IOWA GAMBLING TASK PERFORMANCE IN CANADIAN FEDERAL OFFENDERS

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the Requirements for the Degree Master of Science

Descriptive Note

MASTER OF SCIENCE (2020) McMaster University

Neuroscience Hamilton, Ontario

TITLE:	Iowa Gambling Task Performance in Canadian Federal Offenders
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NUMBER OF PAGES:	xi, 59

Lay Abstract

Criminal offending is thought to be related to impulse control problems. Research has linked offending to poor performance on a decision-making task known as the Iowa Gambling Task (IGT). On the IGT, participants repeatedly choose cards from four decks that provide wins and losses of points. Two decks are "good" and result in an overall gain on the task, and two decks are "bad" and result in an overall loss. In this study, 100 Canadian federal offenders and 89 non-incarcerated control participants completed the IGT. Offenders performed worse than the control group overall, and control participants but not offenders learned the best strategy (i.e., choosing from good decks) over the course of the task. Additionally, offenders with a "Low" criminal risk rating did better than those at "Medium" or "High" risk levels. These results suggest that the IGT may provide important information about the cause and prevention of criminal offending.

Abstract

Rationale: Impulse control deficits are thought to underlie criminal offending. Impulsive choice is a facet of impulse control that refers to a preference for immediate over delayed rewards. This facet of impulse control has been measured empirically using the Iowa Gambling Task (IGT), which provides a metric of overall disadvantageous decision-making, as well as metrics of specific maladaptive decision-making strategies.

Purpose: To investigate impulsive choice as a measure of impairment in offenders as reflected by performance on the IGT, and to examine maladaptive decision-making strategies that may mimic real-life decisions to offend and/or recidivate.

Methods: 100 Canadian federal offenders (34% female, mean age = 39.14 ± 9.74) and 89 controls (39% female, mean age = 37.04 ± 10.79) completed the IGT. The IGT involves repeatedly choosing cards from four decks. Two are "good" and result in a net gain on the task, and two are "bad" and result in a net loss. Decks offer a fixed reward, but vary in loss magnitude and frequency. IGT data were analyzed for net score (number of good choices minus number of bad choices), learning across the task, and deck switching patterns. Other assessments included data on offenders' current sentence and risk level.

Results: Offenders performed significantly poorer than controls in terms of net score. Controls learned the advantageous strategy across the task but offenders did not. Offenders also made greater use of a "win-stay/lose-shift" strategy. Low-risk offenders performed significantly better than medium- or high-risk offenders on the IGT.

Conclusion: These results suggest that, compared with controls, offenders tend to make riskier choices and use maladaptive decision-making strategies that provide a larger

immediate reward but are disadvantageous in the long term. The IGT, as part of a comprehensive assessment of risk, may provide valuable information for preventing criminal offending and recidivism.

Acknowledgements

First, I sincerely thank my supervisor Dr. Michael Amlung, who has been an unwavering source of support and guidance over the years. Thank you as well to my supervisory committee members, Dr. Iris Balodis and Dr. Heather Moulden, for their invaluable contributions in shaping this work. This work was supported by a Memorandum of Understanding between the Correctional Service of Canada (CSC) and the Peter Boris Centre for Addictions Research at McMaster University/St. Joseph's Healthcare Hamilton (PI: Dr. James MacKillop). I must also thank the staff of Research Branch of CSC for their support of this project, especially Dr. Lynn Stewart, Dr. John Weekes, Geoff Wilton, and Kaitlyn Wardrop. I am grateful to the on-site staff at the CSC institutions; I would especially like to acknowledge Larry Ringler, Nancy Pearson, Karen Condison, Jill Collicott, and Brooke McKenzie-Crowe at Warkworth Institution; and Liz Vitek, Jim Salmon, Bilkis Sovani, Diane Germain, and Dzemila Black at Grand Valley Institution. This work could not have been completed without the assistance of Emma Marsden, Vanessa Morris, Tashia Petker, Jane Jomy, and Jennifer Kim in data collection and processing. I must also express my sincere gratitude to the 193 participants whose time and efforts made this work possible.

A special thank you to all the members of the Cognitive Neuroscience of Addictions Laboratory for being my research family and for their unending support. Finally, I want to thank my parents for providing me with continuous encouragement throughout my years of study.

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List of Abbreviations and Symbols

ANOVA:	analysis of variance
χ^2:	chi-squared test statistic
CI:	confidence interval
CSC:	Correctional Service of Canada
DWI:	driving while impaired
η_p^2:	partial eta squared
F:	F-test statistic
GVI-W:	Grand Valley Institution for Women
HiREB:	Hamilton Integrated Research Ethics Board
IGT:	Iowa Gambling Task
IQ:	intelligence quotient
M:	mean
n:	number of participants
OMS:	Offender Management System
p:	probability value
PATH:	Population Assessment for Tomorrow's Health
SD:	standard deviation
SFA:	Static Factors Assessment
t:	Student's t-test statistic
TGNC:	transgender and gender non-conforming
vmPFC:	ventromedial prefrontal cortex
WSLS:	win-stay/lose-shift

Declaration of Academic Achievement

I collaborated with Dr. James MacKillop and Dr. Michael Amlung on the design of this research study. Dr. Amlung and I were responsible for the development of the research questions associated with this project with guidance from Dr. Iris Balodis and Dr. Heather Moulden. Dr. Amlung and I collaborated on obtaining ethics approval from the Hamilton Integrated Research Ethics Board and defining the study methodology. I was responsible for recruiting participants and organizing study visits to Correctional Service of Canada institutions, and Emma Marsden, Vanessa Morris, Tashia Petker, and I collected study data. I was responsible for analyzing and interpreting all data and writing the manuscript.

Introduction

Impulse control deficits have long been implicated as a key contributor to criminal offending. One of the most influential theories of criminogenic factors is Gottfredson and Hirschi's self-control theory, published in their book, *A General Theory of Crime* (Gottfredson & Hirschi, 1990). According to this theory, individuals with low self-control (or impulse control) are unable to consider the long-term consequences of their behaviour, and accordingly are more likely to follow impulses that will result in short-term benefits without factoring into their decisions the potential long-term costs (Gottfredson & Hirschi, 1990). Conversely, people with high levels of self-control understand that crime can result in delayed but serious consequences and thus choose not to engage in illegal behaviour. A large body of empirical literature has provided support for Gottfredson and Hirschi's self-control theory (Burt, 2020). A frequently cited meta-analysis by Pratt & Cullen (2000) found consistent associations between impulse control and crime, leading them to declare that low self-control is "one of the strongest known correlates of crime" (p. 952). Vazsonyi et al. (2017) conducted a meta-analysis of the empirical literature published after Pratt & Cullen's article, and likewise found substantial evidence for this link in both cross-sectional and longitudinal studies.

Because impulse control deficits appear to have a strong and reliable association with criminal behaviour, it is important that they are defined and measured in a consistent manner. Impulsivity is currently understood to be a multidimensional construct composed of three discrete domains: impulsive action, impulsive personality traits, and impulsive

choice (MacKillop et al., 2016). Impulsive action refers to the inability to withhold a prepotent response, and impulsive personality traits are conventionally thought to include a lack of perseverance and premeditation, the proclivity to act on immediate urges under conditions of negative or positive affect, and pursuing activities and experiences that are exciting but may be dangerous (MacKillop et al., 2016; Whiteside et al., 2005). While each of these domains may play a part in the decision to offend, with consideration to the self-control theory the most relevant domain when understanding criminal offending is impulsive choice—valuing smaller sooner rewards over larger later rewards. In other words, impulsive choice in this context refers to choosing to engage in criminal behaviours that may offer immediate gratification but carry the possibility of significant negative consequences (e.g., incarceration and loss of freedom).

Impulsive choice, especially in situations that are complex or uncertain, has been linked to dysfunction of the ventromedial prefrontal cortex (vmPFC; Bechara et al., 1994; Bull et al., 2015; Damasio, 1994). Evidence for this has largely been demonstrated by impaired performance on the Iowa Gambling Task (IGT) by patients with damage to the vmPFC (Bechara et al., 1994; Dunn et al., 2006). The IGT is a complex neurocognitive task that simulates real-life decision-making by incorporating elements of uncertainty, reward, and punishment (Bechara, Damasio, et al., 2000). The IGT measures factors that contribute to making these decisions, such as learning, motivation, and sensitivity to reward and punishment (Bechara, Tranel, et al., 2000; Hughes et al., 2015). Briefly, the IGT involves choosing cards from four decks, each of which result in varying gains and losses of money, with the goal of maximizing overall earnings (Bechara et al., 1994).

Two decks offer higher immediate gains but a long-term overall loss ("bad decks") while the other two decks offer lower immediate gains but a long-term overall gain ("good decks"; Bechara et al., 1994). Within both the two good decks and two bad decks, one deck has frequent losses and one has infrequent losses. Participants are free to switch from any deck to another as often as they like, and the typical version of the IGT ends after 100 selections have been made (Bechara et al., 1994). The most advantageous strategy on the IGT is to choose from the good decks since they result in a long-term gain. Thus, a crucial feature of the IGT is having to forgo an immediate reward in favour of a long-term profit (Dunn et al., 2006). In general, healthy participants tend to sample across decks at the beginning of the task and may initially be drawn to the bad decks, but by the final 20–40 cards are choosing primarily from the good decks (Bechara et al., 1994). However, Bechara et al. (1994) found that patients with vmPFC lesions continue to select from the bad decks across the task (i.e., they fail to learn the advantageous strategy). Bechara and colleagues (1994) attributed this poor performance to an inability to consider the long-term consequences of choices, which they termed "myopia for the future." Since its development, the IGT has been shown to be effective in identifying maladaptive decision-making patterns across clinical populations such as schizophrenia (e.g., Saperia et al., 2019), substance use disorders (e.g., Fridberg et al., 2010; Verdejo-Garcia et al., 2006), gambling disorders (e.g., Brevers et al., 2013), and obsessive-compulsive disorder (e.g., Cavedini et al., 2002).

A number of metrics have been used to evaluate performance on the IGT. Classic IGT analyses calculate a measure of overall performance ("total net score") by

subtracting the number of selections from the bad decks from the number of selections from the good decks, as well as the net score for five blocks of 20 consecutive card choices (Bechara et al., 1994; Bechara, Tranel, et al., 2000). Evaluating block net scores provides valuable information, as net scores on the first block are considered to reflect decision-making under ambiguity, and net scores on the last blocks are considered as decision-making under conditions of risk (Brand et al., 2007). Other methods of analysis examine selections from each individual deck to assess sensitivity to varying frequencies of losses (Buelow & Suhr, 2013). More recently, the number of deck switches across the task has been quantified (Steingroever et al., 2013; Worthy et al., 2013). Cassotti and colleagues (2011) introduced examining the number of deck switches in relation to the previous trial's outcome (i.e., net loss or net gain). They found that while healthy adult participants switched more often following a loss than following a gain, they tended to persevere more after losses compared with groups of children and adolescents who were more likely to switch decks following a loss (Cassotti et al., 2011). The authors note that adaptive performance on the IGT may require a loss-stay strategy, first to learn the characteristics of each deck and later to persevere with the good decks though they result in occasional losses. A number of reinforcement learning models have also been developed to characterize performance on the IGT, and one such model, termed the "win-stay/lose-shift" (WSLS) strategy, looks at strategic adjustments immediately following negative outcomes rather than solely examining long-term advantageous or disadvantageous strategies (Worthy et al., 2013). This type of decision-making strategy

may be relevant to criminal offending—the willingness to tolerate short-term costs or forgo short-term benefits for long-term gains.

The IGT has been administered to offender populations with varied results. The body of literature on IGT performance among offenders is highly heterogenous, conducted with offenders across the world, with a wide age range of participants, a variety of offences (e.g., ranging from traffic offences to homicide), and with modified versions of the IGT. Also of note is the relative dearth of research examining IGT performance among female offenders; of non-forensic studies among offenders, only four have included female participants (Bouchard et al., 2012; Lev et al., 2008; Nestor et al., 2018; Yechiam et al., 2008). The following section reviews the current literature on IGT in offenders.

IGT Performance Among Offenders

Since the late 1990s, a number of empirical studies have characterized performance on the IGT in offenders, and a smaller subset of these studies has directly compared performance between offenders and non-offenders. In general, there is convincing evidence of poor IGT performance by offenders. Three studies examining "impairment" on the IGT (i.e., greater than or equal to 50% disadvantageous choices) found that 42–84% of offenders were classified as impaired (Lewis et al., 2004; Rodriguez et al., 2017; Rodriguez & Ellis, 2018).

