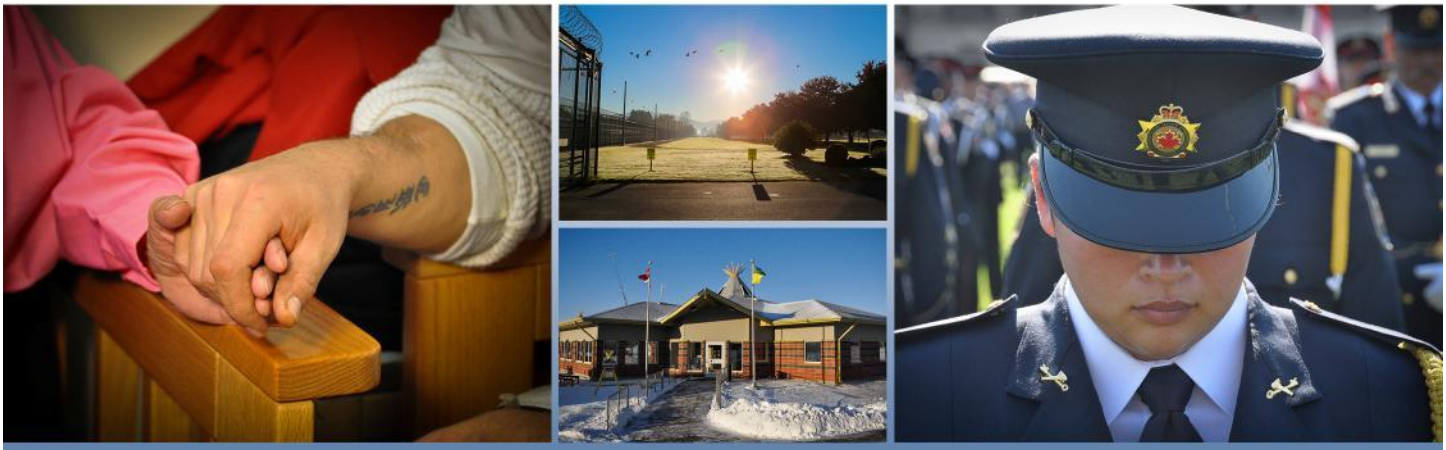
CORRECTIONAL SERVICE CANADA

CHANGING LIVES. PROTECTING CANADIANS.



RESEARCH REPORT

High-resolution Characterization of Impulsivity and Risk Sensitivity Deficits in Canadian Adult Federal Offenders

2022 Nº R-456

Cat. No.: PS83-3/456E-PDF

ISBN: 978-0-660-48359-7

Ce rapport est également disponible en français. Pour en obtenir un exemplaire, veuillez vous adresser à la Direction de la recherche, Service correctionnel du Canada, 340, avenue Laurier Ouest, Ottawa (Ontario) K1A 0P9.
This report is also available in French. Should additional copies be required, they can be obtained from the Research Branch, Correctional Service of Canada, 340 Laurier Ave. West, Ottawa, Ontario K1A 0P9.

Correctional Service Canada | Service correctionnel Canada

Canada

High-resolution Characterization of Impulsivity and Risk Sensitivity Deficits in Canadian Adult Federal Offenders

Amlung, M., Vedelago, L., Balodis, I., Mamak, M.,
McLachlan, K., Moulden, H., Chaimowitz, G., & MacKillop, J.

Peter Boris Centre for Addictions Research
Department of Psychiatry & Behavioural Neurosciences
McMaster University
St. Joseph's Healthcare Hamilton

Correctional Service Canada

2022

Acknowledgements

This work was supported by a Memorandum of Agreement between the Peter Boris Centre for Addictions Research at McMaster University/St. Joseph's Healthcare Hamilton and Correctional Service of Canada. The authors thank the staff of Research Branch of Correctional Service of Canada for their instrumental support of this project, especially Dr. Lynn Stewart, Dr. John Weekes, Mr. Geoff Wilton, and Dr. Kaitlyn Wardrop. We are grateful to the on-site staff at the CSC institutions, including Mr. Larry Ringler, Ms. Nancy Pearson, Ms. Karen Condison, Ms. Jill Collicott, and Ms. Brooke McKenzie-Crowe at Warkworth Institution; and Ms. Liz Vitek, Mr. Jim Salmon, Ms. Bilkis Sovani, Ms. Diane Germain, and Ms. Dzemila Black at Grand Valley Institution. Finally, we thank Ms. Emma Marsden, Ms. Vanessa Morris, Ms. Tashia Petker, and Mrs. Jane DeJesus for assistance with data collection and administration. We dedicate this report to the memory of Dr. Lynn Stewart (1955-2019).

Executive Summary

Key words: *impulse control, risk-taking, offenders, substance use disorder, technology*

Substance use disorders are highly prevalent among offenders in the criminal justice system, with estimates as high as 70-80% in Canada. Deficits in impulse control (e.g., difficulties with inhibiting inappropriate behavioural responses, inability to delay gratification, or excessive risk-taking) are known to contribute to SUD and criminal behaviour. Recent technological innovations have led to the development of a range of validated computerized assessments of impulse control and risk-taking that provide objective performance-based measures of impulsive behaviour and decision-making. Results from a recent systematic review indicated that offenders exhibit robust and consistent deficits in several domains of impulse control; however, the review also revealed a critical lack of research examining impulse control deficits among female offenders.

This study evaluated the feasibility of using technology-based assessments of impulsivity and risk-taking among adult offenders in Canadian federal correctional institutions in comparison to a sample of sex- and age-matched adult controls from the Hamilton, ON community. Computerized measures were selected from two broad categories, including measures of impulsivity (impulsive choice, response inhibition, and impulsive personality traits) and measures of risk-taking (risky choice, risky-decision making, and risky actions). Five computerized tasks were administered via laptop computer: 1) Go/No-Go task (response inhibition); 2) Balloon Analogue Risk Task (BART, risk-taking); 3) Iowa Gambling Task (IGT, risky decision-making); 4) Stroop Colour-Word Test (response inhibition / interference); and 5) Delay and Probability Discounting Tasks (impulsive and risky decision-making, respectively). Participants also completed a self-report questionnaire assessing five domains of impulsive personality traits. Data from archival CSC assessments and criminal histories were also extracted as part of this study.

Participants in the offender group were recruited from minimum and medium security units at two federal correctional institutions from February 2018 – December 2019. Male offenders (N = 68, mean age = 38.6) were recruited from Warkworth Institution (Cambellford, ON) and female offenders (N =35, mean age = 39.8) were recruited from Grand Valley Institution for Women (Kitchener, ON). Participants in the control group (N = 55 males, 35 females, mean age = 36.8) were recruited from the Hamilton, ON community.

This report has two components. First, a chronology of project development is provided, including initial protocol development, research ethics approval, and establishing relationships with staff and security at the CSC institutions. This also includes a summary of multiple feasibility outcomes. Second, results of statistical analyses comparing performance on the impulsivity and risk-taking measures among offenders and controls are presented and implications of these findings for understanding criminal behaviours and rehabilitation are discussed.

The results provide strong support for the feasibility of collecting technology-based assessments in correctional settings. Participants had minimal issues with performing the tasks and completed them in the time allotted. Verbal feedback during debriefing indicated that participants had a generally positive experience in the study, with several participants expressing an interest in learning more about the results of the study. However, several potentially important barriers were also noted, including computer literacy issues with a small number of participants, difficulty understanding task or questionnaire instructions, and concerns about privacy/confidentiality.

Results for the impulsivity measures indicated that participants in the offender group had significantly steeper delay discounting curves compared to participants in the control group, reflecting an increased preference for smaller-immediate rewards over larger-delayed rewards. There were no significant differences in indices of impulsivity on the Go/No-Go or Stroop tasks and no evidence of increased impulsivity among offenders on the impulsive personality questionnaire. For the risk-taking domain, offenders had significantly steeper probability discounting curves which may reflect a risk-averse preference for certain rewards even if those rewards are smaller. Offenders also did not show preference for decks with overall advantageous outcomes on the IGT, perhaps indicating a deficit in reward-related learning in response to rewards and punishment. There were no significant differences for risk-taking behaviours on the BART.

Taken together, these results support the feasibility of conducting technology-based assessments of impulse control in federal correctional institutions. Comparisons between offenders and controls suggest that across both impulsivity and risk-taking domains, deficits were found for decision-making tasks but not tasks involving impulsive or risky actions. These were not global deficits, but selectively pertained to overvaluing immediate and certain rewards, and exhibiting insensitivity to unfavourable contingencies in terms of reward / punishment learning. These areas in particular have promise in terms of improving prediction models of recidivism and rehabilitation.

Table of Contents

Introduction

High Rates of Substance Use Disorders among Offenders

A high percentage of offenders in the correctional system show evidence of some form of substance use disorder. A recent-meta analysis of 24 studies with a total of 18,388 prisoners across 10 countries found that the pooled prevalence estimate of alcohol use disorder was 24% (Fazel, Yoon, & Hayes, 2017). Overall prevalence of illicit substance use disorder was comparable to the alcohol estimates, but rates in female prisoners were significantly higher compared to males (Fazel et al., 2017). In Canada specifically, data from Correctional Service of Canada (CSC) reports indicate high rates of substance-related problems among male and female offenders. For men, almost 70% of offenders had a substance-related problem, with 37% in the moderate-to-severe range (Kelly & Farrell MacDonald, 2015). Rates among women offenders were slightly higher, with between 77-80% having a substance-related problem and 55% falling in the moderate-to-severe range (Farrell MacDonald, 2014a).

Increased severity of substance use problems is associated with reduced likelihood of being granted discretionary release (Farrell MacDonald, 2014b). Severity of SUD is a major contributing factor to the re-admission of offenders back into custody following release, with research indicating that as high as 70% of offender release suspensions involve alcohol or drugs (Farrell MacDonald, 2014b; Weekes, Millson, Porporino, & Robinson, 1994). Finally, a recent CSC report examining predictors of return to custody indicated a significant interaction between gender and severity of SUD. At low SUD severity, men were substantially more likely to return to custody relative to females, but this gap disappeared as severity of SUD increased (Biro & Farrell MacDonald, 2015). In general, empirical research on substance use problems among female offenders is limited compared to male offenders, and this represents an important gap in the literature.

Collectively, these disorders pose unique challenges for institutions, particularly in terms of providing adequate screening and treatment, understanding factors that contribute to relapse, and the role of substance abuse in reoffending. Despite the high prevalence of SUD, the psychological and neurobiological mechanisms that contribute to the development of addictions in corrections populations are not well understood. In a report on substance abuse in corrections, the Canadian Centre on Substance Use and Addiction emphasized the need for efficacious and

"best practice" assessments and treatments that are well-founded in theory and based on empirical data (Canadian Centre on Substance Abuse, 2004). This report argued that interventions should target "criminogenic" factors that are predictive of criminal behaviour. The present study was designed to examine the role of one potential criminogenic factor: deficits in impulse control. In the following sections, the relevance of impulse control deficits for addictive disorders and criminal behaviour are outlined, providing a strong empirical rationale for the current study.

Poor Impulse Control is a Core Feature of Addictive Disorders

Several decades of empirical research have found consistent evidence of impulse control deficits in individuals with addictive disorders (de Wit, 2009; Perry & Carroll, 2008). Impulse control is a multi-faceted construct that is often captured on behavioural tests measuring inhibitory control, risk taking, delay of gratification, and self-report scales assessing impulsive personality traits. The multidimensional nature of impulsivity has been confirmed via factor analytic studies. For instance, MacKillop et al. (2016) examined a battery of impulsivity-related measures in a sample of 1252 healthy young adults and found a three-factor model provided the best fit to the data. The three factors included: 1) impulsive choice, reflecting preferences for immediate over delayed rewards; 2) impulsive action, reflecting ability to inhibit automatic or inappropriate motor responses; and 3) impulsive personality traits, reflecting self-reported attributions of impulsive behavioural tendencies (MacKillop et al., 2016). Difficulty in delaying gratification in favour of immediate rewards has been argued to be a central process in addiction (Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014). For example, two meta-analyses have indicated that people with addictive disorders are much more likely to prefer smaller-immediate rewards over larger-delayed rewards on measures of delayed reward discounting (Amlung, Vedelago, Acker, Balodis, & MacKillop, 2017; MacKillop et al., 2011). Additionally, people with substance use disorders show pronounced deficits in the ability to inhibit or suppress inappropriate behavioural responses on laboratory response inhibition tasks (e.g., Fillmore, 2003). These deficits are thought to play a key role in loss of control over one's drug use as well as poor decisions made while under the influence of drugs and alcohol. Finally, a greater propensity to engage in risky behaviour is also commonly observed in addiction (Bornovalova, Daughters, Hernandez, Richards, & Lejuez, 2005; Dahne, Richards, Ernst, MacPherson, &

Lejuez, 2013). This includes taking physical risks while intoxicated, such as driving a vehicle or engaging in other risky activities (e.g., swimming, climbing, etc.). Collectively, these deficits have been shown to have important implications for the initial development of addictive disorders, severity of disorder, and response to addiction treatment.

