**Novice electronic gambling machine players' decision-making, cognitive flexibility and emotional self-regulation.**



A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Doctorate of Psychology

Department of Psychology

Memorial University of Newfoundland

July, 2024

St. John's, Newfoundland and Labrador

*"And beside all this, between us and you there is a great gulf fixed:*

*so that they which would pass from hence to you cannot;*

*neither can they pass to us, that would come from thence."*

- Luke 16:26

**Abstract**

It is not known why some novice gamblers eventually develop Gambling Disorder while most do not. This study tested predictions from two competing models of Gambling Disorder etiology: the Pathways Model of Problem and Pathological Gambling (Blaszczynski & Nower, 2002) and the Allostatic Model of addictions (Koob & Schulkin, 2019) applied to Gambling Disorder. Participants were drawn from introductory psychology courses and screened as non-gamblers ($N = 91$). They completed computerized versions of the Iowa Gambling Task (IGT-2), Wisconsin Card Sorting Task (WCST-64), and a Difficulties with Emotional Regulation Scale (DERS). Risk-taking tendencies were observed by having participants play a typical electronic slots game for up to 15 min. Higher betting on the slots game was positively correlated with the frequency of Deck A selections on the IGT-2 ($r$=.30, $p$=.005) and with lower total DERS scores ($r$=-.31, $p$=.003). There were no statistically significant correlations involving slots betting and the WCST-64. Greater risk-taking on the slots game was correlated with more frequent wins, partial losses that were disguised as wins, bonus game features, and the largest nominal amount won on a single spin. However, there were no significant correlations between betting behaviors and the 'payback percentage', defined as total winnings as a proportion of total wagers made throughout the session. Post-game ratings were positively correlated with frequency of reinforcing outcomes. These findings suggest that novice gamblers' likelihood of further gambling participation may be elevated by high sensitivity to immediate rewards and low difficulty self-regulating negative emotions. These findings are consistent with the Allostatic Model; they are not consistent with Pathways Model.

## Dissemination

Aspects of this doctoral research were disseminated in the following outlet:

MacLaren, V., McDonald, V., Hollett, K. B., & Harris, N. (2022). Gambling Associated Risk-taking Behaviors Correlate with Emotional Regulation and the Iowa Gambling Task but not Wisconsin Card Sorting. *Journal of Gambling Studies, 39, 829-841*.

## Acknowledgements

I wish to thank my doctoral supervisor, Professor Nick Harris, for his help, encouragement, and tolerance throughout this project. I also am very grateful to Valerie MacDonald and Kayla Hollett, who worked diligently to collect the data that are reported herein. I also thank my dissertation committee members, Professors Darcy Hallett and Brent Snook for their thoughtful and timely reviews. I also thank members of the examination committee, Professors Matthew Keough, Jonathan Fawcett, and Jacqueline Carter. Finally a very warm thank you to the faculty, staff and students in the PsyD program who helped make my time at Memorial University a wonderful and life-changing experience.

## List of Tables

## List of Figures

## List of Abbreviations

| | |
|---|---|
| Difficulties in Emotional Regulation Scale | DERS |
| Dorsolateral Prefrontal Cortex | DLPFC |
| Electronic Gaming Machines | EGM |
| Gambling Disorder | GD |
| Gaming Experiences Questionnaire | GEQ |
| Gambling Motives Questionnaire | GMQ |
| Iowa Gambling Task | IGT |
| Loss Disguised as Win | LDW |
| Personality Assessment Inventory | PAI |
| Problem Gambling Severity Index | PGSI |
| Revised Neuroticism, Extraversion and Openness Personality Inventory | NEO PI-R |
| Wisconsin Card Sorting Task | WSCT |

## List of Appendices

**Table of Contents**

## 1.0 **Introduction**.

Human beings are specialized for acquiring complex behaviors and adapting ourselves to meet the demands of our circumstances. Flexibility gives us the capacity for immense individual variation, but it comes at the cost of our vulnerability to developing habits of thought, feeling and behavior that can limit the expression of individual potential. Hedonically gratifying activities like gambling and substance use can motivate rigid patterns of excess that diminish health and long-term quality of life. The purpose of this thesis was to improve current understanding of how the neuroadaptation of human motivational and self-regulatory systems can contribute to addictive behavior. The strategy of this research was to treat gambling as a model through which to investigate mechanisms that may underlie the transition from impulsive reward-seeking into compulsive addiction. This approach is premised upon the belief that human action is varied and multidetermined. It is nevertheless explainable and composed of functional elements that are common to nearly all people. Such elements underlie our ability to adapt to our surroundings and to accommodate our internal physiological and neural processes so that we can make successful adjustments as needed. The focus of investigation was how the elements of decision-making, cognitive flexibility and emotional self-regulation can contribute to maladaptive changes in behavior when people are exposed to potentially addictive gambling games.

### *1.1 Theoretical Orientation.*

A scientific theory is a logically coherent account of some aspect of the natural world that explains all relevant observations and has not been disproven by evidence contrary to its predictions (Popper, 1959). A good theory captures the essence of causal relationships between measurable phenomena that covary consistently (Bradford Hill, 1965), and can therefore be used to justify predictions about future observations that may be expected to occur under certain conditions. Specific hypotheses must follow logically from theory. A good psychological theory can be pragmatically useful for clinicians if it informs the conceptualization of individual psychopathology, including predisposing, precipitating and maintaining factors that may be targets for intervention (Suhr, 2015).

This thesis was oriented within a functional framework of psychology that considers perceptual, cognitive, affective, and physiological mechanisms as potentially useful constructs for explaining the behavior of individuals within and across settings. Empirical evidence was collected and quantitatively analyzed to test relationships hypothesized to exist amongst operationally defined constructs that were logically deduced from the *Allostatic Model* of addiction (Koob & Le Moal, 2001; Koob & Schulkin, 2019). The focus of this thesis was the betting behavior of novices exposed to Electronic Gambling because those games are known to be the most addictive form of gambling (Binde, Romild & Volberg, 2017; MacLaren, 2016; Mazar, Zorn, Becker & Volberg, 2020). Gambling is the prototypical behavioral addiction, as shown by the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders (DSM-5) having included Gambling Disorder (GD) in the "Substance Use and Addictive Disorders" category because of *"evidence that gambling behaviors activate reward systems similar to those activated by drugs of abuse and produce some behavioral symptoms that appear comparable to those produced by Substance Use Disorders" (p. 481).*

In this study, standardized behavioral and self-report measures were collected cross-sectionally and analysed in a correlational design. Data were collected from young novice gamblers with the intention of contrasting the findings from this target population against present understanding of experienced gamblers and to thereby inform a developmental conception of how addictive behavior may progress over time. Variations in the style and extent of gambling behavior across individuals were conceived as potential markers of individual tendencies toward so-called ‘externalizing’ or ‘internalizing’ behavior that are known to relate structurally (Kotov et al., 2017) to clinically meaningful dimensions of personality (Ben-Porath & Tellegen, 2020). The externalizing and internalizing spectra were originally discovered through factor analysis of pediatric psychopathology (Achenbach, 1966) and extended to adult syndromes (Kotov et al., 2017). Externalizing is a dimension that accounts for comorbidity among substance use disorders, oppositional defiant disorder, conduct disorder, adult antisocial behavior, intermittent explosive disorder, and attention deficit/hyperactivity disorder. Internalizing represents depressive, anxiety, posttraumatic stress, obsessive–compulsive, and eating disorders. Externalizing corresponds to the 5-factor personality model traits of low Agreeableness and low Conscientiousness; whereas Internalizing correlates with high Neuroticism and low Extraversion (Kotov et al., 2010). These spectra and trait domains may also be conceived at the neurobiological level in terms of approach motivation mediated by the Behavioral Activating System (e.g., reward seeking mediated by the ventral striatum and other dopaminergic systems) versus punishment sensitivity mediated by the Fight-Flight-Freeze System (e.g., fear and defensive behavior mediated by the extended amygdala), respectively (Corr, DeYoung & McNaughton, 2013). Some of the behavioral correlates of betting behavior that were tested in this study were specifically designed to index individual variations in responsivity to signals of immediate versus delayed reward and executive control.

Addictive gambling behavior was conjectured to emerge out of an interplay between individual predisposition and exposure to electronic gambling games that activate and sustain idiographic mechanisms that underlie risk-taking behavior (MacLaren, 2016). Following this orientation, the research strategy was to sample gambling behavior of novice players in a controlled yet ecologically relevant setting along with standardized tasks that could serve as markers for the mechanisms that the Allostatic Model predicts to be active during the pre-addictive acquisition and/or maintenance stages of addiction. Characterizing novice players in this way was intended as a counterpart to current understanding of decision-making (Ioannidis, Hook, Wickham, Grant & Chamberlain, 2019; Kovács, Richman, Janka, Maraz & Andó, 2017), cognitive flexibility (Van Timmeren, Daams, Van Holst & Goudriaan, 2018) and emotional self-regulation (Marchica, Mills, Derevensky & Montreuil, 2019) in people with GD. Converging evidence in favor of a developmentally informed Allostatic Model could provide a critical challenge to the notion that there exist qualitatively distinct "subtypes" of people whose excessive gambling is acquired and maintained by nomothetic features that persist within individuals over time.

The Pathways Model (Blaszczynski & Nower, 2002) is a well-known etiological account of how GD emerges out of individual predispositions and exposure to gambling. This supposedly results in three discrete types of people who gamble excessively: a) a behaviorally conditioned subtype whose excessive gambling is incentivized by the opportunity to win money; b) an antisocial-impulsivist subtype that acquires GD through use of gambling as an externalizing behavior that is driven by the excitement of risk-taking; and c) an emotionally vulnerable subtype that acquires GD through use of gambling as an internalizing behavior that is motivated by immersion in the games and experiential avoidance of negative thoughts and emotions.

### *1.2 Conceptualization of Gambling Disorder.*

Gambling is a popular passtime and most Canadians participate in some form of legal gambling (MacLaren, 2016). A relatively small number of adults have GD or may be considered 'problem gamblers' at any point in time (Ferris & Wynne, 2001). The prevalence of past-year problem gambling appears to have declined in Canada from an estimated prevalence of 1.1% in Statistics Canada's 2002 nationally representative Canadian Community Health Survey, down to 0.6% in its most recent iteration in 2018 (Williams, Leonard, Belanger, Christensen, El-Guebaly, Hodgins, et al., 2020). Other Canadian surveys carried out by provincial governments found the prevalence to be somewhat higher at 2.4% (Williams, Volberg & Stevens, 2012). A series of nationally representative surveys conducted 6 months prior, during, and 6 months after the Canadian pandemic lockdown found that gambling participation declined and did not fully recover afterward (Shaw, Hodgins, Williams, Belanger, Christensen, el-Guebaly, Nady, McGrath & Stevens, 2022). An online summary of current statistics indicates little change in gambling participation in Canada, with revenues topping $1.2 billion in 2021 and 2% of Canadians over age 15 reporting significant problems associated with excessive gambling (Bush, 2023).

Despite the trend toward lower gambling participation, a significant minority of Canadians are negatively affected by excessive gambling. Financial losses may negatively impact people at all levels of involvement in gambling (Browne, Volberg, Rockloff & Salonen, 2020). Negative consequences of excessive gambling include monetary debt (Meltzer, Bebbington, Brugha, Farrell & Jenkins, 2012), bankruptcy (Grant, Schreiber, Odlaug & Kim, 2010), family violence (Dowling, Jackson, Suomi, Lavis, Thomas, Patford, et al., 2014), and marital breakdown (Black, Shaw, McCormick & Allen, 2012). There is also high comorbidity with psychiatric illness according to a meta-analysis of 11 studies that examined mental health problems in people with GD (*N* = 121,760); the weighted average prevalence of substance use disorders was 57.5%, as well as 37.4% for anxiety disorders and 37.9% for depressive mood disorders (Lorains, Cowlishaw & Thomas, 2011).

One popular theory of GD is the so-called “Pathways Model of Problem and Pathological Gambling” (Blaszczynski & Nower, 2002; Nower, Blaszczynski & Anthony, 2022), which proposes three distinct subtypes of gamblers that each acquire GD via different prototypical courses (see Figure 1). According to that model, the three subtypes are identified as ‘behaviorally conditioned’, ‘emotionally vulnerable’, and ‘antisocial-impulsivist’. The behaviorally conditioned gamblers are conceived as having acquired the habit of excessive gambling through exposure to opportunities to participate in gambling and receiving positive reinforcement through memorable wins; they are not believed to be otherwise predisposed toward excessive gambling. The emotionally vulnerable group is different in that they are thought to have heritable temperaments and/or early life histories that create a transdiagnostic predisposition toward so-called ‘internalizing’ behaviors (Krueger, Caspi, Moffitt & Silva, 1998). The mechanism postulated to cause their excessive gambling is a maladaptive habit of coping with distress by experiential avoidance. Likewise, the antisocial-impulsivist gamblers are believed to be predisposed toward gambling because they have a temperamental disposition toward impulsivity, risk-taking and other ‘externalizing’ behaviors (Eaton, Rodriguez-Seijas, Carragher & Krueger, 2015). The most recent iteration of the Pathways Model (Nower et al., 2022) further asserts that the antisocial-impulsivists’ excessive gambling is motivated by experiential avoidance as well as a search for personal meaning. For example, the Gambling Pathways Questionnaire (Nower & Blaszczynski, 2017) includes items such as “Gambling gives me purpose in life” and “A big win at gambling would give my life meaning” in its Meaning Motivation subscale. Despite its inclusion in the revised Pathways Model, the evidence supporting the Meaning motive comes only from that single study; it has not yet been replicated.

Those authors further contend that, once exposed to gambling, all three subtypes proceed toward problem gambling due to easy availability of opportunities to gamble. The behavior is made habitual by positive reinforcement (i.e., winning large prizes), negative reinforcement (i.e., avoiding distress by immersion in gambling activity), and cognitive distortions that tend to exaggerate the benefits and minimize the harms of gambling. A systematic review of 13 studies that attempted to classify problem gamblers into subtypes according to the Pathways Model (total N=6,182 in 14 samples) found that approximately 44% were classified at behaviorally conditioned, 27% were emotionally vulnerable, 21% were antisocial-impulsivist, and 8% did not match the 3 subtypes (Kurilla, 2021).

The Pathways model specifies emotional self-control motives for the emotionally vulnerable and antisocial-impulsivist subtypes. Through the so-called ‘Coping motivation’, gambling behavior is negatively reinforced by distracting the player from generalized worry or distress. The Coping Motive is usually measured as a continuous variable using the Gambling Motives Questionnaire (Stewart & Zack, 2008). This originated in research on motives for addictive behavior that used the Drinking Motives Questionnaire (Cooper, 1994), a Likert-scale self-report measure of drinking for Coping (e.g., “You drink to forget your worries.”), Enhancement of positive mood (e.g., “You drink because it helps you enjoy a party.”), and Social engagement (e.g., “You drink to be sociable.”). The scale was adapted into the Gambling Motives Questionnaire (Stewart & Zack, 2008) and later expanded (e.g., Dechant & Ellery, 2011) to include financial motives (e.g., “You gamble to win money.”) and other motives

(Wardell et al., 2015). Gambling motives are important because they are a critical point of differentiation between the problem gambler subtypes of the Pathways Model.

*1.2.1 Meta-analyses of Gambling Motives and Problem Gambling*

There presently is no published meta-analysis of the relationships between gambling motives and symptoms of GD. There is a meta-analysis of 44 studies (Tabri, Xuereb & Clark, 2022) that was focused on financial motives, and this was found to correlate $r$=.29 with frequency of gambling and $r$=.35 with problem gambling, with the 95% confidence intervals for those effects indicating non-zero effect sizes when the Coping, Enhancement and Social motives were statistically controlled through meta-regression. Curiously, those authors did not report findings for the Coping, Enhancement or Social motives. This is a peculiar situation, given that such motives have been consistently implicated in other addictive behaviors, especially alcohol. A meta-analysis of 254 studies with a total of 130,745 participants (Bresin & Mekawi, 2021) found that the Coping motive correlated $r$=.26 with drinking frequency, $r$=.27 with drinking quantity, and $r$=.43 with problems associated with excessive drinking. Similar correlations were also found involving Enhancement (i.e., $r$=.39 with frequency, $r$=.40 with quantity, and $r$=.46 with problems) and Social (i.e., $r$=.35 with frequency, $r$=.32 with quantity, and $r$=.41 with problems) motives. The absence of a meta-analysis of studies examining potential links between Coping, Enhancement and Social motives and problem gambling is a noteworthy gap in the research literature.

To address the need for meta-analytic evidence of the link between problem gambling and motives, the present author did a search for all English-language peer-reviewed publications that reported statistical evidence testing the relationship between self-report measures of problem gambling severity and the Coping, Enhancement, or Social motives measured by self-reports derived from the Gambling Motives Questionnaire. The articles included in the meta-analysis by Tabri and colleagues (2021) were searched, as well as the 405 articles that cited the original paper by Stewart & Zack (2008) according to a Google scholar search conducted in October, 2023. A total of 32 studies were identified that reported correlations or other statistics that could be used to estimate correlations between the Coping motive and measures of problem gambling severity (total N=14,026), and 30 of these studies also reported findings for the Enhancement and Social motives (total N=13,241). As shown in Appendix A (parts A.1, A.2 and A.3), the overall effect sizes may be considered 'large' for Coping ($r$=.52; 95% C.I.=.44-.60, see Appendix A.1), medium for Enhancement ($r$=.43; 95% C.I.=.34-.51, see Appendix A.2), and small for Social motives ($r$=.25; 95% C.I.=.20-.31, see Appendix A.3). Although this simple meta-analysis did not explore covariance between these variables, nor potential moderators or mediators of the relationships, it does appear that the exclusion of the Enhancement motive from the revised Pathways Model is a discrepancy with current scientific evidence that is within the scope of that theory.

*1.2.2 Strengths of the Pathways Model.*

One strength of the Pathways Model is the nomological alignment of its proposed subtypes with the latent factors proposed in the more universal Reinforcement Sensitivity Theory of Personality (Corr, 2008; Grey & McNaughton, 1982), which has neurobiological substrates that mediate individual response tendencies under conditions of reward and punishment. Modern personality trait theory suggests that human beings vary along dimensions that may be expressed as externalizing and/or internalizing psychopathology (Kotov et al., 2017). The Pathways Model may be viewed as an instance of this scheme being applied to GD as a behavior that may involve people reacting mostly to extrinsic contingencies (i.e., behaviorally conditioned), or with significant intrinsic dispositions toward internalizing (i.e., emotionally vulnerable) or externalizing behaviors (i.e., antisocial-impulsivist). Unfortunately, since this framework covers nearly all people, it follows that nearly any set of cross-sectional observations of gamblers' personality traits and motives may be explained in terms of normal behavioral learning or in terms of abnormality along the internalizing and externalizing dimensions. Thus, a major conceptual weakness of the Pathways Model is that it may appear 'confirmed' whether a particular gambling behavior is observed to correlate with tendencies toward externalizing, internalizing, neither or both.

The Pathways model also fails to account for the possibility that individuals might be motivated to gamble through different mechanisms at different stages of their developmental progression through the acquisition, maintenance, remission, and relapse stages of their addiction. General predispositions toward psychopathology, including high Neuroticism and Disagreeableness might contribute to pathological expression of internalizing and/or externalizing behaviors at different stages of GD. If this is true, then the so-called subtypes might simply reflect within-subject changes to how pathological gambling behavior is expressed over time. Evidence for longitudinal changes in gambling behavior and the motives that sustain the behavior would refute the discrete GD subtypes that are critical to the Pathways Model.

### *1.2.3 Developmental progression of gambling behavior.*

Cross-sectional studies of the personality traits found among people who gamble excessively have shown significant involvement of traits associated with Neuroticism, Disagreeableness, and Impulsivity (MacLaren, Fugelsang, Harrigan & Dixon, 2011) that mirrors the pattern found in people who use intoxicating substances excessively (Kotov, Gamez, Schmidt & Watson, 2010). Several non-prospective studies have used statistical clustering methods to identify subgroups of problem gamblers with features that conceptually align with the behaviorally conditioned, emotionally vulnerable, or antisocial-impulsivist prototypes (Gupta, Nower, Derevensky, Blaszczynski, Faregh & Temcheff, 2013; Ledgerwood & Petry, 2010; Moon, Lister, Milosevic & Ledgerwood, 2017; Nower, Martin, Lin & Blanco, 2013; Turner, Umesh, Warren & Masood, 2008; Valleur et al., 2016). These consistent findings may be interpreted as support for the Pathways Model but cross-sectional studies do not allow causal inference and cannot directly test the etiological mechanisms purported to underlie the origin and progression of the three purported subtypes of the Pathways Model. Three longitudinal studies have been published that bear directly on the validity of the idea that different personality configurations predispose toward progression from casual gambling to pathological gambling along the behaviorally conditioned, emotionally vulnerable, or antisocial-impulsivist trajectories.

The first prospective test of the Pathways model (Allami, Vitaro, Brendgen, Carbonneau, Lacourse & Tremblay, 2017) consisted of a latent profile analysis of the features found in a subsample of 180 French-speaking Quebecois adolescents who reported symptoms indicating high risk for GD by young adulthood on the adolescent South Oaks Gambling Screen (SOGS-RA; Winters, Stinchfield & Fulkerson, 1993). They were drawn from two samples ($N$=1033 and N=3017) of students who had teacher ratings of depression, anxiety, impulsivity, hyperactivity, and antisocial or aggressive behavior collected at age 12 using the Social Behavior Questionnaire (Tremblay, Desmarais-Gervais, Gagnon & Charlebois, 1987). Substance use problems were self-reported by participants at age 14, and problems from substance use and gambling were self-reported at ages 16 and 23 years. Latent profile analysis found four clusters that had features identified as being consistent with the three Pathways Model subtypes, plus a fourth group of eight participants who had a combination of the antisocial-impulsivist and emotionally vulnerable features. At age 12, the 36 participants identified as “biologically vulnerable” (i.e., antisocial-impulsivist) had significantly higher ratings of impulsivity (M=8.25, SD=2.52), hyperactivity (M=3.40, 1.15) and antisocial/aggressiveness (M=6.91, SD=3.98) compared to the 31 participants identified as emotionally vulnerable or the 105 identified as behaviorally conditioned. The emotionally vulnerable type had lower impulsivity (M=1.81), hyperactivity (M=0.52) and antisocial/aggressiveness (M=2.42). The behaviorally conditioned type also had lower impulsivity (M=2.07), hyperactivity (M=0.75) and antisocial/aggressiveness (M=2.02). Likewise, those identified as emotionally vulnerable had higher depression (M=3.29) and anxiety (M=3.42) than either of the other two groups. The biologically vulnerable type had lower depression (M=1.36) and anxiety (M=2.65), and the behaviorally conditioned type had even lower depression (M=0.75) and anxiety (M=1.33). At age 16, the three groups did not differ on their self-reported frequency of gambling nor problems associated with gambling. At age 23, the biologically vulnerable type reported more gambling problems (M=2.93) than the behaviorally conditioned type (M=1.73), but there were no other significant differences between the groups’ ratings of gambling frequency or problems.