Offenders versus Controls

Studies examining differences between offenders and non-incarcerated controls have largely found significantly poorer performance among offenders. Studies by Broomhall (2005) and Lev et al. (2008) found that violent incarcerated offenders and traffic offenders, respectively, made significantly more disadvantageous choices when compared with controls (in Broomhall's case, the reference group of healthy controls from Bechara et al., 1994). Yechiam et al. (2008) assessed a number of first-time offenders, including those who had been sentenced for theft, drug offences, sex offences, assault, murder, robbery, and operating a vehicle while impaired. They found no significant difference in IGT performance between offence groups, but all groups performed worse than a control group. Specifically, the control group adopted an advantageous strategy over the course of the task, but offenders did not. A study among driving while impaired with alcohol (DWI) recidivists found that they did significantly poorer than controls in the final block, and that they favoured bad decks to a greater degree than did controls (Kasar et al., 2010). Another study with DWI recidivists performed a median split of offenders into high and low performers on the IGT, and compared with controls, the high performers showed similar performance but the low performers did significantly worse (Bouchard et al., 2012). A study among child sexual abusers found a trend of these participants having lower net scores than non-offenders across IGT blocks—however, the authors caution that child sexual abusers have a lower rate of recidivism compared to other offender groups, and so they may represent a lower

risk group compared to other offenders and may not be reflective of offenders on the whole (Turner et al., 2018).

Three studies have found no significant difference between offenders and controls. Another study among DWI recidivists found no significant differences in total net scores compared with low-risk control drivers (Brown et al., 2016). Beszterczey et al. (2013) found that recidivists had lower total net scores than controls, but this difference did not reach statistical significance. Likewise, Hughes et al. (2015) found no differences in net scores between offenders and controls, though both groups made more advantageous choices in the final block compared with the first block.

Offender Subcategories

The evidence for poorer IGT performance based on offence type is less clear. One study found that offenders who performed poorly on the IGT had more previous arrests for burglary and larceny and fewer for DWI when compared with high performers (Nestor et al., 2018). Among studies of IGT performance and violence or aggression, results are mixed. Two studies have provided indications of a relationship. In a study of Canadian provincially-sentenced offenders, a subgroup of primarily irritable (reactive) aggressors made more disadvantageous choices than did non-violent offenders in the final two blocks of the task, and violent offenders on the whole showed essentially no progression on the task (Levi et al., 2010). Broomhall (2005) found differences among subtypes of violent offenders, showing that reactive aggressors made more disadvantageous choices on the task than did instrumental (proactive) aggressors.

However, Bueso-Izquierdo et al. (2016) found no significant differences in net scores between intimate partner violence offenders and other crime groups. Likewise, the Yechiam et al. (2008) study mentioned above found that violent and non-violent offenders did not differ in terms of net scores.

Three studies have examined IGT performance specifically among sex offenders. In two studies, one group found no significant differences in task performance between older first-time sex offenders, historical sex offenders, and non-sex offenders (Rodriguez et al., 2017), or between first-time child exploitation materials offenders, historical sex offenders, and non-sex offenders (Rodriguez & Ellis, 2018). Turner et al. (2018) gave incarcerated child sexual abusers two modified versions of the IGT in which good decks had pictures of nude adults and bad decks had pictures of nude children, and vice versa. Offenders with a more severe intensity of sexual attraction to children tended to select child decks whether they were good or bad—indicating that the more intense the pedophilic interests, the more it interfered with the task and resulted in dysfunctional decision-making.

Recidivism

A less-explored but promising area of research is the potential predictive power of IGT performance for recidivism. Beszterczey et al. (2013) followed recently released ex-offenders who were taking part in an offender reentry service program. At 3- to 6-month follow-up, total net scores were significantly correlated with rearrest/reincarceration such that higher scores corresponded with a lower rate of recidivism. Though not statistically

significant, non-recidivists trended toward having higher total net scores than recidivists. Bouchard et al. (2012) found that among DWI recidivists, IGT high performers had significantly fewer past convictions and less severe alcohol misuse than low performers, suggesting that they may be at lower risk for future recidivism.

Forensic Settings and Offenders with Mental Disorders

The body of literature on IGT performance in offenders with mental disorders largely suggests that there is no evidence that offenders with mental disorders perform worse than offenders without mental illness or than non-offenders. Prisoners with a traumatic brain injury (Kuin et al., 2019) or attention deficit hyperactivity disorder (Güleç, 2006) performed at an equivalent level to unaffected prisoners. Several studies have examined psychopathy among offenders and its relation to IGT performance. In general, studies have not found evidence for a relationship between psychopathy and measures of advantageous performance on the IGT (Hughes et al., 2015; Kuin & Masthoff, 2016; Lösel & Schmucker, 2004; Schmitt et al., 1999; Yao et al., 2019), with the exception of Beszterczey et al. (2013), who found that higher levels of psychopathy were correlated with lower total net scores. A meta-analysis of IGT performance in forensic populations found no significant differences between patients and controls (Jones et al., 2019). A study not included in this meta-analysis echoed these results in forensic patients with personality disorders or severe mental illness (Young et al., 2013). However, two studies have found differences between subgroups of forensic patients. A study conducted with forensic psychiatric inpatients in Ontario found that those with

psychopathy chose significantly more cards from the bad decks than did patients without psychopathy, and showed impairment in learning the advantageous strategy over the course of the task (Mitchell et al., 2002). Another study conducted in Ontario showed that, compared with both controls and other types of aggressors, forensic inpatients classified as instrumental aggressors had significantly lower total net scores on the IGT (Bass & Nussbaum, 2010).

Current Study

Based on these findings among offenders and theoretical considerations of impulse control as a criminogenic factor, the present study aims to investigate impulsive choice as a measure of impairment in offenders as reflected by performance on the IGT, and to conduct a preliminary investigation of a maladaptive strategy of decision-making that may result in adverse real-life decisions such as criminal offending and recidivism. This study adds to the limited extant literature of IGT among female offenders, and compares performance on the IGT between offenders of different criminal risk levels. Previous studies in offenders have largely examined only net scores on the IGT—importantly, the current study provides a comprehensive examination of performance on the IGT, including total and block net scores, individual deck selections, deck switches, and use of the WSLS strategy.

Methods

Participants

The participants for this project comprised an offender group and a group of age- and sex-matched controls. The study received full approval from the Hamilton Integrated Research Ethics Board (HiREB Project #3946).

Offender Sample

Federally sentenced offenders were recruited for this study. In Canada, offenders who are given a sentence of two or more years serve their sentence in federal institutions managed by the Correctional Service of Canada (CSC). In order to enroll a representative sample of offenders, the eligibility criteria for this study were kept as open as possible and offenders were not selected based on the details of their offences. Offenders were incarcerated at either Warkworth Institution for men located in Trent Hills, Ontario, or Grand Valley Institution for Women (GVI-W) located in Kitchener, Ontario. Warkworth Institution is a medium-security facility with a rated capacity of 537 offenders, and GVI-W is a multi-level facility with a rated capacity of 215 offenders. Eligibility criteria for the offender sample included: (a) currently incarcerated at a federal institution; (b) minimum or medium security level; (c) 18–55 years of age; and (d) fluent in English. Participants were excluded if they posed a security risk for the staff or researchers or required accommodations such as shackles or a protective glass barrier. A total of 103 offenders (Warkworth Institution $n = 68$; GVI-W $n = 35$) participated. One offender was

excluded from analyses due to early termination of the IGT, one was excluded due to choosing from only one deck, and one was excluded because they self-reported that they were choosing decks in a pre-determined pattern (i.e., playing a song with the card decks as piano keys); data from a final sample of 100 offenders were used for analyses.

Control Sample

Control participants were recruited from the Hamilton, Ontario community, and every effort was made to match groups on sex, age (± 5 years), and education (± 2 years). Eligibility criteria for this sample were: (a) 18–55 years of age; and (b) fluent in English. A total of 90 control participants were enrolled. One participant was excluded from data analysis due to responding with "Prefer not to respond" to nearly half of the self-report items, suggesting a lack of effort. A final sample of 89 control participants were included in analyses.

Procedures

Offender Sample

Offenders were recruited for participation in the study via the following procedure: (1) inclusion criteria were provided to the CSC Research Branch, who conducted a search of an electronic database of currently incarcerated offenders who met these criteria; (2) a list of eligible offenders in random order was sent to the researchers; (3) this list was then sent to a staff liaison at the institutions, who gave the selected offenders a flyer with information about the study and directions for returning the flyer if

they were interested in participating; (4) interested offenders returned their flyer to the staff liaison who then reported the list of names to the researchers; (5) the researchers drafted daily visit schedules; and (6) institutional staff liaisons informed offenders about their scheduled session and issued movement passes for the designated day and time.

Data collection occurred over the course of 2 years during 13 separate visits by the research staff to the institutions. Research staff conducted 90-minute sessions with offenders onsite, in private offices in administrative buildings or on living units. Offenders completed a number of tasks and questionnaires. Offenders were given a reference sheet with response options for each of the self-report measures, and items were asked verbally by the researcher. No correctional officers or other staff were present in the room during the research session. In the interest of safety, the door to the office was kept slightly ajar during sessions and the researchers were equipped with personal portable alarms.

Due to concerns about the heightened risk of coercion inherent to conducting research with incarcerated individuals, a multi-stage informed consent process was implemented. First, an informed consent form was drafted at a grade nine reading level. This consent form was read aloud to the participant as they followed along with a second copy. A second consent document was developed for this study which involved asking participants a series of open-ended questions about the purpose of the research, the procedures, and details related to privacy and voluntary participation. Participants had to answer all six questions correctly for consent to be considered valid. Following this,

participants were given an opportunity to ask any questions about the study and their rights as a research participant. If participants' understanding of the study and willingness to participate was gauged by research staff as satisfactory based on these processes, participants initialed each page and signed the consent form. In accordance with CSC policy, offenders were not able to be compensated for their participation in the study, though they were offered certificates of participation if they so desired.

Once in-person data collection was completed, a list of enrolled participants was sent to the CSC Research Branch, who in turn provided research staff with enrolled offenders' data from the Offender Management System (OMS). The OMS is a database containing information about offenders' major offence(s), along with overall ratings and specific indicators of criminal risk.

Control Sample

For the non-incarcerated control sample, data collection occurred at the Peter Boris Centre for Addictions Research located at St. Joseph's Healthcare Hamilton's West 5th site. Participants were recruited via flyers posted on community notice boards and advertisements on online classified sites. Participants were also drawn from the Population Assessment for Tomorrow's Health (PATH) cohort, a research registry of community participants maintained by the Peter Boris Centre for Addictions Research. Interested participants contacted the research study by telephone or e-mail, and if they were eligible a research session was scheduled. Written informed consent was obtained

from all participants before beginning the session. At the end of the session, participants received a $40 gift card and a transportation voucher.

Measures

Data was collected from two sources: in-person assessments and archival data from CSC. During in-person sessions, participants completed an extensive battery of self-report questionnaires assessing demographics, historical substance and alcohol use, impulsive personality traits, and mental health, along with five neurocognitive tasks measuring risk-taking, decision-making, and response inhibition. The current study examines a subset of this data as reviewed below.

Demographics

Demographic variables including age, sex, gender, race/ethnicity, and years of education were collected via self-report questionnaires.

Archival CSC Data

Archival data was obtained from CSC including details about major offence(s), sentence length, among others variables. The Static Factors Assessment (SFA) was used as a measure of criminal risk. The SFA provides an overall rating of low, medium, or high static risk based on 137 items that are categorized into three domains: (1) Criminal History Record; (2) Offence Severity Record; and (3) Sex Offence History Checklist (Maaike Helmus & Forrester, 2017). Due to five participants being recently incarcerated

and thus not yet administered risk assessments, SFA data was only available for 95% of the sample.