Impulse Control Deficits and Substance Misuse Contribute Substantially to Criminal Behaviour.

Use and misuse of alcohol and other drugs is strongly associated with criminal activity (e.g., violence, property offences, etc.). CSC data on federal offenders indicate that alcohol or drugs were a major contributing factor in a range of offences, including driving under the influence, assault, theft, murder, and robbery/breaking and entering (Brochu et al., 2002). For example, in nearly half (47%) of women offenders, criminal offending was related to substance use (Farrell MacDonald, 2014a). In another study, severity of substance use was related to the probability of committing a violent offence and being a previous offender (Farrell MacDonald, Gobeil, Biro, Ritchie, & Curno, 2015). Combined use of alcohol and drugs was associated with an even greater risk of violent crime and disciplinary offences.

A relatively extensive literature has linked self-control and impulse control deficits with criminal offending (e.g., Longshore, 1998; Moffitt et al., 2011). The research findings in this area were recently reviewed in a Research Report prepared for CSC (Amlung et al., 2018) and also in a recent published systematic review (Vedelago et al., 2019). Previous studies have reported that criminal behaviour is associated with difficulty inhibiting inappropriate responses (Chen, Tien, Juan, Tzeng, & Hung, 2005; Chen, Muggleton, Juan, Tzeng, & Hung, 2008) and problems delaying gratification on delay discounting tasks (Åkerlund, Golsteyn, Grönqvist, & Lindahl, 2016; Carroll et al., 2017; Lee, Derefinko, Milich, Lynam, & DeWall, 2017; Mishra & Lalumière, 2017). In addition, steeper discounting of delayed monetary rewards significantly predicts future engagement in criminal behaviour even after controlling for several other known risk factors (Lee et al., 2017). For a comprehensive review of the literature in this area, see Amlung et al. (2018).

Although there is a fairly robust literature on impulse control deficits among offenders, the systematic reviews by Amlung et al., (2018) and Vedelago et al. (2019) highlighted the lack of research focused on female offenders. Of the 28 studies included in the Vedelago et al. (2019) systematic review, 23 studies included only male offenders, 3 included both males and females,

and 2 focused exclusively on females. For the 3 studies that include both males and females, no analyses of sex differences were reported. Therefore, the present study sought to directly address this important gap in the literature.

Rationale for Current Study

Given the importance of impulse control deficits in both addictive disorders and criminal activity, the need to develop novel ways of assessing these deficits is high. In recent years, there have been numerous technological advances in the assessment of impulse control. These advances include the development of neurocognitive tasks to characterize maladaptive decision-making (e.g., impulsivity, risk taking, inhibitory control). The primary advantage of these measures is that they are objective and performance-based and likely not prone to issues that commonly accompany self-report measures of impulsivity (e.g., demand characteristics and other sources of bias). The current study utilized a multidimensional approach to quantifying impulse control behaviours among federal offenders informed by previous factor analytic studies (MacKillop et al., 2016). Future secondary analyses stemming from this study will examine associations between performance on these measures and addictive behaviours, dynamic and static risk factors, and criminal history.

The purpose of this study was to investigate the feasibility of using technology-based assessments of impulse control among a sample of male and female federal offenders in two CSC correctional institutions in Ontario Region. The primary goal was to compare performance on the impulse control measures between the male and female offender samples and non-incarcerated male and female comparison subjects from the community who were approximately matched demographically based on age and sex. This design permits a thorough analysis of differences in impulse control between male and female participants, thereby addressing the critical gap identified in the prior systematic reviews.

The findings from this study are described below in two major sections. This report first describes the feasibility analyses, which included evaluating the logistical constraints of administering technology-based assessments in federal correctional institutions. The goal was to determine if significant computer literacy barriers exist, practical concerns about bringing outside computer equipment into the institution, and determining optimal ways to administer study measures given limitations of internet connectivity. This study also evaluated if this

population required significantly greater time to complete computerized assessments compared to durations observed in previous research with these tasks. These are all important potential barriers from the institutional perspective. Second, the report then describes differences on the impulse control measures between offender and control samples in terms of behavioural responses on the neurocognitive tasks and multiple domains of impulsive personality traits measured by a validated self-report impulsiveness scale.

Method

Study Design & Timeline

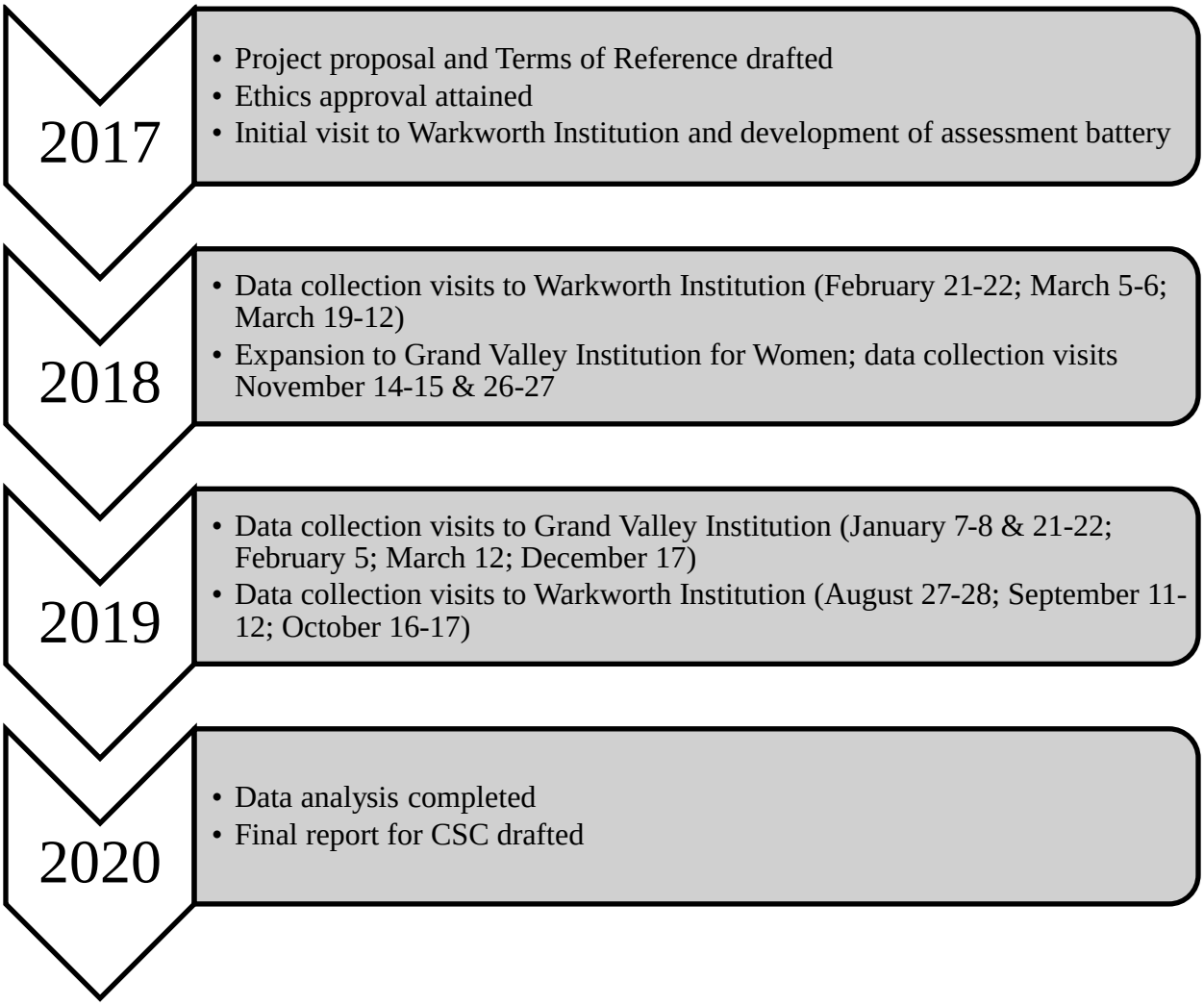
The study utilized a cross-sectional case-control design in which participants completed a single in-person testing session with a trained research assistant that lasted approximately one hour. Offenders (cases) were compared to non-incarcerated individuals from the community (controls). This study was completed from July 2017-March 2020 (see Figure 1) and this process was comprised of study design, research ethics approval, and data collection from a sample of adult offenders from Canadian federal correctional institutions and a sample of comparison control participants from the Hamilton, ON community.

Research Ethics Compliance and Informed Consent Procedures

The study received full approval from the Hamilton Integrated Research Ethics Board (HiREB Project # 3946). Amendments to add the female offender sample and community comparison samples were submitted and approved by HiREB in August 2018.
Obtaining ethics approval required multiple iterations and extensive protocol refinement following ongoing dialogue with various stakeholders (e.g., staff of the CSC Research Branch, staff at the CSC institutions, and members of the local research ethics board).

To mitigate the heightened risk of coercion due to the incarcerated status of the participants, a multi-stage informed consent process was implemented. First, an informed consent form was drafted according to a ninth-grade reading level. This consent form was read aloud to the participant as they followed along with a second copy. Participants signified their understanding by initialling each page. Finally, participants signed the consent form. 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. Participants were also given multiple opportunities to ask questions about the study and their rights as a research participant.

Figure 1. Project Timeline



Participant Eligibility Criteria

In order to enroll a representative sample of offenders, the eligibility criteria for this study were kept as open as possible. Eligibility criteria for the offender sample included: (1) currently incarcerated at Warkworth Institution (males) or Grand Valley Institution for Women (females); (2) minimum or medium security level; (3) 18-55 years of age; and (4) fluent in English. In addition, offenders who posed a security risk for the staff or researchers (e.g., requiring shackles or a protective glass barrier) were excluded. These eligibility criteria were provided to staff at the CSC Research Branch, who subsequently extracted a random sample of offenders who met the criteria from the Offender Management System (OMS) database (additional recruitment procedures described below). The same age and language criteria were applied to the non-incarcerated community comparison sample. Every attempt was made to recruit control participants who were approximately matched to offenders based on sex, age (+/- 5 years) and education (+/- 2 years).

Measures

Impulse Control Measures. Participants completed a multidimensional computerized assessment of behavioural measures and self-report questionnaires broadly categorized into two categories—measures of impulsivity (including impulsive choice, response inhibition, and impulsive personality traits) and measures of risk-taking (including risky decision-making tasks). Individual measures are described in Table 1. Five computerized tasks assessing impulsive choice and impulsive action were administered to all participants. using a Dell 15.7" widescreen laptop computer with wireless mouse. Schematics of task stimuli are provided in Appendix A. Participants also completed a self-report questionnaire assessing five domains of impulsive personality traits. Specifically, the short version of the UPPS-P Impulsiveness Scale (Cyders, Littlefield, Coffey, & Karyadi, 2014) comprised 20 items across five subscales: negative urgency, positive urgency, lack of premeditation, lack of perseverance, and sensation seeking.

Table 1. Impulsivity and Risk-taking Measures

Domain	Measure	Description
Impulsivity	Delay Discounting	Task assessing dichotomous choices between smaller-immediate and larger-delayed monetary rewards. All rewards are hypothetical.
	Go/No-Go Task	Task assessing ability to inhibit automatic behavioural responses to visual cues. Participants press a key or inhibit a response depending on specific letter cues presented in the center of the screen.
	Stroop Colour-Word Test	Task assessing ability to suppress automatic responses under cognitive conflict. Colour names are presented in either a congruent ink colour or an incongruent ink colour, and participants must respond by indicating the ink colour while disregarding the actual word presented.
	Short UPPS-P Impulsiveness Scale	Self-report questionnaire assessing five domains of impulsive personality traits, including negative urgency, positive urgency, lack of premeditation, lack of perseverance, and sensation seeking.
Risk-taking	Probability Discounting	Task assessing dichotomous choices between smaller-certain and larger-uncertain monetary rewards. All rewards are hypothetical.
	Balloon Analogue Risk Task (BART)	Risk-taking game involving earning points by pumping up a virtual balloon with an unknown air capacity, that when reached, results in a popped balloon. For each balloon, each pump earns an increasing number of points that can be collected at any time, but all points are lost if the balloon pops.
	Iowa Gambling Task (IGT)	Card game involving choices from four decks that vary based on magnitude and probability of wins/losses of points. Two decks provide larger wins and larger losses (“disadvantageous decks”), and two decks provide smaller wins and smaller losses (“advantageous decks”).

Additional Measures of Interest. Participants also completed a battery of self-report questionnaires assessing demographic variables, mental health, history of traumatic life experiences, and history of substance use. The Verbal Reasoning subscale of the Shipley Institute of Living Scale – Second Edition was administered to participants who were enrolled after November 2018. To minimize potential issues with reading fluency, each questionnaire was read aloud by the research assistant and participants provided verbal responses according to a scale sheet provided to them by the researcher. Of note, these measures were not analyzed for the current report.