These findings are consistent with the presence of transdiagnostic predispositions toward externalizing and internalizing behaviors, respectively (Kotov et al., 2017). However, the roles played by such dispositions in the etiology of excessive gambling as predicted by the Pathways Model were not entirely borne out. The Pathways Model suggests heightened vulnerability to excessive and problematic gambling among antisocial-impulsivist and emotionally vulnerable subtypes compared to the behaviorally conditioned type; however, the three groups gave similar ratings of gambling frequency at ages 16 and 23. Similarly, there were no between-group differences in ratings of gambling related problems at age 16. The only significant difference in gambling outcome was that at age 23 the antisocial-impulsivist group rated their problems due to gambling as being higher than the behaviorally conditioned group. The main finding of that study was the greater gambling problems reported among the participants at age 23 who had appeared to be predisposed toward externalizing pathology at age 12. More recent longitudinal data on Quebecois adolescents and young adults has further supported the finding that youth externalizing behavior is a potent risk factor for later gambling problems. Greater baseline externalizing problems, lower baseline internalizing problems, and a less significant decrease in externalizing problems over time predicted gambling engagement (Richard, Temcheff, Fletcher, Lemieux, Derevensky & Déry, 2022). Stable high externalizing behaviours in development appear to increase one's risk of gambling behaviours in adolescence (Fletcher, Richard, Boutin, Lemieux, Déry, Derevensky & Temcheff, 2023).

The second prospective test of the Pathways Model came from a subsample of 125 first-time problem gamblers selected from two adult samples (*N*=3065 and 1056) in the Quinte region of Ontario (Mader et al., 2019). None of those people reported significant symptoms of GD in the first wave of the longitudinal study but they did so in at least 1 of 4 subsequent annual time points. Several validated measures of problem gambling were used, including the Canadian Problem Gambling Index (Ferris & Wynne, 2001), the Problem & Pathological Gambling Measure (Williams & Volberg, 2014) and the National Opinion Research Center DSM-IV Gambling Screen (Gerstein et al., 1998). One major finding of the Quinte longitudinal study, as well as a similar study conducted in Alberta by the same authors, was that problem gambling is not static; transient episodes of excessive gambling and associated problems are typical (Williams et al., 2015). To test the Pathways model, a latent class analysis was used to identify three groups of participants on the basis of self-reported impulsivity, social dysfunction, antisociality, premorbid depression, problematic substance-use and anxiety related disorders at wave 1. Compared to the other two groups, those identified as matching the behaviorally conditioned type had significantly lower scores on impulsivity measured by the Revised Neuroticism, Extraversion and Openness Personality Inventory (NEO PI-R; Costa & McCrae, 2008), and Non-support and Antisocial scores of the Personality Assessment Inventory (PAI; Morey, 1991). The group identified as matching the antisocial-impulsivist type had the highest scores on those three variables, as well as greater involvement in substance use than the first group. The third group had impulsivity and non-support scores that fell between those of the behaviorally conditioned and antisocial-impulsivist groups. However, these participants did not appear to match the emotionally vulnerable prototype as described in the Pathways model, as they had significantly higher PAI antisocial scores than the behaviorally conditioned group and none of the three groups differed significantly on measures of depressive or anxious symptoms. It is notable that the lifetime history of gambling involvement in this sample was quite lengthy overall, and that the mean age of self-recalled gambling initiation was at age 17 for the antisocial-impulsivist group. This was significantly younger than the behaviorally conditioned group who started at age 23.8. The third group recalled starting to gamble at age 19.9 and was not significantly different from the other two groups. Also, the onset of problematic gambling was significantly earlier for the third group ($M$=43.8) compared to the behaviorally conditioned group ($M$=54.0); the antisocial-impulsivist group ($M$=48.2) was not significantly different from the other two groups. The main implication of this study is that people experiencing their first episode of problematic gambling seem to vary along a dimension of psychopathology that runs from low (i.e. behaviorally conditioned) to high severity of externalizing behavior (i.e. antisocial-impulsivist).

The third prospective study to test the Pathways Model used latent class analysis to statistically identify three groups that align broadly with the Pathways Model according to self-report measures of impulsivity, anxiety, depression, drug use, and alcohol dependence that were collected from a sample of 566 Manitoban young adults (Dowd, Keough, Jakobson, Bolton & Edgerton, 2020). The stability of assignment to the three subtypes was tested using data collected at a 2-year follow up and subjected to latent transition analysis. It was found that the emotionally vulnerable problem gamblers were likely to transition into non-problem gamblers but the pattern for antisocial-impulsivist problem gamblers was quite different; they were equally likely to transition into non-problem gamblers or into the emotionally vulnerable group. These findings replicate and expand upon the dynamic and transient nature of problem gambling identified by Williams et al (2015). The major finding of this study was that individuals can progress from one subtype into another, which flies directly in the face of the Pathways Model and its assumption of prepotent personality dimensions that are stable etiological determinants of excessive gambling behavior. Moreover, when there is progression from one subtype to another, the pattern seems to be from antisocial-impulsivist to emotionally vulnerable and not the other way around. These findings are difficult to reconcile with the Pathways Model and explaining these results requires an additional theoretical construct that can accommodate this progression. Although heritable predispositions toward internalizing and/or externalizing behavior may be involved in the developmental course of GD, it seems that post-adolescents are capable of undergoing changes that may underlie their movement from one problem gambler subtype to another.

An episode of excessive gambling during young adulthood can be a life-changing experience with lasting financial and social impacts. The course of individual development might be affected to the degree that motives for gambling could shift from excitement and reward-seeking to the experiential avoidance of negative affect. This idea is consistent with findings from an analysis of the reliability of self-reported gambling motives that was conducted on 2795 participants in the Quinte longitudinal study who cited Enhancement (e.g., "because it's exciting"), Coping (e.g., "to forget your worries"), Social (e.g., "because it's what most of your friends do when you get together"), or Financial (e.g., "to win money") reasons for past-year gambling (McGrath & Thege, 2018). A mere 22% of participants cited the same primary motive across all five time points and such motivational shifts might reflect individuals transitioning amongst gambler subtypes. Similarly, an analysis of the Manitoba longitudinal data (Lambe, Mackinnon & Stewart, 2015) found the Enhancement motive to be the only significant predictor when these young adults' Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001) scores were regressed onto the Enhancement, Coping, and Social motives measured by the Gambling Motives Questionnaire (GMQ; Stewart & Zack, 2008). In contrast, PGSI and GMQ data collected from a sample of 849 Ontarian casino patrons were subjected to cluster analysis and it was found that those who endorsed both Enhancement and Coping had a significantly higher likelihood of having clinical-range PGSI scores than a second group who primarily endorsed the Enhancement motive, or a third group who endorsed neither Coping nor Enhancement (MacLaren, Harrigan & Dixon, 2012). Note that this sample had a mean age of 55.5 years and recall that the Quinte study found that gambling participation spanning late adolescence through middle age is typical of problem gamblers. It therefore seems likely that the older casino patrons in the MacLaren et al. sample had experienced protracted exposure to gambling compared to the young adults in the Manitoba longitudinal study. Chronic exposure may account for the progression of gambling motives across the Lambe et al. study (i.e. young adult gamblers' Enhancement motive) versus the MacLaren et al. study (i.e. older problem gamblers' Enhancement and Coping motives). This progression of motivational drivers of excessive gambling converges with the pattern of subtype progression described by Dowd et al. (i.e. a trajectory from antisocial-impulsivist to emotionally vulnerable subtype).

### *1.3 The Allostatic Model of Addiction.*

The Allostatic Model of addiction (Koob & Schulkin, 2019) is a widely studied and influential theory of substance use disorders that has developmental progression as a core premise. It states that human beings adapt to their environment by processes that sensitize to counteract the effects of internal and external disturbances of homeostasis, including drugs of abuse that mimic the neurophysiological effects of natural reinforcers at supraphysiological levels of intensity. These disturbances are mediated by opioid and dopaminergic neurotransmission in the nucleus accumbens of the ventral striatum that underlies subjective reward and "liking". The disturbances also involve the dopaminergic mesolimbic system that projects from ventral tegmental area of the midbrain through the medial forebrain bundle to produce motivationally potent "wanting" (Robinson & Berridge, 1993). The liking aspect creates positively-valenced feelings of excitement or joy, whereas the wanting aspect produces negatively-valenced feelings of distress and craving. Koob's model builds upon the Incentive Sensitization theory of addiction proposed by Robinson and Berridge, according to which craving and compulsive drug seeking behavior is learned through physiological habituation of drug-liking and sensitization of drug-wanting with repeated exposure.

The Allostatic Model proposes the additional sensitization of separate compensatory mechanisms that may be behavioral and/or humoral. The net cognitive, affective, and physiological response to an acute dose is conceived as being determined by two opposing systems. The first is the activation of hedonic and other modulatory systems; the second is compensatory or so-called ‘opponent processes’ that act to dampen the effects of the first system. The two systems serve to self-regulate the responses to stimulation and maintain homeostasis (Solomon & Corbit, 1974). The net effect of repeated exposure to the homeostasis-disturbing agent is reduced acute effects (i.e. tolerance) and the paradoxical increase in craving and withdrawal effects during abstinence that tend to be the inverse of the acute effects (e.g., ataxia during alcohol intoxication versus tremor during withdrawal). This accounts for the well-known phenomenon of conditioned tolerance, in which non-drug stimuli can greatly affect the magnitude of drug response through classical conditioning, and the increased likelihood of drug overdose when opiates are consumed in novel settings without conditioned stimuli that would otherwise evoke protective compensation (Siegel, 1983). To the extent that compensatory mechanisms apply to self-regulation of emotional state, the net effect is reduced acute hedonic response and tonically diminished affective tone. Thus, the term “allostasis” in the Allostatic Model refers to chronically enhanced negative affect that may promote further drug-seeking or gambling that is sustained through negative reinforcement. Development of an addiction is thereby characterized by a shift away from impulsive pleasure-seeking that is sustained through positive reinforcement, and increasingly compulsive seeking of preferred drugs and associated stimuli as a means of reducing negative affect with the addictive behavior becoming more rigid and exclusive over time as the cycle of negative reinforcement becomes predominant in the individual’s lifestyle. Thus, impulsive reward-seeking tends to wane over time in favor of compulsive punishment-avoiding behaviors that provide subjective escape from or avoidance of negative emotions. In other words, the motivation for ingesting psychoactive drugs shifts from the seeking of positive states to the avoiding of negative states.

The scope of a complete and useful theory that explains substance use or any other addictive behavior must encompass the causes, symptoms, and factors that maintain the addictive behavior. Addictions can involve a wide variety of psychoactive substances and are typically characterized by excessive consumption, loss of control, preoccupation, craving, interference with usual roles, continued use despite causing problems, reduced participation on other activities, exposure to physical hazard due to use, continued use despite exacerbation of another psychological or physical ailment, tolerance and withdrawal (American Psychiatric Association, 2013). These symptoms define the scope of behavioral phenomena that must be accounted for by a valid theory of addiction. Each of these symptoms may be either more or less pronounced depending on the substance or behavior involved. For instance, alcohol and opiates have potent ability to induce physical withdrawal symptoms upon termination of continued use, whereas withdrawal from chronic excessive cannabis use causes mostly emotional distress, and hallucinogens do not have an established withdrawal syndrome. Gambling provides a useful platform to examine the nature of addictive processes because it occurs in the absence of direct pharmacological influence on the neurobehavioral substrates that underly the behavior.

### *1.3.1 Allostatic model applied to Gambling Disorder.*

Applying the Allostatic Model to a theoretical understanding of gambling addiction must account for the criteria required for a DSM-5 diagnosis of Gambling Disorder (GD). Such a diagnosis requires at least four of the symptoms depicted in Figure 2 to be present in the absence of a manic or hypomanic episode.

The first six of the nine DSM-5 symptoms of Gambling Disorder align with the cycle that maintains addictive behavior according to the Allostatic Model as depicted in Figure 2; the symptoms numbered 7 through 9 indicate the presence of distress and/or functional impairment associated with excessive time and money being expended. Symptom #1 (need to gamble with increasing amounts to achieve desired excitement) is unique among this set of symptoms because it is the only one that is likely to occur in people without GD who may enjoy gambling but not necessarily in a compulsive way. Such participation is nevertheless necessary for the player to be exposed to the anticipation and experience of exciting wins and it may be quantified by frequency and intensity of gambling behavior. Frequency can be captured by how often the person participates in gambling activities; intensity can be captured by time and money spent gambling. In the present study, intensity of gambling upon initial exposure of novice players of Electronic Gaming Machines (EGM) was operationalized as their mean wager per spin while playing in a controlled setting.

A homeostasis-disrupting level of reward is a necessary entry point into the addictive cycle as described in the Allostatic Model. According to the model, addictive behavior is maintained by a cycle that consists of three recurring phases: binge-intoxication, withdrawal and negative affect, and preoccupation and anticipation. Betting large amounts of money and experiencing the extreme hedonic reward of winning a large prize is the gambling analog to initial exposure to powerful drugs of abuse that can stimulate the neurophysiological substrates underlying reward and motivation at supraphysiological levels. Frequent and/or intense gambling sessions may lead to clinically significant functional impairment and/or distress.

The symptoms numbered 2 through 4 align with the withdrawal and negative affect component of the cycle according to the Allostatic Model. With repeated exposure to the powerful emotional states evoked by risk taking and winning, compensatory mechanisms are acquired that promote adaptation. These allostatic processes are presumed to be a function of the normal self-regulatory processes in the limbic system and basal ganglia that underlie motivation and behavior. These are not conceived as a strengthening of executive (i.e. top down) inhibitory processes but rather as the addition of a sensitized tendency toward negative affect. By such an opponent process mechanism the systems that mediate negative affect are sensitized and remain so even when not engaged in activities that stimulate positive affect such as gambling. The net effect is a chronic increase in negative affect, as well as a tendency for negative affective states to be evoked during times of stress or as conditioned responses evoked by signals associated with punishment or non-reward. Hence, negative affect may be tonically increased by not having access to gambling (or not having money to gamble with), after losing money gambling, or by other sources of distress. At this point, a person with GD may experience a compulsion to gamble that is motivated through negative reinforcement as a means of reducing the negative affect. This would explain the trend toward greater pathology as experienced gamblers progress from Enhancement-driven gambling as a means of seeking reward (i.e. which mirrors the antisocial-impulsivist prototype according to the Pathways model) to Coping-driven gambling as a means of self-regulating negative affect (i.e. the Emotionally Vulnerable prototype). Thus, when viewed as exemplars of the processes believed to be in play according to the Allostatic model, symptom #1 represents the binge phase, symptoms numbered 2, 3, and 4 represent the withdrawal and negative affect phase, and symptoms numbered 5 and 6 represent the preoccupation and anticipation phase. As this cycle recurs during an episode of problem gambling, symptoms 7 through 9 may emerge and represent the transition from recreational gambling to problematic GD.

### *1.4 Electronic Gambling Machines and Risk-Taking.*

The mechanisms by which EGMs influence players' risk-taking behavior have been well documented in laboratory and field research (Schüll, 2012). The overall goal of effective EGM design is to entice the player into betting large amounts of money on each iteration of the game so that when they win, the prize amount is sufficiently rewarding to stimulate ongoing play over an extended duration and to leave the player open to returning to play the game in the future. The monetary amounts wagered by players are *prima facie* valid measures of risk-taking. Variations in the willingness of different novice players to assume risk when exposed to an identical game can be attributed to the characteristics of players that are associated with such risk-taking. For example, wealthy novice players might find a moderately large prize to be less rewarding than less affluent player given the same prize. Likewise, player who have less temperamental sensitivity to reward might find a moderately-sized prize to be less rewarding than do players with higher reward sensitivity. If such variations exist, then it follows that the design of modern EGMs might allow them to capitalize on the between-subject variations that pose a susceptibility to GD.

It has long been recognized that EGM games can be made either more or less habit forming by game designers (Griffiths, 1993), and these games have changed a great deal since their legalization in 1985. The oldest games were electromechanical "one armed bandit" devices that typically had three vertically oriented reels that would spin rapidly when the player pulled a lever to initiate play. When the reels stopped spinning, the symbols printed on them would land in alignment with a horizontally oriented 'payline'. The player would win a cash prize if all three reels had identical symbols aligned with the payline. Such machines randomly delivered wins of various amounts, but the arrangement of symbols on the reels ensured that the prize amounts delivered over many spins would ultimately be less than the amounts spent by players. This difference between players' expenditures and the prizes is known as the 'hold', and the average amount returned to players as prizes is the 'payback percentage'. The payback percentage is a software-determined value, which is approximated over the lifespan of an EGM game, and which is typically between 80% and 98%, meaning that the machine holds an average of between 2% and 20% of the money spent by players. Early three-reel machines could be set up to have different holds by changing the physical reels, but modern versions are computerized with the game outcomes programmed by software that uses a random number generator to determine results of individual spins and ensuring the desired hold over many repeated plays. The most modern machines have done away with the physical reels altogether, and simply display pictures of spinning reels on a computer touchscreen. Different versions of EGM games can be presented to players with different design themes, animated images and sounds, all the while using the same underlying software protocol to set the hold. Some machines, particularly Video Lottery Terminals that appear in licensed non-casino venues in most Canadian provinces, allow players to select from many different games that appear different whilst having the same hold. Regardless of the physical manifestation of the game played on EGM, the programmed hold cannot be influenced by the player (Harrigan, Dixon, MacLaren, Collins & Fugelsang, 2011).

Nevertheless, there are other structural elements of modern EGMs that experimental neuroimaging studies have shown to promote excessive gambling behavior by manipulating incentive salience under conditions of uncertainty (Clark, Boileau & Zack, 2018). It has been alleged that modern EGMs have high addiction potential because *"EGMs are intentionally designed with carefully constructed design elements (structural elements) that modify fundamental aspects of human decision-making and behaviors, such as classical and operant conditioning, cognitive biases, and dopamine signals."* (Yücel, Carter, Harrigan, van Holst & Livingstone, 2018). The interaction of EGM features and basic human learning processes is a central route through which gambling behavior may become habitual and problematic.

Modern EGMs appear designed to diminish players' ability to effortfully control their own behavior and resist the emotional pull of reward anticipation. Despite the hold being a fixed entity, modern EGMs communicate an impression to players that they can exert some influence over their chances of winning money (please see Dixon, Harrigan, Sandhu, Collins & Fugelsang, 2010 for an example of a modern EGM game called Lucky Larry's Lobstermania). Since different machines can be programmed with different holds, players can learn to identity the machines with the least disadvantageous payback percentages and prefer to play them (Dixon, Fugelsang, MacLaren & Harrigan, 2013). Modern EGM games also typically have five reels instead of three, and they permit players to make independent but simultaneous bets on multiple paylines. When betting on a single payline, the player is likely to encounter a high frequency of misses that consist of more than one winning symbol being on the payline, but without enough matching symbols to win a prize. Indeed, the matching symbol may be displayed but in the wrong location. These 'near-misses' have been shown to occur with high frequency in three-reel games (Harrigan, 2008), and to elicit sympathetic arousal (Dixon, Harrigan, Jarick, MacLaren, Fugelsang & Sheepy, 2011), while promoting continued play (Dixon, MacLaren, Jarick, Fugelsang & Harrigan, 2013) by activating central mechanisms of reward (Sescousse, Janssen, Hashemi, Timmer, Geurts, Ter Huurne, Clark & Cools, 2016). On modern games with multiple paylines, players can avoid such missed opportunities by increasing the number of paylines they place wagers upon, which poses an additional consequence. Since each payline is technically an independent opportunity to make a bet, there are more opportunities to win more than the amount wagered per line when multiple wagers are placed simultaneously. Indeed, it is possible to win on several paylines and even a single win among the many wagers will be celebrated with victorious animations and reinforcing sounds (Dixon, Harrigan, Santesso, Graydon, Fugelsang & Collins, 2014). However, placing wagers on multiple paylines requires spending more money per spin. One very common outcome known as 'Losses Disguised as Wins' (LDWs; Dixon, Harrigan, Sandhu, Collins & Fugelsang, 2010) occurs when the total cost per spin is greater than the total of all amounts that are won on the paylines. LDWs increase the rate at which subjective signals of winning are delivered and thereby shrink the average length of losing streaks (Harrigan, Dixon, MacLaren, Collins & Fugelsang, 2011), and increase behavioral reinforcement of continued play (Dixon, Graydon, Harrigan, Wojtowicz, Siu & Fugelsang, 2014), despite a high frequency of positively valanced outcomes being LDWs which result in monetary loss. Moreover, players may adjust the amount of money wagered per payline with winnings that are directly proportional to the amounts that they wager, so they can increase or decrease their risk and anticipated reward at will (Haw, 2009). Experienced players are fully aware of the control they can exert over the rate of reinforcement by adjusting the number of paylines they bet upon, as well as the amount of time it will take for them to deplete their funds by titrating their wagers (MacLaren, 2015). Nevertheless, they prefer to play with the high reinforcement rate that comes from high expenditure on multiple paylines (Templeton, Dixon, Harrigan & Fugelsang, 2015). Such preference for immediate reward and disregard for expenditures is characteristic of externalizing behavior. The control they exert is quite real in terms of their choice of lower hold machines, high reinforcement rate, and large magnitude wins, but there is absolutely nothing that a player can do to shift the hold from its programmed setting and improve their odds of winning money (Harrigan, MacLaren, Brown, Dixon, & Livingstone, 2014). Indeed, the behaviors they must do to increase the rate of subjective reinforcement (i.e. betting on multiple paylines per spin to increase frequency of wins and LDWs), and the magnitude of wins (i.e. placing larger bets per line to increase the absolute but not proportional size of any winnings), merely serve to increase the amounts that they spend per spin. Finally, each spin takes approximately three seconds to complete, and players report immersive and dissociative subjective states during episodes of continued play (Murch & Clark, 2019), and this appears to motivate escapist gambling in those who have individual characteristics that predispose them toward addictive behavior (MacLaren, Ellery & Knoll, 2015). Such reliance on experiential avoidance as a means of temporarily escaping one's concerns may be a manifestation of an internalizing tendency.