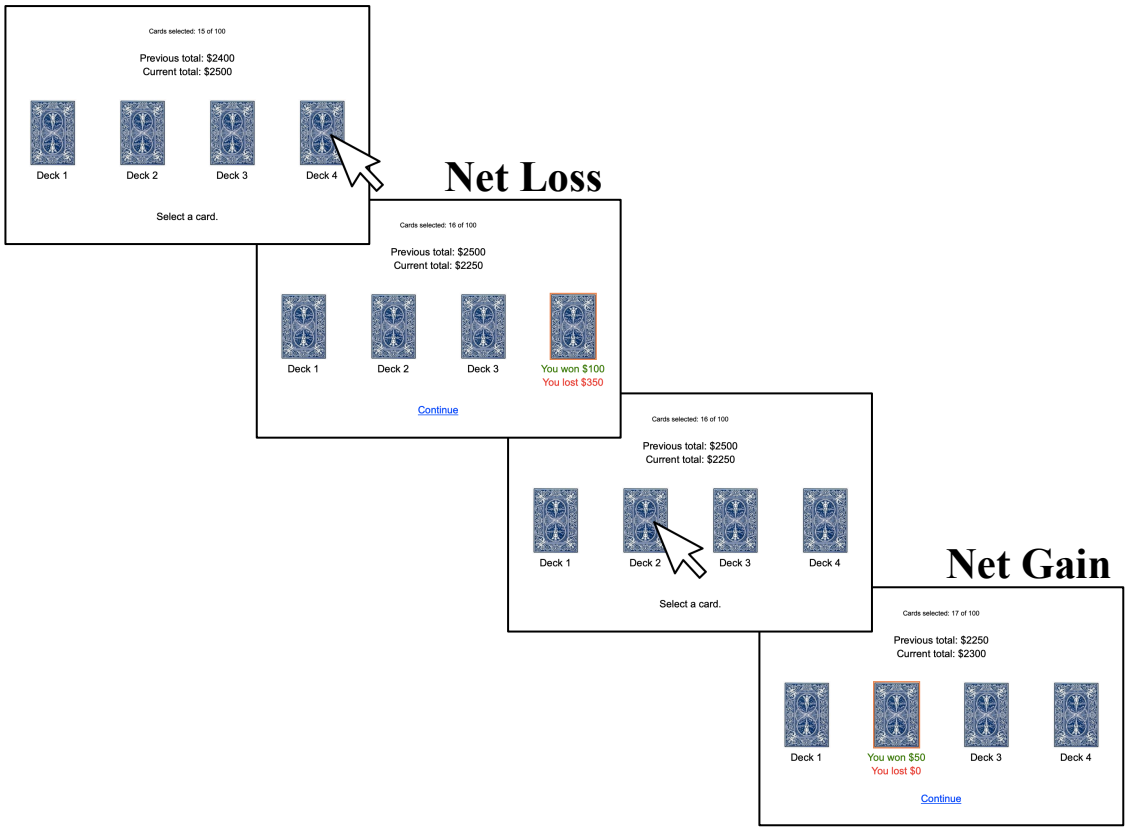
Iowa Gambling Task

The IGT (Bechara, 2007; Bechara et al., 1994) involves making choices from four decks of cards that provide fixed reward amounts but vary based on the frequency and magnitude of losses. The computerized version used for this study was obtained from Millisecond Test Library and administered using Inquisit 4 Lab (Millisecond, n.d.). The original version of the task uses monetary rewards and losses; due to the setting of the current study, the research team decided to alter the task so that points were won and lost instead of money. To our knowledge, this is a novel modification to the IGT. Previous research has found that versions of the task using facsimile money result in equivalent performance to versions using real money, which suggests that this alteration to reinforcer type may not affect IGT performance (Bowman & Turnbull, 2003; Fernie & Tunney, 2006).

Participants are presented with four decks of cards (see **Figure 1** for a task schematic). They are instructed to repeatedly select a card from any of the decks. Each card results in points won but may also result in a loss of points. Participants are told that some decks are more profitable than others, and that they should select cards from the most profitable decks as to maximize their total earnings (see **Appendix A** for complete task instructions). This type of "hint" regarding good versus bad decks has been shown to be vital for good performance on the IGT (Balodis et al., 2006; Fernie & Tunney, 2006).

Figure 1

Iowa Gambling Task Schematic



Note. Examples of a net gain and a net loss trial. Points won and points lost are presented in green and red text, respectively, below each card. Number of card selections remaining and total current points are presented at the top of the screen.

Each card selected from Decks A and B provides a gain of 100 points, and each card from Decks C and D provides a gain of 50 points. However, each deck results in occasional losses that vary on two dimensions: magnitude and frequency (see **Table 1** for deck gain/loss configuration). On Deck A, 50% of cards incur losses ranging from 150 to

350 points. On Deck B, 10% of cards result in a loss of 1250 points. On Deck C, 50% of cards give participants a loss of 50 points. On Deck D, 10% of cards result in a loss of 250 points. Per 10 cards, Decks A and B lead to a net loss of 250 points while Decks C and D lead to a net gain of 250 points. Therefore, an advantageous strategy for participants is to choose more cards from Decks C and D than from Decks A and B. Thus, Decks A and B are termed "bad decks" and Decks C and D are termed "good decks." As noted, decks also vary in terms of frequency of loss such that Decks B and D incur less frequent losses while Decks A and C provide more frequent losses. Importantly, deck positions onscreen were randomized across participants.

Table 1

Iowa Gambling Task Deck Configuration

Deck	Points Gained	Potential Points Lost	Probability of Loss	Net Points per 10 cards
A	100	150, 200, 250, 300, or 350	50%	-250
B	100	1250	10%	-250
C	50	50	50%	+250
D	50	250	10%	+250

Net Scores. The primary dependent measure of impulsive choice on the IGT is the total net score, calculated as the number of cards selected from the good decks minus the number of cards selected from the bad decks (i.e., [Deck C + Deck D] - [Deck A + Deck B]). However, this metric does not assess whether a change in decision-making occurs over the course of the task while the participant learns the outcomes of each deck. This change is important to characterize since the first trials of the IGT reflect choices made under ambiguity, and the final trials present a more accurate view of participant's decision-making under conditions of risk (Brand et al., 2007). Accordingly, performance can be assessed in groups of 20 consecutive card choices, resulting in 5 blocks (i.e., Block 1: trials 1–20; Block 2: trials 21–40; Block 3: trials 41–60; Block 4: trials 61–80; Block 5: trials 81–100). Net scores are calculated for each block using the same calculation for total net score.

Deck Choices. Several studies (e.g., Bull et al., 2015; Lin et al., 2007; Steingroever et al., 2013) have examined deck choices at a more granular level by comparing the proportion of cards selected from each deck, rather than grouping good and bad decks together. In this way, deck preferences based on the frequency and magnitude of losses can be assessed. Participants' deck preferences were calculated as the proportion of choices from each deck by block.

Deck Switches. A stabilization of preferences on the IGT was characterized as the proportion of switches from one deck to another across blocks. The standard IGT assumption is that deck preferences stabilize across the task in healthy controls (Bechara

et al., 1994). Previous research has provided support for a decrease in deck switches among healthy controls (Bull et al., 2015; Cassotti et al., 2011); however, evidence for an equivalent proportion of switches in each block has also been reported (Steingroever et al., 2013). In the current study, the overall proportion of deck switches, along with switches following net gains and net losses, was calculated by block. The overall proportion of switches per block was calculated as the number of switches divided by the total number of trials per block (i.e., 20). Net gain trials were any trials in which the amount of money won minus the amount of money lost was zero or above. Conversely, net loss trials were trials in which the amount of money won minus the amount of money lost was below zero. The proportion of switches following net gains per block was calculated as the number of switches following net gain trials divided by the total number of gain trials. Similarly, the proportion of switches following net loss trials per block was calculated as the number of switches following net loss trials divided by the total number of loss trials.

Results

Sample Characteristics

Demographics

Sample demographics are presented in **Table 2**. Importantly, within the offender group, age, years of education, and racial distribution did not significantly differ among

Warkworth and GVI-W offenders, *p*s > .05. These demographic variables also did not differ among males and females within the control group, *p*s > .05.

Differences Between Groups. Between-group comparisons revealed that offenders and controls did not significantly differ in terms of age, $t(187) = -1.40$, $p = .162$, and sex distribution, $\chi^2 = .58$, $p = .448$. However, groups significantly differed with regard to years of education, $t(187) = 4.66$, $p < .001$. On average, the offender group had slightly less than 1 year beyond secondary education ($M = 12.75$)—1.5 fewer years of education than the control group, which had slightly more than 2 years of post-secondary education ($M = 14.25$). During recruitment, the groups were approximately matched on years of education ± 2 years, and the absolute difference in years of education for offenders and controls was within this range. With respect to race, the control group had a significantly greater proportion of White/European individuals compared to the offender group, $\chi^2 = 12.64$, $p < .001$. A comprehensive characterization of the race distribution is found in **Table 2**. This difference in race distribution between groups is reflective of the overrepresentation of people of colour within the Canadian federal justice system (i.e., 46% non-Caucasian; Public Safety Canada Portfolio Corrections Statistics Committee, 2018). Given these group differences, IGT task performance analyses were conducted twice, first without covariates and then covarying for years of education and race distribution.

Table 2

Demographic Characteristics

Variable	Offenders (n = 100)	Controls (n = 89)	t / χ^2	p
Age			-1.40	.162
M ± *SD*	39.14 ± 9.74	37.04 ± 10.79		
Range	20-60	20-55		
Sex assigned at birth (%)			.58	.448
Male	66.0	60.7		
Female	34.0	39.3		
TGNC (%)	3.0	2.2		
Years of education			4.66	< .001
M ± *SD*	12.75 ± 2.10	14.25 ± 2.34		
Range	8-18	8-20		
Race (%)			12.64	< .001
White/European	61.0	84.3		
Black/African	12.0	3.4		
Indigenous	11.0	1.1		
Asian	4.0	5.6		
Hispanic	2.0	0.0		
More than one race/Other	10.0	5.6		

Note: n = number of participants; M = mean; SD = standard deviation; TGNC = transgender and gender non-conforming.

Offender Profile

Data from CSC indicated that 74% of the offender sample were serving their first federal sentence, 19% were serving their second federal sentence, and 7% were serving their third or fourth federal sentence. There was a range of major offences (see **Table 3**).

Table 3

Major Offences of Offender Group

Major Offence	*n*	%
Homicide		31.0
Second degree murder	12	
First degree murder	10	
Manslaughter - all others	5	
Impaired driving causing death	3	
Attempted murder - all others	1	
Sexual Offences		24.0
Sexual assault	6	
Sexual interference	6	
Incest	2	
Luring a child under 18	2	
Possession of child pornography	2	
Sexual assault with a weapon - all others	2	
Distribution of child pornography	1	
Sexual assault causing bodily harm - all others	1	
Sexual assault with a weapon	1	
Sexual assault with threats to cause bodily harm – others	1	
Property Offences		14.0
Robbery - all others	6	
Break and enter and commit indictable offence	4	
Fraud over $5000	3	
Theft over $5000	1	
Drug Offences		13.0
Possession of Schedule I/II substance for the purposes of trafficking	6	
Importing/exporting of Schedule I substance - more than 1 kg	3	
Importing/exporting of Schedule I/II substance	3	
Trafficking in Schedule I/II substance	1	
Offences of Violence		11.0
Assault with a weapon	3	
Aggravated assault	2	
Assault causing bodily harm	2	
Causing death by criminal negligence - all others	2	
Assault - threats of violence	1	
Assault with intent to resist arrest	1	
Weapons Offences		4.0
Possession of a prohibited or restricted firearm with ammunition	1	
Possession of a weapon contrary to prohibition order	1	
Unauthorized possession of a firearm	1	
Using an imitation firearm in commission of an offence	1	
Conspiracies		2.0
Conspiring to commit an indictable offence	1	
Counselling an indictable offence that is not committed	1	
Administration of Justice Offences		1.0
Breach of recognizance to keep the peace	1	

The most common major offences were homicide (31% of sample) and sexual offences (24% of sample), with a smaller proportion of the sample serving a sentence for property offences (14%), drug offences (13%), offences of violence (11%), weapons offences (4%), conspiracies (2%), and administration of justice offences (1%). Of note, many participants had additional offences but only the most serious offence contributing to the current sentence was noted in the CSC dataset.

With regard to sentence length, 33% of participants were serving a life/indeterminate sentence, and the sentence lengths of the remaining offenders ranged from 2 to just over 15 years, with a median sentence length of 3 years. Of offenders with determinate sentences, 29% were serving a sentence of under 4 years, and 38% were serving a sentence of 4 or more years. The distribution of sentence lengths in our sample is representative of those of the total CSC population (Public Safety Canada Portfolio Corrections Statistics Committee, 2018). At the time of their research session, offenders had served a median of 2.2 years of their sentence, and this value ranged from 6.1 weeks to 27.5 years served. Regarding SFA risk ratings, at the time of their session, five participants had not yet been administered the SFA due to being recently incarcerated. Of the remaining 95 offenders, 10.5% were rated as being a low criminal risk, 30.5% had a risk rating of medium, and 58.9% had a risk rating of high.

