are usually available. As there is no established way of determining effect size or power in these types of regression analyses, I chose not to make mention of these concepts.

Table 12

Complete Binary Logistic Regression Predicting Severe Violent Offending Covarying Age and Intelligence

Predictor	z	Exp(β) [95% Conf. Interval]	Std. Error
$CWIT_{I/S\text{-}CN}$	-2.51*	.66 [.48 – .91]	.11
ST_{PSA}	-1.96*	.73 [.54 - 1.00]	.11
$ST_{OAD}{}^{c}$	2.24*	1.03 [1.00-1.06]	.02
$VF_{CS\text{-}TC}$	-1.75	.72 [.50 - 1.06]	.14

Note. Wald χ^2 (6) = 14.71, $p < .05$. Age and intelligence served as covariates. [c] indicates a cumulative percentile rank, which is out of 100. All other scores are scaled scores which have a mean of 10, a standard deviation of 3, and a maximum of 20. $CWIT_{I/S\text{-}CN}$ = Colour-Word Interference Test Inhibition/Switching minus Colour Naming, ST_{PSA} = Sorting Test Percent Sorting Accuracy, ST_{OAD} = Sorting Test Overly Abstract Descriptions, $VF_{CS\text{-}TC}$= Verbal Fluency Category Switching Total Correct.
.*N* = 77
**p* < .05

Using this model, six of the nine offenders who had committed a severe violent offence were correctly classified. All of the 68 offenders who had not committed a severe violent offence were correctly identified. In other words, the sensitivity was 67% and the specificity was 100%.

To assess multicollinearity, Pearson correlations were calculated for the D-KEFS scores that predicted violence (see Table 13). Examination of Table 13 shows a small number of significant correlations, with the largest correlations being between the scores

ST_{SRDS} and ST_{PR} ($r = .88, p < .01$). These latter two variables were not run in a regression together, therefore this large correlation was not considered problematic.

Table 13

Correlations Among Significant Predictors of Violence

	1	2	3	4	5	6	7	8
1. TT_{TAS}	—	.08	.12	.13	.14	.05	-.01	-.16
2. V_{CS-TC}		—	.29*	.15	.24*	.03	.07	.03
3. ST_{SRDS}			—	.19	.88**	-.20	.03	.08
4. ST_{PSA}				—	.03	.04	.02	-.27*
5. ST_{PR}					—	.15	-.02	.11
6. ST_{OAD}						—	-.17	.10
7. $CWIT_{I/S-CN}$							—	.17
8. $CWIT_{I/SCE}$								—

Note. TT_{TAS} = Tower Test Total Achievement Score, VF_{CS-TC}= Verbal Fluency Category Switching Total Correct, ST_{SRDS} = Sorting Test Sort Recognition Description Score, ST_{PSA} = Sorting Test Percent Sorting Accuracy, ST_{PR} = Sorting Test Perceptual Rules, ST_{OAD} = Sorting Test Overly Abstract Descriptions, $CWIT_{I/S-CN}$ = Colour-Word Interference Test Inhibition/Switching minus Colour Naming, $CWIT_{I/SCE}$ = Colour-Word Interference Test Inhibition/Switching Corrected errors.

$N = 77$

$*p < .05$, $**p < .01$

Discussion

Central Findings

Differences on the D-KEFS between offenders and controls. As was expected, the offender group demonstrated impairments in a number of executive abilities as reflected by lower scores on subtests of the D-KEFS compared to a group of controls. These differences persisted despite covarying age and intelligence. More specifically, in regards to their performance on the Tower Test, offenders were less accurate when moving the disks than were the controls. Poor accuracy suggests that offenders were employing less effective strategies in constructing the towers (e.g., moving the disks more impulsively; Delis et al., 2001). Individuals demonstrating these test behaviours may similarly have difficulty formulating and executing effective plans in daily life.