### *1.5 The Iowa Gambling Task, immediate reward and externalizing.*

The Iowa Gambling Task (IGT; Beshara, 1994) is a computerized neuropsychological test of decision making in which participants select cards from simulated decks that contain rewards and losses of various sizes. The IGT measures individual sensitivity to immediate versus delayed reward and performance is negatively affected by lesions in the ventromedial prefrontal (José, Samuel & Isabel, 2020), an area believed to be critical in the integration of sensory, affective, and cognitive information when making decisions under conditions of uncertainty (Damasio, 1996). Decision-making assessed by the IGT has also been found to be greatly diminished in people with GD, such that they prefer choices that produce immediate large rewards at the cost of long-term losses, over smaller immediate rewards that lead to greater delayed rewards. Meta-analysis of seven primary studies found a large standardized mean difference (Cohen's *d* = 1.03) between groups of people with GD and healthy control groups (Kovács, Richman, Janka, Maraz & Andó, 2017). Although the extent to which the GD groups were involved in EGM play is not known, it is interesting to note some of the similarities between the choices available to experimental participants as they perform the IGT and the options that are available to EGM players. The rate of reinforcement and the magnitude of reinforcement are both controllable in each of these tasks. It would therefore seem likely that novice players who have a predisposition toward disadvantageous decision-making would be likewise affected in their behavior by either the IGT-2 or by a modern EGM.

The IGT captures individual variations in the balance between sensitivity to immediate rewards versus the fear of aversive outcomes. Disproportionate activation of impulsive or aggressive behavior by signals associated with reward is the essence of externalizing behavior. This has been borne out in systematic reviews of the IGT in people with substance use disorders (Kovacs et al., 2017) and other externalizing pathology (Buelow & Suhr, 2009).

One of the major predictions of the present study was a significant correlation between differential choice of disadvantageous decks on the IGT-2 (i.e., choices that result in large wins but with losses that accumulate faster than the winnings) and novice players' average expenditure per spin on an EGM game. Support for this hypothesis would suggest that people with poor decision-making are at greater risk of excessive EGM expenditure, even among novice players. Such a finding would be consistent with the Pathways Model as it would reflect the behavior of some novices who have externalizing tendencies. They would be potential gamblers of the antisocial-impulsivist subtype. Such a finding would also be consistent with the Allostatic model, as high betting motivated by reward-seeking would be expected of novices who have not yet adapted to the homeostasis-disrupting effect of recurrent gambling episodes.

### *1.6 The Wisconsin Card Sorting Task, cognitive flexibility and internalizing.*

The Wisconsin Card Sorting Task (WSCT; Kongs, Thompson, Iverson & Heaton, 2000) is a neuropsychological test of cognitive flexibility in which participants must sort cards according to the color, shape, or number of symbols on the cards, and then sort them according to a different dimension when the sorting rule changes without warning. Performance of the task involves response inhibition, working memory and perceptual set-shifting, and these components appear to be mediated by lateral prefrontal cortex, anterior cingulate and inferior parietal lobule. Perseveration has been found to be a problem for people with GD attempting the WCST, such that they persist in making judgements according to one perceptual dimension despite a rule change signifying the need to attend to another perceptual dimension of the stimuli (i.e. colour, form, or number). Meta-analysis of nine primary studies found a medium-sized standardized mean difference (Cohen's $d = 0.51$) between groups of people with GD and healthy control groups (van Timmeren, Daams, Van Holst & Goudriaan, 2017).

The WCST is a complex task that requires executive control to attend to one aspect of the cards while disregarding other dimensions, and then to shift one's perceptual set to focus on a different dimension and hold that in working memory while sorting the cards. This flexibility of executive control seems to tap the mindful focusing of attention to the exclusion of competing cognitions. A deficiency in this ability to cognitively self-regulate would be a likely contributor to the pessimistic and avoidant ruminations that are typical of internalizing pathology. This notion is supported by consistently high WCST perseverative errors across studies of depression

(Parkinson, Rehman, Rathbone & Upadhye, 2020), obsessive-compulsive disorder (OCD; Henry, 2006) and eating disorders (Westwood, Stahl, Mandy & Tchanturia, 2016). It should be noted that these reviews found depression and OCD to be associated with poor performance on many cognitive tasks.

One of the major predictions of this study was a significant correlation (e.g., $r > .30$) between WCST perseverations and average expenditure per spin on an EGM game. Support for this hypothesis would suggest that people with poor executive function are at greater risk of excessive EGM expenditure, even among novice players. Such a finding would be consistent with the Pathways Model as it would reflect the behavior of some novices who have internalizing tendencies.

### *1.7 Difficulties in Emotional Regulation Scale and emotional self-regulation.*

Two exploratory self-report measures were utilized in the study that were intended to characterize a phenomenon whereby people who report greater difficulty with emotional self-regulation may be particularly influenced by the hedonically pleasurable experience of large EGM wins, and hence report more positive appraisals of the games after playing them. To explore this possibility, a self-report scale known as the Difficulties in Emotional Regulation Scale (DERS; Gratz & Roemer, 2004) was completed by participants before the IGT, WCST, and EGM game. Afterward they also completed a 10-item questionnaire consisting of the Positive Affect and Flow subscales (Dixon, Gutierrez, Stange, Larche, Graydon, Vintan & Kruger, 2019) taken from the core version of the Gaming Experiences Questionnaire (IJsselsteijn, de Kort, Poels, Jurgelionis & Bellotti, 2007).

Ratings of emotion regulation on the DERS have been found to be poorer in an Australian sample of treatment seeking problem gamblers compared with clinical and nonclinical control groups (Williams, Grisham, Erskine & Cassedy, 2012), and in a Spanish sample of treatment seeking problem gamblers compared with a nonclinical control group (Jauregui, Estevez & Urbiola, 2016). Correlational studies in student and young adult samples have found significant associations between DERS subscale scores and a self-report measure of problem gambling (Estevez, Jauregui, Sanchez-Marcos, Lopez-Gonzalez & Griffiths, 2017), as well as escapist gambling motives (Weatherly & Miller, 2013; Weatherly & Cookman, 2014), and impulsivity among young adults who gamble (Schreiber, Grant & Odlaug, 2012). Correlational studies have also found significant associations between DERS scores and self-report measures of problem gambling in an adult sample from Turkey (Elmas, Cesur & Oral, 2017) and an online sample (Poole, Kim, Dobson & Hodgins, 2017).

The Pathways Model is consistent with evidence for different subtypes of problem gamblers (Vachon & Bagby, 2009) and that people may differ in their motives for excessive gambling (Stewart & Zack, 2008). Ratings of gambling to temporarily dissociate from negative emotional states have been found to be a strong correlate of problem gambling among EGM players (MacLaren et al., 2012, 2015; Thomas et al., 2009). Although the present study used a student sample that was comprised mainly of novice gamblers, it was predicted that those with higher DERS scores would be more prone to risk-taking as a function of their having less self-control. Such a finding would imply vulnerability to excessive gambling among the subset of novices who have that personality feature. At a later stage of involvement in gambling, such players might seek immersive EGM play as a form of escapism and avoidant coping.

This study was designed to test several predictions about player characteristics that would impact their betting behavior on a simulated EGM game. First, it was predicted that high reward sensitivity operationalized by the Iowa Gambling task would correlate positively with betting larger amounts. Secondly, it was predicted that cognitive flexibility as measured by the Wisconsin Card Sorting Task would correlate negatively with the betting behavior. Third, it was predicted that self-reported problems with emotional self-regulation as measured by the DERS would correlate positively with betting behavior. Finally, it was predicted that increased betting behavior would coincide with ratings of interest in playing real EGM games in the future. These predictions were tested in a sample of university students. Although results derived using this sample may not fully represent the entire population of young adults when initially exposed to electronic games of chance, they are likely to provide reasonable fidelity in testing the predictions of interest.

## 2.0 Methods

### *2.1 Participants*

All procedures were approved by the Memorial University Interdisciplinary Committee on Ethics in Human Research. One hundred undergraduate student volunteers were recruited using an online participant research experience pool. Each participant was remunerated with two research experience points toward their introductory Psychology course grade. Each participant was also promised at least one ticket that would be entered into a random draw for a $500 prepaid Visa card. They were told that the study would take approximately 90 minutes to complete and that the number of draw tickets allocated to them would be contingent upon their performance in the laboratory tasks. Participants were tested individually by a Research

Assistant who was blind as to the testing condition to which each participant was randomly assigned. A detailed declaration of informed consent was signed by each participant after reading it and having any questions answered by the Research Assistant.

Participants were screened for possible problematic gambling using the 9-item Problem Gambling Severity Index of the Canadian Problem Gambling Inventory (PGSI; Ferris & Wynne, 2001). Participants with PGSI scores greater than 3 were allowed to complete all the experimental tasks except for the Slot Machine game. The final sample consisted of 91 participants with PGSI scores that fell within the 'Nonproblem or Low Risk' range (i.e. 0-2). Participants ages ranged from 18-53 years (M=21.5; SD=4.86). Sixty participants (65.9%) identified as female and 31 identified as male (34.1%).

### *2.2 Measures*

Participants completed two self-report questionnaires (PGSI and DERS) and two neurocognitive tests (IGT-2 and WCST-64). They then watched a video explaining how to play the EGM game, which they then played for up to 15 minutes, followed by an abbreviated form of the GEQ. The total time to complete these tasks was approximately 1.25 hours. Participants also completed the Internet Addiction Test (IAT; Young, 1998) as part of a separate study. Their scores ranged from 22-67 out of 100 possible points on the IAT (M=39.2, SD=10.2). It is noted that generalizing results from this student sample to the wider population of gamblers may be limited by the degree to which the measures invariantly reflect the constructs they are intended to measure across the sample and the population.

### *2.2.1 Problem Gambling Severity Index (PGSI)*

The 9-item PGSI of the Canadian Problem Gambling Inventory (Ferris & Wynne, 2001) is commonly used in population surveys and as a measure of gambling involvement. The PGSI was completed as a self-report questionnaire. The PGSI items were answered with a 4-point Likert scale (0 = never, 1 = sometimes, 2 = most of the time, 3 = always or almost always) and summed to give a total score that could range from 0 to 27. The original development of the PGSI was based on self-report data from a Canadian population survey of 3,120 adults who completed the PGSI. Concurrent validity was tested by co-administration of the South Oaks Gambling Screen (Lesieur & Bloom, 1987), test-retest reliability was examined in a subsample of 417 respondents who repeated the CPGI approximately 3-4 weeks later, and external validity was tested by clinical interview of 143 who also underwent a clinical interview. In that study, the inter-item reliability was Cronbach's alpha = 0.84 and optimal scoring ranges were derived for classifying respondents. These cutoffs were 0 (nongamblers and non-problem gamblers), 1-2.5 (low-risk gamblers), 3-7.5 (moderate-risk gamblers), and 8-27 (problem gamblers).

In the present study, participants completed the 9 items of the PGSI with questions about their age and sex. Those with scores of 3 or greater (i.e. low-risk, moderate-risk, and problem gamblers) were allowed to participate in the study but they did not play the slot machine game and their data were excluded from analyses.

### *2.2.2 Difficulties in Emotion Regulation Scale (DERS)*

The DERS (Gratz & Roemer, 2004) is a 36-item scale that measures self-reported patterns of emotional regulation. The DERS items were answered with a 5-point Likert scale (1 =

almost never, 2 = sometimes, 3 = about half the time, 4 = most of the time, 5 = almost always) and summed to give a total score that could range from 36 to 180.

The DERS contains six subscales with questions about: the tendency to respond to a negative emotion with a secondary negative emotion (nonacceptance), the ability to engage in goal directed behavior while experiencing negative emotion (goals), the ability to refrain from acting impulsively when experiencing negative emotion (impulse control), the tendency to attend to emotional states (awareness), the belief that little can be done to effectively regulate emotions (strategies), and the ability to clearly identify emotional states (clarity). A higher total score indicates greater difficulties regulating emotions in general. The item content of the DERS is mostly focused on the regulation of negative emotions.

The original development of the DERS (Gratz & Roemer, 2004) used self-report data from 358 undergraduate university students aged 18-55, and the scale had high inter-item reliability (Cronbach's alpha = .93). Inter-item reliability of DERS in the present sample was Cronbach's alpha = .95; see Table 1 for other descriptive statistics.

### *2.2.3 Iowa Gambling Task (IGT-2)*

The IGT-2 (Bechara, Damasio, Damasio & Anderson, 1994) is a computerized test of decision-making under risky conditions. Participants start with a "loan" of $2000 in simulated money and attempt to earn enough money to reduce the debt by making 100 selections from four simulated card decks labelled A, B, C, and D. All card draws result in a win, but the cards from decks A and B result in wins that average $100 and the cards from decks C and D result in wins that average $50. Some cards also result in a loss that is concurrent with the amount won. The cards in deck A have a 50% chance of having a loss of $250. The cards in deck B have a 10%

chance of having a loss of $1250. The cards in deck C have a 50% chance of having a loss of $50. The cards in deck D have a 10% chance of having a loss of $250. With these parameters, repeatedly choosing cards from decks C and D leads to net positive results and choosing from decks A and B leads to net negative results. People who are relatively insensitive to signals of reward (i.e. large prizes) or who are sensitive to signals of punishment (i.e. losses exceeding gains) will learn to choose cards from decks C and D. Others who are relatively sensitive to signals of reward or who are insensitive to punishment will continue to choose cards from decks A and B. The main variable of interest is the difference between the number of cards drawn from advantageous decks C and D minus the number of cards drawn from disadvantageous decks A and B. A higher number of Deck A selections indicates higher sensitivity to immediate rewards.

#### *2.2.4 Wisconsin Card Sorting Task (WCST-64)*

The 64-item computerized version of the WCST-64 (Heaton & Psychological Assessment Resources Staff, 2000) was used to measure cognitive inflexibility in the form of response perseveration. Participants are instructed to sort cards according to a concept of shape, colour, or number. The shapes, colours, and numbers of the figures shown on the cards are orthogonal. Feedback indicating correct or incorrect sorts is given after each card is sorted. After 10 consecutive correct sorts, the concept according to which the participant must sort subsequent cards is changed. Inability to begin sorting according to the new dimension can result in perseveration errors, in which the participant continues to sort cards according to the expired rule. Each participant’s percent perseveration error will be the main variable of interest. A higher number of perseverative errors indicates greater difficulty with cognitive flexibility.

Conceptually, low cognitive flexibility might be associated with a tendency toward rigid patterns of thought that can underlie or maintain maladaptive emotional or behavioral aspects of psychopathology.

### *2.2.5 Gaming Experiences Questionnaire (GEQ)*

Ten items taken from the Gaming Experiences Questionnaire (GEQ; IJsselsteijn, de Kort, Poels, Jurgelionis, & Bellotti, 2007) were selected that measure self-reported Immersion (i.e. “I was fully occupied with the game”, “I forgot everything around me”, “I lost track of time”, “I was deeply concentrated in the game”, “I lost connection with the outside") and Positive Affect (i.e. “I thought it was fun”, “I felt happy”, “I felt good”, “I enjoyed it”, “I felt content or excited") associated with computer gaming. Items from these two subscales were chosen to replicate the 10-item measure used by Dixon and colleagues (2019). The GEQ items were answered with a 5-point Likert scale (0 = not at all, 1 = a little bit, 2 = somewhat, 3 = a lot, 4 = extremely) and summed to give a total score that could range from 0 to 40.

As noted by Dixon and colleagues, the originators of the GEQ (Poels, de Kort, & IJsselsteijn, 2007, c.f. Dixon et al., 2019) reported inter-item reliability for the GEQ subscales from .71 to .89. Inter-item reliability of the 10 GEQ items used in the present sample was Cronbach’s alpha = .91; see Table 1 for other descriptive statistics.

## ***2.3 Procedure***

Participants were tested individually in a Psychology department lab (SN1056) on Memorial University, St. John’s campus. A detailed declaration of informed consent was signed by each participant after he or she read it and had any questions or concerns addressed to his or her satisfaction by the Research Assistant.

Participants completed two brief self-report questionnaires about excessive gambling (PGSI) and emotional regulation (DERS), as described above. They were then instructed to complete computerized tasks measuring decision-making (IGT-2) and perseveration (WCST-64), as described above. The order of these two neurocognitive tasks was counterbalanced to control for potential practice effects, with half of the participants completing the IGT-2 first and WCST-64 second, and half completing the WCST-64 first and the IGT-2 second. The order of testing for each participant was randomized by selecting 1 of 48 sealed envelopes that were prepared before the start of the experiment and that each contained the test order for a participant. The stack was used for the first batch of 48 participants and then they were resealed, shuffled, and used for the remaining participants. The instructions given to participants who had PGSI scores of 3 or greater were placed back into envelopes and placed in the stack. Data collection continued until 100 participants completed the testing.

Participants with PGSI scores less than 3 (i.e. nongamblers and low-risk gamblers according to PGSI) then proceeded to the simulated EMG task. The restriction of only including participants with scores less than 3 on the PGSI was intended to limit the sample to include only novice and non-problem gamblers. It was anticipated that a small number of participants would report PGSI scores of 3 or greater; in fact, there were 9 out of 100 such participants. They were allowed to complete the experiment but not to play the EGM game. Participants then watched a video explaining how to play the EGM game. Versions of the video were constructed with segments that demonstrated playing with maximal and minimal lines crossed with maximal and minimal wagers per line. All possible combinations were presented and arranged in a Latin

Square design to control for potential order effects. All of the videos had the same introductory and concluding segment.

Participants then played a home computer version of a commercially available EGM game called Lucky Larry's Lobstermania, which has been described elsewhere (Dixon, Harrigan, Sandhu, Collins & Fugelsang, 2010). The game was presented using a touchscreen, with the same settings described by MacLaren (2015). The game had a setup identical to that used by MacLaren (2016), and participants had full control over the paylines and the credits they could bet per payline. Participants were motivated to attempt to earn credits by the promise of earning tickets toward a draw for a large monetary prize (a $500 prepaid Visa card). A similar procedure was used in a past experiment conducted by this author (MacLaren, 2015) and it was found to provide adequate motivation for participants to participate actively in the experimental gambling simulation. At the beginning of the test block, the following instructions were read to the participants:

> "I want to see how you can use what you know about the game to increase your chances and have fun playing. So, I want to see you playing at your best. I will start you out with 5,000 credits and let you play for up to 15 min or until you get down to below 250 credits. You can adjust the number of paylines you want to bet on and the number of credits to bet per line, and you can play as fast or slow as you like throughout the 15 minutes. You are not playing for real money so focus on showing how well you can play it. I also have something to motivate you to do your best. At the end of the experiment, we are going to be holding a draw for a $500 prepaid Visa gift card. There will be 100 people in the experiment and one of you will be randomly chosen to get that prize. You will get tickets for the draw by playing well and winning. At the end of your 15-minute session, I am going to write down how many credits you have left remaining, and you will get 1 ticket for every 100 credits you have showing on your balance. So, for example if you have 1000 credits at the end I will give you 10 tickets but, if you have 10000 credits, I will give you 100

tickets! Everyone in the experiment will get at least 1 ticket for the draw, even if you go down to zero, but the more credits you have, the better your chances. Also, the person who has the most credits among the 100 of you will get one extra ticket as a bonus for being the top player."

Participants played for up to 15 minutes or until their credit balances fell below 250 (i.e. the amount required for a maximal bet). The screen was recorded during each play session using Camtasia software and the videos were reviewed offline. The paylines and credits bet per line each spin were read off the video recordings and were manually entered into a spreadsheet for analysis. Each participant's mean paylines per spin, mean credits wagered per line on each spin, and mean total amount wagered per spin were calculated. Participants then completed the GEQ to provide feedback about the game and were dismissed.

## 3.0 Results

### *3.1 Descriptive statistics and correlations.*

Descriptive statistics for the DERS, IGT-2, WCST-64, EGM betting behavior, EGM game outputs, and GEQ are reported in Table 1. Pearson correlations between DERS, IGT-2 and WCST-64 and measures of EGM betting behavior are shown in Table 2. There was a significant *negative* correlation between DERS total scores and participants' average bets per spin ($r$=-.31, $p$=.003). A scatterplot of DERS total scores versus average wagers is depicted in Figure 4. It is noted that the distribution of average wagers is quite skewed, with many participants placing relatively small average wagers and few participants making comparatively high average wagers. The relationship between average wagers and DERS may be attributable to the contribution of average bets per spin to the total amounts wagered, which correlated significantly with DERS (*r*=-.28, *p*=.008), rather than the average number of lines which was not significantly correlated with DERS (*r*=-.06, *p*=.576). As shown in Table 1, this pattern of findings was consistent across most of the subscales that make up the total score. The negative correlation between DERS and EGM wagers was an unexpected finding.

There was a significant negative correlation between IGT-2 total scores and average wagers per spin (*r*=-.22, *p*=.039). This indicates that higher reward sensitivity is associated with higher wagers. This relationship appears to be attributable to the contribution of average bets per spin to the total amounts wagered, which correlated significantly with IGT-2 total scores (*r*=-.23, *p*=.030), rather than the average number of lines which was not significantly correlated with IGT-2 total (*r*=-.10, *p*=.347). This correlation was strongest in the third of 5 blocks of IGT-2 trials, as this was the only block with a total score that correlated significantly with average wagers (*r*=-.21, *p*=.049). The correlation between IGT-2 scores and average wagers appears attributable to selections of cards from Deck A, which was the only deck that correlated significantly with average wagers (*r*=.30, *p*=.005). Further analyses of the contribution of IGT-2 to EGM play behaviors used Deck A selections as the predictor variable representing IGT-2 performance. A scatterplot of IGT-2 Deck A selections versus average EGM wagers is depicted in Figure 5.

There was a nonsignificant negative correlation between WCST-64 Perseverative Errors and average wagers per spin (*r*=.16, *p*=.129). This relationship appears to be attributable to the contribution of average number of lines played to the total amounts wagered (*r*=.20, *p*=.064) rather than the average bet per line which was clearly not correlated (*r*=.12, *p*=.256). As shown in Table 1, there were no other measures of WCST-64 performance that correlated with EGM play behaviors. Further analyses of the contribution of WCST-64 to EGM play behaviors used

Perseverative Errors as the predictor variable representing WCST-64 performance. A scatterplot of WCST-64 Perseverative Errors versus average EGM wagers is depicted in Figure 6.