Iowa Gambling Task Performance

Net Scores

There were no significant sex differences on IGT performance measured by total net score within offenders, $p = .682$, or within controls, $p = .263$. Offenders performed significantly poorer than controls on the IGT as assessed by mean total net score (offenders: -12.36 ± 33.87; controls: 1.73 ± 37.37; $t(187) = -2.72$, $p = .007$). This result remained significant after adjusting for race distribution and years of education, $F(1, 185) = 9.33$, $p = .003$, $\eta_p^2 = .048$. Mean total and block net scores are presented in **Table 4**. **Figure 2** provides a graphical representation of this data. In this figure, values above zero reflect greater choices from the good decks than from the bad decks. As evident in the figure, both groups made more choices from bad decks during the first three blocks (the prototypical pattern on the IGT of choosing from decks randomly before the development of true preferences; Bechara et al., 1994, 1999). However, only the control group appeared to learn the advantageous strategy and achieved a positive net score by Blocks 4 and 5. The offender group showed a modest improvement over time, but the group mean for offenders did not surpass zero over the course of the task. Bonferroni-corrected pairwise comparisons showed a statistically significant improvement in mean net score for controls from Block 1 ($M = -2.67$, $SD = 7.89$) to Block 5 ($M = 3.78$, $SD = 11.48$), $p < .001$, but offenders did not see the same improvement from Block 1 ($M = -2.96$, $SD = 7.78$) to Block 5 ($M = -.94$, $SD = 9.46$), $p = .536$.

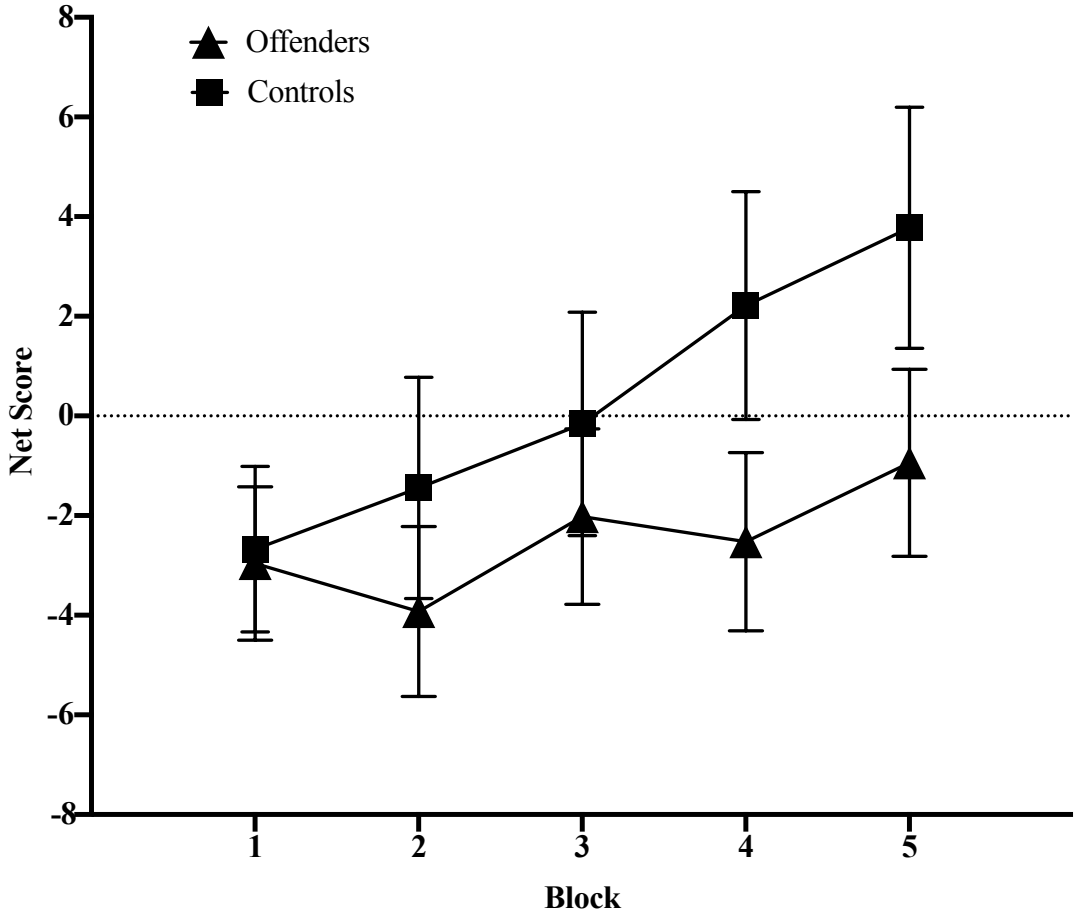
Table 4

Mean Total and Block Net Scores

Net Score	Offenders (n = 100)	Controls (n = 89)	t (187)	p
	M (SD)	M (SD)		
Total	-12.36 (33.87)	1.73 (37.37)	2.72	.007
Block 1	-2.96 (7.78)	-2.67 (7.89)	.25	.802
Block 2	-3.92 (8.60)	-1.44 (10.54)	1.78	.076
Block 3	-2.02 (8.88)	-.16 (10.65)	1.31	.192
Block 4	-2.52 (9.01)	2.22 (10.88)	3.28	.001
Block 5	-.94 (9.46)	3.78 (11.48)	3.06	.003

Figure 2

Mean Block Net Scores of Offenders and Controls



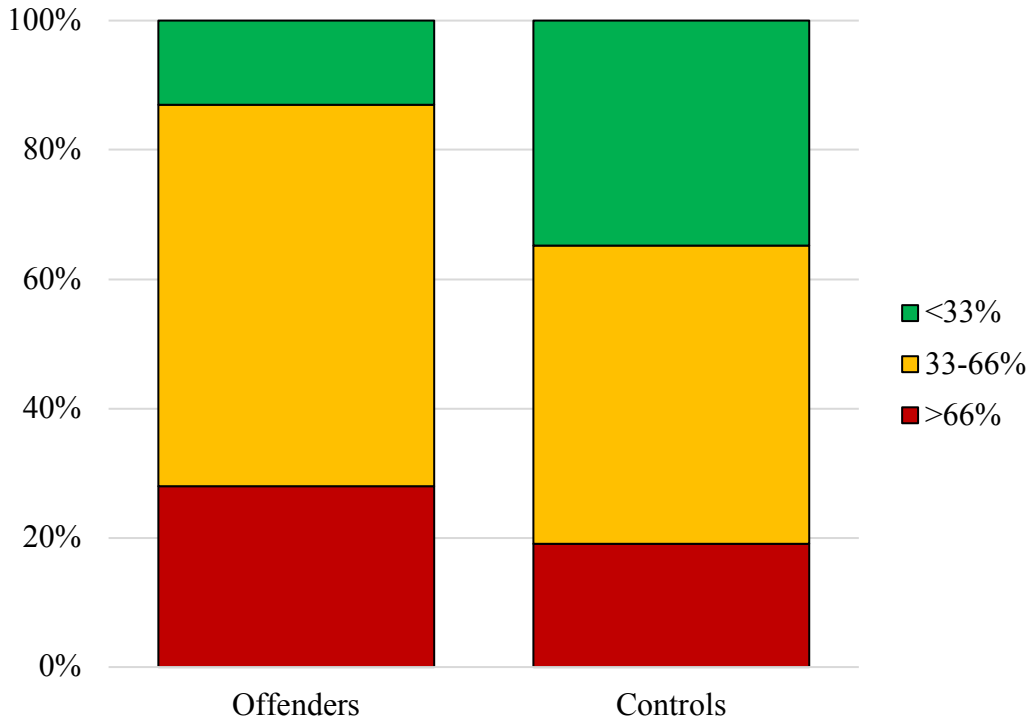
Note. Bars represent 95% Confidence Intervals (CI).

A 2 (Group: offender, control) × 5 (Block: 1–5) mixed ANOVA (Greenhouse-Geisser corrected) revealed significant main effects of Block, $F(3.51, 656.49) = 11.77$, $p < .001$, $\eta_p^2 = .059$, and Group, $F(1, 187) = 7.39$, $p = .007$, $\eta_p^2 = .038$. A significant Group × Block interaction was found, $F(3.51, 656.49) = 3.42$, $p = .012$, $\eta_p^2 = .018$. After covarying for race and years of education, significant main effects of Block, $F(3.52,$

650.29) = 2.49, p =.05, η_p^2 = .013, and Group, $F(1, 185) = 9.33$, p = .003, η_p^2 = .048, remained, along with a significant Group × Block interaction, $F(3.52, 650.29) = 4.78$, p = .001, η_p^2 = .025. These results indicate that the control group progressively began to prefer choosing cards from the good decks over the course of the task to a greater degree than did the offender group. Follow-up one-way ANOVAs identified that mean net scores did not significantly differ between groups in Blocks 1 to 3, ps > .076, but did differ significantly in Blocks 4 and 5, ps < .003. **Figure 3** illustrates this effect, showing that a significantly smaller proportion of offenders primarily chose from the good decks than did control participants in Blocks 4 and 5, $\chi^2 = 12.70$, p = .002.

Figure 3

Proportion of Participants Choosing from Bad Decks in Blocks 4 and 5



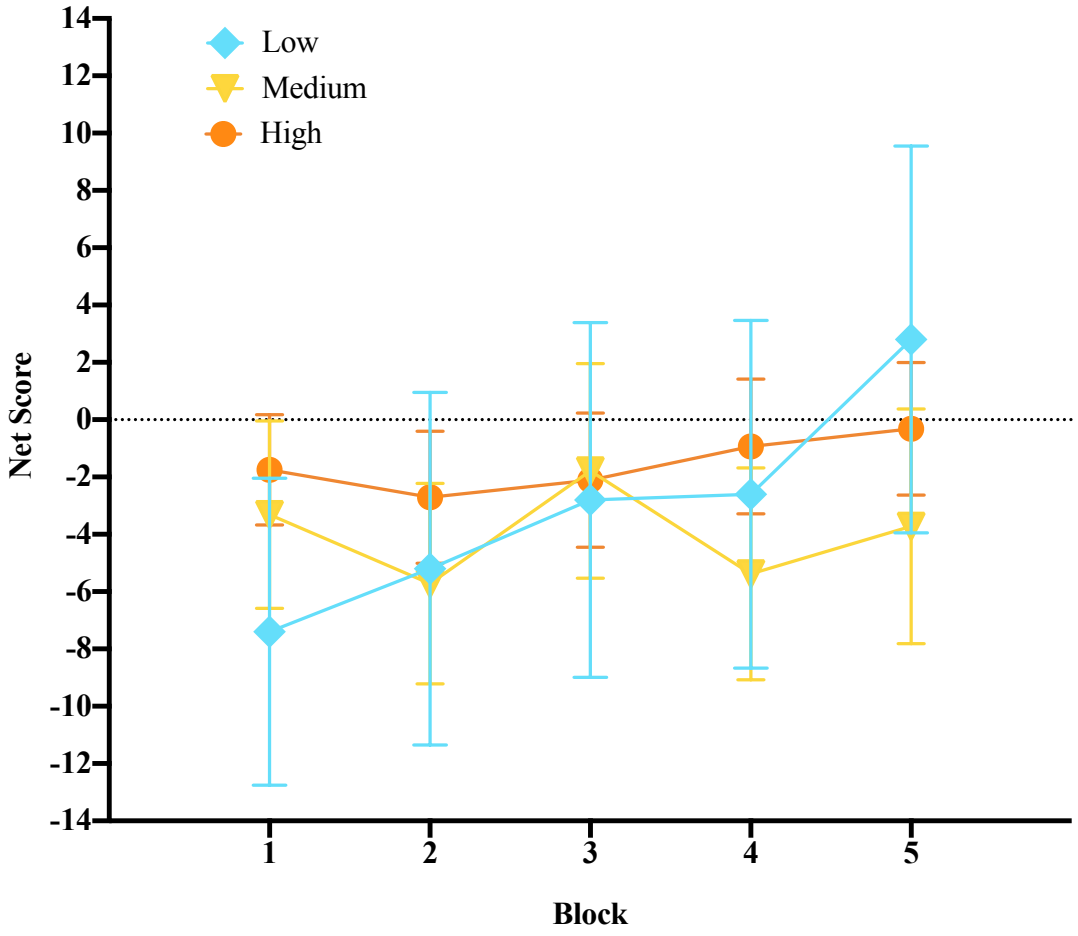
Note. Colours represent percentage of choices from bad decks in Blocks 4 and 5. Green represents < 33% disadvantageous choices, yellow represents 33–66% disadvantageous choices, and red represents > 66% disadvantageous choices.