Archival CSC Data. The study also involved analysis of archival data provided by CSC. These data were collected by CSC as part of standard intake assessments. The specific measures are described in Table 2.

Table 2. Archival Measures from CSC Intake Assessments

Measure	Description
Dynamic Factors Identification and Analysis-Revised (DFIA-R)	Assessment of criminogenic needs (dynamic needs). Consists of 100 indicators across 7 domains (e.g., employment/education, marital/family, community functioning, substance abuse, personal/emotional, attitude, and associates). Each domain is rated on a 5-point scale according to risk severity.
Static Factors Assessment (SFA)	Provides an overall rating of low, medium, or high static risk across three areas: criminal history, offence severity, and sex offence history. Complete scale is 151 items.
Computerized Assessment of Substance Abuse (CASA)	Computerized assessment of current and past substance use, including validated screeners for alcohol and drug use disorder severity as well as quantity/frequency of substance use.
Computerized Mental Health Intake Screening System (COMHISS)	The COMHISS is comprised of four scales: **Brief Symptom Inventory (BSI)** – Assesses the presence of 53 mental health symptoms in the past week. Standardized scores are generated for nine subscales: somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety, hostility, phobia, paranoia, and psychoticism. Three overall scores are also provided. **Depression, Hopelessness, & Suicide Screening (DHS)** – Validated clinical scale of depressive symptoms **Adult ADHD Self-Report Scale (ASRS)** – Validated self-report screener for ADHD in adults **General Ability Measure for Adults (GAMA)** – Neuropsychological assessment of nonverbal IQ

Procedures for On-Site Data Collection at Warkworth Institution

Institutional Profile. Warkworth Institution is a medium-security federal correctional facility for men, located in Campbellford, Ontario (approximately 172 km from Toronto). The institution is based on a structured campus design where offender accommodations are direct observation living units. It has a rated capacity of 537 offenders.

Establishing Relationships & Security Clearances. Several steps were undertaken in order to establish a strong working relationship between the Peter Boris Centre for Addictions Research and Warkworth Institution. Initially, a memo was sent from National Headquarters (NHQ) to the Warden of the institution, and the Assistant Warden was appointed as the primary contact person. Unit Assistants were appointed as direct staff liaisons to facilitate scheduling of data collection visits. Dr. Amlung made an initial onsite visit to Warkworth in November 2017 during which he met with the Assistant Warden to discuss logistics. Following this, procedures were initiated for obtaining research staff security clearance and authorization for technology required for data collection (laptops, etc.).

Recruitment Strategy. Inclusion and exclusion criteria for participation were provided by the research team to NHQ. A search of the OMS databases returned the electronic records of 387 offenders located at Warkworth Institution. A list of these offenders in random order was sent to the researchers. This list was then sent to the staff liaison at Warkworth along with a study flyer to be distributed. If offenders were interested in learning more about the study, they returned their flyer with their name by placing it in a drop box on their living unit. The staff liaison then reported the list of names to research staff, at which point daily visit schedules were drafted and movement passes were issued.

Data Collection Visits. The research team traveled to Warkworth Institution on six separate occasions for data collection (February 21-22, March 5-6, and March 19-21, 2018; August 27-28, September 11-12, and October 16-17, 2019). The visits comprised a total of thirteen testing days. The first data collection visit was conducted by three research assistants, one acting as a float between the two offices while research sessions occurred. For all subsequent visits, two research assistants were found to be sufficient staffing. Data collection was conducted from 8am each morning to 4pm each afternoon, with a two-hour lunch break. For the first three visits, each participant was allotted 60 minutes to complete all tasks and questionnaires, and each day allowed for ten participants (six before lunch and four after lunch). Following changes to the

protocol (i.e., addition of new self-report measures), sessions were expanded to 90 minutes and each day allowed for six participants.

Security procedures were followed as per institutional requirements. Research staff were issued gate passes for each day of data collection. Once at the institution and through security check, researchers were escorted from the main entrance to the administration building by staff. Data collection was conducted in two private offices either in the administration building or on a living unit. In the interest of safety, the door to each office was kept slightly ajar and the researcher was equipped with a personal portable alarm.

Procedures for On-Site Data Collection at Grand Valley Institution for Women

Institutional Profile. Grand Valley Institution for Women is a multi-level institution located in Kitchener, Ontario (approximately 107 km from Toronto). The main compound consists of small group accommodation houses for minimum- and medium-security offenders, and in the minimum-security compound offenders live in a residential-style apartment unit. Grand Valley Institution has a rated capacity of 215 offenders.

Establishing Relationships & Security Clearances. A similar process was followed to establish relationship with the staff at Grand Valley Institution and to obtain necessary security and technology clearances. After a memo was distributed by NHQ and approved by the Warden, an institutional liaison was assigned to assist with study implementation. Dr. Amlung and two staff members traveled to Kitchener in September 2018 for an on-site orientation meeting to discuss how the study would fit within institutional procedures. Following this, procedures were initiated for obtaining research staff security clearance and authorization for technology required for data collection (laptops, etc.).

Recruitment Strategy. As with the Warkworth sample, inclusion criteria were applied to a search of the OMS databases for offenders located at Grand Valley Institution. A list of these offenders in random order was sent to the researchers. This list was then sent to the staff liaison at Grand Valley Institution along with a study flyer to be distributed. If offenders were interested in learning more about the study, they returned their flyer with their name to the Mental Health Unit. The staff liaison then reported the list of names to research staff, at which point daily visit schedules were drafted and movement passes were issued.

Data Collection Visits. The research team traveled to Grand Valley Institution on seven

occasions for data collection (November 14-15 and November 26-27, 2018; January 7-8, January 21-22, February 5, March 12, and December 17, 2019). The visits comprised a total of eleven testing days. Data collection was conducted from 8am each morning to 4pm each afternoon, with a two-hour lunch break. Each participant was allotted 90 minutes to complete all tasks and questionnaires, with each day allowing for eight participants.

Security procedures were followed as per institutional requirements. Research staff were issued gate passes for each day of data collection. Once at the institution and through security check, researchers were assigned a visitor pass and personal portable alarm and were escorted from the main entrance to the Mental Health Unit by staff. Data collection was conducted in two adjacent private offices in the Mental Health Unit.

Procedures for Data Collection for Non-Incarcerated Community Comparison Sample

Setting and Recruitment Strategy. Data collection for the non-incarcerated comparison sample occurred at the Peter Boris Centre for Addictions Research located at St. Joseph's Healthcare Hamilton's West 5th site. Participants were recruited from the Hamilton, ON community 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.

Data Collection Procedures. Participants who met eligibility criteria based on an initial telephone interview were scheduled for a single in-person testing session lasting 90 minutes. Computerized impulse control measures and self-report assessments were completed in a private testing room. At the end of the session, participants were debriefed and received a $40 gift card and vouchers for transportation/parking.

Results

Sample Characteristics

Sample characteristics for the three cohorts are presented in Table 3. Comparison of demographic variables between groups revealed no significant difference in age ($p = .15$) or sex ($p = .31$). There were statistically-significant differences in difference in level of education, $F(3,189) = 6.83$, $p < .001$, and racial distribution, $\chi^2 (2) = 23.32$, $p = .002$. With respect to education, pairwise comparisons indicated that the male offender group had significantly lower education compared to the male control group ($p < .001$), but the female offender group did not significantly differ from the female control group ($p = .11$). Male and female offenders were not significantly different from each other ($p = .38$), nor were male and female controls ($p = .35$). On average, offender group had slightly less than one year beyond secondary education (12.8) and the control had slightly more than two years beyond secondary education (14.2) (i.e., the combined offender group had 1.4 fewer years of education compared to the control group). With respect to race, the offender group had a significantly greater percentage of non-white individuals compared to the control group (42% vs. 17%).

Data from CSC indicated a range of primary/major offences for the offender sample (see Table 4). Of note, many participants had additional offences but only the major offence is reported for this report. Murder and sexual assault were most common major offences. Fifty-two percent of offences were categorized as a Schedule 1 offence, and thirty-four participants (33%) were serving indeterminate (life) sentences. Of the remaining participants not serving indeterminate sentences, the median sentence length was 4.3 years (range 2-15.7 years).

Table 3. Sample Characteristics

Variable	Warkworth Institution Offenders	Grand Valley Institution Offenders	All Offenders	Hamilton-area Comparison Participants
N	68	35	103	90
Age (M(SD); range)	38.6 (8.7); 21-55	39.8 (11.3); 20-60	39.0 (9.6); 20-60	36.9 (10.8); 20-55
Sex	100% Male	100% Female	60% Male 40% Female	61% Male 39% Female
Transgender identity	0%	6%	2%	1%
Education years (M(SD); range)	12.7 (2.0); 8-20	13.1 (2.5); 8-18	12.8 (2.2); 8-20	14.2 (2.3); 8-20
Race				
White/European	59%	57%	58%	83%
Black/African	16%	9%	14%	3%
Indigenous	9%	14%	11%	1%
Asian	4%	3%	4%	5%
More than one race/Other	12%	17%	14%	7%

Note: M = mean; SD = standard deviation

Table 4. Major offences for Warkworth and Grand Valley samples.

Major Offence	N	% of Sample
Second degree murder	12	11.7%
First degree murder	11	10.7%
Sexual assault	11	10.7%
Assault	7	6.8%
Possession of schedule I/II substance for purposes of trafficking	6	5.8%
Robbery	6	5.8%
Sexual interference	6	5.8%
Manslaughter	5	4.9%
Break and enter and commit	4	3.9%
Fraud over	3	2.9%
Impaired driving causing death	3	2.9%
Import/export schedule I/II substance	3	2.9%
Import/export schedule I substance – more than 1 kg	3	2.9%
Unauthorized possession of firearm	3	2.9%
Aggravated assault	2	1.9%
Distribution of child pornography	2	1.9%
Incest	2	1.9%
Luring a child under 18	2	1.9%
Possession of child pornography	2	1.9%
Attempted murder	1	1%
Breach of recognizance to keep peace	1	1%
Cause death by criminal negligence	1	1%
Conspire to commit indictable offence	1	1%
Counselling indictable offence not committed	1	1%
Invite sexual touching	1	1%
Possession of weapon contrary to a prohibition order	1	1%
Theft over $5,000	1	1%
Traffic in schedule I/II substance	1	1%
Use imitation firearm in commission of offence	1	1%

Preliminary Evaluation of Feasibility

Analysis of feasibility for the Warkworth Institution and Grand Valley Institution sites suggested no major barriers to successful data collection. None of the participants at either site terminated the study early and no adverse events occurred during data collection. Sessions were easily completed within the allotted time limits, and participants with existing time commitments (e.g., work, groups, etc.) that truncated session length were able to return later in the day or the next day to complete their session. When asked about their experience during debriefing, participants generally reported positive comments and no major negative experiences were reported. In fact, some of the participants expressed a desire to learn more about the results of the study and reported that they received personal satisfaction in contributing to research, especially if the findings may someday help others in the same position.

Descriptive analysis of researcher notes and spontaneous participant comments recorded during the session revealed several potentially important considerations for future research in this setting. A few participants raised concerns about confidentiality and the study procedures (e.g., who will have access to the data, why they were chosen to participate, etc.). In addition, several participants made comments related to issues with literacy or following along with the measures (e.g., the questionnaires had too many response options; time frame for questions was unclear). In response to this, a minor alteration was made to the questionnaire scale sheet (numbers were added above the response options for ease of answering).

In general, participants seemed fluent with computers and did not have any major difficulties completing the computerized tasks. A small number of participants reported that they had never used a computer before or had very limited computer experience. However, the researchers noted that these participants were able to complete the tasks with a modest amount of assistance. One participant did require the researcher to operate the computer mouse to enter the responses to the questionnaires that he indicated by pointing. One participant commented that the stimuli were too small and that his performance was negatively affected.

In sum, the general conclusion from the present feasibility scan is that the assessments were well-tolerated and participants had no major issues with completing computerized tasks.

Impulsivity Measures

Delay Discounting Decision-Making. Responses on the two delay discounting measures

($100 and $1000 magnitudes) were analyzed to estimate each participant's hyperbolic discounting rate. This index, denoted as *k*, corresponds to the rate at which the larger reward loses value as a function of its delay. Larger *k* values reflect steeper discounting of delayed rewards which is commonly interpreted as a more impulsive decision-making pattern. Smaller *k* values reflect shallower discounting and a less impulsive pattern. The *k* values obtained in this study were significantly skewed (as is common), so the values were normalized using a logarithmic transformation.