On the Colour-Word Interference Test offenders were found to perform more slowly on a measure of inhibition that controlled for colour naming speed. Similarly, the offenders were slower at switching back and forth between naming the dissonant ink colors and reading the words, performance which reflects problems with inhibition and with cognitive flexibility (Delis et al., 2001). Offenders were found to commit more corrected errors, both in the condition measuring inhibition and in the condition measuring inhibition and cognitive flexibility. Taken together, offenders' slower response speed and increased number of errors are indicative of trouble inhibiting prepotent verbal responses and thinking flexibly. Broomhall (2005) suggested that these deficits likely make complex social situations involving conflict challenging for offenders. That is, individuals who have trouble altering behaviour in response to environmental changes, if combined with difficulties in verbal inhibition, are at a higher risk of becoming confused by environmental change, saying something that instigates a confrontation, and being provoked into physical violence.

When examining scores from the Sorting Test it was found that offenders had difficulty identifying correct target sorts on their own, difficulty describing their sorts, and difficulty describing the sorts created by the experimenter. These deficits are indicative of problems with initiation, problem-solving behaviour, transferring knowledge into action, concept formation, and flexibility of responding (Delis et al., 2001). In terms of their modality-specific problem solving skills, offenders were found to have difficulty identifying perceptual rules, but not verbal rules. This pattern may indicate that offenders either have trouble solving perceptual problems, or that they have trouble shifting set from identifying verbal sorts to perceptual sorts. Taken together, the offenders appeared to have difficulty adapting their cognitive processing strategies to face new and unexpected conditions in the environment. An example of how this cognitive inflexibility may manifest itself in everyday life is insistently acting in a way that has been shown to be effective in previous situations yet is ineffective in a new situation.

A final score from the Sorting Test indicated that the offender group gave more abstract descriptions of their sorts and of the sorts created by the experimenter than did the controls. A large number of these types of descriptions is thought to indicate limited expressive language abilities. That being said, offenders did not show any impairment on scores from the Verbal Fluency Test, a measure of the ability to generate words fluently. It may be that although offenders can generate single words fluently, they have specific problems combining these words into complete thoughts or meaningful explanations.

Taken together, offenders' performance on the D-KEFS indicated that these individuals were characterized by impairments in cognitive flexibility, inhibition, problem solving, impulse control, planning, concept formation, and abstract thinking. Offenders displayed an intact ability to initiate behaviour and an intact ability to produce speech fluently.

The magnitude of the aforementioned effects are small according to Cohen's (1988) benchmark for interpreting effect size. However, these small effects fall within the range of effects outlined by Morgan and Lilienfeld (2002) in their meta-analytic review of the literature examining the relationship between executive functioning and criminal behaviour. Trusty, Thompson, and Petrocelli (2004) pointed out that "small effect sizes for very important outcomes can be extremely important, as long as they can be replicated" (p. 109). Understanding the causal underpinnings of criminality and violence is of the utmost importance for society (Public Safety and Emergency Preparedness Canada, 2005), and so, although replication is necessary, these small effects are quite meaningful.

If an individual lacks intact executive abilities, navigating through situations that could be solved by crime (e.g., solving financial strain, coping with a provocative interpersonal encounter) will inevitably be more problematic. For example, an individual who is not able to accurately examine the outcome of previous decisions due to difficulties in altering their behaviour in response to environmental changes and due to difficulties problem-solving will likely structure decisions poorly in the future. Complicating the situation further, an inability to inhibit prepotent responses and increased impulsivity may make dealing with ambiguous situations even more difficult, which may result in further criminal involvement.

It should be noted that although the offender sample was predominantly violent, not every offender had committed a violent offence. Therefore, the deficits that were identified for the group are not necessarily characteristic of violent offenders, but rather of criminals in general. The global deficits in executive functioning identified by performance on the D-KEFS are fairly consistent with what many researchers have found when examining incarcerated populations. Bergeron and Valliant (2001) found that offenders significantly differed from controls on measure of executive functioning. Similarly, Valliant et al. (2003) identified executive deficits in a group of incarcerated offenders, and they found that these deficits were worse in offenders who had committed multiple crimes rather than in offenders who had committed a single crime. Some research suggests that these deficits are characteristic of offenders who commit violent crimes (Barker et al., 2007; Broomhall, 2005; Fishbein, 2000), although other research has suggested that offenders who commit violent offences and those who commit nonviolent offences do not differ in their executive abilities (Greenfield & Valliant, 2007; Hoaken et al., 2007). The current results cannot provide support for whether non-violent offenders differ from those who are violent; however, they do support the hypothesis that criminals, in general, are characterized by global deficits in executive functioning. The current results also indicate that the executive deficits in criminals persist despite covarying age and intelligence.