### *3.2 Prediction of EGM behaviors.*

Hierarchical regression analysis tested the relative magnitude of contributions of 3 predictors of interest (i.e. DERS total score, IGT-2 deck A selections, and WCST-64 perseverative errors) to average EGM wagers as criterion. The effects of age (in years) and sexual identity (categorically coded as female=2; male=1) were entered in the first block of the hierarchical regression. This was intended to statistically control for any potential spurious relationships between these demographic variables and the predictor and criterion variables. The remaining predictors were simultaneously entered into the second block of the regression. To check for potential redundance amongst predictors, a set of Pearson correlations was calculated. As shown in Table 3, IGT-2 deck A selections were negatively correlated with WCST-64 perseverative errors ($r$=.21, $p$=.042) but neither of these predictors were correlated significantly with DERS total scores. As shown in Table 4, the regression model significantly predicted Average Wager Per Spin ($R^2$=.198, $F_{(5,85)=}$4.19, $p$=.002). The significant predictors were DERS total scores and the number of IGT deck A selections. This indicates that the Average Wager Per Spin was significantly increased by participants having low difficulty in self-regulating negative emotions and by heightened sensitivity to immediate rewards.

Follow up analyses were conducted with the same set of predictor variables but with Average Bet Per line and Average Lines Played as the criterion variables. The follow up analyses found a similar pattern when average EGM wagers per line was the criterion variable, but non-significance when average lines played was the criterion. As shown in Table 4, when Average Bet Per Line was regressed onto age and sex, followed by DERS total scores, IGT Deck A selections, and WCST-64 Perseverative Errors, the model was significant ($R^2$=.171, $F_{(5,85)}$=3.52, $p$=.006) and only significant predictor was the DERS total scores.

As shown in Table 6, when Average Lines Played was the criterion, the model was not significant ($R^2$=.073, $F_{(5,85)}$=1.34, $p$=.256).

### *3.3 EGM play behaviors and game outcomes.*

As shown in Table 7, larger mean wager per spin was positively correlated with higher frequency of wins greater than the total amount bet, wins that were less than the total amount bet, and players' largest wins in the play session being larger. As expected, larger mean wager per spin was also correlated negatively with the frequency of losing spins in which no money was won. The frequencies of wins, losses disguised as wins, and losses all had substantially larger correlations with the number of lines played rather than with the average amount bet per line. This was also true of the frequency of Bonus Features, which was expected because playing more lines provides greater opportunity to trigger the Bonuses. The magnitude of the largest amount won in the session was correlated somewhat more positively with the amounts bet per line than with the average number of lines played, which was expected because the nominal size of wins is proportional to the bets per line.

Importantly, the effects of player behavior did not have significant correlations with the Payback Percentage, which is the proportion of total wagers that were returned to the players as prizes (see Table 7). These findings replicate past findings by Harrigan and colleagues (2014) that indicate players have considerable control over the frequency and nominal size of the prizes that are won during an EGM play session, but they do not control their chances of profiting monetarily from playing EGMs. Descriptive statistics for Payback Percentage are given in Table 1. Sixty of the 91 participants (65.9%) had a Payback Percentage that was less than 100%. It is noted that these findings were strongly affected by one participant who stopped playing after betting a total of 21 credits on 12 spins, two of which resulted in wins of 350 and 987 credits. That outlier's Payback Percentage was 18.9 Standard Deviations from the mean of the other 90 participants, who had mean=93.0%, median=87.5%, SD=46.7%, min=1.32%, max=285.2%. If that outlier were excluded, the correlations reported in Table 7 involving Payback Percentage would be $r$=.09 ($p$=.380) for Average Wager Per Spin, $r$=.07 ($p$=.530) for Average Bets Per line, $r$=.11 ($p$=.284) for Average Lines Played, $r$=.28 ($p$=.009) for GEQ Total, and point biserial $r$=.21 ($p$=.047) for Would Play for Money.

### *3.4 Game outcomes and player ratings of the game.*

Table 7 contains the correlations between the participants' post-play ratings of the EGM and the frequencies of wins, losses disguised as wins, losses and bonus features, as well as the nominal size of largest wins and the proportion of wagers returned to players in the form of prizes. As expected, more positive GEQ ratings were correlated significantly with greater frequency of wins, losses disguised as wins, and bonus features, as well as fewer losses. The GEQ ratings were also correlated positively with the nominal size of players' largest wins and the total amounts that they won relative to the total amounts that they wagered. These findings suggest that greater risk-taking results in game outputs that are associated with a more subjectively enjoyable gaming experience.

When asked whether they would play the EGM game outside the lab for real money if given the chance, 21 of the 91 participants (23.1%) indicated that they would do so and 70 (76.9%) indicated that they would not, and these proportions were significantly different than 50% (binomial $p<.001$). Point bi-serial correlations between this dichotomous choice of playing this game for money and frequencies of wins, losses disguised as wins, losses, bonus features and size of largest wins were all statistically significant (see Table 7). If these lab simulation findings generalize to real-world settings, they suggest that positive game outcomes may increase players' willingness to play EGMs in the future.

## 4.0 Discussion

This study was focused on etiological factors that may be involved in the progression of novice EGM players toward development of gambling behaviors that may become problematic and lead to GD. The focus on EGMs was informed by past research that has indicated that this form of gambling is the most hazardous in terms of its contribution to problems associated with gambling. This appears to be due to the continuous nature of the activity and design features that promote a misperception among players that the frequency and magnitude of winning game outcomes can be partially controlled by strategic play. Such contortions of reality are commonly attributed to problem gamblers' proclivity toward so-called "cognitive distortions" (e.g., Jefferson & Nicki, 2003), but the origin of such beliefs lies also in the EGMs that actively promote them (Schüll, 2012). Indeed, the present study replicated the well-established finding that players' chosen style of playing EGMs aligns with the frequency of audiovisual signals of reward and without due regard to the true percentage of wagers that are returned as prizes (Dixon et al., 2010, 2014; Harrigan et al., 2011, 2014, MacLaren, 2015).

## *4.1 Key Findings*

### *4.1.1 Novice players' reward sensitivity predicts higher EGM wagers.*

The Pathways and Allostatic models both suggest that individual sensitivity to reward, as operationalized by poor performance on the IGT-2, would correlate with betting larger amounts on the EGM game. The Pathways Model predicts this because antisocial-impulsivist gamblers are believed to seek risk and to be hypersensitive to reward. The Allostatic Model similarly predicts that people who are hypersensitive to reward may gamble excessively because they are motivated by the anticipation and euphoria of winning. This major hypothesis was supported by the finding that the frequency of Deck A selections in the IGT-2 correlated with participants' Average Wagers Per Spin on the EGM. This effect appears to have been due to greater Average Bets Per Line increasing the Average Wager Per Spin rather than the number of Average Lines Played. Consequently, the number of Deck A selections was a significant predictor of Average Wager Per Spin and Average Bet Per Line in regression analyses. Those regression analyses indicated that Deck A selections and DERS scores made significant independent contributions to these indicators of betting behavior, while age, sex and WCST Perseverative Errors were not significant predictors.

### *4.1.2 Novice players' cognitive flexibility does not predict EGM betting behavior.*

Meta-analysis by van Timmeren and colleagues (2018) has shown that people with GD have poorer cognitive flexibility than healthy controls, as operationalized by perseverative error on Wisconsin Card Sorting Tasks. Such executive deficit may be predicted from the Pathways Model as a predisposing factor in the etiology of GD among antisocial-impulsivist and

Emotionally Vulnerable gamblers. It follows that novices at the lower end of the population distribution of executive control might have poor WCST-64 performance and also bet large amounts upon initial encounter with an EGM. If such an effect exists, it would seem likely to be statistically detectable in the present sample of young adults due to individual variations in prefrontal cortex maturation. The complete absence of significant correlations between measures of WCST-64 performance and EGM play among our sample of novice players is clearly not consistent with the Pathways Model. Moreover, these null findings cannot be blamed on inadequate statistical power, as this study yielded significant correlations between measures of IGT-2 and EGM play that were predicted from the Pathways and Allostatic models.

A core feature of the Allostatic Model is the maladaptive progression of individual features that result from chronic exposure to the homeostatic disturbance of addictive behaviors. Such features might include tonically enhanced negative emotional tone associated with withdrawal, cognitive preoccupation with addictive behavior-related cues during craving, and the maladaptive avoidance of such thoughts and feelings in relapse. Thus, diminished executive self-control may be central to the affective, cognitive, and behavioral mechanisms by which addictive behavior is maintained. The null correlations between WCST-64 and EGM performance in the present study are contrary to the idea that executive dysfunction predisposes novice players toward excessive EGM betting. These findings do not rule out the possibility that such features might emerge later in the subset of novice gamblers who might go on to persistent excessive gambling and development of Gambling Disorder in the future, so future research will have to test to see if this pattern is seen later in the progression of GD, as the Allostatic Model would predict it would happen at some point.

*4.1.3 Novice players' difficulty in emotional self-regulation predicts lower EGM wagers.*

The Pathways and Allostatic Models both predict that poor emotional self-regulation might be a maintaining factor in GD. This has been confirmed by a systematic review by Marchica, Mills and Derevensky (1999), which found that among the 14 studies of emotional self-regulation and problem gambling, 4 had large effect sizes (i.e., Cohen's d=0.90-1.02), and 6 had medium effect sizes (i.e., Cohen's d=0.50-0.70). The present study found moderate correlations between DERS scores and Average Wager Per Spin and Average Bet Per Line. These inverse relationships between self-reported emotional self-regulation difficulty and betting behavior were quite consistent across the DERS subscales, with correlations ranging from $r$=-.16 to -.28. These findings in our novice sample are directly at odds with the studies of experienced gamblers that were reviewed by Marchica and colleagues (2019). This suggests a potentially interactive relationship such that novice players' maturation into experienced gamblers coincides with a directional change in the relationship between their emotional self-regulation difficulty and betting behavior. Specifically, this relationship between these variables among novices (i.e. difficult emotional self-regulation predicts reduced betting behavior in novices) versus experienced gamblers (i.e. difficult emotional self-regulation predicts increased problematic gambling behavior) is consistent with the developmental progression of motives in the Allostatic model.

*4.1.4 Novice player's experience of winning outcome predicts interest in playing EGMs.*

Betting behavior was positively correlated with desirable outcomes from the EGM game. This includes positive correlations between Average Wager Per Spin, Average Bet Per Line, and Average Lines Played (correlations ranging from $r$=.22 to $r$=.75) and behavioral reinforcers such as Wins, LDWs, and the largest win amount; likewise, there were significant negative correlations (ranging from -.33 to -.85) with the frequency of losses.

Desirable EGM outcomes were in turn correlated with scores on the Gaming Experience Questionnaire items, with correlations ranging from $r$=.21 to .33, with losses negatively correlated with GEQ scores ($r$=-.31). Moreover, the same pattern was found for the frequency of endorsing a single item that indicated interest in playing a similar EGM game in real life if such opportunity is encountered in the future. Together, these findings support the external validity of this study, as factors that increase betting behavior (i.e. high IGT Deck A selections and low DERS scores) may increase exposure to positive game outcomes (i.e. wins and LDWs) and thereby motivate future participation in EGM gambling. It is noted that betting behavior was positively correlated with behavioral reinforcers but not with the payback percentage, which is programmed to be independent of betting behavior by the game designers.

### *4.2 Implications for the Pathways Model*

The origin of excessive and problematic gambling behavior has been the subject of a great deal of research framed within the Pathways Model. That model conceptualizes problem gambling as emerging out of an interplay between the behavior-reinforcing nature of many forms of gambling, including EGMs, and the characteristics of some players that predispose them toward excessive gambling. It is therefore supposed that behaviorally conditioned, emotionally vulnerable, and antisocial-impulsivist gamblers differ from the majority who are able to gamble recreationally and never engage in gambling that is excessive, compulsive, and not problematic in any clinically significant way. However, there is an emerging body of longitudinal research that is not consistent with the notion of equipotential predisposing factors that motivate these individuals to gamble in an unhealthy way, as suggested by the Pathways Model. Instead, the findings of three large longitudinal studies conducted in Quebec (Allami et al., 2017), Manitoba (Dowd et al., 2019, 2020) and Ontario (Williams et al., 2015) are more consistent with progression of gambling that is motivated by different mechanisms at different stages of addiction. In the initial stages, risk-taking may be motivated by fun or thrill-seeking and that is not opposed by fear of negative outcomes. This is consistent with the behaviorally conditioned and antisocial-impulsivist subtypes of the Pathways Model, but the model also predicts a group of emotionally vulnerable gamblers who would choose to gamble as a means of distraction and avoiding negative emotional states. This latter prediction does not appear to be the case in current longitudinal studies, even though EGMs are easily accessible to young adults in Canada (MacLaren, 2016) and they provide an effective means of experiential avoidance (Dixon et al., 2019).

This study tested the role of reward sensitivity in promoting the betting behavior of novice EGM players. The IGT-2 is a well-known measure of decision-making that can be affected by high sensitivity to immediate rewards despite longer term losses versus immediate delay of gratification and longer-term reward. This measure has face-validity as a gambling-related task that would make sense to participants in a study focused on gambling behavior. Performance on the IGT-2 has also been shown across multiple studies to be poorer among people with GD or alcohol use disorder (Kovács et al., 2017). A critical finding of the present study was the significant negative correlation between IGT-2 total scores and participants' average wagers per spin and per line. This appears to have been attributable largely to their selection of cards from Deck A, which is the worst deck in terms of preferring immediate rewards at the expense of longer-term losses. This finding indicates that high sensitivity to immediate reward is present both in people with GD, as shown across the studies meta-analyzed by Kovács and colleagues, and also contributes to higher risk-taking among novice EGM gamblers in the present study. This finding might be interpreted as evidence of higher risk-taking associated with the externalizing behavior of the antisocial-impulsivist subtype in the Pathways Model but would only be true for people of that subtype. It is also consistent with the Allostatic model in that willingness to engage in risk-taking at potentially homeostasis-disrupting levels of intensity may lead to the development of compensatory opponent processes that underlie tolerance, craving and withdrawal.

This study also operationalized cognitive flexibility using a well-known neuropsychological test that has face validity as a gambling-related task. The WCST-64 is sensitive to poor working memory and the ‘shift’ aspect of executive function mediated by the Dorsolateral Prefrontal Cortex (DLPFC). A lack of such cognitive flexibility is a likely mechanism involved in the persistence of activities that are used for experiential avoidance. It therefore makes sense that perseverative errors on various versions of the WCST have been shown to be worse among people with GD across studies (Van Timmeren et al., 2018). To the extent that this might reflect the tendency toward cognitive inflexibility of gamblers who are prone to internalizing or other traits associated with the emotionally vulnerable subtype of the Pathways Model, it would be predicted that WCST-64 perseverative errors would be positively associated with greater participation in EGM play. However, this study found no significant correlation between any of the WCST-64 performance measures and any of the EGM gambling behaviors. This result is not consistent with the presence of a subset of participants within this sample with features matching the emotionally vulnerable subtype hypothesized by the Pathways Model. This finding is more consistent with the Allostatic Model, as it would not predict the presence of cognitive inflexibility among novice gamblers, but rather that those with a tendency toward perseveration and low cognitive flexibility might self-select as problematic gamblers and perhaps even develop greater sensitivity to negative emotional states as their gambling progresses into a chronic relapsing condition characterized by maladaptive and excessive gambling as a means of experiential avoidance.

### *4.3 Implications for the Allostatic Model*

The Allostatic model proposed by Koob and colleagues (e.g., Koob and Schulkin, 2019) is derived from human and animal studies of compensatory reactions to chronic exposure to drugs of abuse such as alcohol and opiates. The pharmacological agents have been shown to evoke behavioral changes over time, including as a shift from impulsive drug taking that is motivated by positive reinforcement, to compulsive drug seeking that is motivated by negative reinforcement. There is also typically a reduction of behaviors that are not directly associated with seeking, consuming, and recovering from use of the drug. These adaptations are said to result from compensatory responses to repeated homeostatic disturbances by the drug, and these include tonically reduced dopaminergic and GABA-ergic neurotransmission in the basal forebrain reward system, as well as sensitized corticotrophin releasing factor in the extended amygdala system that mediates the stress response. Behaviorally, these changes underlie increased drug tolerance and craving (i.e. habituated drug liking despite sensitized drug wanting), and diminished hedonic tone during withdrawal (i.e. dysphoria motivating relapse as a means of avoidance). These behavioral phenomena are readily observed in human clinical populations and the cognitive, emotional and behavioral features of people with Substance Use Disorders are clearly different from healthy adults. The neuroadaptive mechanisms that may underlie these changes have been extensively manipulated and studied in animal models, but such experimental manipulation is impossible in humans as it would require controlled administration of addictive drugs to novices until they become addicted. The features of GD have been well characterized and it appears similar to Substance Use Disorder in many respects, thus prompting its inclusion as a behavioral addiction in the DSM-5. However, the developmental progression from novice gambler to GD is not fully understood. The present study provides evidence that complements existing studies of experienced gamblers to suggest that the longitudinal progression may be conceptualized according to the Allostatic model.

Support for this contention comes from 3 key findings. First, the positive relationship between novices' reward dependence measured by IGT-2 and their betting behavior matches what is predicted in both novices and problem gamblers. Second, the null relationship between cognitive flexibility measured by WCST perseverative errors matches what is predicted to be present after chronic adaptation to intense gambling experiences. Finally, the inverse relationship between difficulties in emotional self-regulation (i.e. fear) measured by DERS shows a very different pattern in novices compared with previous studies of problem gamblers. This suggests that relations between emotion regulation and problem gambling change over the course of the progression of early problem gambling to late problem gambling, as is the case with other addictive behaviors according to the Allostatic Model.

### *4.4 Study Limitations*

One potential obstacle to studying the time-course of GD is the need for quantifiable indicators that can operationally define the mechanisms within players that may interact with important features of EGMs and other forms of gambling in a way that promotes acquisition and/or maintenance of excessive gambling behavior. Self-report measures of gambling motives and cognitive distortions are useful, but the consistency of their construct validity for novice and well-experienced gamblers is rather dubious. For instance, it is unclear whether gambling “To get a ‘high’ feeling”, as measured in the Gambling Motives Questionnaire (Stewart & Zack, 2008), could have the same subjective meaning to a novice gambler as it does to a person with a long history of problem gambling. This creates a somewhat paradoxical situation in the sense that there is a need to measure relevant constructs at different points in the natural history of problem gamblers but fidelity of the measures themselves may or may not be consistent if the respondents’ perceptions of self-report items shift over time.

This might have been somewhat problematic in the present study, as one self-report measure produced a robust and unexpected finding: the negative correlation between DERS scores and average wager per line and per spin was quite unexpected. The idea that experiential avoidance of negative emotional states should be positively correlated with more risk-taking would be consistent with past research with problem gamblers (Jauregui et al., 2016; Williams et al., 2012). However, the exact opposite was found in this sample. One possible explanation for this serendipitous finding can be found by careful examination of the items in the DERS, which are heavily weighted to reflect difficulties with regulation of *negative* emotions. Twenty-seven of the 36 DERS items begin with the phrase “When I’m upset” and it is possible that the participants may have interpreted such distress to mean states of anxiety or fear. If this explanation is correct, then the negative correlation between DERS and betting could reflect low sensitivity to signals of punishment or non-reward as a contributor to greater willingness to assume risk whilst seeking reward. This post-hoc explanation is consistent with the Reinforcement Sensitivity theory (Corr, 2008; Gray & McNaughton, 2000).

Another important study limitation is the focus on developmental progression at a theoretical level using cross sectional data at the empirical level. To ideally test the predictions of the Pathways and Allostatic models would require longitudinal data such as IGT-2, WCST-64 and DERS to be collected in young adulthood and again many years later after a subgroup of the participants have developed into problem gamblers. Such a cross-lagged panel design would allow stronger causal statements to be made, but it would not be feasible due to the monetary cost of including sample large enough to overcome the rate of drop out over a period of many years. The percentage of such a sample that eventually develops Gambling Disorder would likely be very small so retaining an adequate sample of the would require an enormous initial pool to be tested at the beginning of the study. The present study avoided those pitfalls by resting conclusions upon what is currently known about the features of problems gamblers, including meta-analytic evidence of their poor performance on WCST-64 and IGT-2, and looking for correlations between the player behavior of novices and those same measures. Comparing this novice data to later studies of problem gamblers can therefore be suggestive and help inform current understanding of the origins of Gambling Disorder and perhaps extend to other addictive disorders generally.

### *4.5 Conclusions*

This study used acute observations of gambling behaviors as the criterion variables in analyses that attempted to estimate the relative contributions of sensitivity to reward, self-reported difficulty with regulation of negative emotions, and cognitive flexibility to gambling behavior. The willingness of participants to assume risk was associated with the expected outcomes of the EGM game. Although individual outcomes are randomly determined, games of this type are programmed to deliver larger and more frequent wins as players risk more money per spin (as well as larger losses). These outcomes were, in turn, associated with greater immersion and enjoyment on the GEQ and self-reported willingness to play the game in real life for real money if the opportunity were to present itself.

This study provides converging evidence that aligns with current understanding of the game features that promote excessive gambling (Schull, 2012) and meta-analyses of the performance of people with GD on measures of reward sensitivity (Kovács, Richman, Janka, Maraz & Andó, 2017), cognitive flexibility (Van Timmeren, Daams, Van Holst & Goudriaan, 2018), and personality (MacLaren, Fugelsang, Harrigan & Dixon, 2011). On the whole, these studies are more consistent with the Allostatic model, whereby prepotent sensitivity to reward and fearlessness in the face of potential monetary loss may contribute to risk-taking among novice and recreational gamblers that could lead to winning experiences that are intensely exciting and homeostasis-disrupting. Large winnings associated with large risk may be thought of as the behavioral addiction analogue to exposure to drugs of abuse that stimulate the mesolimbic reward system and supraphysiological levels of intensity. According to the Allostatic model, the powerful behavior-reinforcing effects of such experiences are likely to stimulate continued exposure to gambling and may lead to chronic changes to brain motivational systems and/or prefrontal self-regulatory functions that underlie allostatic adaptation. To this end, the present study provides a key piece in the conception of addictive behavior, whether exclusively behavioral in the case of gambling or with pharmacological influence in the case of substance use disorders, as an example of the human capacity for adaptative or maladaptive development.