Two offenders did not complete the delay discounting measures, resulting in final group sizes of 101 offenders and 90 control participants. There were no significant differences between male and female participants within each group for either magnitude (*p*s > .94), so the groups were collapsed by sex. Differences between offenders and controls were examined using a 2 (Group: offender, control) x 2 (Magnitude: $100, $1000) mixed ANOVA on log(*k*) values (see Figure 2). The Group effect was statistically significant, $F(1,189) = 6.71$, $p = .01$, partial $\eta^2 = .03$. The well-established Magnitude effect was also present, $F(1,189) = 34.28$, $p < .001$, partial $\eta^2 = .15$, indicating that participants were more impulsive for smaller ($100) compared to larger ($1000) rewards. However, there was not a Group x Magnitude interaction, $F(1,189) = 0.95$, $p = .33$, partial $\eta^2 = .01$, suggesting that the groups were not differentially impacted by reward magnitude. Delay discounting curves for the two reward magnitudes and groups are presented in Figure 3. Both figures clearly indicate that the offender group exhibited steeper (more impulsive) discounting for both reward magnitudes.

In sum, the offender group exhibited a significant increase in delay discounting rate for both reward magnitudes relative to controls. This difference is commonly interpreted as an impulsive choice pattern that is associated with a decreased willingness to wait for delayed rewards.

Figure 2. Log-Transformed Delay Discounting Rates by Group and Reward Magnitude

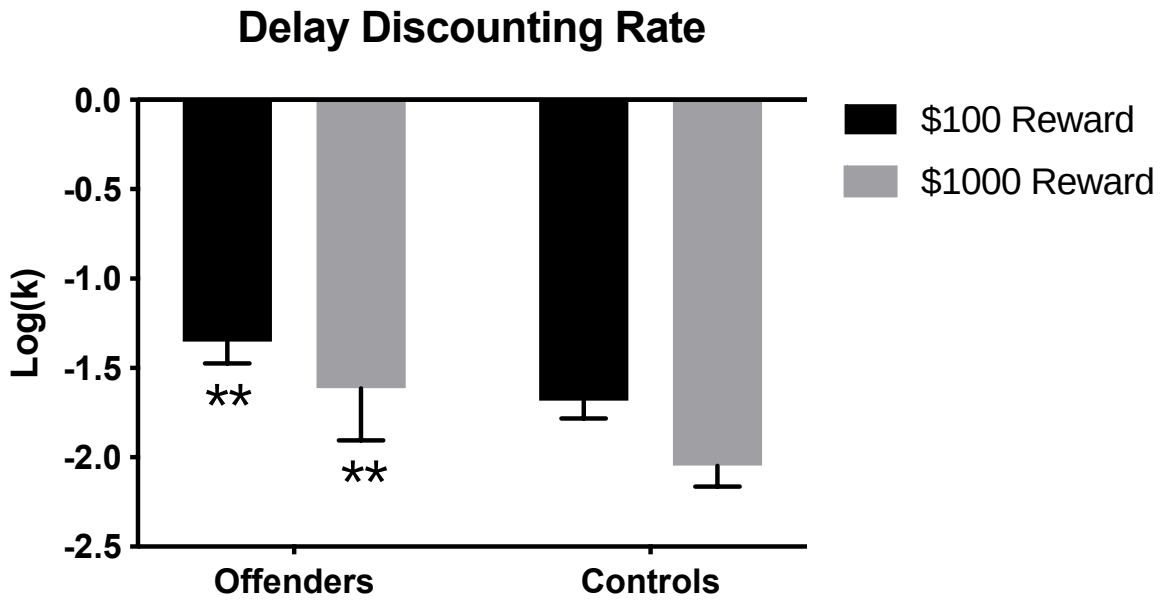
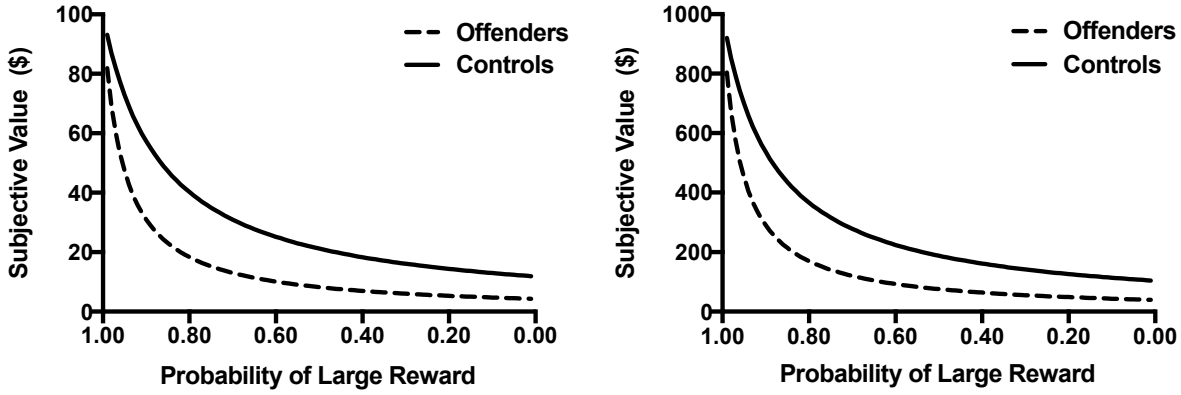


Figure 3. Delay Discounting Curves by Group and Reward Magnitude

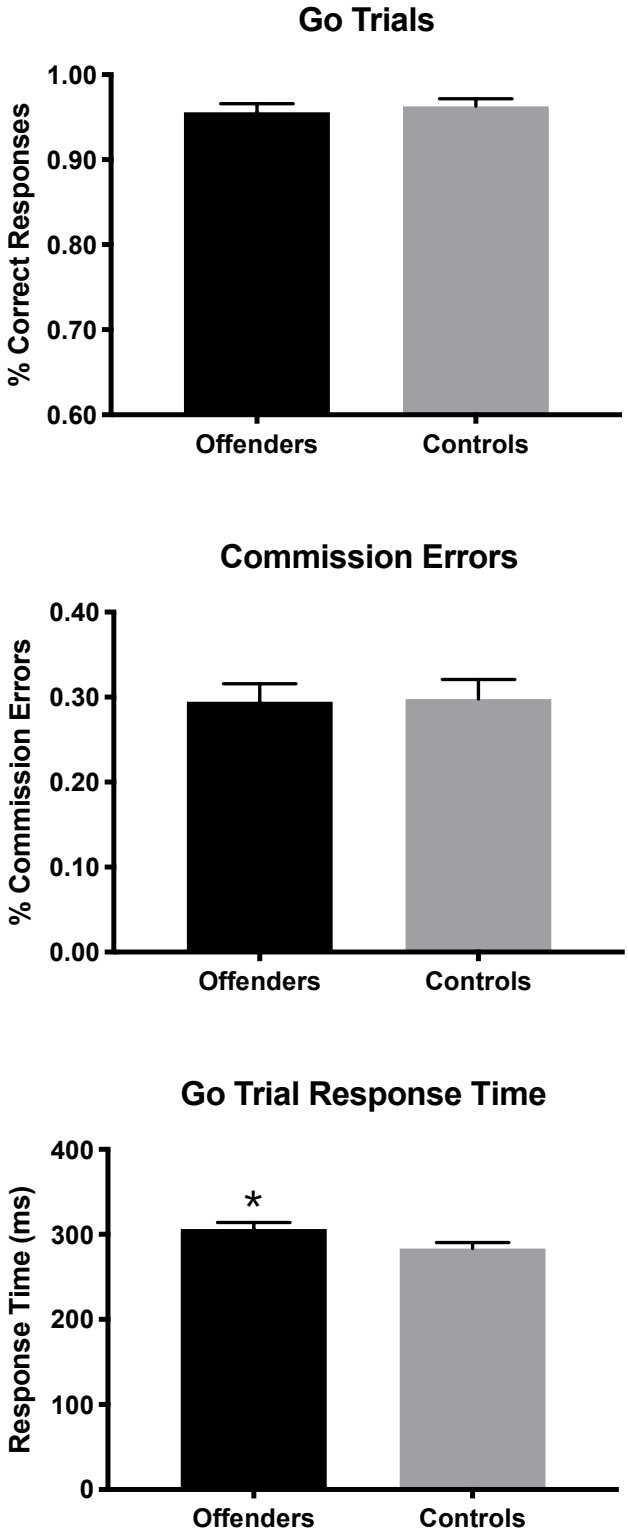


Response Inhibition on Go/No-Go Task. The primary outcome variables on the Go/No-Go task included: 1) percentage of commission errors (i.e., incorrect responses on No-Go trials, reflecting an inability to suppress the response); 2) percentage of correct Go trials; and 3) response time on correct Go trials. Performance on the Go/No-Go task was first examined for effort and understanding of task instructions. Participants were excluded if they made more than 20% invalid responses (defined as button presses that were faster than 100ms, indicating participants were anticipating the letter cues and not actually responding to the cues themselves). Participants were also excluded if their performance on Go trials was less than 50%, indicating a lack of understanding of the basic instructions of the task. This resulted in exclusion of 7 participants (3 offenders, 4 controls) and final group sizes of 100 offenders and 86 controls. There were no significant differences between male and female offenders for any of the Go/No-Go indices (*p*s > .52); groups were collapsed by sex.

Performance on the Go/No-Go task by group is presented in Figure 4. Differences between offenders and controls were examined using separate univariate ANOVAs which revealed a significant difference for response time on Go trials, $F(1,184) = 4.62$, $p = .03$, partial $\eta^2 = .02$. Offenders were, on average, 23 milliseconds slower on Go trials compared to controls. Groups were not significantly different for percent correct on Go trials, $F(1,184) = 0.78$, $p = .38$, partial $\eta^2 = .00$, or percentage of commission errors, $F(1,184) = 0.01$, $p = .91$, partial $\eta^2 = .00$.

In sum, these results do not suggest that there were robust differences in response inhibition on the Go/No-Go task between offenders and comparison participants.

Figure 4. Response Inhibition Performance on Go/No-Go Task

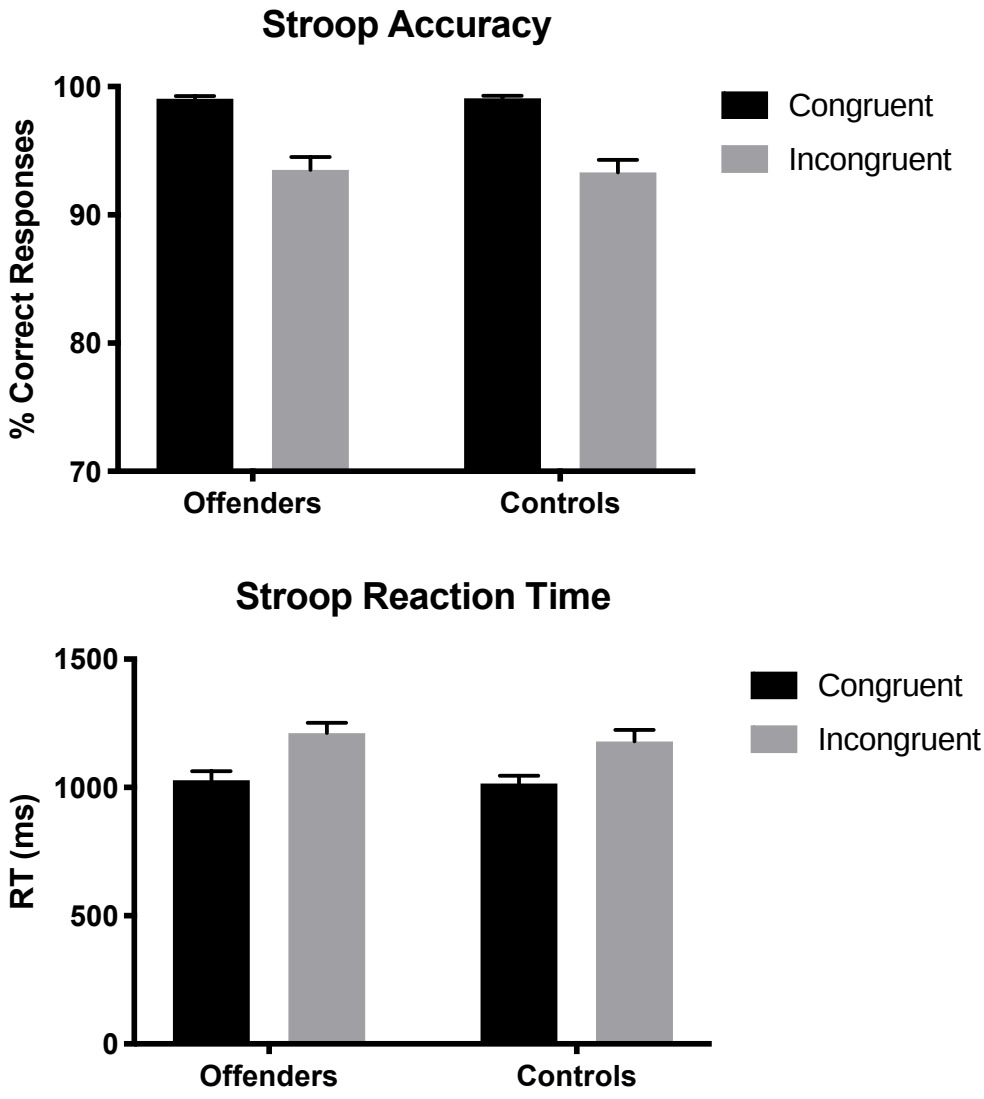


Response Inhibition on the Stroop Task. Three primary outcome variables were calculated for the Stroop Task: 1) percentage of correct responses for congruent trials (i.e., colour name matches ink colour); 2) percentage of correct responses for incongruent trials (i.e., colour name does not match ink colour); 3) response times for congruent and incongruent trials. Stroop task data from one participant was excluded due to a lack of understanding of task instructions. Specifically, this individual's accuracy was < 10% correct on incongruent trials and 100% on control and congruent trials suggesting that the participant was uniformly responding to the word and not the ink colour as instructed. The final sample with valid Stroop data included 103 offenders and 89 controls.