A number of potential explanations exist for why offenders exhibited deficits in executive functioning. First, it is possible that individuals who become involved with the legal system experienced atypical development of executive functions during childhood, resulting in these individuals having been impaired their entire lives. This explanation is in line with the theory that physical aggression is characteristic of young children; however, becomes less frequent with age (Tremblay et al., 1996), within a similar time frame of marked improvements in executive functioning (Zelazo & Müller, 2002). Séguin and Zelazo (2005) proposed that though this pattern of declining aggression and increasing executive functioning is characteristic of most children, there are cases in which executive functioning is atypical, and subsequently children continue to display high levels of physical aggression and antisocial behaviour throughout their lives. It may be that, as children, the offenders in the present study remained aggressive due to atypical development of executive functioning, and consequently these individuals have always been at risk of engaging in criminal activity.

Alternatively, the offenders may have developed executive abilities normally during childhood, but experienced something later in life that caused a decline in executive abilities. A number of factors are known to contribute to the deterioration of executive abilities. One factor of particular interest in the present study was traumatic brain injury. Although no definitive conclusions can be made, the executive dysfunction evidenced by this group of incarcerated offenders may be due, in part, to a high incidence of brain injury. Sixty-eight percent of the offenders reported that they had incurred a head injury at some point in their life, 45% losing consciousness, and 43% requiring hospitalization. Given that these rates are well above those of the general public (Cassidy et al., 2004), and that traumatic brain injury has been associated with a decline in executive functioning (Bufkin & Lutrell, 2005; Hawkins & Trobst, 2000; Marsh & Martinovich, 2006), the offenders in the present study may have incurred lasting structural and functional brain abnormalities that contributed to their deficits. Although an interesting observation, it is not known whether these injuries occurred before or after criminal behaviour began, so this relationship is only speculative in nature. Executive functioning is related to neurological dysfunction; however, it is difficult to infer specific deficits from the above findings without the accompaniment of structural or functional imaging technology. Although some authors have identified neural substrates of specific executive abilities, brain-behaviour relationships are difficult to confirm/conclude based solely on neuropsychological testing.

Predictors of frequency and severity of violence. As discussed above, the second goal of the current research was to investigate whether executive abilities could predict the frequency and severity of past violent offending. To my knowledge, this is the first research study to examine specific executive abilities as possible predictors of violence. The latter count ended up being dichotomous, so rather than predicting frequency of severe violent offending, whether an offender had committed a severe violent offence or not was predicted.

Several scores from the D-KEFS were identified as predictive of the frequency of violent offending in a given year. Said another way, results suggested that offenders who scored lower on measures sensitive to concept formation, flexibility of thinking, and problem solving skills, similar abilities that differentiated offenders from controls, were more likely to have committed an increasingly large number of violent offences than were offenders who scored higher on these measures. Similarly, offenders who scored lower on a measure of spatial planning, rule learning, and impulsivity were more likely to commit an increasingly larger number of violent offences. Finally, the fewer corrected errors an offender made on the switching condition of the Colour Word Interference Test, the more likely they were to have an increased rate of violent offending. This latter finding was surprising because the offenders, as a group, were more likely to commit corrected errors than were controls. The current finding is idiosyncratic, and given the exploratory nature of this research, not easily explained by anything currently in the literature. This finding may be the result of a Type I error, or alternatively may indicate that offenders who commit an increasingly large number of violent offences become less likely to correct their errors on the Colour-Word Interference Test because they lack the ability to monitor their behaviour as they perform tasks.

In the second set of regression analyses, a number of variables were predictive of whether an offender had committed a severe violent offence. These results suggested that the more impaired an offender was at inhibiting prepotent verbal responses and in concept formation, the more likely they were to have committed a severe violent offence. Similarly, offenders who scored lower on measures of cognitive flexibility were more likely to have committed a severe violent offence. Contrary to expectation, the more intact offenders' expressive language abilities (as evidenced by a low number of abstract sorting descriptions) the more likely they were to have committed a severe violent offence.