**References**

Achenbach, T. M. (1966). The classification of children's psychiatric symptoms: A factor-analytic study. *Psychological Monographs: General and Applied, 80*(7), 1–37. **https://doi.org/10.1037/h0093906**

Allami, Y., Vitaro, F., Brendgen, M., Carbonneau, R., Lacourse, E., & Tremblay, R. E. (2017). A longitudinal empirical investigation of the pathways model of problem gambling. *Journal of Gambling Studies, 33,* 1153–1167. **http:// doi.org/10.1007/s10899-017-9682-6**

American Psychiatric Association (2013). Diagnostic and Statistical Manual of Mental *Disorders, 5th edition (DSM-5).* American Psychiatric Association. **https://doi.org/10.1176/appi.books.9780890425596**

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. **http://doi.org/10.1016/0010-0277(94)90018-3**

Ben-Porath, Y. S., & Tellegen, A. (2020). *Minnesota Multiphasic Personality Inventory 3 Manual for Administration, Scoring and Interpretation.* Pearson Canada. **https://www.pearsonclinical.ca/store/caassessments/en/mmpi/Minnesota-Multiphasic-Personality-Inventory-3/p/P100008228.html** accessed November 1, 2023

Binde, P., Romild, U., & Volberg, R. A. (2017). Forms of gambling, gambling involvement and problem gambling: evidence from a Swedish population survey. *International Gambling Studies*, *17*(3), 490-507. **http://doi.org/ 10.1080/14459795.2017.1360928**

Black, D. W., Shaw, M. C., McCormick, B. A., & Allen, J. (2012). Marital status, childhood maltreatment, and family dysfunction: A controlled study of pathological gambling. *The Journal of Clinical Psychiatry, 73(10),* 1293-1297. **http://doi.org/doi: 10.4088/JCP.12m07800**

Blaszczynski, A., & Nower, L. (2002). A pathways model of problem and pathological gambling. *Addiction*, *97*(5), 487-499. **http://doi.org/10.1046/j.1360-0443.2002.00015.x**

Bradford Hill, A. (1965). The environment and disease: association or causation? *Proceedings of the Royal Society of Medicine, 58(5),* 295-300. **https://doi.org/10.1177/003591576505800503**

Bresin, K., & Mekawi, Y. (2021). The "why" of drinking matters: A meta-analysis of the association between drinking motives and drinking outcomes. *Alcoholism: Clinical and Experimental Research*, *45*(1), 38-50. **https://doi.org/10.1111/acer.14518**

Browne, M., Volberg, R., Rockloff, M., & Salonen, A. H. (2020). The prevention paradox applies to some but not all gambling harms: Results from a Finnish population-representative survey. *Journal of Behavioral Addictions, 9*(2), 371-382. **http://doi.org/ doi: 10.1556/2006.2020.00018**

Buelow, M. T., & Suhr, J. A. (2009). Construct validity of the Iowa gambling task. *Neuropsychology Review, 19*(1), 102-114. **http:doi.org/10.1007/s11065-009-9083-4**

Bush, O. (2023). Gambling Statistics in Canada. **https://madeinca.ca/gambling-canada-statistics/** accessed November 1, 2023.

Clark, L., Boileau, I., & Zack, M. (2018). Neuroimaging of reward mechanisms in gambling disorder: An integrative review. *Molecular Psychiatry, 24,* 674-693. **http://doi.org/ 10.1038/s41380-018-0230-2**

Cooper, M. L., (1994). Motivations for alcohol use among adolescents: Development and validation of a four-factor model. *Psychological Assessment, 6(2),* 117-128. **https://doi.org/10.1037/1040-3590.6.2.117**

Corr, P. J. (2008). Reinforcement sensitivity theory (RST): Introduction. in P Corr (ed.) *The Reinforcement Sensitivity Theory of Personality.* London: Cambridge University Press. **https://doi.org/10.1017/CBO9780511819384.002**

Corr, P. J., DeYoung, C. G., & McNaughton, N. (2013). Motivation and personality: A neuropsychological perspective. *Social and Personality Psychology Compass, 7*(3), 158-175. **https://doi.org/10.1111/spc3.12016**

Costa Jr, P. T., & McCrae, R. R. (2008). *The Revised NEO Personality Inventory (NEO-PI-R).* Sage Publications, Inc. **https://doi.org/10.4135/9781849200479.n9**

Dixon, M. J., Fugelsang, J. A., MacLaren, V. V., & Harrigan, K. A. (2013). Gamblers can discriminate 'tight' from 'loose' electronic gambling machines. *International Gambling Studies, 13*(1), 98-111. **https://doi.org/10.1080/14459795.2012.712151**

Damasio, A. R. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 351*(1346), 1413–1420. **https://doi.org/ 10.1098/rstb.1996.0125**

Dechant, K., & Ellery, M. (2011). The effect of including a monetary motive item on the gambling motives questionnaire in a sample of moderate gamblers. *Journal of Gambling Studies*, *27*, 331-344. **https://doi.org/10.1007/s10899-010-9197-x**

Dixon, M. J., Graydon, C., Harrigan, K. A., Wojtowicz, L., Siu, V., & Fugelsang, J. A. (2014). The allure of multi-line games in modern slot machines. *Addiction, 109*(11), 1920-1928. **https://doi.org/10.1111/add.12675**

Dixon, M. J., Gutierrez, J., Stange, M., Larche, C. J., Graydon, C., Vintan, S., & Kruger, T. B. (2019). Mindfulness problems and depression symptoms in everyday life predict dark flow during slots play: Implications for gambling as a form of escape. *Psychology of Addictive Behaviors, 33*(1), 81, 81-90. **https://doi.org/10.1037/adb0000435**

Dixon, M. J., Harrigan, K. A., Jarick, M., MacLaren, V., Fugelsang, J. A., & Sheepy, E. (2011). Psychophysiological arousal signatures of near-misses in slot machine play. *International Gambling Studies, 11*(3), 393-407. **https://doi.org/10.1080/14459795.2011.603134**

Dixon, M. J., Harrigan, K. A., Sandhu, R., Collins, K., & Fugelsang, J. A. (2010). Losses disguised as wins in modern multi-line video slot machines. *Addiction, 105,* 1819–1824. **https://doi.org/10.1111/j.1360-0443.2010.03050.x**

Dixon, M. J., Harrigan, K. A., Santesso, D. L., Graydon, C., Fugelsang, J., & Collins, K. (2014). The impact of sound in video slot machine play. *Journal of Gambling Studies, 30,* 913-929. **https://doi.org/10.1007/s10899-013-9391-8**

Dixon, M. J., MacLaren, V., Jarick, M., Fugelsang, J. A., & Harrigan, K. A. (2013). The frustrating effects of just missing the jackpot: Slot machine near-misses trigger large skin conductance responses, but no post-reinforcement pauses. *Journal of Gambling Studies, 29*(4), 661-674. **https://doi.org/10.1007/s10899-012-9333-x**

Dowd, D. A., Keough, M. T., Jakobson, L. S., Bolton, J. M., & Edgerton, J. D. (2019). A latent class analysis of young adult gamblers from the Manitoba Longitudinal Survey of Young Adults. *International Gambling Studies, 19*(1), 148-166. **https://doi.org/10.1080/14459795.2018.1520909**

Dowd, D. A., Keough, M. T., Jakobson, L. S., Bolton, J. M., & Edgerton, J. D. (2020). A longitudinal examination of gambling subtypes in young adulthood. *International Gambling Studies*, *20*(2), 185-199. **https://doi.org/10.1080/14459795.2019.1697343**

Dowling, N. A., Jackson, A. C., Suomi, A., Lavis, T., Thomas, S. A., Patford, J., Harvey, P., Battersby, M., Kozoil-LcLain, J., Abbott, M., & Bellringer, M. E. (2014). Problem gambling and family violence: Prevalence and patterns in treatment-seekers. *Addictive behaviors, 39*(12), 1713-1717. **https://doi.org/10.1016/j.addbeh.2014.07.006**

Eaton, N. R., Rodriguez-Seijas, C., Carragher, N., & Krueger, R. F. (2015). Transdiagnostic factors of psychopathology and substance use disorders: a review. *Social Psychiatry and Psychiatric Epidemiology*, *50*(2), 171-182. **https://doi.org/10.1007/s00127-014-1001-2**

Elmas, H. G., Cesur, G., & Oral, E. T. (2017). Alexithymia and Pathological Gambling: The Mediating Role of Difficulties in Emotion Regulation. *Turkish Journal of Psychiatry, 28*(1), 1-7. **https://www.turkpsikiyatri.com/Data/UnpublishedArticles/c9yohu.pdf** accessed November 1, 2023

Estevez, A., Jauregui, P., Sanchez-Marcos, I., Lopez-Gonzalez, H., & Griffiths, M. D. (2017). Attachment and emotion regulation in substance addictions and behavioral addictions. *Journal of Behavioral Addictions, 6*(4), 534-544. **https://doi.org/10.1556/2006.6.2017.086**

Ferris, J., & Wynne, H. (2001). *The Canadian Problem Gambling Index: Final Report.* Canadian Centre on Substance Abuse. **http://jogoremoto.pt/docs/extra/TECb6h.pdf** Accessed November 1, 2023

Fletcher, É., Richard, J., Boutin, S., Lemieux, A., Déry, M., Derevensky, J., & Temcheff, C. (2023). Trajectory Classes of Externalizing and Internalizing Symptoms to Adolescent Gambling Participation: An Exploratory Study. *Journal of Gambling Studies, 1-13.* **https://doi.org/ 10.1007/s10899-022-10182-y**

Grant, J. E., Schreiber, L., Odlaug, B. L., & Kim, S. W. (2010). Pathologic gambling and bankruptcy. *Comprehensive Psychiatry, 51*(2), 115-120. **https://doi.org/ 10.1016/j.comppsych.2009.04.002**

Gerstein, D., Murphy, S., Toce, M., Hoffmann, J., Palmer, A., Johnson, R., Larison, C., Chuchro, L., Buie, T., Engelman, L., Hill, M. A., Volberg, R., Harwood, H., Tucker, A., Christiansen, E., Cummings, W. & Sinclair, S. (1999). *Gambling Impact and Behavior Study: Report to the National Gambling Impact Study Commission.* Chicago: National Opinion Research Center. **https://www.norc.org/content/dam/norc-org/pdfs/GIBSFinalReportApril1999.pdf** accessed November 1, 2023

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment, 26*(1), 41-54. **https://doi.org/10.1023/B:JOBA.0000007455.08539.94**

Gray J.A. & McNaughton N. (2000). The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system. Oxford University Press. **https://global.oup.com/booksites/content/9780198522713/** accessed November 1, 2023

Griffiths, M. D. (1993). Fruit machine gambling: The importance of structural characteristics. *Journal of Gambling Studies, 9,* 101–120. **https://doi.org/10.1007/BF01014863**

Gupta, R., Nower, L., Derevensky, J. L., Blaszczynski, A., Faregh, N., & Temcheff, C. (2013). Problem gambling in adolescents: An examination of the pathways model. *Journal of Gambling Studies, 29*(3), 575–588. **https://doi.org/ 10.1007/s10899-012-9322-0**

Harrigan, K. H. (2008). Slot machine structural characteristics: Creating near misses using high award symbol ratios. *International Journal of Mental Health and Addiction, 6,* 353–368. **https://doi.org/ 10.1007/s11469-007-9066-8**

Harrigan, K., Dixon, M., MacLaren, V., Collins, K., & Fugelsang, J. (2011). The maximum rewards at the minimum price: Reinforcement rates and payback percentages in multi-line slot machines. *Journal of Gambling Issues, (26),* 11-29. **https://doi.org/10.4309/jgi.2011.26.3**

Harrigan, K., MacLaren, V., Brown, D., Dixon, M. J., & Livingstone, C. (2014). Games of chance or masters of illusion: multiline slots design may promote cognitive distortions. *International Gambling Studies, 14*(2), 301-317. **https://doi.org/10.1080/14459795.2014.918163**

Haw, J. (2009). The multiplier potential of slot machines predicts bet size. *Analysis of Gambling* Behavior, 3, 1–6. **https://repository.stcloudstate.edu/agb/vol3/iss1/1** accessed November 1, 2023

Heaton, R. K., & Psychological Assessment Resources Staff (2000). *WCST-64: computer version 2*. Psychological Assessment Resources. **https://www.parinc.com/Products/Pkey/481** accessed November 1, 2023.

Henry, J. (2006). A meta-analytic review of Wisconsin Card Sorting Test and verbal fluency performance in obsessive-compulsive disorder. *Cognitive Neuropsychiatry*, *11*(2), 156-176. **https://doi.org/10.1080/13546800444000227**

IJsselsteijn, W., de Kort, Y., Poels, K., Jurgelionis, A., & Bellotti, F. (2007). *Characterising and measuring user experiences in digital games.* Paper presented at the International Conference on Advances in Computer Entertainment Technology (ACE 2007), Salzburg, Austria. **http://www.webcitation.org/6Rfx7u6SI** accessed November 1, 2023.

Ioannidis, K., Hook, R., Wickham, K., Grant, J. E., & Chamberlain, S. R. (2019). Impulsivity in gambling disorder and problem gambling: a meta-analysis. *Neuropsychopharmacology*, *44*(8), 1354-1361. **https://doi.org/ 10.1038/s41386-019-0393-9**

Jauregui, P., Estevez, A., & Urbiola, I. (2016). Pathological gambling and associated drug and alcohol abuse, emotion regulation, and anxious-depressive symptomatology. *Journal of Behavioral Addictions, 5*(2), 251-260. **https://doi.org/10.1556/2006.5.2016.038**

Jefferson, S., & Nicki, R. (2003). A new instrument to measure cognitive distortions in video lottery terminal users: The Informational Biases Scale (IBS). *Journal of Gambling Studies*, *19*(4), 387-403. **https://doi.org/10.1023/a:1026327926024**

José, R. G., Samuel, A. S., & Isabel, M. M. (2020). Neuropsychology of executive functions in patients with focal lesion in the prefrontal cortex: A systematic review. *Brain and Cognition*, *146*, 105633. **https://doi.org/10.1016/j.bandc.2020.105633**

Koob, G. F., & Le Moal, M. (2001). Drug addiction, dysregulation of reward, and allostasis. *Neuropsychopharmacology*, *24*(2), 97-129. **https://doi.org/10.1016/S0893-133X(00)00195-0**

Koob, G. F., & Schulkin, J. (2019). Addiction and stress: An allostatic view. *Neuroscience & Biobehavioral Reviews, 106,* 245-262. **https://doi.org/ 10.1016/j.neubiorev.2018.09.008**

Kotov, R., Gamez, W., Schmidt, F., & Watson, D. (2010). Linking “big” personality traits to anxiety, depressive, and substance use disorders: a meta-analysis. *Psychological Bulletin, 136*(5), 768. **https://doi.org/10.1037/a0020327**

Kotov, R., Krueger, R. F., Watson, D., Achenbach, T. M., Althoff, R. R., Bagby, R. M., Brown, T. A., Carpenter, W. T., Caspi, A., Clark, L. A., Eaton, N. R., Forbes, M. K., Forbush, K. T., Goldberg, D., Hasin, D., Hyman, S. E., Ivanova, M. Y., Lynam, D. R., Markon, K... & Zimmerman, M. (2017). The Hierarchical Taxonomy of Psychopathology (HiTOP): A dimensional alternative to traditional nosologies. *Journal of Abnormal Psychology*, *126*(4), 454. **https://doi.org/10.1037/abn0000258**

Kovács, I., Richman, M. J., Janka, Z., Maraz, A., & Andó, B. (2017). Decision making measured by the Iowa Gambling Task in alcohol use disorder and gambling disorder: a systematic review and meta-analysis. *Drug and Alcohol Dependence*, *181*, 152-161. **https://doi.org/ 10.1016/j.drugalcdep.2017.09.023**

Krueger, R. F., Caspi, A., Moffitt, T. E., & Silva, P. A. (1998). The structure and stability of common mental disorders (DSM-III-R): a longitudinal-epidemiological study. *Journal of Abnormal Psychology*, *107*(2), 216. **https://doi.org/10.1037//0021-843x.107.2.216**

Kurilla, A. (2021). Is subtyping of gamblers based on the pathways model of problem and disordered gambling valid? A systematic review. *Journal of Gambling Studies*, 1-24. **https://doi.org/ 10.1007/s10899-020-09995-6**

Lambe, L., Mackinnon, S. P., & Stewart, S. H. (2015). Validation of the gambling motives questionnaire in emerging adults. *Journal of Gambling Studies, 31*(3), 867-885. **https://doi.org/10.1007/s10899-014-9467-0**

Ledgerwood, D. M., & Petry, N. M. (2010). Subtyping pathological gamblers based on impulsivity, depression and anxiety. *Psychology of Addictive Behaviors, 24*(4), 680–688. **https://doi.org/10.1037/a0019906**

Lesieur, H. R., & Blume, S. B. (1987). The South Oaks Gambling Screen (SOGS): A new instrument for the identification of pathological gamblers. *American Journal of Psychiatry, 144*(9), 1184-1188. **https://doi.org/10.1176/ajp.144.9.1184**

Lorains, F. K., Cowlishaw, S., & Thomas, S. A. (2011). Prevalence of comorbid disorders in problem and pathological gambling: Systematic review and meta-analysis of population surveys. *Addiction*, *106*(3), 490-498. **https://doi.org/10.1111/j.1360-0443.2010.03300.x**

MacLaren, V. V. (2015). Experienced EGM players know how to control the reinforcement rate and time on device. *Journal of Gambling Studies, 31*(4), 1789-1798. **https://doi.org/ 10.1007/s10899-014-9498-6**

MacLaren, V., Ellery, M., & Knoll, T. (2015). Personality, gambling motives and cognitive distortions in electronic gambling machine players. *Personality and Individual Differences, 73,* 24-28. **https://doi.org/10.1016/j.paid.2014.09.019**

MacLaren, V. V., Fugelsang, J. A., Harrigan, K. A., & Dixon, M. J. (2011). The personality of pathological gamblers: A meta-analysis. *Clinical Psychology Review, 31*(6), 1057-1067. **https://doi.org/10.1016/j.cpr.2011.02.002**

MacLaren, V. V., Harrigan, K. A., & Dixon, M. (2012). Gambling motives and symptoms of problem gambling in frequent slots players. *Journal of Gambling Issues, (27),* 1-13. **https://doi.org/10.4309/jgi.2012.27.8**

MacLaren, V. V. (2016). Video lottery is the most harmful form of gambling in Canada. *Journal of Gambling Studies, 32*(2), 459-485. **https://doi.org/10.1007/s10899-015-9560-z**

Mader, J., Christensen, D. R., & Williams, R. J. (2019). An evaluation of the pathways model using the quinte longitudinal dataset. *International Gambling Studies*, *19*(3), 417-431. **https://doi.org/10.1080/14459795.2019.1602158**

Marchica, L. A., Mills, D. J., Derevensky, J. L., & Montreuil, T. C. (2019). The role of emotion regulation in video gaming and gambling disorder: A systematic review. *Canadian Journal of Addiction*, *10*(4), 19-29. **https://doi.org/10.1097/CXA.0000000000000070**

Mazar, A., Zorn, M., Becker, N., & Volberg, R. A. (2020). Gambling formats, involvement, and problem gambling: which types of gambling are more risky? *BMC Public Health*, *20*, 1-10. **https://doi.org/10.1186/s12889-020-08822-2**

McGrath, D. S., & Thege, B. K. (2018). The categorical stability of gambling motives among community-recruited gamblers: A longitudinal assessment. *Journal of Gambling Studies, 34*(1), 21-38. **https://doi.org/ 10.1007/s10899-017-9687-1**

Meltzer, H., Bebbington, P., Brugha, T., Farrell, M., & Jenkins, R. (2013). The relationship between personal debt and specific common mental disorders. *The European Journal of Public Health, 23*(1), 108-113. **https://doi.org/ 10.1093/eurpub/cks021**

Moon, M., Lister, J. J., Milosevic, A., & Ledgerwood, D. M. (2017). Subtyping non-treatment-seeking problem gamblers using the pathways model. *Journal of Gambling Studies, 33*(3), 841-853. **https://doi.org/10.1007/s10899-016-9658-y**

Morey, L. C. (1991). *Personality Assessment Inventory*. Psychological Assessment Resources. **https://www.parinc.com/Products/Pkey/287** Accessed November 1, 2023.