Associations between Net Scores and Offender Characteristics. Exploratory analyses were conducted to investigate whether associations exist between IGT performance and offender characteristics (i.e., sentence length, major offence category, criminal risk as assessed by SFA rating). Sentence length and offence type (i.e., homicide, sexual, property, drug, violence, weapons, conspiracies, and administration of

justice offences) did not have main effects nor interactions with Block on net scores. However, a 3 (SFA rating: low, medium, high) × 5 (Block: 1–5) mixed ANOVA (Greenhouse-Geisser corrected) revealed no main effect on IGT performance of SFA rating, $F(2, 92) = 1.22$, $p = .301$, $\eta_p^2 = .026$, but did reveal a significant main effect of Block, $F(3.52, 323.56) = 4.24$, $p = .004$, $\eta_p^2 = .044$, and a significant SFA rating × Block interaction, $F(7.03, 323.56) = 2.19$, $p = .034$, $\eta_p^2 = .045$. After controlling for race and years of education, there was again no main effect of SFA rating, $F(2, 90) = .93$, $p = .399$, $\eta_p^2 = .020$, and the main effect of Block was rendered non-significant, $F(3.51, 315.66) = .455$, $p = .672$, $\eta_p^2 = .006$. However, there was still a significant SFA rating × Block interaction on IGT performance, $F(7.02, 315.66) = 2.04$, $p = .050$, $\eta_p^2 = .043$. Follow-up Bonferroni-corrected pairwise comparisons indicated that the low-risk group experienced a significant improvement in task performance from Block 2 ($M = -5.20$, $SD = 8.60$) to Block 5 ($M = 2.80$, $SD = 9.44$), $p = .043$, but the medium- and high-risk groups' net score did not improve over time (**Figure 4**).

Figure 4

Mean Block Net Scores by Static Factors Assessment Risk Rating



Note. Bars represent 95% CI.

Deck Choices

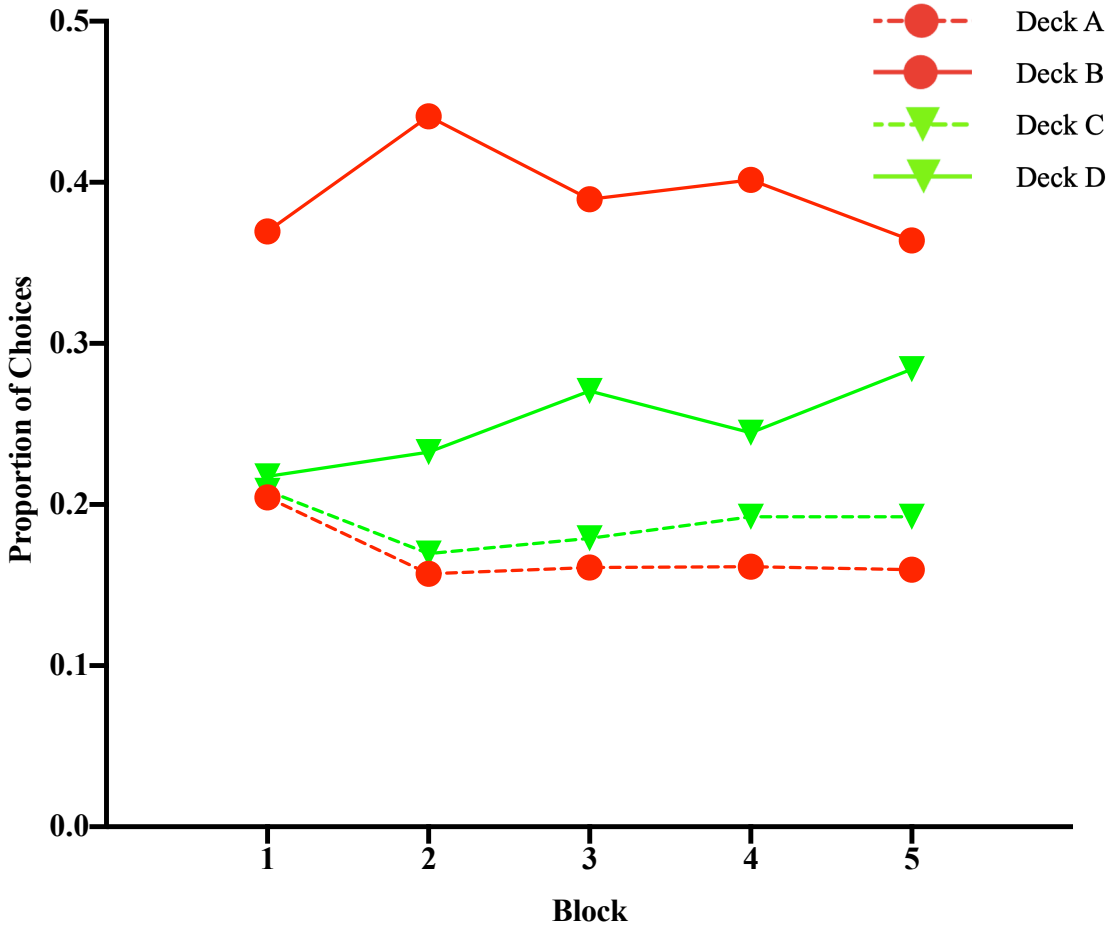
In order to present a more granular view of bad and good deck choices, selections from each of the four decks across the course of the task were examined (**Figures 5A** and **5B**). These representations of the data are increasingly favoured by IGT researchers and

illustrate the effect of block on deck choices (Bull et al., 2015). **Figure 5A** shows that offenders have a clear preference for the bad Deck B across the task (i.e., large, low frequency losses). In addition, by Block 5 offenders on average prefer Decks B and D (i.e., decks with a low frequency of losses) to Decks A and C. **Figure 5B** shows that, in contrast, controls appear to be less sensitive to the frequency of losses by Block 5, and show a declining preference for Deck B and are increasingly favouring the good decks (Decks C and D). This finding suggests that offenders may have an increased sensitivity to the frequency, rather than the magnitude, of losses.

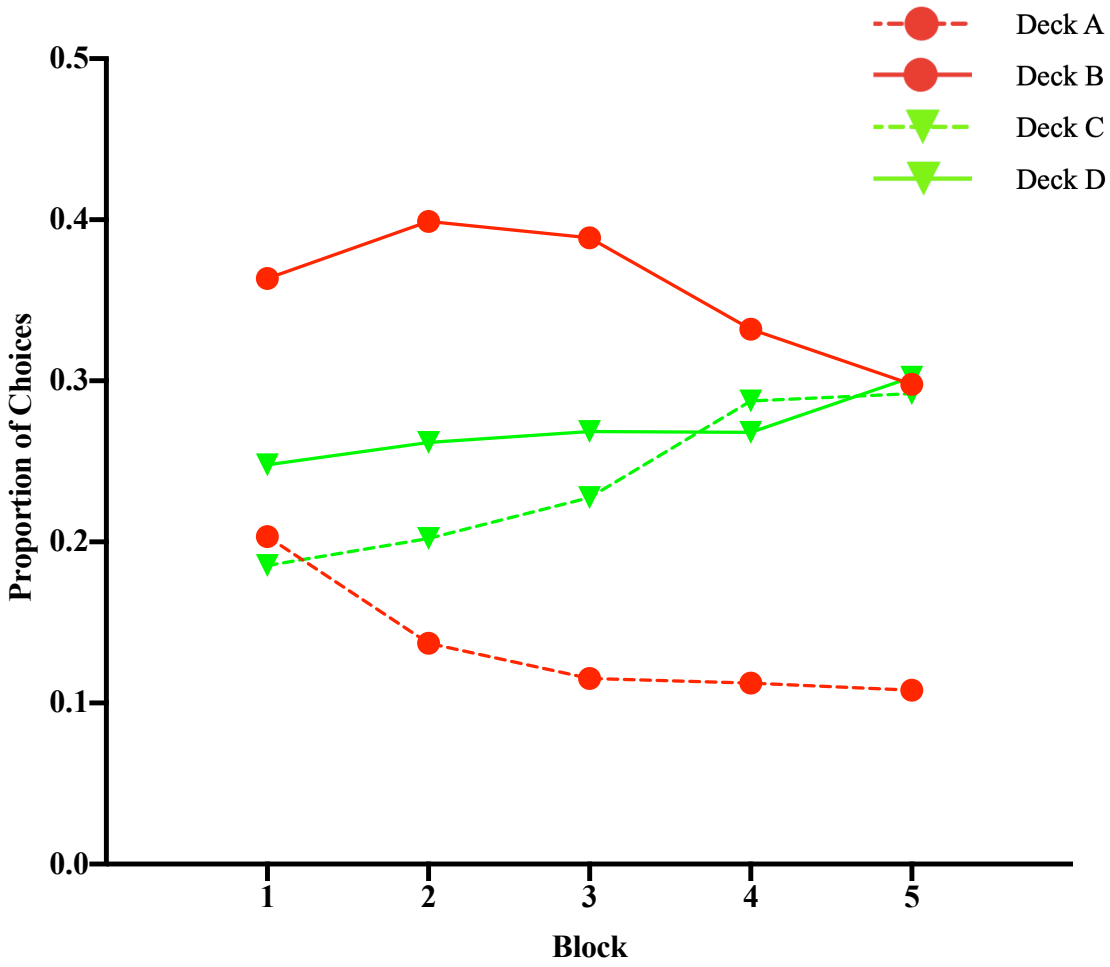
Figure 5 (continued on next page, note follows)

Mean Proportion of Choices from Each Deck Across Blocks

A



B



Note. Red lines indicate bad decks; green lines indicate good decks. Dashed lines represent decks with frequent losses; solid lines represent decks with infrequent losses. Decks A and B result in 100-point wins and Decks C and D results in 50-point wins. Decks B and D have lower frequency & higher magnitude losses, and Decks A and C have higher frequency & lower magnitude losses. Panel A: Offender group's selection from decks. Panel B: Control group's selection from decks.

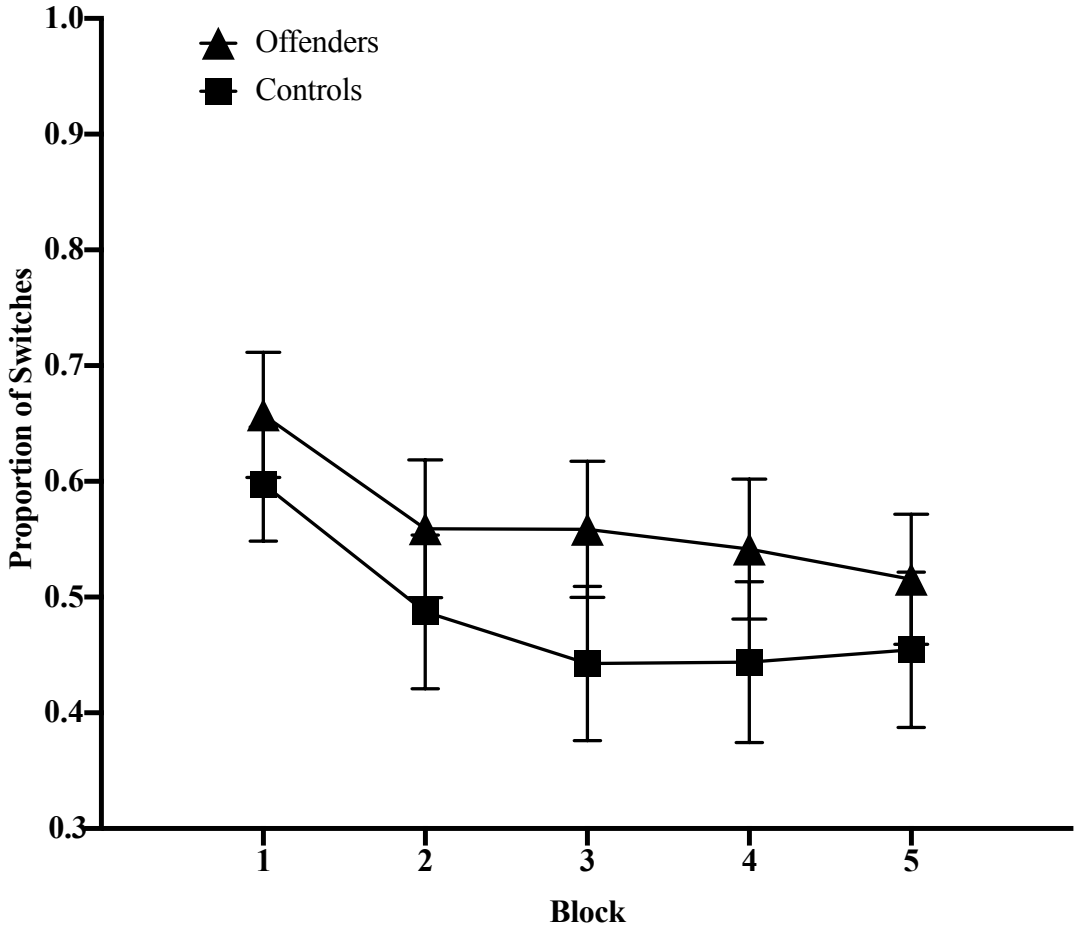
Deck Switches

Deck choice analyses suggest that offenders may prefer decks with a lower frequency of losses. To investigate whether offenders show a higher sensitivity to immediate losses, we analyzed deck switching overall, and deck switches following net loss trials and net gain trials (i.e., "win-stay/lose-shift" strategy; Worthy et al., 2013).