There were no significant differences between male and female participants (*p*s > .395), so groups were collapsed by sex. Performance on the Stroop task by group is presented in Figure 5. Both groups made more errors on the incongruent trials; however, there was not a significant difference between offenders and controls in percent correct for congruent trials, $F(1,190) = 0.00$, $p = .97$, partial $\eta^2 = .00$, or incongruent trials $F(1,190) = 0.02$, $p = .88$, partial $\eta^2 = .000$. Both groups exhibited the classic Stroop effect for response times with slower responses for incongruent compared to congruent trials. There was no significant differences in response times between groups for congruent trials, $F(1,190) = 0.08$, $p = .78$, partial $\eta^2 = .00$, or incongruent trials $F(1,190) = 0.02$, $p = .56$, partial $\eta^2 = .00$.

In sum, both groups exhibited the classic Stroop interference effect for percentage correct, but offenders did not perform disproportionately differently on incongruent trials relative to the comparison group.

Figure 5. Response Inhibition Performance on Stroop Task



Impulsive Personality Traits (UPPS-P). Mean scores on each of the five subscales of the short UPPS-P impulsiveness questionnaire were compared between groups. One participant in the control group did not provide complete data on the UPPS-P, resulting in a final sample size of 103 offenders and 89 controls. Mean subscales by group are presented in Table 5. Univariate analyses of variance indicated the only significant difference between groups was for lack of perseverance. Specifically, control participants reported higher scores on this subscale compared to offenders, $F(1,190) = 8.23$, $p < .005$, partial $\eta^2 = .04$. No other subscales differed between groups (ps > .10).

In sum, there were minimal differences in self-reported impulsive personality traits across the five domains of the UPPS-P scale. The only scale that showed a significant effect was a lower group mean for lack of perseverance in the offender group compared to the control group, although the absolute difference was modest (0.2 points on a 4-point scale).

Table 5. Mean Scores on the UPPS-P Impulsiveness by Groups

	Controls (N=89)		Offenders (N=103)		
	M	***SE***	***M***	***SE***	***p***
Negative urgency	2.34	0.09	2.35	0.08	.952
Lack of perseverance	1.87	0.05	1.67	0.05	.005**
Lack of premeditation	1.82	0.06	1.84	0.06	.786
Sensation seeking	2.54	0.07	2.55	0.07	.898
Positive urgency	1.76	0.08	1.94	0.07	.101

Note: ** $p < .01$; M = mean; SE = standard error

Risk-Taking Measures

Probability Discounting Decision-Making. The primary dependent measure of risky decision-making on the probability discounting task is the hyperbolic discounting rate denoted as *h*. While the analysis steps involved with calculating *h* are analogous to *k* values from delay discounting, the interpretation is reversed. Delay discounting rates (*k*) and probability discounting rates (*h*) are inversely-related in terms of pathological choice patterns; higher *h*s reflect more risk-averse choices and higher *k*s reflect steeper (more impulsive) discounting.

The probability discounting rates (*h*) were significantly skewed, as is common, and these values were logarithmically transformed prior to analysis. Two participants did not provide complete probability discounting data. Specifically, one participant in the offender group did not complete either magnitude, and one participant in the control group did not complete the $100 version. The final sample for the ANOVA analysis included 102 offenders and 89 control participants. There were no significant differences in probability discounting between male and female participants, so groups were collapsed by sex.

Differences in probability discounting (log(*h*) values) between groups were examined using a 2 (Group: offender, control) x 2 (Magnitude: $100, $1000) mixed ANOVA. Group means by magnitude are shown in Figure 6. There was a significant main effect of Group, $F(1,189) = 4.72$, $p = .03$, partial $\eta^2 = .02$, but neither the Magnitude ($p = .72$) nor Group x Magnitude interaction ($p = .12$) were statistically significant. Probability discounting curves by group and magnitude are shown in Figure 7.

In sum, the offender group exhibited steeper probability discounting compared to controls indicating a generally risk-averse pattern of decision making for larger uncertain rewards. In other words, the offender group favoured the smaller certain rewards to a greater extent compared with the larger riskier rewards.

Figure 6. Log-Transformed Probability Discounting Rates by Group and Reward Magnitude

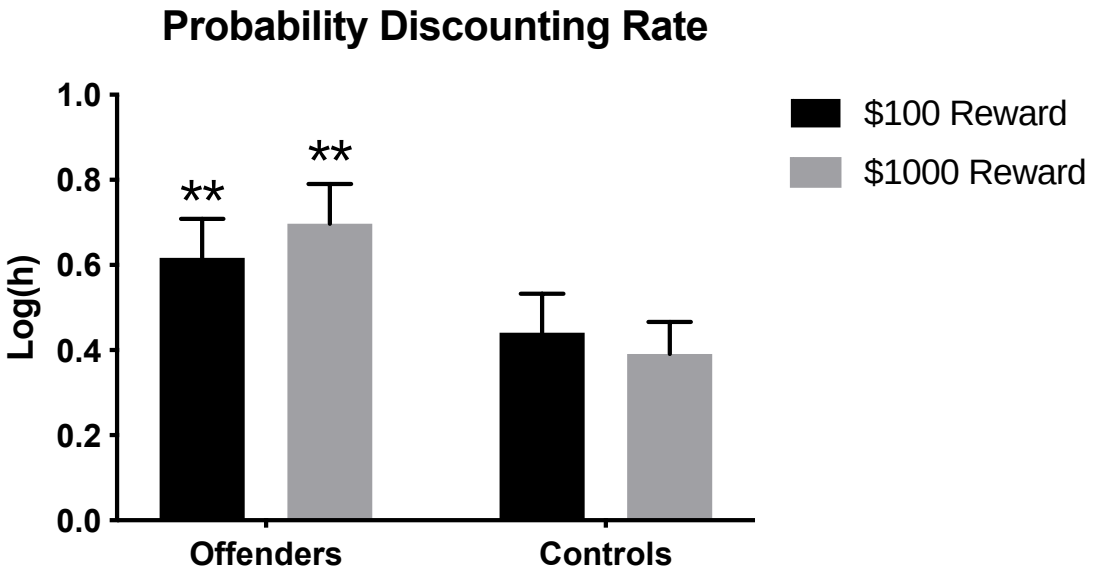
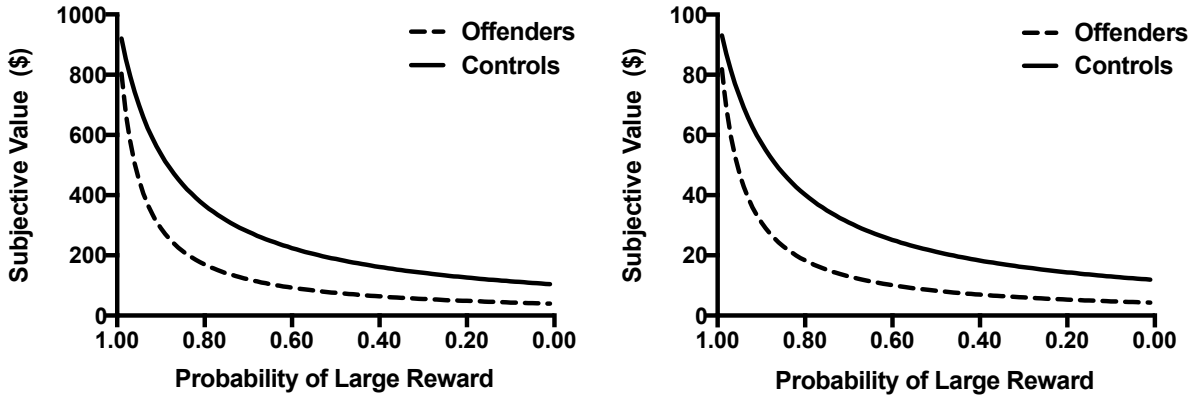


Figure 7. Probability Discounting Curves by Group and Reward Magnitude

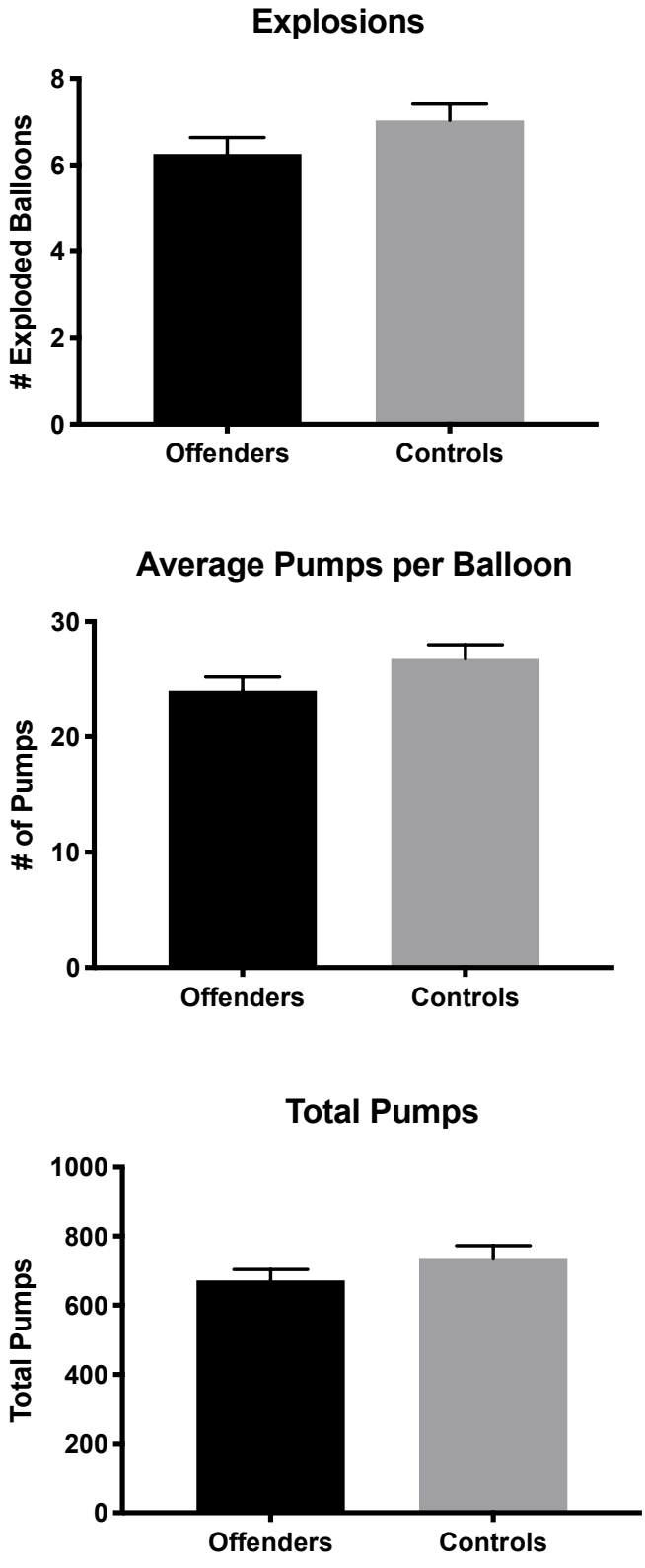


Risk Taking on the Balloon Analogue Risk Task (BART). Three indices of risk-taking were generated from the BART, including: 1) the total number of exploded balloons; 2) the average number of pumps across unexploded balloons; and 3) the total number of pumps across all trials. There were no significant differences between male and female participants for any of the BART indices (*p*s > .821); groups were collapsed by sex. There were no data quality or performance issues identified on the BART, thus the final sample size for analysis included 103 offenders and 90 controls.

Performance on the BART by group is presented in Figure 8. There were no significant differences between groups for total exploded balloons, $F(1,191) = 2.11$, $p = .15$, partial $\eta^2 = .01$, average pumps per unexploded balloons, $F(1,191) = 2.23$, $p = .14$, partial $\eta^2 = .01$, or total number of pumps, $F(1,191) = 1.84$, $p = .18$, partial $\eta^2 = .01$.