This latter finding was surprising because, as a group, the offenders were impaired in expressive language abilities. However, it seems that offenders who are less impaired are more likely to have committed a severe violent offence. Although unexpected, this finding is consistent with Robert Hare's suggestion that violent psychopaths are verbally fluent, and have little difficulty expressing themselves through spoken language (Hare, 1993). Although those convicted of severe violent crimes are not necessarily all psychopathic, 25 to 30% of incarcerated offenders are classified as psychopaths, and these individuals are characterized by higher rates of severe violent offending (Hare, Hart, & Harpur, 1991). Some of the offenders charged with severe violent offences may have exemplified psychopathic tendencies, being characterized by fluent, expressive speech and consequently scored higher on the measure of expressive language. An alternative explanation for this unexpected finding may involve the dynamic of escalation in violent encounters. Many incidents of conflictual violence are preceded by a verbal exchange (i.e., insults, provocations). People with poorer verbal abilities may be more likely to keep quiet, and therefore avoid to escalation to physical conflict. In contrast, offenders with more intact expressive language abilities might incite the escalation of the conflict up to the point of serious violence.

Offenders who committed frequent violent offences, and/or a severe violent offence were characterized by similar executive deficits as the entire groups of offenders. The difference was that more violent offenders seemed to evidence more severe impairments in cognitive flexibility, inhibition, problem solving, impulse control, planning, concept formation, and abstract thinking. Taken together, executive dysfunction may not be specific to offenders who commit violent acts, but rather deficits may be more severe in these individuals.

It was also of interest whether these significant predictors were able to correctly classify offenders as having committed a severe violent offence or as not having committed a severe violent offence. The individual ability of each predictor to correctly classify offenders was weak. When the significant predictors were run in a regression together, it was found that 67% of the offenders who had committed a severe violent offence were correctly classified and that 100% of the offenders who had not committed a severe offence were correctly classified. These results are meaningful because, based on four scores of executive functioning, a considerable percentage of the severe violent offenders were correctly identified without a single false positives.

Likewise, Foster and colleagues (1993) found that measures of executive functioning were able to predict the frequency of aggressive behaviour. However, these same authors were unable to find executive measures that predicted the severity of aggressive behaviour. Differences in methodology may in part explain why Foster et al. were unable to identify predictors of aggression severity. First, the present study utilized more appropriate statistical techniques for dealing with count data than did Foster et al. (Walters, 2007). Moreover, Foster et al. recorded offenders' aggressive behaviour over the course of one year whereas offenders' entire adult histories of violent offending were recorded in the present study. The complete history of offending may have provided more information about the true relationship between executive functioning and frequency and severity of violence. By measuring longer periods there should be more individual variability and greater variance which could result in larger effects.

The magnitude of the predicted changes in rates of offending by each score was not large; however, given the importance of predicting violent offending in society, these findings are still extremely meaningful. It is also important to stress that although these findings are very meaningful, they are preliminary, warranting further replication before any definitive conclusions can be drawn. Furthermore, it would be of interest to follow-up with this group of offenders in a number of years in order to see whether their scores from the D-KEFS predict future rates of violent offending.

As mentioned previously, research investigating executive abilities in offenders tends to focus on the division of violent versus non-violent offenders. A major problem with studying offenders in this manner has been confusion over what criteria should be used to identify violent offenders. Serin and Preston (2001) reviewed a variety of the criteria used to classify offenders as violent or non-violent, including the following: index offence, attitudes (e.g., hostility), emotions, (e.g., anger), and victim selection (e.g., spousal assault). Inconsistencies in the use of these criteria contribute to the ambiguity of findings. My approach to dealing with offence history was to avoid classification all together and to examine the frequency of violent offences, while at the same time also considering severity. This approach was a significant strength of the present study, and may have resulted in more generalizable data.