Murch, W. S., & Clark, L. (2019). Effects of bet size and multi-line play on immersion and respiratory sinus arrhythmia during electronic gaming machine use. *Addictive Behaviors, 88,* 67-72. **https://doi.org/10.1016/j.addbeh.2018.08.014**

Nower, L., Blaszczynski, A., & Anthony, W. L. (2022). Clarifying gambling subtypes: The revised Pathways Model of Problem Gambling. *Addiction, 117,* 2000-2008. **https://doi.org/10.1111/add.15745**

Nower, L., & Blaszczynski, A. (2017). Development and validation of the Gambling Pathways Questionnaire (GPQ). *Psychology of Addictive Behaviors, 31(1),* 95-109. **https://doi.org/10.1037/adb0000234**

Nower, L., Martin, S. S., Lin, K., & Blanco, C. (2013). Subtypes of disordered gamblers: Results from the national epidemiologic survey on alcohol and related conditions (NESARC). *Addiction, 108*(4), 789–798. **https://doi.org/10.1111/add.12012**

Parkinson, W. L., Rehman, Y., Rathbone, M., & Upadhye, S. (2020). Performances on individual neurocognitive tests by people experiencing a current major depression episode: A systematic review and meta-analysis. *Journal of Affective Disorders, 276,* 249-259. **https://doi.org/ 10.1016/j.jad.2020.07.036**

Poels, K., de Kort, Y. A. W., & IJsselsteijn, W. A. (2007). *D3.3: Game Experience Questionnaire: Development of a self-report measure to assess the psychological impact of digital games*. Eindhoven, the Netherlands: Technische Universiteit Eindhoven. **https://pure.tue.nl/ws/files/21666952/Fuga_d3.3.pdf** accessed November 1, 2023

Poole, J. C., Kim, H. S., Dobson, K. S., & Hodgins, D. C. (2017). Adverse childhood experiences and disordered gambling: assessing the mediating role of emotion dysregulation. *Journal of Gambling Studies, 33*(4), 1187-1200. **https://doi.org/10.1007/s10899-017-9680-8**

Popper, K. (1959). The logic of scientific discovery. Routledge. **https://www.routledge.com/The-Logic-of-Scientific-Discovery/Popper-Popper/p/book/9780415278447** accessed November 1, 2023

Richard, J., Temcheff, C., Fletcher, É., Lemieux, A., Derevensky, J., & Déry, M. (2022). Externalizing and internalizing trajectories to adolescent gambling: a longitudinal study. *International Gambling Studies, 128*, 1-19. **https://www.researchgate.net/publication/355048643_Externalizing_and_Internalizing_Problem_Pathways_to_Youth_Gambling_A_Longitudinal_Study_Across_Childhood_and_Adolescence** accessed November 1, 2023

Robinson, T.E., & Berridge, K.C. (1993). The neural basis of drug craving: an incentive-sensitization theory of addiction. *Brain Research Reviews, 18,* 247–291. **https://doi.org/ 10.1016/0165-0173(93)90013-p**

Schreiber, L. R., Grant, J. E., & Odlaug, B. L. (2012). Emotion regulation and impulsivity in young adults. *Journal of Psychiatric Research, 46*(5), 651-658. **https://doi.org/ 10.1016/j.jpsychires.2012.02.005**

Schüll, N. D. (2012). Addiction by design: Machine gambling in Las Vegas. Princeton University Press. **https://press.princeton.edu/books/paperback/9780691160887/addiction-by-design** accessed November 1, 2023

Sescousse, G., Janssen, L., Hashemi, M., Timmer, M., Geurts, D., Ter Huurne, N., Clark, L., & Cools, R. (2016). PO-30: increased brain sensitivity to near-misses in pathological gamblers. *Journal of Behavioral Addictions, 5*(S1), 58-59. **https://go.gale.com/ps/i.do?p=AONE&u=googlescholar&id=GALE|A459058639&v=2.1&it=r&sid=AONE&asid=211c327f** accessed November 1, 2023

Shaw, C. A., Hodgins, D. C., Williams, R. J., Belanger, Y. D., Christensen, D. R., el-Guebaly, N., ... & Stevens, R. M. (2022). Gambling in Canada During the Pandemic: 6 Months After the National COVID Lockdown. *Canadian Journal of Addiction*, *13*(3), 36-45. **https://doi.org/ 10.1097/CXA.0000000000000157**

Siegel, S. (1983). Classical conditioning, drug tolerance, and drug dependence. In *Research advances in alcohol and drug problems, vol. 7* (pp. 207-246). Springer, Boston, MA. **https://link.springer.com/chapter/10.1007/978-1-4613-3626-6_6** accessed November 1, 2023

Suhr, J. A. (2015). *Psychological assessment: A problem-solving approach.* Guilford Publications. **https://www.guilford.com/books/Psychological-Assessment/Julie-Suhr/9781462519583** accessed November 1, 2023

Solomon, R.L., & Corbit, J.D. (1974). An opponent-process theory of motivation: 1. Temporal dynamics of affect. *Psychological Review, 81,* 119–145. **https://doi.org/10.1037/h0036128**

Stewart, S. H., & Zack, M. (2008). Development and psychometric evaluation of a three-dimensional Gambling Motives Questionnaire. *Addiction, 103*(7), 1110-1117. **https://doi.org/10.1111/j.1360-0443.2008.02235.x**

Stewart, S. H., & Zack, M. (2008). Development and psychometric evaluation of a three-Dimensional Gambling Motives Questionnaire. *Addiction, 103(7),* 1110-1117. **https://doi.org/10.1111/j.1360-0443.2008.02235.x**

Tabri, N., Xuereb, S., Cringle, N., & Clark, L. (2022). Associations between financial gambling motives, gambling frequency and level of problem gambling: a meta-analytic review. *Addiction, 117(3),* 559-569. **https://doi.org/10.1111/add.15642**

Templeton, J. A., Dixon, M. J., Harrigan, K. A., & Fugelsang, J. A. (2015). Upping the reinforcement rate by playing the maximum lines in multi-line slot machine play. *Journal of Gambling Studies, 31*(3), 949-964. **https://doi.org/10.1007/s10899-014-9446-5**

Thomas, A. C., Allen, F. C., & Phillips, J. (2009). Electronic gaming machine gambling: Measuring motivation. *Journal of Gambling Studies, 25,* 343–355. **https://doi.org/10.1007/s10899-009-9133-0**

Tremblay, R. E., Desmarais-Gervais, L., Gagnon, C., & Charlebois, P. (1987). The Preschool Behavior Questionnaire: Stability of its factor structure between cultures, sexes, and socioeconomic classes. *International Journal of Behavioral Development, 10 (4),* 467-484. **https://doi.org/10.1177/016502548701000406**

Turner, E. N., Umesh, J., Warren, S., & Masood, Z. (2008). Pathways to pathological gambling: Component analysis of variables related to pathological gambling. *International Gambling Studies, 8*(3), 281–298. **https://doi.org/10.1080/14459790802405905**

Vachon, D. D., & Bagby, R. M. (2009). Pathological gambling subtypes. *Psychological Assessment, 21,* 608–615. **https://doi.org/10.1037/a0016846**

Van Timmeren, T., Daams, J. G., Van Holst, R. J., & Goudriaan, A. E. (2018). Compulsivity-related neurocognitive performance deficits in gambling disorder: A systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews*, *84*, 204-217. **https://doi.org/ 10.1016/j.neubiorev.2017.11.022**

Valleur, M., Codina, I., Venisse, J., Romo, L., Megalon, D., Fatseas, M., Chereau-Boudet, I., Gorsane, M., Guilleux, A., Jeu, G., Grall-Bronnex, M., & Challet-Bouju, G. (2016). Towards a validation of the three pathways model of pathological gambling. *Journal of Gambling Studies, 32*(2), 757–771. **https://doi.org/10.1007/s10899-015-9545-y**

Wardell, J. D., Quilty, L. C., Hendershot, C. S., & Bagby, R. M. (2015). Motivational pathways from reward sensitivity and punishment sensitivity to gambling frequency and gambling-related problems. *Psychology of Addictive Behaviors*, *29*(4), 1022. **https://doi.org/ 10.1037/adb0000066**

Weatherly, J. N., & Cookman, M. L. (2014). Investigating several factors potentially related to endorsing gambling as an escape. *Current Psychology, 33*(3), 422-433. **https://doi.org/10.1007/s12144-014-9220-y**

Weatherly, J. N., & Miller, K. B. (2013). Exploring the factors related to endorsing gambling as an escape. *International Gambling Studies, 13*(1), 52-64. **https://doi.org/10.1080/14459795.2012.703214**

Westwood, H., Stahl, D., Mandy, W., & Tchanturia, K. (2016). The set-shifting profiles of anorexia nervosa and autism spectrum disorder using the Wisconsin Card Sorting Test: a systematic review and meta-analysis. *Psychological Medicine, 46*(9), 1809-1827. **https://doi.org/ 10.1017/S0033291716000581**

Williams, A. D., Grisham, J. R., Erskine, A., & Cassedy, E. (2012). Deficits in emotion regulation associated with pathological gambling. *British Journal of Clinical Psychology, 51*(2), 223-238. **https://doi.org/10.1111/j.2044-8260.2011.02022.x**

Williams RJ, Hann RG, Schopflocher D, West B, McLaughlin P, White N, King K & Flexhaug T (2015). *Quinte longitudinal study of gambling and problem gambling.* Report prepared for the Ontario Problem Gambling Research Centre. Guelph, Ontario. **http://hdl.handle.net/10133/3641** accessed November 1, 2023

Williams R. J., & Volberg RA (2014). Classification Accuracy of Four Problem Gambling Assessment Instruments. *International Gambling Studies, 14 (1),* 15-28. **https://doi.org/10.1080/14459795.2013.839731**

Winters, K. C., Stinchfield, R. D., & Fulkerson, J. (1993). Toward the development of an adolescent gambling problem severity scale. *Journal of Gambling Studies, 9*(1), 63–84. **https://doi.org/10.1007/BF01019925**

Young, Kimberly S. (1998). Internet addiction: The emergence of a new clinical disorder. CyberPsychology & Behavior, 1(3), 237-244. **https://doi.org/10.1089/cpb.1998.1.237**

Yücel, M., Carter, A., Harrigan, K., van Holst, R. J., & Livingstone, C. (2018). Hooked on gambling: a problem of human or machine design? *The Lancet Psychiatry, 5*(1), 20-21. **https://doi.org/10.1016/S2215-0366(17)30467-4**

**Table 1**

*Descriptive statistics for DERS, IGT-2, WCST-64, EGM behaviors, EGM outputs, and GEQ.*

| Measure | Mean | Median | SD | Min | Max |
|---|---|---|---|---|---|
| DERS Total | 81.9 | 78 | 23.2 | 43 | 144 |
| DERS Nonacceptance | 12.9 | 11 | 5.96 | 6 | 29 |
| DERS Goals | 15.5 | 15 | 5.09 | 5 | 25 |
| DERS Impulsivity | 10.4 | 9 | 4.27 | 6 | 26 |
| DERS Awareness | 14.1 | 14 | 4.64 | 6 | 24 |
| DERS Strategies | 17.6 | 17 | 6.75 | 8 | 38 |
| DERS Clarity | 11.3 | 11 | 3.85 | 5 | 22 |
| IGT-2 Net Total (trials 1-100) | 22.9 | 28 | 26.8 | -50 | 72 |
| IGT-2 Deck A selections | 13.6 | 14 | 5.64 | 3 | 28 |
| IGT-2 Deck B selections | 24.9 | 23 | 10.9 | 9 | 60 |
| IGT-2 Deck C selections | 27.0 | 24 | 14.3 | 5 | 60 |
| IGT-2 Deck D selections | 34.4 | 31 | 14.1 | 15 | 60 |
| WCST-64 Perseverative Errors | 7.85 | 6 | 4.36 | 3 | 21 |
| WCST-64 Categories Achieved | 3.63 | 4 | 1.25 | 0 | 5 |
| WCST-64 Trials to First Category | 14.0 | 11 | 9.38 | 10 | 65 |
| WCST-64 Failure to Maintain Set | 0.40 | 0 | .058 | 0 | 2 |
| WCST-64 Conceptual Level Responses | 45.1 | 49 | 11.2 | 7 | 58 |
| WCST-64 Learning to Learn | -3.48 | -1.32 | 8.85 | -35.9 | 14.5 |
| EGM play: Total number of spins | 161.0 | 163.0 | 63.8 | 12.0 | 500.0 |
| EGM play: Average Wager Per Spin | 52.0 | 34.2 | 53.0 | 1 | 250 |
| EGM play: Average Bet Per Line | 3.66 | 2.86 | 2.44 | 1 | 10 |
| EGM play: Average Lines Played | 12.8 | 11.6 | 6.93 | 1 | 25 |
| EGM output: Wins (percent of trials) | 14.0% | 14.1% | 4.6% | 2.2% | 25.2% |
| EGM output: LDWs (%) | 6.4% | 6.1% | 4.2% | 0% | 15.3% |
| EGM output: Losses (%) | 79.6% | 78.1% | 7.7% | 63.7% | 97.8% |
| EGM output: Bonus Features (%) | 0.59% | 0% | .77% | 0% | 3% |
| EGM output: Largest Win (credits) | 1953 | 1216 | 2675 | 4 | 20000 |
| EGM Payback Percentage (total wins/wagers)* | 103.1% | 88.2% | 103.5% | 1.3% | 975.9% |
| GEQ Total | 16.0 | 17 | 8.16 | 0 | 31 |

**Note:* Payback Percentage findings are strongly affected by 1 outlier; please section 3.3 of Results for explanation.

**Table 2**

*Correlations between DERS, IGT-2 and WCST-64, and measures of EGM betting behaviors.*

| Measure | Average Wager Per Spin | Average Bet Per Line | Average Lines Played |
|---|---|---|---|
| DERS Total | **-.31(.003)** | **-.28(.008)** | -.06 (.576) |
| DERS Nonacceptance | **-.21(.046)** | **-.25(.017)** | .05(.612) |
| DERS Goals | **-.28(.008)** | **-.22(.041)** | -.15(.150) |
| DERS Impulsivity | **-.22(.038)** | -.19(.073) | -.07(.542) |
| DERS Awareness | **-.26(.012)** | **-.24(.022)** | -.06(.557) |
| DERS Strategies | -.21(.051) | -.16(.138) | .01(.936) |
| DERS Clarity | **-.25(.016)** | **-.23(.026)** | -.11(.307) |
| IGT-2 Net Total (trials 1-100) | **-.22(.039)** | **-.23(.030)** | -.10(.347) |
| IGT-2 Deck A selections | **.30(.005)** | **.28(.007)** | .07(.498) |
| IGT-2 Deck B selections | .12(.280) | .14(.196) | .08(.427) |
| IGT-2 Deck C selections | -.05(.657) | -.09(.424) | -.04(.744) |
| IGT-2 Deck D selections | -.16(.134) | -.13(.211) | -.06(.582) |
| WCST-64 Perseverative Errors | .16(.129) | .12(.256) | .20(.064) |
| WCST-64 Categories Achieved | .03(.793) | .05(.643) | -.17(.109) |
| WCST-64 Trials to First Category | -.04(.682) | -.03(.805) | -.01(.922) |
| WCST-64 Failure to Maintain Set | -.09(.382) | -.12(.249) | .04(.734) |
| WCST-64 Conceptual Level Responses | -.09(.422) | -.06(.607) | -.17(.107) |
| WCST-64 Learning to Learn | -.12(.258) | -.17(.105) | -.00(.994) |

*Note:* Pearson correlations with *p* values in parentheses; significant correlations are **boldfaced**.

**Table 3**

*Correlations among DERS, IGT-2 and WCST-64.*

| IGT-2 scores and DERS total | WCST-64 Perseverative Errors | WCST-64 Categories Achieved | WCST-64 Trials to First Category | WCST-64 Failure to Maintain Set | WCST-64 Conceptual Level | WCST-64 Learning to Learn | DERS Total |
|---|---|---|---|---|---|---|---|
| IGT-2 Net Total (trials 1-100) | **-.30(.004)** | **.21(.043)** | -.12(.265) | -.11(.320) | **.24(.022)** | .16(.131) | .10(.336) |
| IGT-2 Deck A selections | **.21(.042)** | -.14(.176) | -.06(.563) | .03(.751) | -.18(.096) | **-.28(.008)** | -.15(.152) |
| IGT-2 Deck B selections | **.26(.012)** | -.19(.076) | .18(.095) | .11(.298) | -.21(.051) | -.06(.593) | -.05(.651) |
| IGT-2 Deck C selections | -.09(.40) | -.10(.373) | -.14(.186) | -.01(.913) | .10(.370) | .03(.809) | .04(.723) |
| IGT-2 Deck D selections | -.20(.061) | .11(.321) | .03(.772) | -.09(.415) | .13(.213) | .13(.228) | .06(.576) |
| DERS Total | -.11(.317) | -.04(.679) | -.16(.129) | **.23(.032)** | .07(.516) | .06(.548) | - |

*Note:* Pearson correlations with *p* values in parentheses; significant correlations are **boldfaced**.

**Table 4**

*Regression of Average Wager Per Spin onto age, sex, DERS total scores, IGT-2 deck A selections, and WCST-64 perseverative errors.*

| Predictor | *b* | SE | *t* | *p* | β | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| Intercept | 101.184 | 41.941 | 2.41 | 0.018 | | | |
| Age | -1.999 | 1.111 | -1.80 | 0.076 | -.183 | -.386 | .019 |
| Sex | 7.908 | 11.146 | 0.71 | 0.480 | .071 | -.128 | .270 |
| DERS total | -0.714 | 0.234 | **-3.06** | **0.003** | **-.312** | -.515 | -.109 |
| IGT Deck A | 2.485 | 0.965 | **2.58** | **0.012** | **.264** | .060 | .469 |
| WCST-64 PE | 0.680 | 1.231 | 0.55 | 0.582 | .056 | -.146 | .257 |

**Table 5**

*Regression of Average Bet Per Line onto age, sex, DERS total scores, IGT-2 deck A selections, and WCST-64 perseverative errors.*

| Predictor | *B* | SE | *t* | *p* | β | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| Intercept | 5.305 | 1.959 | 2.71 | .008 | | | |
| Age | -.083 | 0.052 | -1.60 | .112 | -.166 | -.372 | .040 |
| Sex | 0.547 | 0.521 | 1.05 | .296 | .107 | -.095 | .309 |
| DERS total | -0.030 | 0.011 | **-2.71** | **.008** | **-.281** | -.487 | -.075 |
| IGT Deck A | 0.117 | 0.045 | 2.59 | .011 | .270 | .063 | .478 |
| WCST-64 PE | 0.008 | 0.058 | 0.15 | .885 | .015 | -.190 | .220 |

**Table 6**

*Regression of Average Lines Played onto age, sex, DERS total scores, IGT-2 deck A selections, and WCST-64 perseverative errors.*

| Predictor | *b* | SE | *t* | *p* | β | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| Intercept | 13.461 | 5.889 | 2.29 | .025 | | | |
| Age | -0.221 | 0.156 | -1.42 | .161 | -.155 | -.372 | .063 |
| Sex | 1.791 | 1.565 | 1.15 | .256 | .123 | -.091 | .337 |
| DERS | -.023 | 0.033 | -0.69 | .492 | -.076 | -.294 | .142 |
| IGT Deck A | 0.077 | 0.136 | 0.57 | .572 | .063 | -.157 | .282 |
| WCST-64 PE | 0.245 | 0.173 | 1.41 | .161 | .154 | -.063 | .371 |

**Table 7**

*Correlations between EGM play behaviors, game outcomes, and ratings of the game.*

| EGM behaviors and game ratings | Wins | LDWs | Losses | Bonus Features | Largest Win | Payback Percentage |
|---|---|---|---|---|---|---|
| Average Wager Per Spin | **.44 (<.001)** | **.55 (<.001)** | **-.56 (<.001)** | -.05 (.643) | **.39 (.001)** | -.03 (.773) |
| Average Bet Per Line | **.22 (.036)** | **.36 (<.001)** | **-.33 (.002)** | -.13 (.218) | **.36 (<.001)** | -.05 (.673) |
| Average Lines Played | **.73 (<.001)** | **.75 (<.001)** | **-.85 (<.001)** | **.28 (.007)** | **.24 (.021)** | -.03 (.782) |
| GEQ total | **.27 (.009)** | **.26 (.012)** | **-.30 (.003)** | **.28 (.008)** | **.22 (.033)** | **.22 (.040)** |
| Would Play for Money | **.21 (.043)** | **.33 (.001)** | **-.31 (.003)** | **.29 (.005)** | **.21 (.046)** | .04 (.690) |

*Note:* Pearson correlations with *p* values in parentheses; significant correlations are **boldfaced**.

**Figure 1**

*The pathways model of problem and pathological gambling (from Nower, Blaszczynski & Anthony, 2022).*

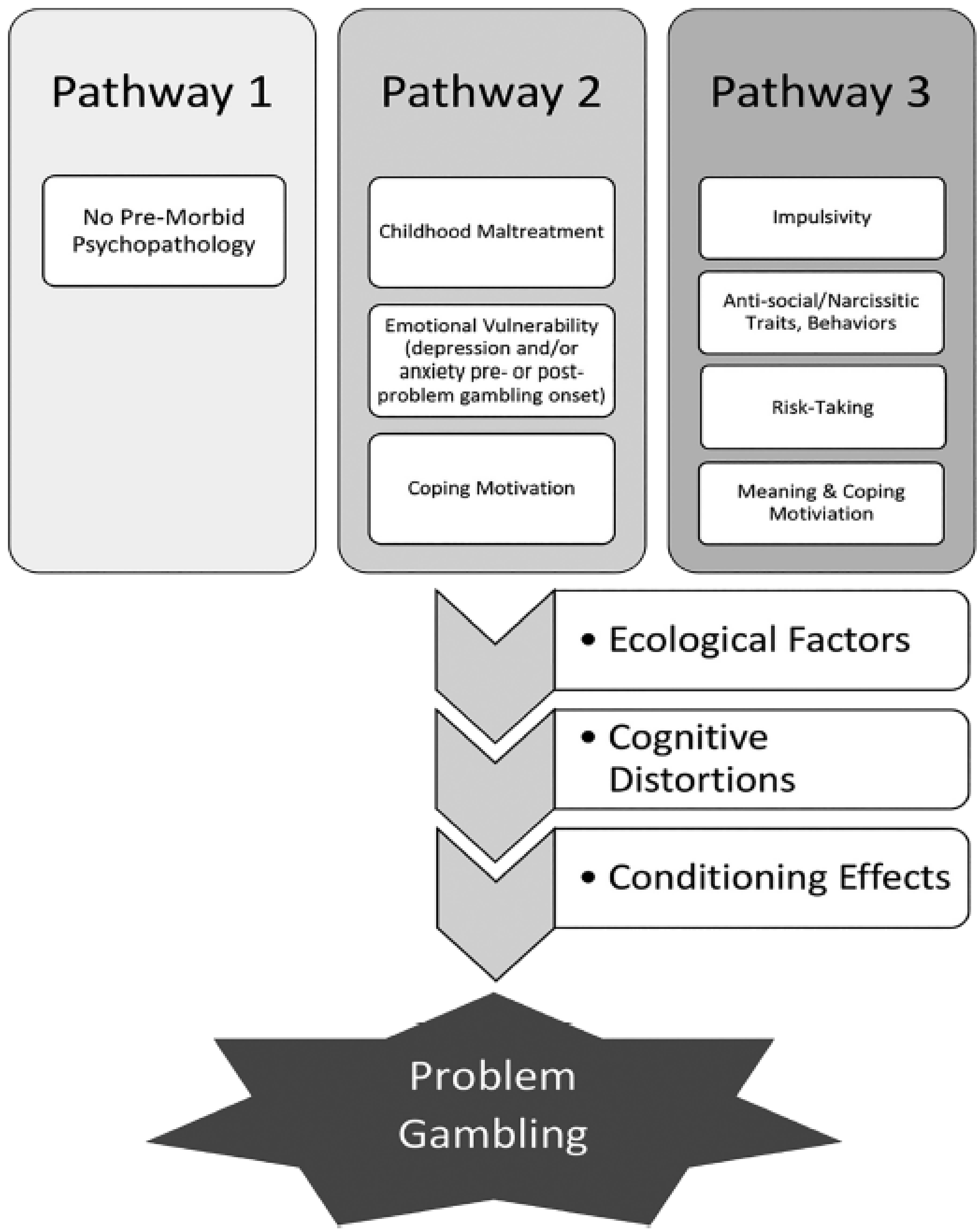
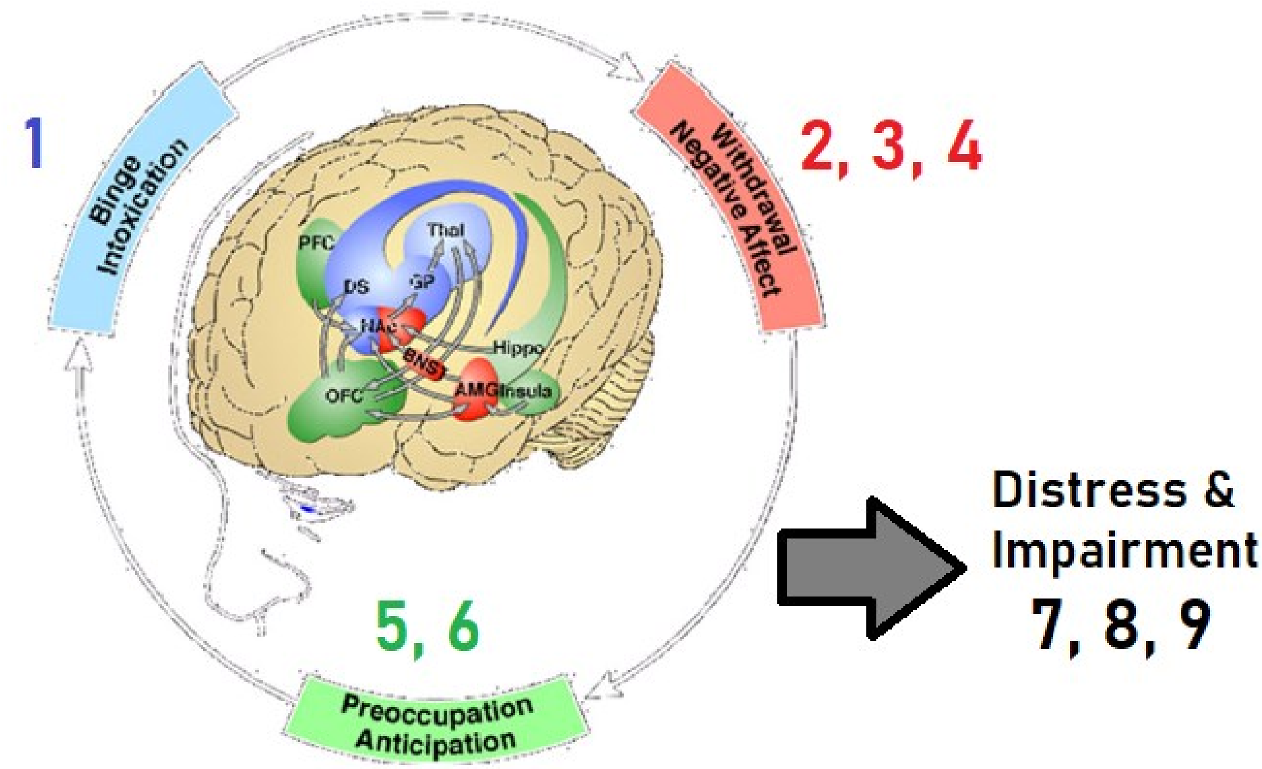