In sum, the offenders were not significantly different from controls for any of the indicators of risk-taking generated from the BART.

Figure 8. Balloon Analogue Risk Task Performance by Group.

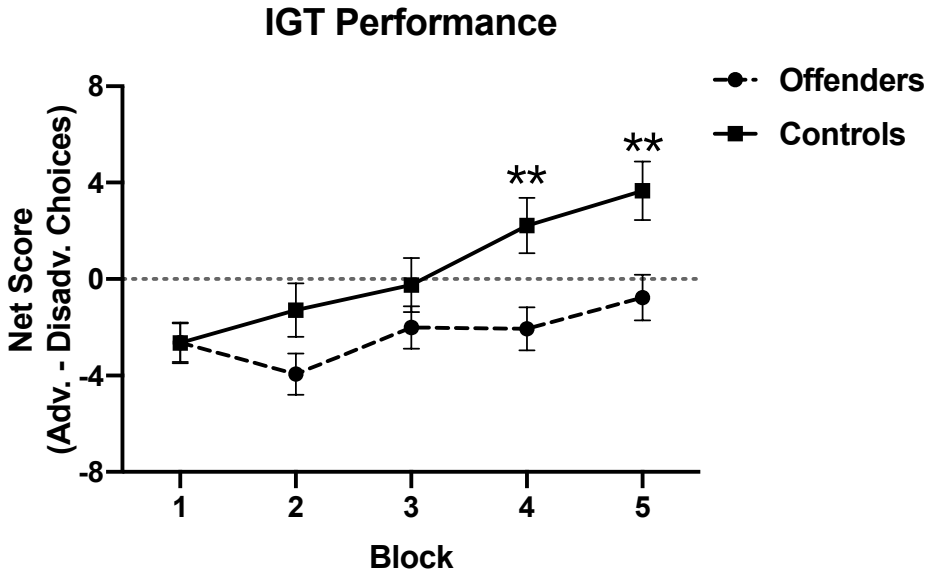


Risky Decision-Making on Iowa Gambling Task (IGT). The Iowa Gambling Task involves choices from four decks of cards, two of which are considered advantageous based on the potential positive points gained over time, and two are considered disadvantageous based on the potential points lost over time. The primary dependent measure of decision-making on the IGT is the number of advantageous choices minus the number of disadvantageous choices. This net score was calculated for each of the five blocks. Three participants (2 offenders, 1 control) were excluded due to low effort on the task, defined as only sampling from one deck on every trial. The final sample size for analysis was 101 offenders and 89 controls.

Mean IGT difference scores by group for the five blocks of the task are presented in Figure 9. Values above zero on this figure reflect greater choices from the advantageous decks relative to the disadvantageous decks. As evident in the figure, both groups made more disadvantageous choices during the first 2 blocks (the prototypical pattern on the IGT). However, only the control group learned the reward outcomes over time and showed a net positive IGT 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. This pattern was confirmed statistically via a 2 (Group: Offender, Control) x 5 (Block: 1-5) mixed ANOVA. Significant main effects of Group, $F(1,188) = 6.25$, $p = .013$, partial $\eta^2 = .032$, and Block $F(4,757) = 11.99$, $p < .001$, partial $\eta^2 = .060$, were present. More importantly, the Group x Block interaction was also significant, $F(4,757) = 3.31$, $p = .011$, partial $\eta^2 = .017$, indicating the control group improved to a significantly greater extent than the offender group. Follow-up univariate ANOVAs for each block indicated that the two groups did not significantly differ for blocks 1-3 (ps > .07) whereas the control group exhibited more advantageous choices than the offender group in blocks 4-5 (ps < .001).

In sum, the offender group continued to make card choices that were considered to be disadvantageous (risky) across all blocks, as indicated by their IGT net score remaining below zero for the entire task. By comparison, the control participants developed a preference for the advantageous (less risky) decks over the course of the task.

Figure 9. Preferences for Advantageous IGT Decks across Blocks in Offender and Controls



Discussion

The objective of this study was to evaluate the feasibility and utility of using technology-based assessments to examine impulse control deficits in a sample of male and female offenders in Canadian federal correctional institutions compared to a sample of sex- and age-matched control participants from the community. This study also aimed to investigate sex differences between male and female offenders given the dearth of the literature investigating these differences. Over a two-year period, data were collected from a sample of 103 adult offenders from two federal correctional institutions and 90 adult community control participants. The primary results of this study are summarized below.

Summary of Feasibility Results

Feasibility of Protocol Design. The process of developing the protocol, obtaining research ethics approval, and building working relationships with the staff at Warkworth and Grand Valley Institutions progressed smoothly and according to the anticipated timeline. The smoothness of this process was aided by an ongoing dialogue between the research team, the staff of CSC Research Branch, and the administration at both institutions. Multiple iterations of the study protocol and other study documents ensured that the research procedures were consistent with institutional security policies. The assistance of the on-site staff liaisons was also critical for ensuring that the technology equipment was properly registered and cleared with security. As a result, site visits were completed with essentially no challenges.

Feasibility of Recruitment and Data Collection. Despite the constraints and unique circumstances that accompany collecting data in correctional environments, the team was able to successfully complete multiple data collection visits to the institutions over a two-year period. The majority of scheduled sessions had >75% enrollment, however a number of participants either declined to participate or did not show for their scheduled appointments. Preliminary analyses of feasibility indicated that computer literacy could be a factor when conducting studies that rely primarily on computer tasks. Between 5-10% of participants commented that they had never used a computer, had limited computer experience, or had difficulty seeing the stimuli or

responding to the tasks using the mouse. Otherwise, participants were generally highly engaged in the computer tasks, and research staff only noted minor instances of low effort (e.g., participants commenting that the measures were "boring" or "dumb"). There was minimal missing data for computer tasks and questionnaires, and data quality control analyses indicated active effort on the tasks, with only a very small number of participants excluded for some of the measures.

Summary of Impulsivity and Risk-taking Results

Performance on Impulsivity Measures. The first domain of measures assessed several dimensions of impulsivity, including impulsive choice (delay discounting task), response inhibition (Go/No-Go and Stroop tasks), and impulsive personality traits (UPPS-P questionnaire). Delay discounting results indicated that the participants in the offender group preferred smaller-sooner rewards over larger-delayed rewards to a greater extent than controls. This was evident in significantly steeper discounting curves for the offender group across both reward magnitudes ($100 and $1000), which can be interpreted as the offenders devaluing delayed rewards were devalued much more steeply by offenders compared to controls. As discussed below, steeper discounting of delayed rewards is commonly observed across a number of clinical populations, including people with substance use disorders, psychiatric diagnoses, attentional problems, and obesity, among others. The implications of this pattern of immediate reward bias for understanding offending and rehabilitation are discussed in the next section.

In contrast to delay discounting, offenders and controls did not significantly differ in their ability to inhibit automatic responses on the Go/No-Go or Stroop tasks. The offender group was significantly slower to respond on Go trials on the Go/No-Go task, but the absolute difference was modest (<30 milliseconds). Finally, there were minimal differences with respect to impulsive personality traits. Offenders did not report greater engagement in impulsive behaviors under high positive or negative emotional states (positive urgency and negative urgency, respectively), nor did they report greater sensation seeking or lack of premeditation before acting. Although there was a significant difference for lack of perseverance, with offenders reporting slightly greater perseverance compared to controls, the absolute difference was minimal (approximately 0.2 points on a 4-point rating scale).

In sum, the pattern of results for the impulsivity measures suggests that offenders were characterized by impulsivity on the measures related to decision-making, but not on the measures related to impulsive actions.

Performance on Risk-Taking Measures. The assessment of risk-taking was multidimensional, including two measures of risky decision-making (probability discounting task and IGT) and a measure of risky behaviour (BART). Significant differences between offenders and controls were found for two of the three measures. Participants in the offender group exhibited steeper probability discounting compared to participants in the control group, which reflects a greater preference for smaller-certain rewards over larger-uncertain rewards. Higher probability discounting rates are reflective of a risk-averse decision-making pattern with the offenders, indicating that they on average prefer to forgo larger rewards if it means receiving a smaller reward for certain. This is somewhat surprising to the extent that it suggests higher, not lower risk aversion, which is inconsistent with the notion that offenders have a greater orientation to risk. On the other hand, it can be interpreted as being reflective of greater reward sensitivity, as offenders were less willing to leave reward receipt up to chance. Although not statistically significant, the pattern of pumps and explosions on the BART task suggests a similar pattern of risk aversion in the offender group. Compared to controls, the mean number of pumps and explosions was lower in the offender group.

Performance on the IGT indicated that the offender group failed to learn the advantageous decks over the course of five blocks and continued to disproportionately sample from the disadvantageous decks in the final two blocks of the task. The disadvantageous decks are characterized by larger gains on some trials, but the losses on other trials are substantially greater, resulting in a net loss over time. The choice patterns obtained on the IGT suggest that offenders were, on average, not adjusting their choices to avoid the large losses associated with the disadvantageous decks to get access to the "richer" winning cards. Planned secondary analyses of the IGT data will examine trial-by-trial choice preferences to determine if participants switch to a different deck after a loss or whether they continue to choose from the disadvantageous decks even after experiencing a penalty. An alternative explanation is that the offender group simply failed to identify the desk contingencies, exhibiting a deficit in reward/punishment learning, rather than reduced risk aversion. Taken together, the risk-taking

results suggest there are deficits in decision-making elements of risk-taking and not necessarily in behavioral or action-based elements of risk-taking.

Sex Differences in Impulse Control and Risk-Taking. Studies of differences in impulse control and risk-taking between male and female offenders are limited, and published studies have reported inconsistent results. Direct comparisons of male and female offenders and controls in the present study did not reveal robust sex differences for any of the behavioural tasks or impulsive personality subscales.

Implications

The pattern of results suggests that compared to control participants, offenders were characterized by decision-making deficits on measures of impulsive choice, probabilistic reward choice, and risk-related reward learning. These preliminary findings—if replicated in a larger, more geographically diverse sample of offenders—may have important implications for understanding criminal behaviour, rehabilitation during incarceration, and prevention of recidivism.

With respect to greater preference for smaller-immediate rewards among offenders compared to controls, this pattern of impulsive choice suggests that offenders are more focused on immediate gains over delayed rewards. This could potentially explain some aspects of offending behaviour, especially when offences are associated with seeking immediate rewards or outcomes. This may also indicate that offenders have a shortened temporal perspective (i.e., their cognitive temporal window is focused more on the short-term instead of the future) compared to control participants. Similar shortened time perspectives have been reported in individuals with substance use disorders (Petry, Bickel, & Arnett, 1998). Therefore, institutional programs may benefit from addressing short-term benefits of rehabilitation, not only long-term outcomes. Impulsive delay discounting may also predict recidivism following release from institutions, akin to research showing that delay discounting rates predict relapse following substance use treatment (Sheffer et al., 2012; Yoon et al., 2007). Finally, emerging cognitive-based interventions such as episodic future thinking may be useful for certain offenders (Bulley & Gullo, 2017; Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013; Stein et al., 2016). Episodic future thinking seeks to shift temporal focus more toward the future by having individuals

interact with personally-relevant cues associated with positive future events (e.g., vividly imagining to future family events). In the context of incarceration, these episodic future cues could be related to positive future outcomes associated with good behaviour, such as family visits, increased privileges, or reduction in sentence length via good behaviour.

The pattern of decision-making on the probability discounting task may also have meaningful implications for programming both during incarceration and following release from institutions. Offenders exhibited a risk-averse choice pattern on the probability discounting task whereby they preferred certain rewards over probabilistic rewards even though certain rewards were smaller in magnitude. For rehabilitation programming to be maximally effective, institutions may benefit from making the outcomes of these programs as concrete and certain as possible. This could include focusing on smaller gains that are more likely to occur vs. larger-scale outcomes that are perceived as less likely to happen.

For both delay and probability discounting tasks, offenders' preferences for smaller-immediate and smaller-certain rewards may also reflect life experiences with adversity or socioeconomic hardship. In other words, histories of negative outcomes, adverse experiences, or economic struggles may promote a bias toward immediate rewards because delayed rewards may not actually be received due to uncertainty about one's physical location, legal circumstances, or other factors outside of their control. Choosing to obtain a smaller reward that is available immediately or for certain may result from not trusting that they will have an opportunity to acquire the reward in the future. Finding ways to add stability to offenders' lives following release from institutions may help partially to mitigate these biases for immediate rewards and risk-averse tendencies.