An additional strength of the present study was the decision to control for age and intelligence in all analyses. Jurado and Rosseli (2007) emphasized that the findings from many studies investigating executive functioning need to be interpreted with caution as they do not consider mediating variables when measuring executive abilities. These mediating variables can include constructs such as age and intelligence. Evidence that supports the consideration of these particular variables comes from research finding that executive functioning is significantly correlated with age (Fisk & Sharp, 2004) and intelligence (Miyake et al., 2000). In an attempt to prevent individual differences in age from masking important effects (given the broad age range of the offenders in the present sample), age was covaried in each analysis. Additional support for this decision came from Blackburn, Mullings, Marquart, and Trulson's (2007) findings that age was predictive of violent offending. In addition, the ability to understand and recall the relatively complex rules involved in some measures of executive functioning could presumably be affected by low intelligence (Séguin, Boulerice, Harden, Tremblay, & Pihl, 1999). Because of the positive relationship between intelligence and executive functioning and because offenders are known to have lower intelligence, previous research supporting a relationship between executive functioning and violence may have simply been a consequence of the offenders' lower intelligence rather than their executive dysfunction. Therefore, intelligence was covaried in each analysis as it was unquestionably more appropriate to acknowledge that an overlap between intelligence and executive abilities exists than to ignore it.

Despite the broad range of deficits found and significant predictors identified, a number of theoretical considerations need to be discussed given the lack of agreement in the literature regarding issues pertaining to executive functioning and to violence. These issues include the problems associated with measuring executive functioning, the relationship between cognitive and social variables, and the conceptualization of violence as a unitary construct.

Problems with Measuring Executive Functioning

Executive dysfunction is clinically significant; however, it is difficult to define. Consequently, precise measurement has proven elusive. Although significant and very meaningful, it is possible that the findings from the present study were not as robust as might have been expected due to the difficulty of precisely measuring executive abilities. Chan, Shum, Toulopoulou, and Chen (2008) discussed a number of problems with current measures of executive functioning, particularly focusing on the issue of ecological validity. Ecological validity, or the degree to which results from the laboratory generalize to the real world, has been a significant area of criticism for experimental tasks and traditional neuropsychological tests of executive functioning. For example, patients with frontal lobe lesions performed equally well as controls on traditional neuropsychological tests, but they nonetheless experienced many difficulties in everyday life activities (Shallice & Burgess, 1991). Conventional experimental tasks demand relatively simple responses to single events. More complex multi-step tasks in daily life may require a more complicated series of responses not captured by the currently available measures of executive functioning.

There are many discrepancies between experimental tasks and naturalistic tasks of executive functioning encountered in everyday life (Chan et al., 2008). It is possible that the particular conditions under which participants in the present study were tested (i.e. well lit, quiet, structured environment) were so different from most situations in the real world that there was little correspondence between the cognitive resources tapped in the examination condition and those tapped in real-world situations (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). This structured environment may have resulted in an overestimation of the offenders' abilities. It is important to consider that in daily life people are faced with ambiguous, unstructured situations and it is likely in these situations that criminal activity most frequently occurs.

Currently there is no perfect way to quantify true everyday cognitive abilities, as any form of assessment is associated with a certain degree of error. Future research examining the relationship between executive functioning and violence should focus on the ecological validity of the measures used. In addition, more ecologically valid measures of executive abilities need to be developed in order for researchers to be able to truly quantify this construct.

Relationship Between Social and Cognitive Variables

The present study examined neuropsychological dysfunction in isolation, purposely ignoring prevalent psychosocial factors. This approach was justified given the preliminary nature of the research and given that so little is known about the relationship between executive functioning and criminality. It is acknowledged that the heterogeneity of criminality and of human behaviour in general makes it unlikely that all forms of criminal behaviour share the same etiology. Rather, there are likely a number of factors that contribute to criminality and violence, with executive functioning being one of these variables. Social skills, personality traits, cognitive abilities, early childhood experiences, and a number of other factors likely interact and contribute to criminality. A potential interaction between executive functioning and other variables may have made predictors of violent offending go undetected.