**Figure 2**

*Allostatic model of DSM-5 Gambling Disorder (adapted from Uhl, Koob & Cable, 2019).*




1. need to gamble with increasing amounts of money in order to achieve the desired excitement
2. restlessness or irritability when attempting to cut down or stop gambling
3. often gambling when feeling distressed
4. after losing money gambling, often returning another day to get even
5. frequent preoccupation with gambling
6. repeated unsuccessful efforts to control, cut back, or stop gambling
7. lying to conceal the extent of involvement in gambling
8. jeopardizing or lost a significant relationship, job, or educational or career opportunity because of gambling
9. relying on others to provide money to relieve desperate financial situations caused by gambling

**Figure 3**

*Screenshot of the EGM game, Lucky Larry's Lobstermania (from Dixon, Harrigan, Sandhu, Collins & Fugelsang, 2020).*

**Figure 4**

*Scatterplot of association between Average Wager Per Spin (x axis) and DERS total scores (y).*

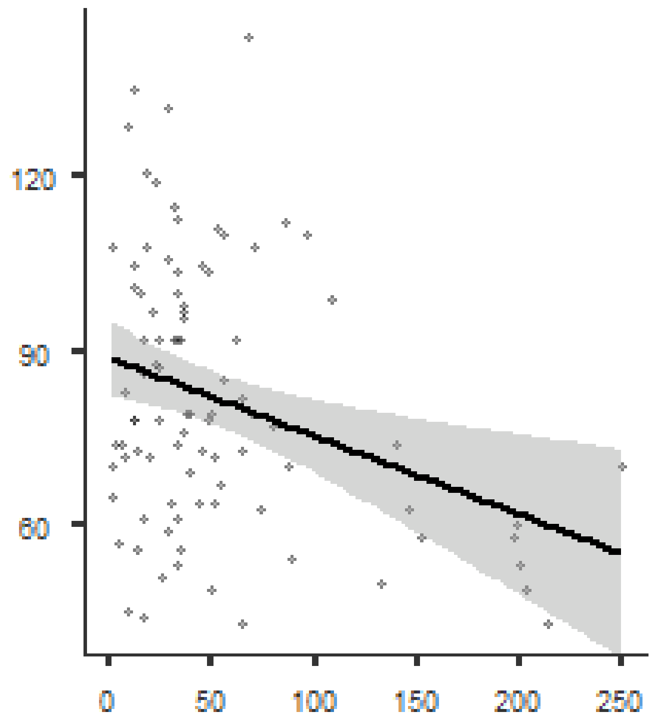


**Figure 5**

*Scatterplot of association between Average Wager Per Spin (x axis) and number of IGT-2 Deck A selections (y).*

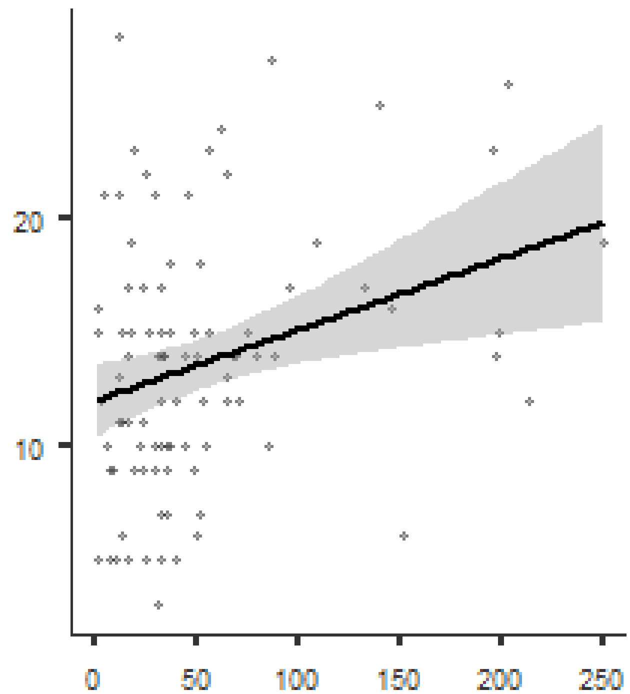
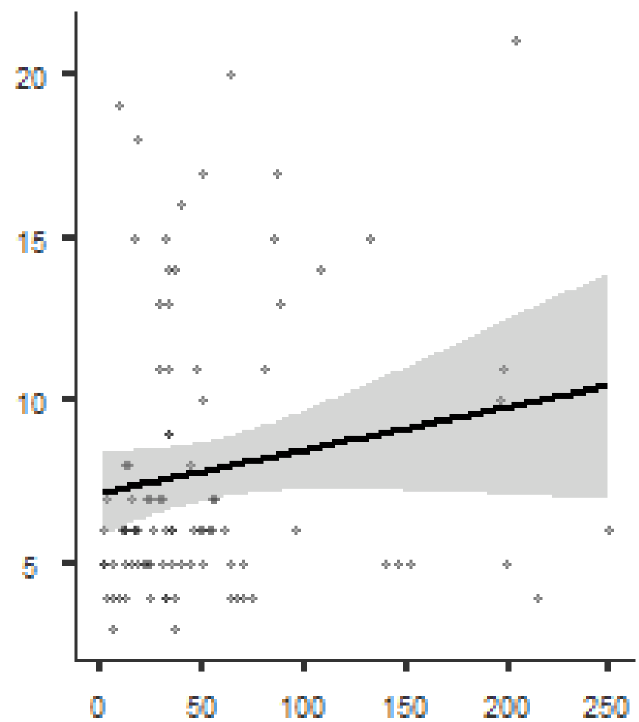


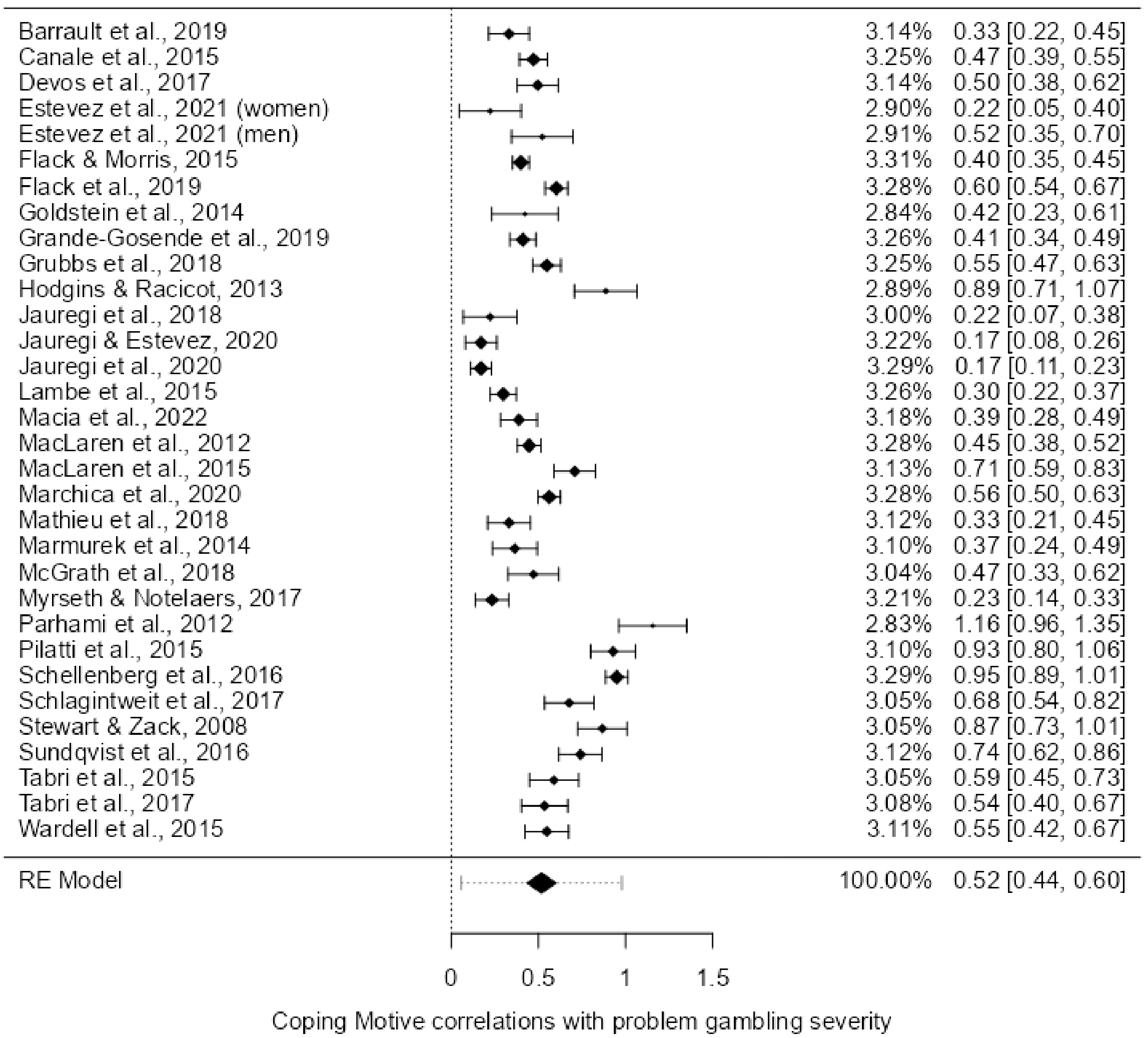
**Figure 6**

*Scatterplot of association between Average Wager Per Spin (x axis) and WCST-64 Perseverative Errors (y).*



**Appendix A.1**

*Meta-analysis of correlations between Coping Motive and problem gambling severity.*

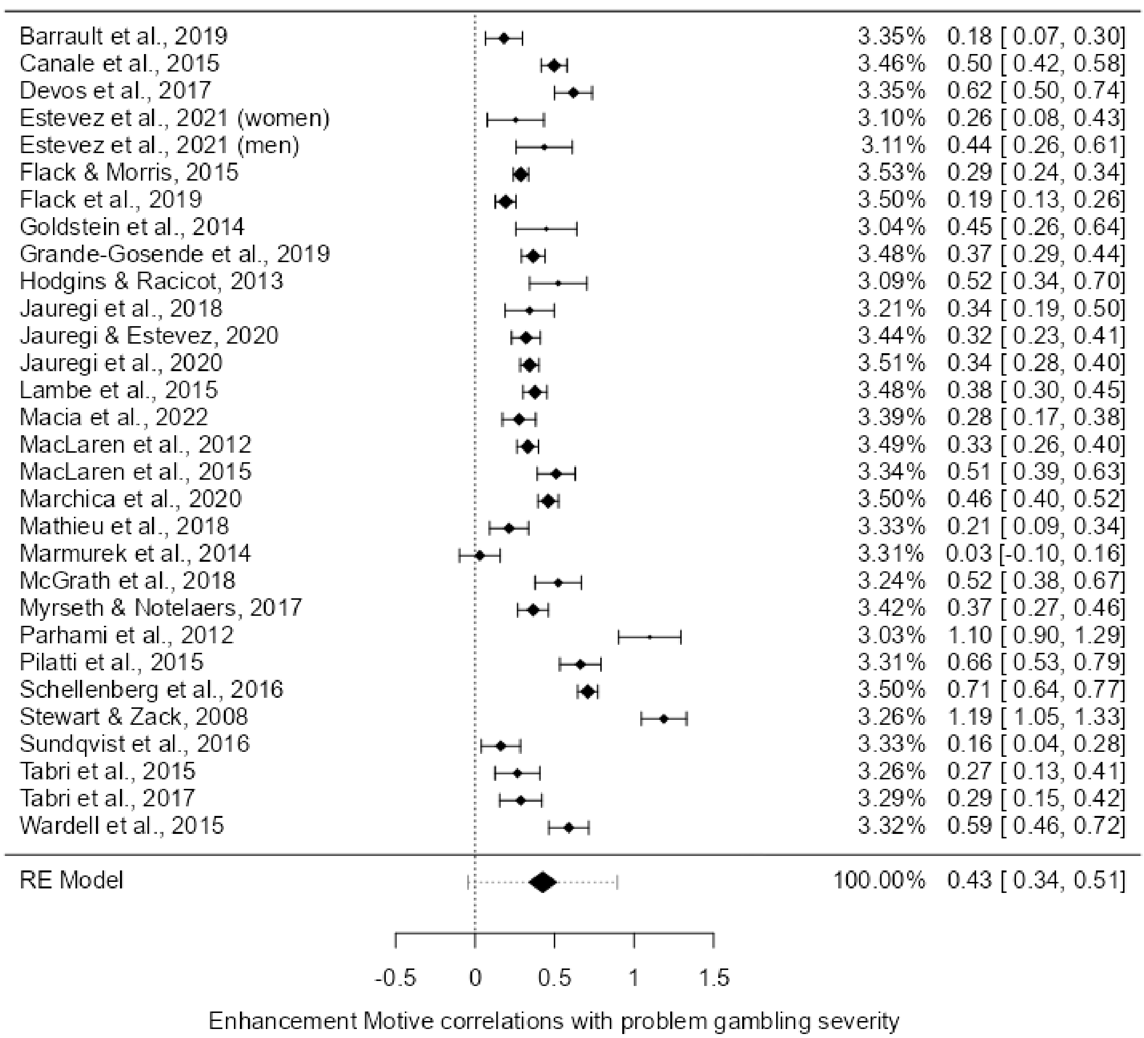


The analysis was carried out using the Fisher r-to-z transformed correlation coefficient as the outcome measure. A random-effects model was fitted to the data. The amount of heterogeneity (i.e., tau$^2$), was estimated using the restricted maximum-likelihood estimator (Viechtbauer 2005). In addition to the estimate of tau$^2$, the Q-test for heterogeneity (Cochran 1954) and the $I^2$ statistic are reported. In case any amount of heterogeneity is detected (i.e., tau$^2$ > 0, regardless of the results of the Q-test), a prediction interval for the true outcomes is also provided. Studentized residuals and Cook's distances are used to examine whether studies may be outliers and/or influential in the context of the model. Studies with a studentized residual larger than the 100 x (1 - 0.05/(2 X k))th percentile of a standard normal distribution are considered potential outliers (i.e., using a Bonferroni correction with two-sided alpha = 0.05 for k studies included in the meta-analysis). Studies with a Cook's distance larger than the median plus six times the interquartile range of the Cook's distances are considered to be influential. The rank correlation test and the regression test, using the standard error of the observed outcomes as predictor, are used to check for funnel plot asymmetry.

A total of k=32 studies were included in the analysis. The observed Fisher r-to-z transformed correlation coefficients ranged from 0.1717 to 1.1568, with the majority of estimates being positive (100%). The estimated average Fisher r-to-z transformed correlation coefficient based on the random-effects model was \hat{\mu} = 0.5187 (95% CI: 0.4358 to 0.6017). Therefore, the average outcome differed significantly from zero (z = 12.2565, p < 0.0001). According to the Q-test, the true outcomes appear to be heterogeneous (Q(31) = 662.5859, p < 0.0001, tau$^2$ = 0.0535, $I^2$ = 95.7893%). A 95% prediction interval for the true outcomes is given by 0.0581 to 0.9794. Hence, even though there may be some heterogeneity, the true outcomes of the studies are generally in the same direction as the estimated average outcome. An examination of the studentized residuals revealed that none of the studies had a value larger than ± 3.1628 and hence there was no indication of outliers in the context of this model. According to the Cook's distances, none of the studies could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry (p = 0.1315 and p = 0.1172, respectively).

**Appendix A.2**

*Meta-analysis of correlations between Enhancement Motive and problem gambling severity.*

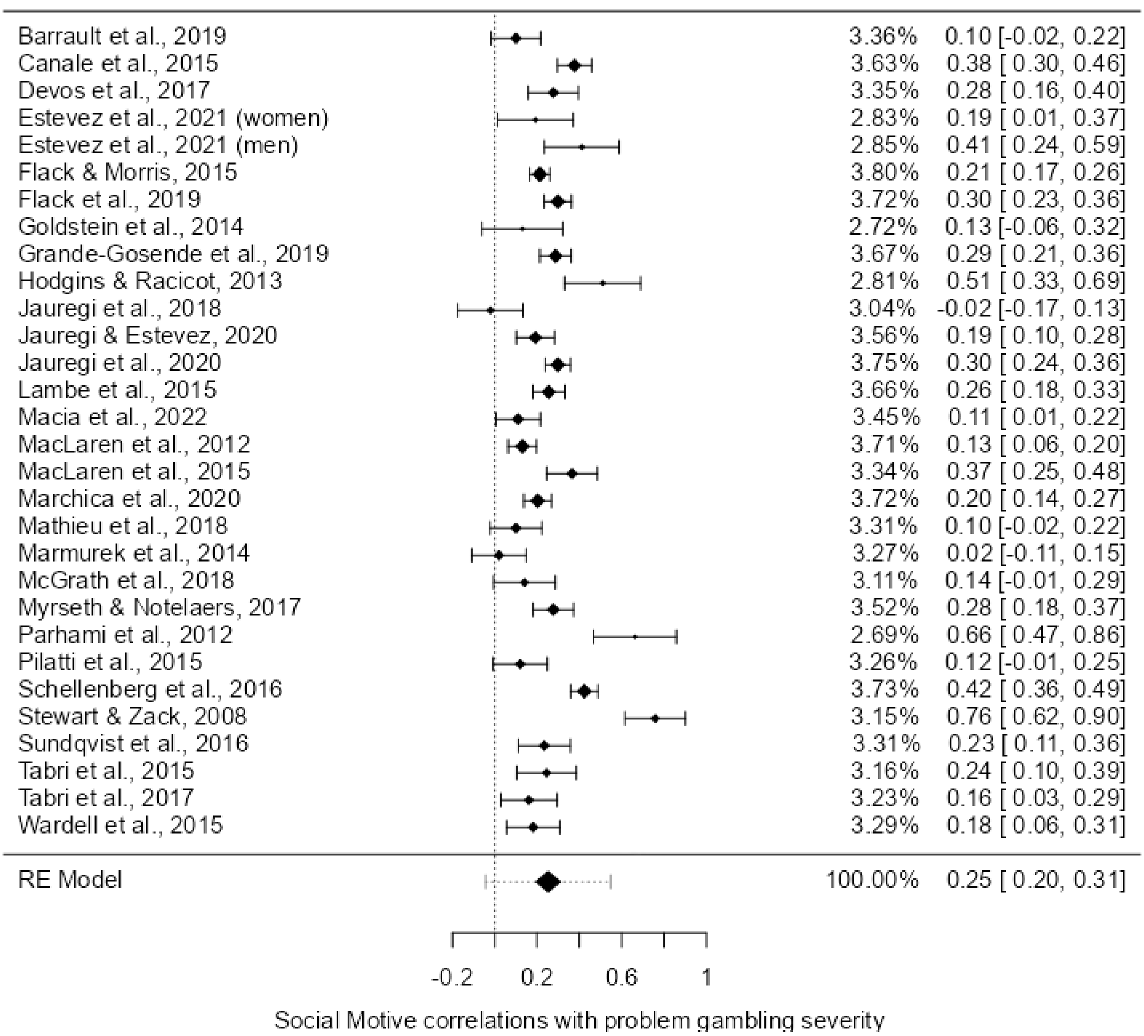


The analysis was carried out using the Fisher r-to-z transformed correlation coefficient as the outcome measure. A random-effects model was fitted to the data. The amount of heterogeneity (i.e., $tau^2$), was estimated using the restricted maximum-likelihood estimator (Viechtbauer 2005). In addition to the estimate of $tau^2$, the Q-test for heterogeneity (Cochran 1954) and the $I^2$ statistic are reported. In case any amount of heterogeneity is detected (i.e., $tau^2 > 0$, regardless of the results of the Q-test), a prediction interval for the true outcomes is also provided. Studentized residuals and Cook's distances are used to examine whether studies may be outliers and/or influential in the context of the model. Studies with a studentized residual larger than the 100 x (1 - 0.05/(2 X k))th percentile of a standard normal distribution are considered potential outliers (i.e., using a Bonferroni correction with two-sided alpha = 0.05 for k studies included in the meta-analysis). Studies with a Cook's distance larger than the median plus six times the interquartile range of the Cook's distances are considered to be influential. The rank correlation test and the regression test, using the standard error of the observed outcomes as predictor, are used to check for funnel plot asymmetry.