Total Switches. Figure 6 presents the mean proportion of switches by block for each group. A 2 (Group: offender, control) × 5 (Block: 1–5) mixed ANOVA (Greenhouse-Geisser corrected) revealed a significant main effect of Block on proportion of switches, $F(3.17, 592.48) = 19.05$, $p < .001$, $\eta_p^2 = .092$, supporting the standard IGT assumption that preferences generally stabilize over the course of the task. There was also a significant main effect of Group, $F(1, 187) = 5.04$, $p = .026$, $\eta_p^2 = .026$, such that offenders had a higher proportion of deck switches than did controls. No significant Group × Block interaction effect on proportion of switches emerged, $F(3.17, 592.48) = .84$, $p = .479$, $\eta_p^2 = .004$. Covarying for race and years of education, no main effects of Block, $F(3.16, 585.15) = .50$, $p = .694$, $\eta_p^2 = .003$, or Group, $F(1, 185) = 2.79$, $p = .097$, $\eta_p^2 = .015$, nor a significant Group × Block interaction, $F(3.16, 585.15) = .51$, $p = .683$, $\eta_p^2 = .003$, on proportion of switches were found.

Figure 6

Mean Proportion of Deck Switches Across Blocks



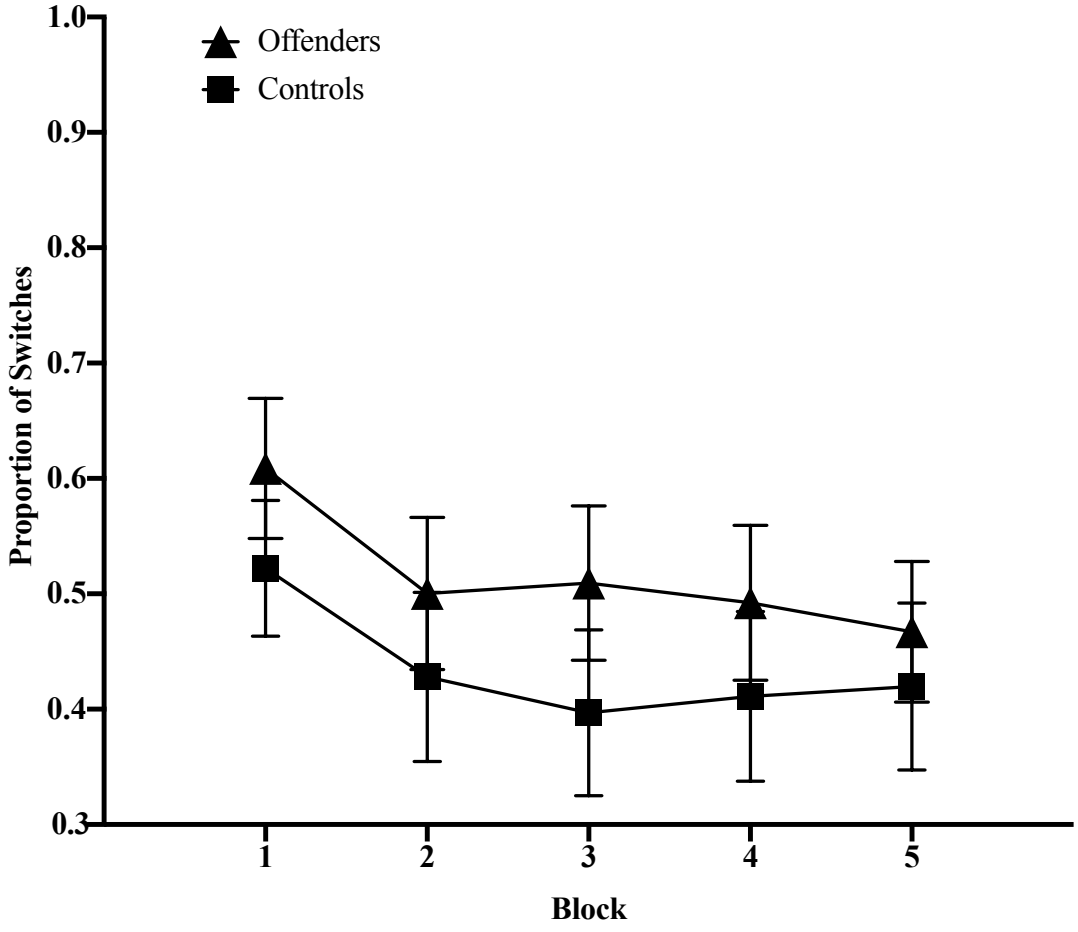
Note. Bars represent 95% CI.

Switches Following a Net Gain Trial. To investigate differences in deck switches based on whether the previous card selection had resulted in a net gain, a 2 (Group: offender, control) × 5 (Block: 1–5) mixed ANOVA (Greenhouse-Geisser corrected) of proportion of switches following a net gain trial was conducted (**Figure 7**).

There were significant main effects on proportion of switches following a net gain trial of Block, $F(3.15, 588.59) = 11.84$, $p < .001$, $\eta_p^2 = .060$, and Group, $F(1, 187) = 4.00$, $p = .047$, $\eta_p^2 = .021$. However, there was no significant Group × Block interaction, $F(3.15, 588.59) = .64$, $p = .595$, $\eta_p^2 = .003$. After covarying for race and years of education, this interaction remained non-significant, $F(3.15, 581.84) = .38$, $p = .775$, $\eta_p^2 = .002$, and both the main effects of Block, $F(3.15, 581.84) = .25$, $p = .873$, $\eta_p^2 = .001$, and Group, $F(1, 185) = 1.82$, $p = .179$ $\eta_p^2 = .010$ were rendered non-significant.

Figure 7

Mean Proportion of Deck Switches Following a Net Gain Across Blocks



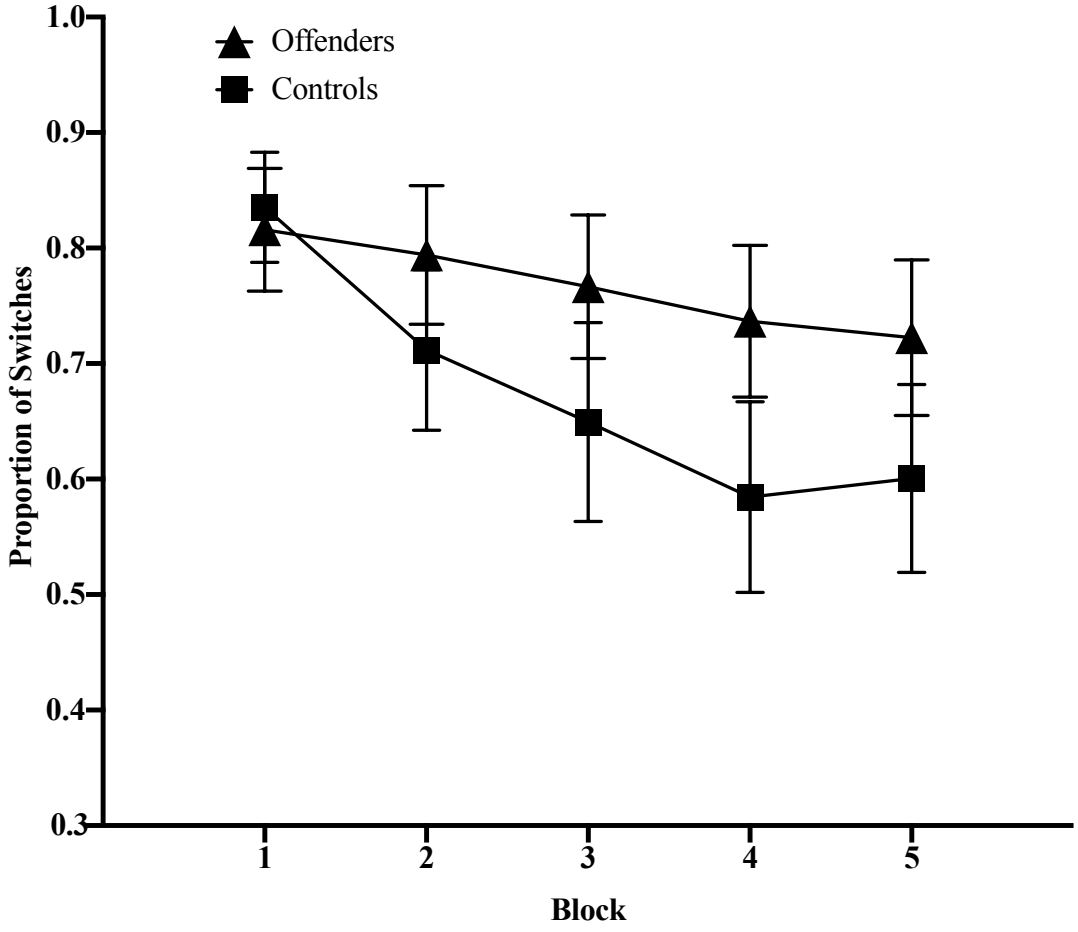
Note. Bars represent 95% CI.

Switches Following a Net Loss Trial. Both offender and control groups made significantly more switches following a net loss versus following a net gain, *p*s < .001. A 2 (Group: offender, control) × 5 (Block: 1–5) mixed ANOVA (Greenhouse-Geisser corrected) of proportion of switches following a net loss trial was conducted (**Figure 8**). Two participants experienced no losses in at least one block, thus the number of

participants in this analysis is 187 instead of 189. Similar to the analyses of total switches and switches following a net gain trial, there were significant main effects of Block, $F(3.52, 651.24) = 14.19$, $p < .001$, $\eta_p^2 = .071$, and Group, $F(1, 185) = 6.54$, $p = .011$, $\eta_p^2 = .034$, on proportion of switches following a net loss. More importantly, there was a significant interaction between Group and Block on proportion of switches following a net loss, $F(3.52, 651.24) = 3.25$, $p = .016$, $\eta_p^2 = .017$. Controlling for race and years of education, there was no longer a significant main effect of Block, $F(3.51, 642.70) = .95$, $p = .425$, $\eta_p^2 = .005$, but the main effect of Group, $F(1, 183) = 7.00$, $p = .009$, $\eta_p^2 = .037$, and the Group × Block interaction, $F(3.51, 642.70) = 2.96$, $p = .024$, $\eta_p^2 = .016$, remained significant. At the beginning of the task, the control group switched decks after net losses to a similar degree to offenders, but follow-up one-way ANOVAs revealed that control participants made significantly fewer deck switches after a net loss than offenders from Block 3 onwards, ps $< .05$. This effect suggests that offenders continued to be especially sensitive to immediate losses across blocks, while the control group changed their strategy across the task to persist after experiencing a loss. In other words, offenders tended to use the WSLS strategy to a greater degree in the final blocks than do controls.

Figure 8

Mean Proportion of Deck Switches Following a Net Loss Across Blocks



Note. Bars represent 95% CI.