The pattern of blunted reward learning on the IGT task may indicate that for some offenders, the ability to adjust one's choices based on punishments or losses may be disrupted. Card choices during first two blocks of the IGT are typically considered to reflect choices under ambiguity as participants are not explicitly told the outcome contingencies associated with the four decks. Participants must learn which decks provide a net advantageous outcome by experiencing the gains and losses associated with the four decks. By the final two blocks of the task, the control participants appeared to have learned which decks were more likely to result in the best overall outcomes (as is typical), but this was not the case in the offenders. Participants in the offender group continued to select cards from the disadvantageous decks that resulted in an

overall reduction in the points that could be gained over the course of the task. Although more fine-grained analyses are needed to unpack this pattern of responding in the offender group, this result may suggest that, on average, the offender group was less able to learn from punishment or losses and adjust their choices accordingly. Whether this decision-making pattern is associated with offending density or chronology of offence behaviours may warrant secondary analyses. From a reward/punishment learning perspective, these results also suggest that contingencies associated with choices and outcomes need to be very explicit and unambiguous for offenders to be able to improve their decision-making over time.

Limitations

The findings of this study should be interpreted in the context of the study's strengths and weaknesses. Strengths of the study include recruitment of both male and female offenders since many prior studies have primarily focused on male offenders. Research on female offenders was notably limited in the prior systematic review conducted by our research team (Vedelago et al., 2019). Another strength is the multidimensional approach used to collect measures of impulse control and risk-taking. The assessment battery was comprised of well-established, psychometrically validated measures of impulsive choice, response inhibition, risky decision-making, risk-taking behaviour, and personality traits.

Limitations of this study include a somewhat modest sample size for the female offender group (33% of the total offender group). The offenders were recruited from minimum and medium-security units at two institutions in the Ontario region. Future studies are needed to determine if similar results are found for offenders in institutions in other Canadian provinces and territories and at higher security levels (i.e., maximum-security vs. medium- or minimum-security). The control participants were recruited from a single geographic area (Hamilton, ON) which may limit the generalizability somewhat. Another limitation pertains to the matching between the offender and control groups. Participants were well-matched on age and sex, with no significant differences between groups for these demographic variables. However, education level and racial distribution did differ between groups. A final consideration for the computerized tasks concerns the type of rewards used. Some studies have used actual monetary rewards for these measures, but institutional regulations prohibited the use of monetary incentives in this study. Although some studies suggest that decisions for hypothetical and actual

rewards are generally consistent (e.g., (Bickel, Pitcock, Yi, & Angtuaco, 2009; Madden, Begotka, Raiff, & Kastern, 2003), this research has not been conducted among non-incarcerated individuals.

Conclusions

Taken together, these results suggest that the computerized measures and questionnaires were well-tolerated and completed within the allotted time. Participants reported their experience to be generally positive during debriefing. Therefore, the present data support the feasibility of conducting technology-based assessments of impulse control in federal correctional institutions. Comparisons between offenders and controls suggest that across both impulsivity and risk-taking domains, deficits were found for decision-making tasks but not tasks involving impulsive or risky actions. These were not global deficits, but selectively pertained to overvaluing immediate rewards and certain rewards, and exhibiting insensitivity to unfavourable contingencies in terms of reward/punishment learning. These findings support the utility of using these measures to gain insights into offender profiles of impulsivity and risk orientation. The areas exhibiting significant differences between offenders and control participants in particular have promise in terms of improving prediction models of recidivism and rehabilitation.

References

Åkerlund, D., Golsteyn, B. H. H., Grönqvist, H., & Lindahl, L. (2016). Time discounting and criminal behavior. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(22 PG-6160–5), 6160–6165. https://doi.org/10.1073/pnas.1522445113

Amlung, M., Vedelago, L., Acker, J., Balodis, I., & MacKillop, J. (2017). Steep delay discounting and addictive behavior: a meta-analysis of continuous associations. *Addiction (Abingdon, England)*, *112*(1), 51–62. https://doi.org/10.1111/add.13535

Bickel, W. K., Johnson, M. W., Koffarnus, M. N., MacKillop, J., & Murphy, J. G. (2014). The behavioral economics of substance use disorders: reinforcement pathologies and their repair. *Annual Review of Clinical Psychology*, *10*, 641–677. https://doi.org/10.1146/annurev-clinpsy-032813-153724

Bickel, W. K., Pitcock, J. A., Yi, R., & Angtuaco, E. J. C. (2009). Congruence of BOLD Response across Intertemporal Choice Conditions: Fictive and Real Money Gains and Losses. *Journal of Neuroscience*, *29*(27), 8839–8846. https://doi.org/10.1523/jneurosci.5319-08.2009

Biro, S. M., & Farrell MacDonald, S. (2015). *Substance Use and Behaviour: The Role of Gender. No RIB 15-01*. Ottawa, ON.

Bornovalova, M. A., Daughters, S. B., Hernandez, G. D., Richards, J. B., & Lejuez, C. W. (2005). Differences in impulsivity and risk-taking propensity between primary users of crack cocaine and primary users of heroin in a residential substance-use program. *Exp Clin Psychopharmacol*, *13*(4), 311–318. https://doi.org/2005-15800-005 [pii]10.1037/1064-1297.13.4.311

Brochu, S., Cousineau, M. M., Gillet, M., Cournoyer, L. G., Pernanen, K., & Motiuk, L. (2002). Drugs, alcohol, and criminal behaviour: A profile of inmates in Canadian Federal Institutions. *Forum on Corections Research*, *13*, 20–24.

Bulley, A., & Gullo, M. J. (2017). The influence of episodic foresight on delay discounting and demand for alcohol. *Addictive Behaviors*, *66*, 1–6. https://doi.org/10.1016/j.addbeh.2016.11.003

Canadian Centre on Substance Abuse. (2004). *Substance Abuse in Corrections FAQs*. Ottawa, ON.

Carroll, A., Hemingway, F., Bower, J., Ashman, A., Houghton, S., Durkin, K., … Lindahl, L. (2017). Impulsivity in juvenile delinquency: Differences among early-onset, late-onset, and non-offenders. *NeuroReport*, *113*(22), 193–198. https://doi.org/10.1097/00001756-200508010-00016

Chen, C.-Y. Y., Tien, Y.-M. M., Juan, C.-H. H., Tzeng, O. J. L. L., & Hung, D. L. (2005). Neural correlates of impulsive-violent behavior: an event-related potential study. *NeuroReport*, *16*(11), 1213–1216. https://doi.org/10.1097/00001756-200508010-00016

Chen, C. Y., Muggleton, N. G., Juan, C. H., Tzeng, O. J. L., & Hung, D. L. (2008). Time pressure leads to inhibitory control deficits in impulsive violent offenders. *Behavioural Brain Research*, *187*(2), 483–488.

Cyders, M. A., Littlefield, A. K., Coffey, S., & Karyadi, K. A. (2014). Examination of a short English version of the UPPS-P Impulsive Behavior Scale. *Addictive Behaviors*, *39*(9), 1372–1376. https://doi.org/10.1016/j.addbeh.2014.02.013

Dahne, J., Richards, J. M., Ernst, M., MacPherson, L., & Lejuez, C. W. (2013). Assessment of Risk Taking in Addiction Research. In J. MacKillop & H. De Wit (Eds.), *The Wiley-Blackwell Handbook of Addiction Psychopharmacology* (pp. 209–231). West Sussex: Wiley-Blackwell.

de Wit, H. (2009). Impulsivity as a determinant and consequence of drug use: a review of underlying processes. *Addiction Biology*, *14*(1), 22–31. https://doi.org/10.1111/j.1369-1600.2008.00129.x

Farrell MacDonald, S. (2014a). *Lifetime Substance Use Patterns of Women Offenders. No RS 14-24*. Ottawa, ON.

Farrell MacDonald, S. (2014b). *Severity of Substance Use, Discretionary Release, and Return to Federal Custody. No RS 14-19.* Ottawa, ON.

Farrell MacDonald, S., Gobeil, R., Biro, S. M., Ritchie, M. B., & Curno, J. (2015). *Women Offenders, Substance Use, and Behaviour. No R-358*. Ottawa, ON.

Fazel, S., Yoon, I. A., & Hayes, A. J. (2017). Substance use disorders in prisoners : an updated systematic review and meta-regression analysis in recently incarcerated men and women. *Addiction*. https://doi.org/10.1111/add.13877

Fillmore, M. T. (2003). Drug abuse as a problem of impaired control: current approaches and findings. *Behavioral & Cognitive Neuroscience Reviews*, *2*(3), 179–197.

https://doi.org/10.1177/1534582303257007

Kelly, L., & Farrell MacDonald, S. (2015). *Lifetime Substance Use Patterns of Men Offenders. No RIB 14-43*. Ottawa, ON.

Koffarnus, M. N., Jarmolowicz, D. P., Mueller, E. T., & Bickel, W. K. (2013). Changing delay discounting in the light of the competing neurobehavioral decision systems theory: a review. *Journal of the Experimental Analysis of Behavior*, *99*(1), 32–57. https://doi.org/10.1002/jeab.2

Lee, C. A., Derefinko, K. J., Milich, R., Lynam, D. R., & DeWall, C. N. (2017). Longitudinal and reciprocal relations between delay discounting and crime. *Personality and Individual Differences*, *111*, 193–198. https://doi.org/10.1016/j.paid.2017.02.023

Longshore, D. (1998). Self-Control and Criminal Opportunity: A Prospective Test of the General Theory of Crime. *Social Problems*, *45*, 102–113.

MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. a., Sweet, L. H., & Munafò, M. R. (2011). Delayed reward discounting and addictive behavior: a meta-analysis. *Psychopharmacology (Berl)*, *216*(3), 305–321. https://doi.org/10.1007/s00213-011-2229-0

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

Madden, G. J., Begotka, A. M., Raiff, B. R., & Kastern, L. L. (2003). Delay discounting of real and hypothetical rewards. *Experimental & Clinical Psychopharmacology*, *11*(2), 139–145.

Mishra, S., & Lalumière, M. L. (2017). Associations Between Delay Discounting and Risk-Related Behaviors, Traits, Attitudes, and Outcomes. *Journal of Behavioral Decision Making*, *30*(3), 769–781. https://doi.org/10.1002/bdm.2000

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., … Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences*, *108*(7), 2693–2698. https://doi.org/10.1073/pnas.1010076108

Perry, J. L., & Carroll, M. E. (2008). The role of impulsive behavior in drug abuse. *Psychopharmacology (Berl)*, *200*(1), 1–26. https://doi.org/10.1007/s00213-008-1173-0

Petry, N. M., Bickel, W. K., & Arnett, M. (1998). Shortened time horizons and insensitivity to

future consequences in heroin addicts. *Addiction*, *93*(5), 729–738. https://doi.org/10.1046/j.1360-0443.1998.9357298.x

Sheffer, C., MacKillop, J., McGeary, J., Landes, R., Carter, L., Yi, R., … Bickel, W. (2012). Delay discounting, locus of control, and cognitive impulsiveness independently predict tobacco dependence treatment outcomes in a highly dependent, lower socioeconomic group of smokers. *Am J Addict*, *21*(3), 221–232. https://doi.org/10.1111/j.1521-0391.2012.00224.x

Stein, J. S., Wilson, A. G., Koffarnus, M. N., Daniel, T. O., Epstein, L. H., & Bickel, W. K. (2016). Unstuck in time: episodic future thinking reduces delay discounting and cigarette smoking. *Psychopharmacology*, *233*(21–22), 3771–3778. https://doi.org/10.1007/s00213-016-4410-y

Vedelago, L., Amlung, M., Morris, V., Petker, T., Balodis, I., McLachlan, K., … MacKillop, J. (2019). Technological advances in the assessment of impulse control in offenders: A systematic review. *Behavioral Sciences & the Law*, *37*(4), 435–451. https://doi.org/10.1002/bsl.2420