As mentioned previously, psychosocial variables have been the focus of a great deal of research in the field of aggression and violence. Researchers have historically aimed at identifying social variables that are precursors of violent behaviour later in life, or that characterize individuals that are currently violent. Over the past 60 years, important progress has been made in delineating psychosocial risk factors, and more recently, potential cognitive risk factors, for violent behaviour (Raine, 2002b). Despite this progress, investigators know surprisingly little about how these risk factors interact in predisposing aggressive or violent behaviour. Furthermore, surprisingly few researchers are investigating this area. Scarpa & Raine (2007) reviewed the known facts on biosocial interaction effects in relation to antisocial and violent behaviour. One interaction of particular interest to the present study was the interaction between neurocognitive deficits and social variables. Lewis, Lovely, Yeager, and Femina (1989) followed 15-year-old juvenile delinquents and found that the combination of neurocognitive deficits and child abuse was associated with higher rates of violent offending than was having only neurocognitive deficits or only experiencing child abuse. Similarly, Moffit (1990) found that boys with low neuropsychological functioning and family adversity scored four times higher on measures of aggression than did boys with either family adversity or neuropsychological deficits.

Raine (2002b) presented an interactional neuropsychological model of antisocial behaviour to explain the above findings. This model was based on the notion that the social and executive functioning demands of late adolescence overload the prefrontal cortex, giving rise to prefrontal dysfunction and a lack of inhibitory control over antisocial and violent behaviour. This processing load occurs at a time when the prefrontal cortex is still developing (Raine, 2002b). Adolescents with early damage to or dysfunction of this brain region would be particularly likely to experience an information overload during this time period, resulting in further dysfunction of the prefrontal cortex, less regulatory control, and further antisocial behaviour. A protective factor for those with a late-maturing but intact prefrontal cortex may be having more social support or fewer social demands placed on them. Raine also discussed a separate group of individuals that may not begin to offend until later in life, due to late life stressors overloading a prefrontal cortex with latent functional impairments.

Raine's (2002b) model is relevant to the present study because social risk factors were not measured or controlled for. It is possible that this neuropsychological interaction is masking the detection of greater executive deficits. It may be that executive deficits result in individuals being more vulnerable to psychosocial risk factors and consequently more likely to be violent. Perhaps if variables such as socioeconomic status, familial abuse, and peer relations had been controlled for, executive functioning might have been found to have greater predictive ability. Joint assessment of both psychosocial and cognitive factors is a critical interdisciplinary approach that warrants further exploration and will likely yield innovative insights into the development of violent behaviour.

Reactive versus Instrumental Violence

Due to the exploratory nature of the research, the conceptualization of violence was kept homogenous. All offences involving intentional acts of physical aggression against another individual likely to cause physical injury were considered violent and summed together. However, it may have been problematic to suggest that violence is homogenous. There has been a distinction made in the literature between two different types of violence. This distinction is based on the underlying motivation of the violent act. Instrumental violence (often referred to as proactive violence), is violence used as a means of obtaining some sort of goal or monetary gain. Instrumental violence is thought to be distinct from reactive violence, or violence used as a defense to a perceived threat. It should be noted that the distinction between reactive and instrumental violence may still be an oversimplification of this construct; some researchers have argued that this dichotomy is too basic, and though once useful, currently lacks value (Bushman & Anderson, 2001). Rather than a simple dichotomy, violent offences are likely characterized by elements of instrumentality and/or reactivity (Woodworth & Porter, 2002).

Notwithstanding the above criticism, support for the distinction between instrumental and reactive subtypes comes from several areas including social cognition, clinical psychology, psychiatry, neurobiology, neurocognition, and psychophysiology (Fontaine, 2007). Blair, Mitchell, and Blair (2005) differentiated these subtypes of aggression by identifying different neural circuitry's responsible for mediating each aggressive response. Additional research has also shown that lesions to the medial and orbital/ventrolateral frontal cortex are associated with increased risk for engaging in reactive aggression whether the lesion occurs in childhood (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999) or adulthood (Grafman, Schwab, Warden, Pridgen, & Brown 1996). Alternatively, atypical amygdala functioning was associated with psychopathy and instrumental acts of violence (Blair, Morris, Frith, Perrett & Dolan, 1999; Blair, 2001). Raine, Ohil, Stoddard, Bihrle, & Burchsbaum (1998) distinguished instrumental and reactive offenders using positron emission tomography finding that reactive offenders were characterized by a decreased prefrontal metabolic activity while instrumental offenders did not show this abnormality in prefrontal metabolism. In a number of studies, researchers have found that reactive aggression is also associated with decreased serotonergic function (Coccaro & Kavoussi, 1997; New et al., 2002). Interestingly, the prefrontal cortex is a region of the brain rich in serotonergic receptors (Santana, de Almeida, Mengod, & Artigas, 2008).