Discussion

The present study aimed to examine decision-making among a sample of 100 Canadian federal offenders and age- and sex-matched controls. Several metrics obtained from the IGT served as measures of decision-making, in addition to the SFA as a measure

of criminal risk level. Compared with controls, offenders showed significant deficits in decision-making resulting in higher levels of impulsive choice as evidenced by lower total net scores, no significant improvement across the task, and a higher proportion of deck switches following a net loss in the final blocks of the task. In addition, within the offender group, risk level emerged as a factor that differentiated performance on the IGT, such that low-risk, but not medium- or high-risk, offenders improved performance across the task. Taken together, these results provide evidence for IGT being a sensitive measure of impulsive choice in offenders. The main findings within the offender group and between offender and control groups are discussed in turn in the following section.

Specifically among offenders, three main findings emerged. First, regardless of offence type or sentence length, offenders performed comparably on the IGT as measured by net scores, and on average did not appear to learn the advantageous strategy across the task (i.e., evidenced by net scores below zero). Offenders showed adequate sampling across decks, so this finding was not likely due to a lack of effort. This result shows a clear pattern of impulsive decision-making that did not appear to improve with repeated experience with deck gain and loss contingencies. It should be noted, however, that offenders show a slight upward trend in net score across the task (i.e., Block 1 net score of -12.36 and Block 5 net score of -.94). Previous studies have shown that extending the IGT to 200 or more trials results in drastically improved performance for control participants (Bull et al., 2015; Fernie & Tunney, 2006). Given more trials, it is very possible that offenders would learn to choose advantageously on the IGT. However, this finding is useful information in itself, in that offenders on a whole may take longer to

learn and develop good decision-making strategies. Findings from future studies testing this hypothesis may have bearing on the efficacy of punishment and intervention strategies in correctional settings.

Examining individual deck preferences provides additional information about the strategies used and preferences formed over the course of the IGT. Offenders showed a preference for decks providing a low frequency of losses regardless of whether they were good or bad decks. Specifically, a strong Deck B preference across the task emerged among offenders. Deck B results in infrequent large losses, but these losses are so substantial that they produce a net loss per 10 trials. Continuing to choose from Deck B despite experience with this potential loss mirrors real-life high-risk behaviours that offer a high reward but occasionally a very large loss; in the criminal offending context, this large loss could represent the possibility of incarceration. It must be noted, however, that in prior research even healthy control participants showed a preference for Deck B over the good Decks C and D, termed the "prominent Deck B" phenomenon (Dunn et al., 2006; Lin et al., 2007). This phenomenon indicates that deck choices may primarily be driven by frequency rather than magnitude of punishments. Because the IGT is so complex with a number of varying parameters, several computational models have been developed to untangle which factors most influence performance (Haines et al., 2018; Lin et al., 2013). While beyond the scope of the current research, applying these models to data from offenders is a promising area of future investigation.

Third, exploratory analyses revealed that offenders rated as being at low criminal risk by a CSC assessment showed improvement in net scores across the task while medium- and high-risk offenders did not. To date, only one longitudinal study has linked higher IGT net scores to lower rates of recidivism (Beszterczey et al., 2013). Because the current study was cross-sectional, we cannot conclusively state that offenders with a low static risk rating did not or will not recidivate after their research session. This is a clear area for future exploration. The results of the current study and future longitudinal studies could have relevance to intervention planning while incarcerated and after release to target the most impaired offender groups.

Turning to differences between offender and control groups, several significant differences emerged. Offenders had lower total net scores than controls. Further, offenders and controls had comparable net scores in Block 1, but diverged across the course of the task such that controls learned the advantageous strategy but offenders did not in the final blocks (i.e., when making decisions under conditions of risk; see Brand et al., 2007). This finding provides evidence that, on a whole, offenders present with elevated levels of impulsive choice compared to controls. This is consistent with the body of literature pointing to offenders being impaired in this domain compared with controls (e.g., Yechiam et al., 2008). In addition, offenders tended to switch decks at a higher frequency than controls. An interesting pattern emerged in terms of switching decks following a loss trial, in which offenders and controls made these switches at a similar proportion at the beginning of the task, but in the final three blocks control participants changed to a strategy of persisting after a short-term loss while offenders continued to

make higher use of the loss-shift strategy. This finding points to offenders' inability to perceive the long-term benefits of good decks despite the losses associated with them. This suggests that immediate losses are more salient to offenders than long-term losses; in the criminal offending context, this could mean that potential long-term losses (such as being incarcerated) are not as salient as immediate outcomes. To our knowledge, this is the first examination of the WSLS strategy for deck switching among offenders; this represents a clear area for future research that may have implications for understanding criminal offending as well as the efficacy of punishments.

The current study has several strengths that should be noted. This study's offender sample was composed of 35% female offenders, and analyses revealed no sex differences in IGT performance. The majority of studies examining IGT performance in offenders recruited solely male samples, and of the few studies that did recruit female offenders (Bouchard et al., 2012; Lev et al., 2008; Yechiam et al., 2008), still upwards of 80% of the sample were male. Though women make up just 6% of the total population of Canadian federal offenders (Public Safety Canada Portfolio Corrections Statistics Committee, 2018), they are a population that may have unique presentations and needs that should be studied further. The current results are also bolstered by multiple sources of data—namely, a neurocognitive assessment and risk assessment data from CSC. Another strength of this study is the multifaceted examination of IGT data. This study expanded beyond the standard metrics used (i.e., total and block net scores) to examine differences on deck choices and switches, metrics that present a fuller idea of the extent of deficits and potential patterns of maladaptive decision-making strategies.

Several limitations should be noted that suggest the current results should be interpreted with some degree of caution. First, the offender sample was recruited from two medium- and minimum-security institutions in one geographic area, which limits the generalizability of the results to offenders outside of Ontario and of different security levels. In addition, the study was cross-sectional and assessed decision-making at one point in the participants' lives. This means that causal inferences about impulse control and crime cannot be drawn from the current data. Further complicating this point is that risk assessments were from archival datasets and were conducted at varying time points—in some cases, years before an offender's research session. Because of the importance of risk assessments to the functioning of a correctional institution, it could be inferred that these assessments are reflective of the offenders' current state regardless of when it was conducted. However, the time lag between assessments still presents a clear limitation in the interpretation of these results.

Another limitation is the lack of collection of certain variables that could affect IGT performance. The IGT requires the collaboration of a number of cognitive processes and good performance is thought to be positively associated with IQ (Barry & Petry, 2008; Gansler et al., 2011; for a review, see Toplak et al., 2010). The current study did not assess for the full range of cognitive processes potentially involved, and we were not able to obtain measures of IQ for all participants due to missing archival data. Other variables not included in analyses that could potentially impact IGT performance are mental health (e.g., depression, anxiety), history of traumatic brain injury, social factors, and problematic drug and alcohol use. In addition, we were not privy to offenders' full

criminal history so we are limited in making conclusions about the relationship between offending and IGT performance. Lastly, unless told unprompted by participants, we do not know if they were consciously following a particular strategy when making card choices on the IGT. Future studies of IGT performance among offenders and other populations would be well-advised to include a manipulation check after administration of the IGT.

The current study provides a clear indication that impulsive choice is one domain in which offenders have deficits, and points to several intriguing directions for future research and may have implications for interventions to improve decision-making strategies. One promising area of research, given the current findings that offenders and controls make differing use of the WSLS strategy, and offenders perform differently based on risk level, is longitudinal research that examines whether various metrics of IGT predict recidivism rates. Future research could also explore other areas of impulse control (i.e., impulsive action, impulsive personality traits) to determine if impulsive choice is a unique feature of offenders or if there are deficits in multiple areas of impulse control. In terms of promising interventions, a meta-analysis of mindfulness interventions in incarcerated populations provided evidence for its efficacy in decreasing impulsivity (Per et al., 2020). Taken together, the current results provide support for impulse control deficits in offenders as measured by several metrics of the IGT.

References

Balodis, I. M., MacDonald, T. K., & Olmstead, M. C. (2006). Instructional cues modify performance on the Iowa Gambling Task. *Brain and Cognition*, *60*(2), 109–117. https://doi.org/10.1016/j.bandc.2005.05.007

Barry, D., & Petry, N. M. (2008). Predictors of decision-making on the Iowa Gambling Task: Independent effects of lifetime history of substance use disorders and performance on the Trail Making Test. *Brain and Cognition*, *66*(3), 243–252. https://doi.org/10.1016/j.bandc.2007.09.001

Bass, S. L. S., & Nussbaum, D. (2010). Decision making and aggression in forensic psychiatric inpatients. *Criminal Justice and Behavior*, *37*(4), 365–383. https://doi.org/10.1177/0093854809360043

Bechara, A. (2007). *Iowa Gambling Task professional manual*. Psychological Assessment Resources, Inc.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, *50*(1–3), 7–15. https://doi.org/10.1016/0010-0277(94)90018-3

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex*, *10*(3), 295–307. https://doi.org/10.1093/cercor/10.3.295

Bechara, A., Damasio, H., Damasio, A. R., & Lee, G. P. (1999). Different contributions of the human amygdala and ventromedial prefrontal cortex to decision-making. *Journal of Neuroscience*, *19*(13), 5473–5481. https://doi.org/10.1523/jneurosci.19-13-05473.1999

Bechara, A., Tranel, D., & Damasio, H. (2000). Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain*, *123*(11), 2189–2202. https://doi.org/10.1093/brain/123.11.2189

Beszterczey, S., Nestor, P. G., Shirai, A., & Harding, S. (2013). Neuropsychology of decision making and psychopathy in high-risk ex-offenders. *Neuropsychology*, *27*(4), 491–497. https://doi.org/10.1037/a0033162

Bouchard, S. M., Brown, T. G., & Nadeau, L. (2012). Decision-making capacities and affective reward anticipation in DWI recidivists compared to non-offenders: A preliminary study. *Accident Analysis and Prevention*, *45*, 580–587. https://doi.org/10.1016/j.aap.2011.09.012

Bowman, C. H., & Turnbull, O. H. (2003). Real versus facsimile reinforcers on the Iowa Gambling Task. *Brain and Cognition*, *53*(2), 207–210. https://doi.org/10.1016/S0278-2626(03)00111-8

Brand, M., Recknor, E. C., Grabenhorst, F., & Bechara, A. (2007). Decisions under ambiguity and decisions under risk: Correlations with executive functions and comparisons of two different gambling tasks with implicit and explicit rules. *Journal of Clinical and Experimental Neuropsychology*, *29*(1), 86–99. https://doi.org/10.1080/13803390500507196

Brevers, D., Bechara, A., Cleeremans, A., & Noël, X. (2013). Iowa Gambling Task (IGT): Twenty years after - gambling disorder and IGT. *Frontiers in Psychology*, *4*, 665. https://doi.org/10.3389/fpsyg.2013.00665

Broomhall, L. (2005). Acquired sociopathy: A neuropsychological study of executive dysfunction in violent offenders. *Psychiatry, Psychology and Law*, *12*(2), 367–387. https://doi.org/10.1375/pplt.12.2.367

Brown, T. G., Ouimet, M. C., Eldeb, M., Tremblay, J., Vingilis, E., Nadeau, L., Pruessner, J., & Bechara, A. (2016). Personality, executive control, and neurobiological characteristics associated with different forms of risky driving. *PLoS ONE*, *11*(2), e0150227. https://doi.org/10.1371/journal.pone.0150227

Buelow, M. T., & Suhr, J. A. (2013). Personality characteristics and state mood influence individual deck selections on the Iowa Gambling Task. *Personality and Individual Differences*, *54*(5), 593–597. https://doi.org/10.1016/j.paid.2012.11.019

Bull, P. N., Tippett, L. J., & Addis, D. R. (2015). Decision making in healthy participants on the Iowa Gambling Task: New insights from an operant approach. *Frontiers in Psychology*, *6*, 391. https://doi.org/10.3389/fpsyg.2015.00391

Burt, C. H. (2020). Self-control and crime: Beyond Gottfredson & Hirschi's theory. *Annual Review of Criminology*, *3*(1), 43–73. https://doi.org/10.1146/annurev-criminol-011419-041344

Cassotti, M., Houdé, O., & Moutier, S. (2011). Developmental changes of win-stay and loss-shift strategies in decision making. *Child Neuropsychology*, *17*(4), 400–411. https://doi.org/10.1080/09297049.2010.547463

Cavedini, P., Riboldi, G., D'annucci, A., Belotti, P., Cisima, M., & Bellodi, L. (2002). Decision-making heterogeneity in obsessive-compulsive disorder: Ventromedial prefrontal cortex function predicts different treatment outcomes. *Neuropsychologia*, *40*(2), 205–211. https://doi.org/10.1016/S0028-3932(01)00077-X

Damasio, A. R. (1994). *Descartes' error: Emotion, reason, and the human brain*. G. P. Putnam's Sons.