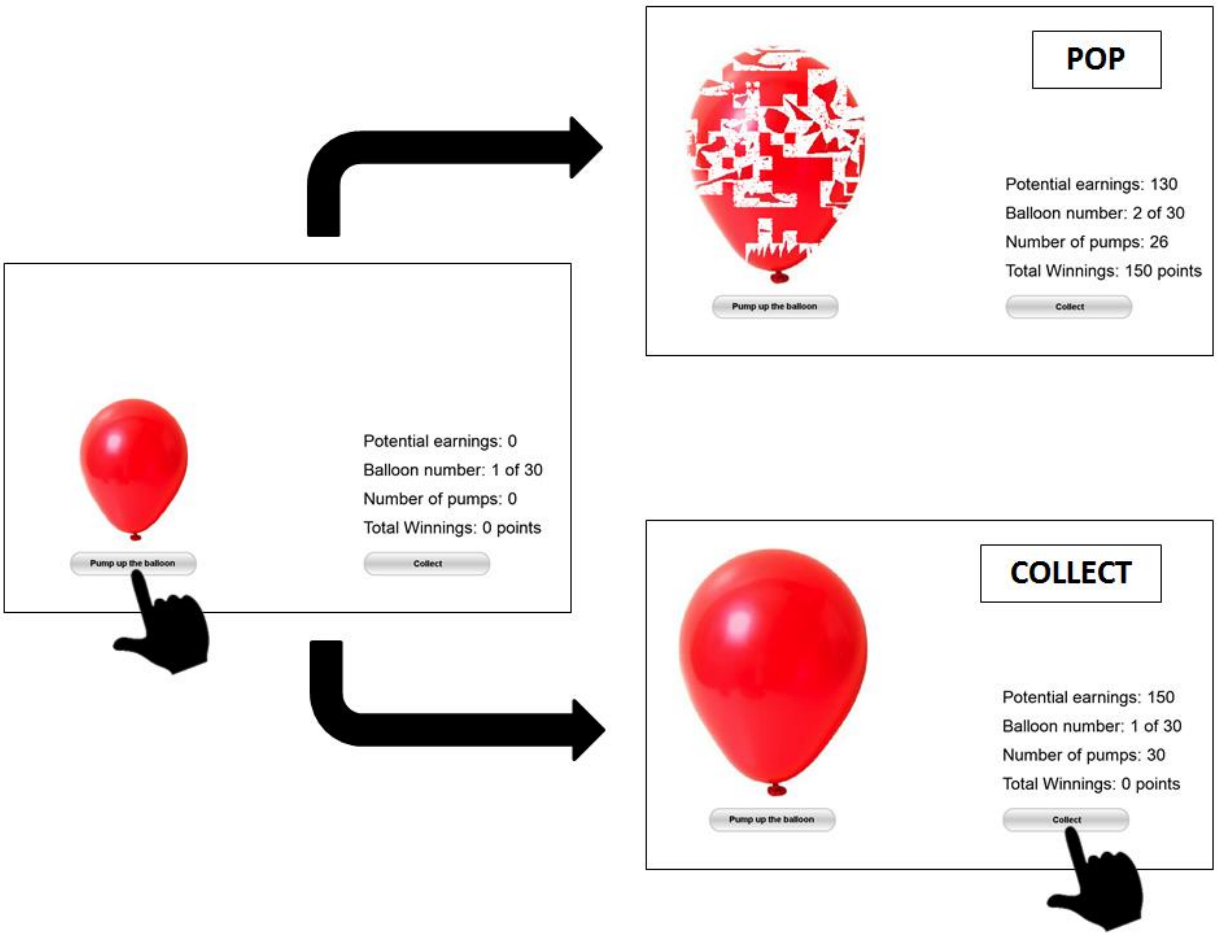
Weekes, J. R., Millson, W. A., Porporino, F. J., & Robinson, D. (1994). *The offender Substance Abuse Pre-Release Program: Intermediate and post-release outcomes*. Ottawa.

Yoon, J. H., Higgins, S. T., Heil, S. H., Sugarbaker, R. J., Thomas, C. S., & Badger, G. J. (2007). Delay Discounting Predicts Postpartum Relapse to Cigarette Smoking Among Pregnant Women. *Experimental and Clinical Psychopharmacology*, *15*(2), 176–186. https://doi.org/10.1037/1064-1297.15.2.186

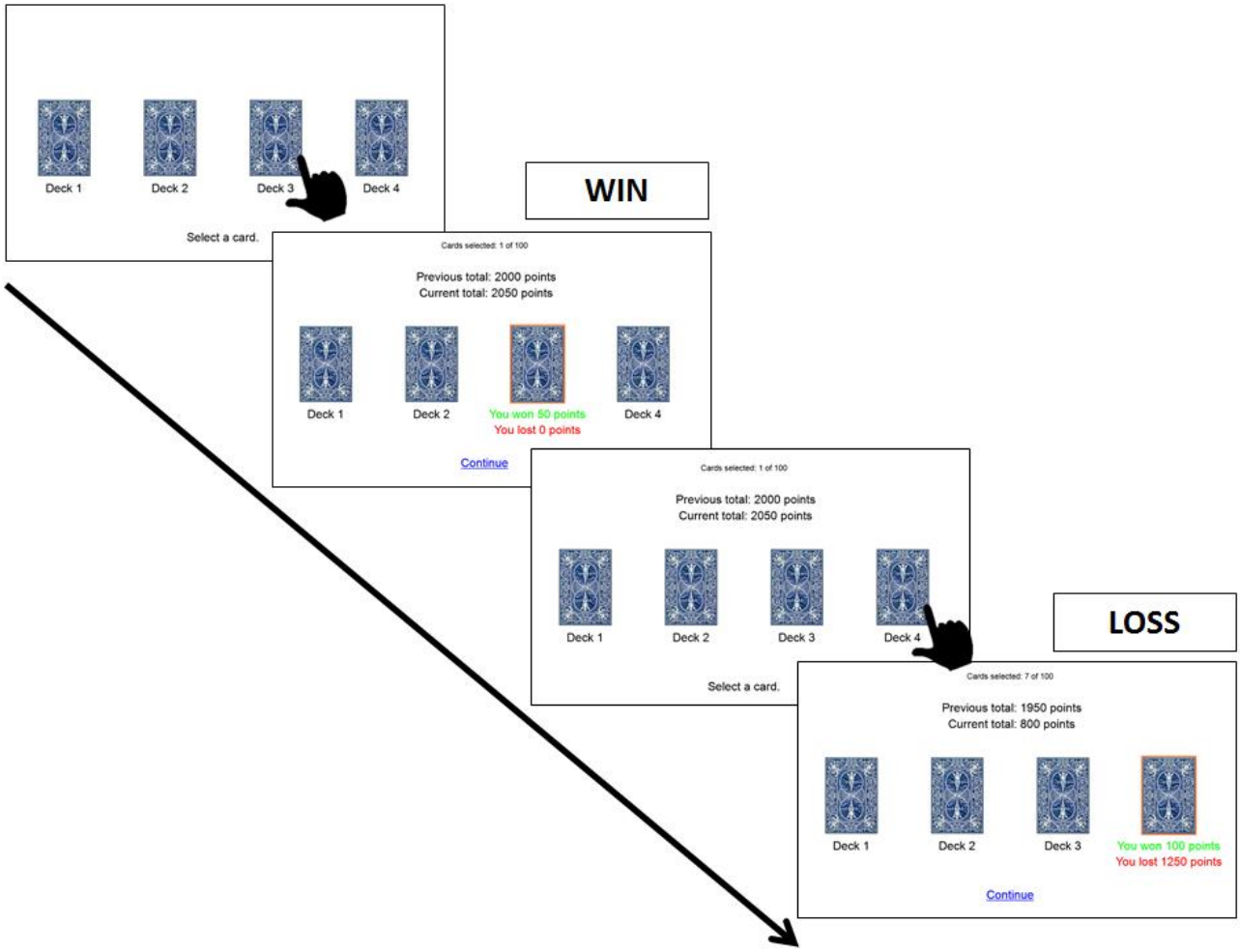
Appendix A

Schematic Depictions of Computerized Task Stimuli

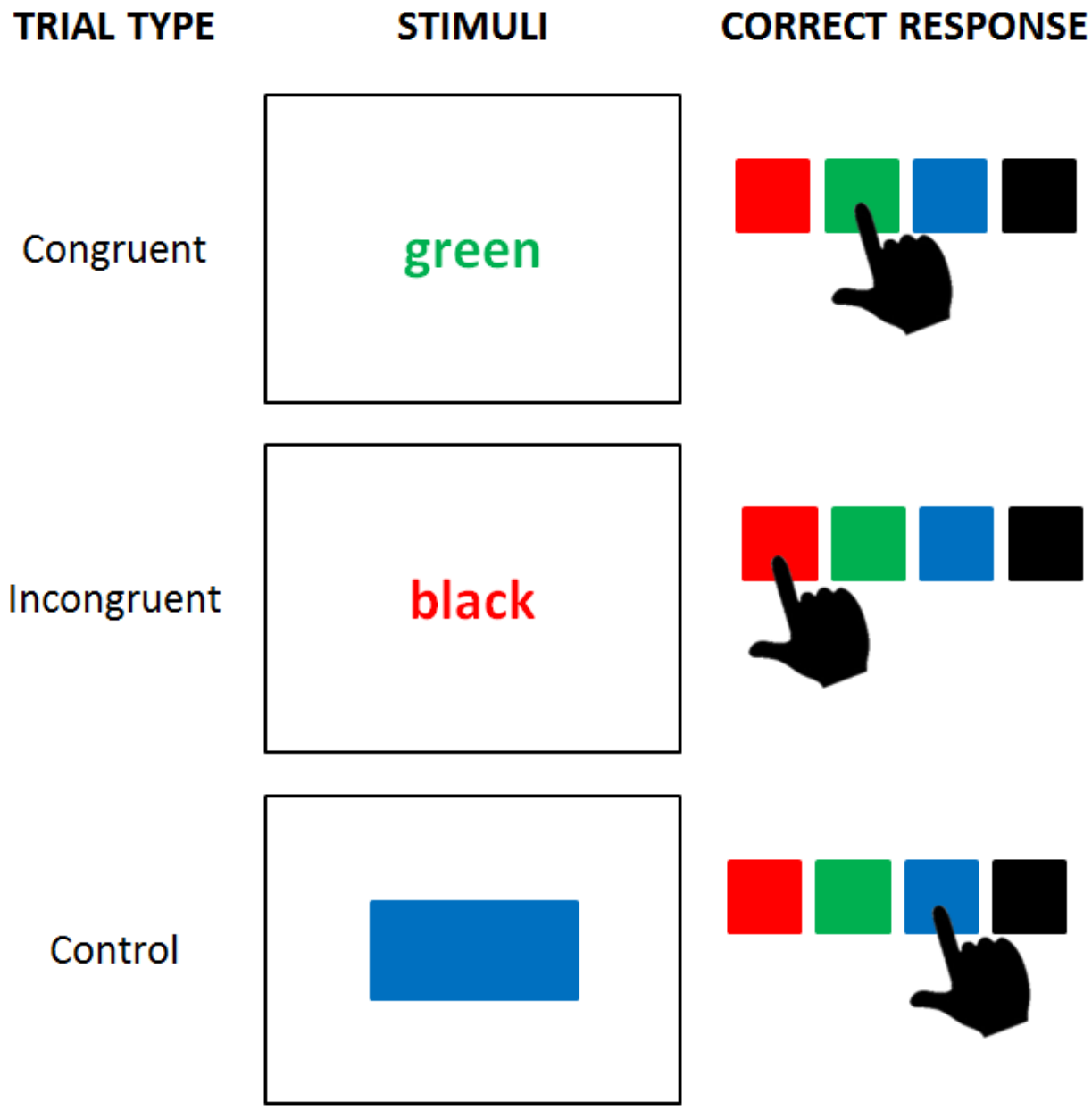
1. Balloon Analogue Risk Task (BART)



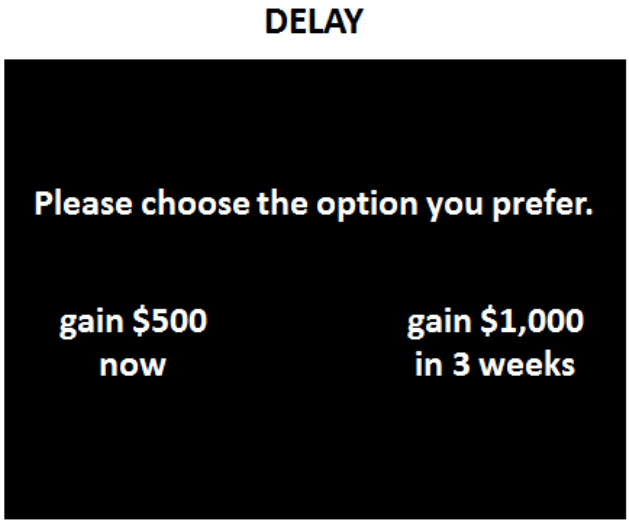
2. Iowa Gambling Task (IGT)

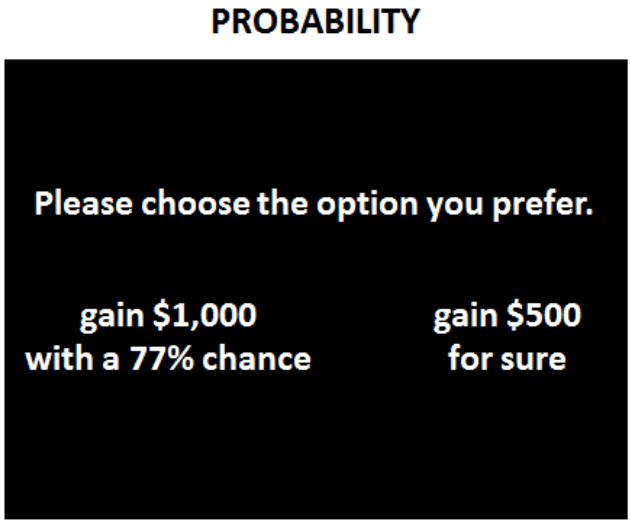


3. Stroop Colour-Word Test



4. Delay and Probability Discounting Tasks





5. Go/No-Go Paradigm