Given the distinct neurological anomalies, individuals who engage in different subtypes of violence may be characterized by unique patterns of executive dysfunction.

In examining the executive abilities of instrumental versus reactive aggressors, Broomhall (2005) found that primarily reactive offenders performed differently than did primarily instrumental offenders on three subtests of the D-KEFS (Verbal Fluency, Design Fluency, and the Colour-Word Interference Test). More specifically, primarily reactive offenders showed impairment in cognitive flexibility, maintaining set, initiation of verbal responding, and verbal inhibition whereas primarily instrumental offenders were impaired in self-monitoring and were found to be more impulsive. These findings suggest that different types of aggressors may be characterized by different executive deficits. Consequently, the decision to examine predictors of violence as a whole rather than of specific subtypes of violence may have concealed other findings. Given the exploratory nature of the current study, it was justifiable to simplify the construct of violence, but, a study similar to the present should be conducted with instrumental and reactive violence being examined separately.

Implications of the Current Research

Violence risk assessment. The value of being able to estimate the likelihood that someone may be violent in the future cannot be overstated. Currently, executive functions (or any cognitive abilities for that matter) are not considered in the most widely used and validated violence risk assessment tools (e.g., Level of Service Inventory - Revised: Andrews & Bonta, 2003; the Violence Risk Appraisal Guide: Quinsey, Harris, Rice, & Cormier, 2008; Historical, Clinical, Risk Management-20: Webster, Douglas, Eaves, & Hart, 1997). Given that violent risk assessment is far from perfect, and given that the present study identified specific scores from the D-KEFS that were able to predict frequency and severity of past violent offending, executive functioning may be a construct that merits further exploration in the field of violent risk assessment. Measures of executive functioning are easy to administer, they are objective, and executive functions are thought to be relatively stable across adulthood. Given these features, executive functioning is a good candidate for evaluation for potential inclusion in risk assessment. Future research should examine the incremental validity of adding measures of executive functioning to violence risk assessments. It would be interesting to see whether executive abilities add anything to prediction over and above the variables already being investigated.

Potential for rehabilitation. Beyond simply assessing individuals' risk for future violence, researchers need to develop interventions to manage or reduce this risk. Given the findings of the present study, executive functioning may be an area that warrants further exploration as a potential avenue for rehabilitation of violent offenders. Improving executive abilities may provide offenders with the means to deal with provocative situations, and such treatment may therefore teach offenders an alternative to violence. Executive dysfunction is not specific to incarcerated offenders, but rather characteristic of a number of clinical populations such as individuals with schizophrenia (Velligan & Bow-Thomas, 1999), attention-deficit disorders (Pliszka, 2007), Tourette's disorder (Bornstein, 1990), and some traumatic brain injury (Cicerone, Levin, Malec, Stuss, & Whyte, 2006; Krpan, Levine, Stuss, & Dawson, 2007). Research in cognitive rehabilitation suggests that with the right techniques, executive dysfunction can be improved significantly in these populations (Cicerone et al., 2006; Rath, Simon, Langenbahn, Sherr, & Diller, 2003; Worthington, 2005). Given these findings, perhaps similar strategies could be applied to developing rehabilitation programs for offenders identified as have deficits in executive functioning. The importance of executive control is highlighted in much of the literature regarding correctional-based programming through both direct (Mullin & Simpson, 2007; Paschall & Fishbein, 2002) and indirect (Blud, Travers, Nugent, & Thornton, 2003; Pugh, 1993) reference. However, changes in how remediation is conceptualized lags behind the accumulating research (Bonta & Cormier, 1999).