Dunn, B. D., Dalgleish, T., & Lawrence, A. D. (2006). The somatic marker hypothesis: A critical evaluation. *Neuroscience and Biobehavioral Reviews*, *30*(2), 239–271. https://doi.org/10.1016/j.neubiorev.2005.07.001

Fernie, G., & Tunney, R. J. (2006). Some decks are better than others: The effect of reinforcer type and task instructions on learning in the Iowa Gambling Task. *Brain and Cognition*, *60*(1), 94–102. https://doi.org/10.1016/j.bandc.2005.09.011

Fridberg, D. J., Queller, S., Ahn, W. Y., Kim, W., Bishara, A. J., Busemeyer, J. R., Porrino, L., & Stout, J. C. (2010). Cognitive mechanisms underlying risky decision-making in chronic cannabis users. *Journal of Mathematical Psychology*, *54*(1), 28–38. https://doi.org/10.1016/j.jmp.2009.10.002

Gansler, D. A., Jerram, M. W., Vannorsdall, T. D., & Schretlen, D. J. (2011). Does the Iowa Gambling task measure executive function? *Archives of Clinical Neuropsychology*, *26*(8), 706–717. https://doi.org/10.1093/arclin/acr082

Gottfredson, M. R., & Hirschi, T. (1990). *A general theory of crime*. Stanford University Press.

Güleç, H. (2006). Technical properties of the Turkish version of the Iowa Gambling Task in adults with attention deficit hyperactivity disorder in male inmates. *Neurology, Psychiatry and Brain Research*, *14*(4), 173–178.

Haines, N., Vassileva, J., & Ahn, W. Y. (2018). The Outcome-Representation Learning model: A novel reinforcement learning model of the Iowa Gambling Task. *Cognitive Science*, *42*(8), 2534–2561. https://doi.org/10.1111/cogs.12688

Hughes, M. A., Dolan, M. C., Trueblood, J. S., & Stout, J. C. (2015). Psychopathic personality traits and Iowa Gambling Task performance in incarcerated offenders. *Psychiatry, Psychology and Law*, *22*(1), 134–144. https://doi.org/10.1080/13218719.2014.919689

Jones, K. A., Hewson, T., Sales, C. P., & Khalifa, N. (2019). A systematic review and meta-analysis of decision-making in offender populations with mental disorder. *Neuropsychology Review*, *29*(2), 244–258. https://doi.org/10.1007/s11065-018-09397-x

Kasar, M., Gleichgerrcht, E., Keskinkilic, C., Tabo, A., & Manes, F. F. (2010). Decision-making in people who relapsed to driving under the influence of alcohol. *Alcoholism: Clinical and Experimental Research*, *34*(12), 2162–2168. https://doi.org/10.1111/j.1530-0277.2010.01313.x

Kuin, N. C., & Masthoff, E. D. M. (2016). Investigating the relationship between psychopathic personality traits and decision making deficits in a prison population. *Journal of Forensic Psychology*, *1*(1), 104. https://doi.org/10.4172/2475-319x.1000104

Kuin, N. C., Scherder, E. J. A., Gijsbers, H., & Masthoff, E. D. M. (2019). Traumatic brain injury in prisoners: Relation to risky decision-making, aggression and criminal behavior. *Journal of Behavioral and Brain Science*, *9*, 289–299. https://doi.org/10.4236/jbbs.2019.97021

Lev, D., Hershkovitz, E., & Yechiam, E. (2008). Decision making and personality in traffic offenders: A study of Israeli drivers. *Accident Analysis and Prevention*, *40*(1), 223–230. https://doi.org/10.1016/j.aap.2007.05.009

Levi, M. D., Nussbaum, D. S., & Rich, J. B. (2010). Neuropsychological and personality characteristics of predatory, irritable, and nonviolent offenders: Support for a typology of criminal human aggression. *Criminal Justice and Behavior*, *37*(6), 633–655. https://doi.org/10.1177/0093854810362342

Lewis, D. O., Yeager, C. A., Blake, P., Bard, B., & Strenziok, M. (2004). Ethics questions raised by characteristics of 18 juveniles awaiting execution in Texas. *The Journal of the American Academy of Psychiatry and the Law*, *32*(4), 408–429.

Lin, C. H., Chiu, Y. C., Lee, P. L., & Hsieh, J. C. (2007). Is deck B a disadvantageous deck in the Iowa Gambling Task? *Behavioral and Brain Functions*, *3*, 1–10. https://doi.org/10.1186/1744-9081-3-16

Lin, C. H., Song, T. J., Chen, Y. Y., Lee, W. K., & Chiu, Y. C. (2013). Reexamining the validity and reliability of the clinical version of the Iowa Gambling Task: Evidence from a normal subject group. *Frontiers in Psychology*, *4*(220). https://doi.org/10.3389/fpsyg.2013.00220

Lösel, F., & Schmucker, M. (2004). Psychopathy, risk taking, and attention: A differentiated test of the somatic marker hypothesis. *Journal of Abnormal Psychology*, *113*(4), 522–529. https://doi.org/10.1037/0021-843X.113.4.522

Maaike Helmus, L., & Forrester, T. (2017). Validating the predictive accuracy of the Static Factors Assessment (SFA) risk scale for federally sentenced offenders in Canada. *Canadian Journal of Criminology and Criminal Justice*, *51*(1), 1–25. https://doi.org/10.3138/cjccj.2015.E04

MacKillop, J., Weafer, J., C. Gray, J., Oshri, A., Palmer, A., & de Wit, H. (2016). The latent structure of impulsivity: impulsive choice, impulsive action, and impulsive personality traits. *Psychopharmacology*, *233*(18), 3361–3370. https://doi.org/10.1007/s00213-016-4372-0

Millisecond. (n.d.). *Iowa Gambling Task (IGT)*. https://www.millisecond.com/download/library/iowagamblingtask/

Mitchell, D. G. V., Colledge, E., Leonard, A., & Blair, R. J. R. (2002). Risky decisions and response reversal: Is there evidence of orbitofrontal cortex dysfunction in psychopathic individuals? *Neuropsychologia*, *40*(12), 2013–2022. https://doi.org/10.1016/S0028-3932(02)00056-8

Nestor, P. G., Woodhull, A., Newell, D., O'Donovan, K., Forte, M., Harding, S., & Pomplun, M. (2018). Clinical, social, and neuropsychological dimensions of the intersection of addiction and criminality. *Journal of the American Academy of Psychiatry and the Law*, *46*(2), 179–186. https://doi.org/10.29158/JAAPL.003745-18

Per, M., Spinelli, C., Sadowski, I., Schmelefske, E., Anand, L., & Khoury, B. (2020). Evaluating the effectiveness of mindfulness-based interventions in incarcerated populations: A meta-analysis. *Criminal Justice and Behavior*. https://doi.org/10.1177/0093854819891457

Pratt, T. C., & Cullen, F. T. (2000). The empirical status of Gottfredson and Hirschi's general theory of crime: a meta-analysis. *Criminology*, *38*(3), 931–964. https://doi.org/10.1111/j.1745-9125.2000.tb00911.x

Public Safety Canada Portfolio Corrections Statistics Committee. (2018). *2018 annual report: Corrections and conditional release statistical overview*. https://www.publicsafety.gc.ca/cnt/rsrcs/pblctns/ccrso-2018/ccrso-2018-en.pdf

Rodriguez, M., Boyce, P., & Hodges, J. (2017). A neuropsychological study of older adult first-time sex offenders. *Neurocase*, *23*(2), 154–161. https://doi.org/10.1080/13554794.2017.1334802

Rodriguez, M., & Ellis, A. (2018). The neuropsychological function of older first-time child exploitation material offenders: A pilot study. *International Journal of Offender Therapy and Comparative Criminology*, *62*(8), 2357–2373. https://doi.org/10.1177/0306624X17703406

Saperia, S., Da Silva, S., Siddiqui, I., Agid, O., Daskalakis, Z. J., Ravindran, A., Voineskos, A. N., Zakzanis, K. K., Remington, G., & Foussias, G. (2019). Reward-driven decision-making impairments in schizophrenia. *Schizophrenia Research*, *206*, 277–283. https://doi.org/10.1016/j.schres.2018.11.004

Schmitt, W. A., Brinkley, C. A., & Newman, J. P. (1999). Testing Damasio's somatic marker hypothesis with psychopathic individuals: Risk takers or risk averse? *Journal of Abnormal Psychology*, *108*(3), 538–543. https://doi.org/10.1037/0021-843X.108.3.538

Steingroever, H., Wetzels, R., Horstmann, A., Neumann, J., & Wagenmakers, E. J. (2013). Performance of healthy participants on the Iowa Gambling Task. *Psychological Assessment*, *25*(1), 180–193. https://doi.org/10.1037/a0029929

Toplak, M. E., Sorge, G. B., Benoit, A., West, R. F., & Stanovich, K. E. (2010). Decision-making and cognitive abilities: A review of associations between Iowa Gambling Task performance, executive functions, and intelligence. *Clinical Psychology Review*, *30*(5), 562–581. https://doi.org/10.1016/j.cpr.2010.04.002

Turner, D., Laier, C., Brand, M., Bockshammer, T., Welsch, R., & Rettenberger, M. (2018). Response inhibition and impulsive decision-making in sexual offenders against children. *Journal of Abnormal Psychology*, *127*(5), 471–481. https://doi.org/10.1037/abn0000359

Vazsonyi, A. T., Mikuška, J., & Kelley, E. L. (2017). It's time: A meta-analysis on the self-control-deviance link. *Journal of Criminal Justice*, *48*, 48–63. https://doi.org/10.1016/j.jcrimjus.2016.10.001

Verdejo-Garcia, A., Bechara, A., Recknor, E. C., & Perez-Garcia, M. (2006). Decision-making and the Iowa Gambling Task: Ecological validity in individuals with substance dependence. *Psychologica Belgica*, *46*, 55–78. https://doi.org/10.5334/pb-46-1-2-55

Whiteside, S. P., Lynam, D. R., Miller, J. D., & Reynolds, S. K. (2005). Validation of the UPPS impulsive behaviour scale: A four-factor model of impulsivity. *European Journal of Personality*, *19*(7), 559–574. https://doi.org/10.1002/per.556

Worthy, D. A., Hawthorne, M. J., & Otto, A. R. (2013). Heterogeneity of strategy use in the Iowa Gambling Task: A comparison of win-stay/lose-shift and reinforcement learning models. *Psychonomic Bulletin and Review*, *20*(2), 364–371. https://doi.org/10.3758/s13423-012-0324-9

Yao, X., Zhang, F., Yang, T., Lin, T., Xiang, L., Xu, F., & He, G. (2019). Psychopathy and decision-making: Antisocial factor associated with risky decision-making in offenders. *Frontiers in Psychology*, *10*(166). https://doi.org/10.3389/fpsyg.2019.00166

Yechiam, E., Kanz, J. E., Bechara, A., Stout, J. C., Busemeyer, J. R., Altmaier, E. M. M., & Paulsen, J. S. (2008). Neurocognitive deficits related to poor decision making in people behind bars. *Psychonomic Bulletin & Review*, *15*(1), 44–51. https://doi.org/10.3758/pbr.15.1.44

Young, S., Gudjonsson, G. H., Goodwin, E. J., Perkins, D., & Morris, R. (2013). A validation of a computerised task of risk-taking and moral decision-making and its association with sensation-seeking, impulsivity and sociomoral reasoning. *Personality and Individual Differences*, *55*(8), 941–946. https://doi.org/10.1016/j.paid.2013.07.472

Appendix A

Iowa Gambling Task Instructions

"In this task, you will be asked to repeatedly select a card from one of the four decks above. You can select a card by clicking on it with your mouse.

With each card, you can win some points, but you can also lose some. Some decks will be more profitable than others. Try to choose cards from the most profitable decks so that your total winnings will be as high as possible.

You will get 100 chances to select a card from the deck that you think will give you the highest winnings. Your total earnings and the number of cards selected will be displayed on screen.

You start with 2000 points. Click "Start" to begin."