The public tend to believe the old proverb that "you cannot teach an old dog new tricks," implying that it is difficult to learn new skills or improve existing skills past late adolescence. However, recent literature in neuroplasticity suggests that this assumption is incorrect. The brain may reach full volume by adolescence, but the number and strength of the connections between neurons continue to increase (Bartzokis, Beckson, Nuechterlein, Edwards, & Mintz, 2001). Neuroimaging studies have recently shown that the volume of white matter connecting the limbic system and the prefrontal cortex continues to increase well into late adulthood (Bartzokis et al., 2001). Moreover, throughout the life span, the human nervous system can adapt to changes and challenges within the environment (Celnik & Cohen, 2003). Neuroimaging and neurophysiological techniques have demonstrated that adult brains are still neuroplastic and this plasticity may have implications for executive functioning (Gonzales Rothi, 2001; Mateer & Kerns, 2000; Turner, & Levine, 2004). Although executive functions are relatively stable throughout adulthood, neuroplasticity may allow individuals to improve these abilities if appropriate strategies are incorporated into programming.

Limitations

As with all research, the findings of the present study must be interpreted within the context of their limitations. The sample for the present study was comprised of offenders who had been convicted of violent offenses of a relatively low severity. Only one offender had committed a violent offence that resulted in lasting injury, and eight offenders had committed murder. This was likely a consequence of sampling from a medium security forensic facility. Although the total number of cases ($N = 77$) was not restrictively small for conducting binary logistic regression (the model used to evaluate severe violent offending), the number of cases in the severe violence cell was small ($N = 9$) and this reduces the efficiency of the estimates (*Stata Data Analysis Examples*, 2009)

Another limitation of the present study was that information on offenders' psychopathology or use of psychotropic medication was not readily available from their files, and so the effects of these variables could not be considered. Much like brain injury, the prevalence of mental illness (e.g., psychosis, mood, anxiety, substance, and personality disorders) is significantly higher among incarcerated offenders than in individuals living in the community (Butler, Allnutt, & Cain, 2005). Performance on tasks of cognitive abilities has been shown to be affected by both clinical and non-clinical levels of anxiety and depression (Williams, Watts, MacLeod, & Matthews, 1997) and attention deficit hyperactivity disorder (Pennington & Ozonoff, 1996). Thus, the influence of mental health issues on offenders' performance on the D-KEFS is unknown. Additionally, a variety of antidepressants, antipsychotics, mood stabilizers, sedatives, hypnotics, and anxiolytics have been found to differentially affect cognitive functioning, particularly in older adults, but also in younger samples (see Brooks & Hoblyn, 2007 for a review). Failure to account for mental health problems and the use of psychotropic medications may have decreased the internal validity of the present study.

Conducting research in a forensic setting involves additional limitations that threaten both internal and external validity of findings. Psychological testing is considered suspicious within the prison culture, as is involvement of the guards, psychologists, and other prison staff. It may be that offenders with the most violent histories were the most suspicious, as they had been incarcerated the longest, and were therefore less likely to participate. As such, the offender population who volunteered to participate in the present study may not be truly representative of all Canadian incarcerated offenders or, more specifically, of the incarcerated violent offenders. An additional problem with testing incarcerated offenders is the issue of motivation. Offenders were initially motivated to participate in the research because they were allowed out of their room for a period of time and because they had the attention of an unfamiliar female. However, once these benefits were obtained, the offenders may not have been motivated to complete the battery to the best of their ability, threatening the internal validity of the research.

Conclusion

The present study was the first of its kind. Offenders were found to be characterized by patterns of broad and pervasive executive dysfunction. More importantly, executive dysfunction was found to be predictive of the frequency and severity of violent offending. Despite the aforementioned limitations, the results from the present study are exciting and, if replicated, have significant implications for society. An understanding of the complex and interconnected variables underlying violence and criminality is a necessary precursor for (a) identifying youth exhibiting violent behaviour early in life and (b) developing and implementing strategic plans for intervening or rehabilitating offenders. Identification of distinct predictors of frequent and severe violent offending calls into question a 'one size fits all' approach to remediation.

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