A total of k=30 studies were included in the analysis. The observed Fisher r-to-z transformed correlation coefficients ranged from 0.0300 to 1.1881, with the majority of estimates being positive (100%). The estimated average Fisher r-to-z transformed correlation coefficient based on the random-effects model was \hat{\mu} = 0.4256 (95% CI: 0.3385 to 0.5127). Therefore, the average outcome differed significantly from zero ($z = 9.5820$, $p < 0.0001$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q(29) = 467.1295$, $p < 0.0001$, $tau^2 = 0.0553$, $I^2 = 95.9410\%$). A 95% prediction interval for the true outcomes is given by -0.0434 to 0.8946. Hence, although the average outcome is estimated to be positive, in some studies the true outcome may in fact be negative. An examination of the studentized residuals revealed that one study (Stewart & Zack, 2008) had a value larger than ± 3.1440 and may be a potential outlier in the context of this model. According to the Cook's distances, two studies (Parhami et al., 2012; Stewart & Zack, 2008) could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p = 0.1654$ and $p = 0.1448$, respectively).

**Appendix A.3**

*Meta-analysis of correlations between Social Motive and problem gambling severity.*



The analysis was carried out using the Fisher r-to-z transformed correlation coefficient as the outcome measure. A random-effects model was fitted to the data. The amount of heterogeneity (i.e., $tau^2$), was estimated using the restricted maximum-likelihood estimator (Viechtbauer 2005). In addition to the estimate of $tau^2$, the Q-test for heterogeneity (Cochran 1954) and the $I^2$ statistic are reported. In case any amount of heterogeneity is detected (i.e., $tau^2 > 0$, regardless of the results of the Q-test), a prediction interval for the true outcomes is also provided. Studentized residuals and Cook's distances are used to examine whether studies may be outliers and/or influential in the context of the model. Studies with a studentized residual larger than the 100 x (1 - 0.05/(2 X k))th percentile of a standard normal distribution are considered potential outliers (i.e., using a Bonferroni correction with two-sided alpha = 0.05 for k studies included in the meta-analysis). Studies with a Cook's distance larger than the median plus six times the interquartile range of the Cook's distances are considered to be influential. The rank correlation test and the regression test, using the standard error of the observed outcomes as predictor, are used to check for funnel plot asymmetry.

A total of k=30 studies were included in the analysis. The observed Fisher r-to-z transformed correlation coefficients ranged from -0.0200 to 0.7582, with the majority of estimates being positive (97%). The estimated average Fisher r-to-z transformed correlation coefficient based on the random-effects model was \hat{\mu} = 0.2525 (95% CI: 0.1953 to 0.3098). Therefore, the average outcome differed significantly from zero ($z = 8.6494$, $p < 0.0001$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q(29) = 196.6451$, $p < 0.0001$, $tau^2 = 0.0218$, $I^2 = 90.3164\%$). A 95% prediction interval for the true outcomes is given by -0.0426 to 0.5476. Hence, although the average outcome is estimated to be positive, in some studies the true outcome may in fact be negative. An examination of the studentized residuals revealed that one study (Stewart & Zack, 2008) had a value larger than ± 3.1440 and may be a potential outlier in the context of this model. According to the Cook's distances, one study (Stewart & Zack, 2008) could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p = 0.9155$ and $p = 0.5203$, respectively).

**Appendix B**

## Problem Gambling Severity Index

**Participant ID:__________**

Date of Birth (YEAR/MONTH/DAY): _______________

Biological sex: Male [ ] Female [ ] Other [ ] Prefer not to say [ ]

Some of these questions may not apply to you but please try to answer as accurately as possible. Think about any gambling activities that you played for money during the past year (e.g., lottery, scratch or pulltab tickets, sports betting, bingo, poker, casino, etc.). Choose the best answer (0, 1, 2, or 3) for each question.

| 0 | 1 | 2 | 3 |
|---|---|---|---|
| Never | Sometimes | Most of the time | Always or almost always |

| | | |
|---|---|---|
| 1 | Have you bet more than you could really afford to lose? | _______ |
| 2 | Have you needed to gamble with larger amounts of money to get the same feeling of excitement? | _______ |
| 3 | Have you borrowed money or sold anything to get money to gamble? | _______ |
| 4 | When you gambled, did you go back another day to try to win back the money you lost? | _______ |
| 5 | Have you felt that you might have a problem with gambling? | _______ |
| 6 | Has gambling caused you any health problems, including stress or anxiety? | _______ |
| 7 | Have people criticized your betting or told you that you had a gambling problem, regardless of whether or not you thought it was true? | _______ |
| 8 | Has your gambling caused any financial problems for you or your household? | _______ |
| 9 | Have you felt guilty about the way you gamble or what happens when you gamble? | _______ |

Ferris, J., & Wynne, H. J. (2001). The Canadian problem gambling index. Ottawa: Canadian Centre on Substance Abuse.

## Appendix C

### Difficulties in Emotion Regulation Scale

**Participant ID: __________**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Almost never (0-10%) | Sometimes (11-35%) | About half the time (36-65%) | Most of the time (66-90%) | Almost always (91-100%) |

Please indicate how often the following 36 statements apply to you by writing the appropriate number from the scale above (1, 2, 3, 4, or 5) in the space alongside each item.

| | | |
|---|---|---|
| 1 | I am clear about my feelings | _______ |
| 2 | I pay attention to how I feel | _______ |
| 3 | I experience my emotions as overwhelming and out of control | _______ |
| 4 | I have no idea how I am feeling | _______ |
| 5 | I have difficulty making sense out of my feelings | _______ |
| 6 | I am attentive to my feelings | _______ |
| 7 | I know exactly how I am feeling | _______ |
| 8 | I care about what I am feeling | _______ |
| 9 | I am confused about how I feel | _______ |
| 10 | When I'm upset, I acknowledge my emotions | _______ |
| 11 | When I'm upset, I become angry with myself for feeling that way | _______ |
| 12 | When I'm upset, I become embarrassed for feeling that way | _______ |
| 13 | When I'm upset, I have difficulty getting work done | _______ |
| 14 | When I'm upset, I become out of control | _______ |
| 15 | When I'm upset, I believe that I will remain that way for a long time | _______ |
| 16 | When I'm upset, I believe that I'll end up feeling very depressed | _______ |
| 17 | When I'm upset, I believe that my feelings are valid and important | _______ |
| 18 | When I'm upset, I have difficulty focusing on other things | _______ |
| 19 | When I'm upset, I feel out of control | _______ |
| 20 | When I'm upset, I can still get things done | _______ |
| 21 | When I'm upset, I feel ashamed with myself for feeling that way | _______ |
| 22 | When I'm upset, I know that I can find a way to eventually feel better | _______ |
| 23 | When I'm upset, I feel like I am weak | _______ |
| 24 | When I'm upset, I feel like I can remain in control of my behaviours | _______ |
| 25 | When I'm upset, I feel guilty for feeling that way | _______ |
| 26 | When I'm upset, I have difficulty concentrating | _______ |
| 27 | When I'm upset, I have difficulty controlling my behaviours | _______ |
| 28 | When I'm upset, I believe that there is nothing I can do to make myself feel better | _______ |
| 29 | When I'm upset, I become irritated with myself for feeling that way | _______ |
| 30 | When I'm upset, I start to feel very bad about myself | _______ |
| 31 | When I'm upset, I believe that wallowing in it is all I can do | _______ |
| 32 | When I'm upset, I lose control over my behaviours | _______ |
| 33 | When I'm upset, I have difficulty thinking about anything else | _______ |
| 34 | When I'm upset, I take time to figure out what I'm really feeling | _______ |
| 35 | When I'm upset, it takes me a long time to feel better | _______ |
| 36 | When I'm upset, my emotions feel overwhelming | _______ |

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. Journal of psychopathology and behavioral assessment, 26(1), 41-54.

## Appendix D

## Gaming Experiences Questionnaire

**Participant ID:__________**

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | A little bit | Somewhat | A lot | Extremely |

Please rate how you were feeling as you played the slot machine game.
Choose the best answer (0, 1, 2, 3, or 4) for each question.

| | | |
|---|---|---|
| 1 | I thought it was fun | _______ |
| 2 | I felt happy | _______ |
| 3 | I felt good | _______ |
| 4 | I enjoyed it | _______ |
| 5 | I felt excited | _______ |
| 6 | I was fully occupied with the game | _______ |
| 7 | I forgot everything around me | _______ |
| 8 | I lost track of time | _______ |
| 9 | I was deeply concentrated in the game | _______ |
| 10 | I lost connection with the outside world | _______ |

11. In the future, I would play this game for money if I had the chance [ ] yes [ ] no

IJsselsteijn, W., De Kort, Y., Poels, K., Jurgelionis, A., & Bellotti, F. (2007). Characterising and measuring user experiences in digital games. In *International conference on advances in computer entertainment technology* (Vol. 620, June).

**Appendix E**

*Ethics Approval Letter*

MEMORIAL UNIVERSITY

Interdisciplinary Committee on Ethics in Human Research (ICEHR)

St. John's, NL Canada A1C 5S7
Tel: 709 864-2561 icehr@mun.ca
www.mun.ca/research/ethics/humans/icehr

| | |
|---|---|
| ICEHR Number: | **20200050-SC** |
| Approval Period: | May 27, 2019 – May 31, 2020 |
| Funding Source: | Not Funded |
| Responsible Faculty: | Dr. Nick Harris<br>Department of Psychology |
| Title of Project: | *Novice electronic gambling machine players' decision-making and cognitive inflexibility may affect risk taking* |

May 27, 2019

Vance MacLaren
Department of Psychology, Faculty of Science
Memorial University of Newfoundland

Dear Vance MacLaren:

Thank you for your correspondence of May 9 and 25, 2019 addressing the issues raised by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) concerning the above-named research project. ICEHR has re-examined the proposal with the clarification and revisions submitted, and is satisfied that the concerns raised by the Committee have been adequately addressed. In accordance with the *Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS2)*, the project has been granted *full ethics clearance* to May 31, 2020. ICEHR approval applies to the ethical acceptability of the research, as per Article 6.3 of the *TCPS2*. Researchers are responsible for adherence to any other relevant University policies and/or funded or non-funded agreements that may be associated with the project.

The *TCPS2* **requires** that you submit an Annual Update to ICEHR before May 31, 2020. If you plan to continue the project, you need to request renewal of your ethics clearance and include a brief summary on the progress of your research. When the project no longer involves contact with human participants, is completed and/or terminated, you are required to provide an annual update with a brief final summary and your file will be closed. If you need to make changes during the project which may raise ethical concerns, you must submit an Amendment Request with a description of these changes for the Committee's consideration prior to implementation. If funding is obtained subsequent to approval, you must submit a Funding and/or Partner Change Request to ICEHR before this clearance can be linked to your award.

All post-approval event forms noted above can be submitted from your Researcher Portal account by clicking the *Applications: Post-Review* link on your Portal homepage. We wish you success with your research.

Yours sincerely,

*for* Kelly Blidook, Ph.D.
Vice-Chair, Interdisciplinary Committee on Ethics in Human Research

KB/lw

cc: Supervisor – Dr. Nick Harris, Department of Psychology, Faculty of Science

**Appendix F**

*Participant Recruitment Letter*

Sona Study Description

**Researchers:** Vance MacLaren, Graduate student, Department of Psychology, Memorial University of Newfoundland, email: vvmaclaren@mun.ca

Valerie McDonald, Undergraduate Student, Department of Psychology, Memorial University of Newfoundland, vmm@mun.ca

**Supervisor:** Dr. Nick Harris, PhD, R Psych, Assistant Professor, Department of Psychology, Memorial University of Newfoundland, Phone: (709) 864-7676, email: nharris@mun.ca

Study duration: 90 minutes

Study location: Science Building, Room SN 1056

Bonus credit points: 2

**Title:** Novice electronic gambling machine players' decision-making and cognitive inflexibility may affect risk taking

The goal of this study is to examine whether there are characteristics of novice gamblers that might affect their risk-taking when they play an electronic slot machine gambling game. The results of this study may contribute to our understanding of gambling behavior and the reasons why some people like to take large risks and others do not like to take large risks when they gamble. In this study, you will be asked to *complete 4 questionnaires and to complete 2 computerized cognitive tasks. You may also be asked to play a simulated slot machine game on a computer.* The questionnaires will have questions about your past gambling activities (if any), your use of the internet, and your style of regulating your emotions. Everyone is welcome to take part in this study, but please note that you will not be asked to play the simulated slot machine game if your questionnaire responses suggest that you may already be heavily involved in gambling.

If you are interested in participating, please sign up for one of the available timeslots. If you have any questions before signing up or would like to enquire about alternative study sessions, please contact the researchers using the information provided in the “Researchers” box below.

If you have any questions before you sign up to participate in the study, please feel free to contact the researchers using the information provided in the “Researchers” box below.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University’s ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

**Appendix G**

*Informed Consent Form (PREP)*

Title: Novice electronic gambling machine players' decision-making and cognitive inflexibility may affect risk taking

Researcher(s): Vance MacLaren, Graduate student, Department of Psychology, Memorial University of Newfoundland, email: vvmaclaren@mun.ca

Valerie McDonald, Undergraduate Student, Department of Psychology, Memorial University of Newfoundland, vmm@mun.ca

Supervisor(s): Dr. Nick Harris, PhD, R Psych, Assistant Professor, Department of Psychology, Memorial University of Newfoundland, Phone: (709) 864-7676, email: nharris@mun.ca

You are invited to take part in a research project entitled *"Novice electronic gambling machine players' decision-making and cognitive inflexibility may affect risk taking."*

This form is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is the informed consent process. Take time to read this carefully and to understand the information given to you. Please contact the researcher, Vance MacLaren, if you have any questions about the study or would like more information before you consent.

It is entirely up to you to decide whether to take part in this research. If you choose not to take part in this research or if you decide to withdraw from the research once it has started, there will be no negative consequences for you, now or in the future.

Introduction:

Our names are Vance MacLaren (doctoral student) and Valerie McDonald (undergraduate student) and we are students in the Department of Psychology at Memorial University of Newfoundland. As part of Vance's PsyD dissertation and Valerie's Directed Study course, we are conducting research under the supervision of Dr. Nick Harris, Assistant Professor in the Department of Psychology at Memorial University of Newfoundland.

Purpose of study:

The purpose of this study is to examine whether there are characteristics of novice gamblers that might affect their risk-taking when they play an electronic slot machine gambling game. The results of this study may contribute to our understanding of gambling behavior and the reasons why some people like to take large risks and others do not like to take large risks when they gamble.

What you will do in this study:

In this study, you will be asked to complete 4 questionnaires and to complete 2 computerized cognitive tasks. You may also be asked to play a simulated slot machine game on a computer. Participation involves answering questions about your age, gender, and the following standardized tasks and questionnaires:

- The *Problem Gambling Severity Index* is a 9-item scale with questions about potential problems that may be associated with excessive gambling behavior in the past year.
- The *Internet Addiction Scale* is a 20-item scale with questions about potential problems that may be associated with excessive online activity in the past month.
- The *Difficulties in Emotion Regulation Scale* is a 36-item scale with questions about how you feel in different situations and how you manage those feelings.
- The *Iowa Gambling* Task is a 10-minute computerized card playing task that assesses how people take risks.
- The *Wisconsin Card Sorting* Task is a 15-minute computerized card playing task that assesses how people categorize things.
- The *Simulated Slot Machine* is a typical slots game that is played on a computer. Everyone is welcome to take part in this study, but please note that you will not be asked to play the simulated slot machine game if your questionnaire responses suggest that you may already be heavily involved in gambling. If you are asked to play this game, you may play it for up to 15 minutes. You will be shown a short video that will explain how to play the game.
- The *Gaming Experiences Questionnaire* is a 10-item scale with questions about your opinion of the simulated slot machine game.

Length of time:

Completing this study will take between 60 and 90 minutes.

Compensation

You will receive one credit point toward your Psychology course per hour of participation or part thereof. Because this study takes more than an hour, you will get 2 credit points.

You will also be entered in a draw for a $500 prepaid VISA giftcard. We anticipate that approximately 100 participants will be in the study and one of you will be randomly chosen as the winner. You will be given tickets for the draw depending on how many "credits" you have on the slot machine game at the end of 15 minutes of play. You will start the game with 5,000 credits at the end you will get 1 ticket for every 100 credits remaining. If you have no credits left or if you are not asked to play the slot machine game, you will still be given 1 ticket for the draw. The draw will be held at the end of the study, which is expected to be in the Fall 2019 semester.

Withdrawal from the study:

There are no consequences to withdrawing from the study. You are free to withdraw from the study at any time, simply by telling the researcher that you longer wish to continue. If you decide that you do not want your data to be included in our study, you can tell the researcher and your individual data will be removed and any records of it will be destroyed. Anyone who withdraws from the study, or chooses not to have their data included, or selects "Research Observation" below, will still receive course credit through PREP.

Possible benefits:

Although you may not receive any immediate, direct benefits yourself, your participation will help us to better understand specific factors that influence gambling behavior. Once the research from this study is compiled, we will share the report with all interested participants. If you would like to receive these results, please provide your email to the researcher and we will e-mail you a copy when the study is completed.

Possible risks:

During your participation in this study it is possible that you may become aware that your gambling behavior, online activity, or emotionality may be adversely affecting your mental health and well-being. As you complete questionnaires in this study, you might find that that the personal nature of some topics may lead you to experience feelings of anxiety, shame or embarrassment. If you find that completing the questionnaires leads you to realize that you may need help, or if you have any concerns about your current mental or psychological functioning, you are encouraged to contact a mental health professional. You can contact a professional through the Mental Health Helpline at 709-737-4668 or the Memorial University Student Wellness and Counselling Centre (UC 5000) at 709-864-8874.

Confidentiality:

The ethical duty of confidentiality includes safeguarding participants' identities, personal information, and data from unauthorized access, use, or disclosure. Confidentiality will be ensured at all times. Only the researchers will have access to any and all data. Your name or other identifying information will not be stored with your scores on the questionnaires and computerized tasks, so it will be impossible for anyone to know your scores.

Anonymity:

Anonymity refers to protecting participants' identifying characteristics, such as name or description of physical appearance. No identifying information will be included on the questionnaires and all information presented or published from the results will be in aggregate form. Every reasonable effort will be made to ensure your anonymity and you will not be identified in any publications without your explicit permission.

Please note that your course instructor will not have access to detailed Psychology Research Experience Pool participation details. He or she will only be able to view the total number of credit points earned by students, and will not know whether you have participated in this, or any other study, nor whether any credit points earned from participation in any study were earned from Research Participation, Research Observation, or completion of the alternative assignment.

Recording of Data:

A recording of the screen will be made by the computer while you play the simulated slot machine game. It will not record any images or sounds of you as you play; only what is displayed on the screen.

Use, Access, Ownership, and Storage of Data:

All data will be stored on a password-protected computer located in Dr. Nick Harris's lab on Memorial University campus. The researchers will be the only people with access to the data. Data will be kept for a minimum of five years as required by Memorial University policy on Integrity of Scholarly Research. Following this five-year period all data will be fully deleted.

Third-Party Data Collection and/or Storage:

Data collected from you as part of your participation in this project will be hosted and/or stored electronically by Qualtrics and is subject to their privacy policy, and to any relevant laws of the country in which their servers are located. Therefore, anonymity and confidentiality of data may not be guaranteed in the rare instance, for example, that government agencies obtain a court order compelling the provider to grant access to specific data stored on their servers. If you have questions or concerns about how your data will be collected or stored, please contact the researcher and/or visit the provider's website for more information before participating. The privacy and security policy of the third-party hosting data collection and/or storing data can be found at: https://www.qualtrics.com/privacy-statement/

Research Participation vs. Research Observation

Your participation in this study is intended to be an educational Research Experience. You therefore have the choice of whether or not to provide data to researchers for inclusion in their analysis. If you consent to provide your data for analysis, please check the box below labeled "Research Participation". However, if you wish to observe the process of research participation without providing data to researchers for inclusion in their analysis, then you may choose to do so, without any loss of experience or credit. If you consent to observe the research experience without providing any data, please check the box below labeled “Research Observation”. Please note that you may choose to change your Research Experience from Participation to Observation at any time before the end of the study session, without loss of experience or credit.

Reporting of Results:

The data collected will be compiled into a report and may be presented and published through peer reviewed forums. These outputs will be a summary of the information obtained and will not include identifying features. The theses that will be published using these data will be publicly available at Memorial University’s QEII library, and accessible online at http://collections.mun.ca/cdm/search/collections/theses.

Sharing of Results with Participants:

Once the report is complete, it will be shared electronically with all participants who request a copy. To request a copy of the study results, please provide your e-mail and Vance MacLaren will send you a copy of the report at the conclusion of the study, which is expected to be at the end of Fall 2019 semester. Email (optional): ___________________________________________ . If you don’t want to give your email now, you can contact Vance MacLaren by email (vvmaclaren@mun.ca) after December 2019 and he will email it to you as soon as it is complete.

Questions:

You are welcome to ask questions at any time before, during, or after your participation in this research. If you would like more information about this study, please contact: Vance MacLaren at vvmaclaren@mun.ca, Valerie McDonald at vmm@mun.ca, or Dr. Nick Harris, at (709) 864-7676 or nharris@mun.ca.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research, such as the way you have been treated or your rights as a participant, you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

Consent:

Your signature on this form means that:

- You have read the information about the research.
- You have been able to ask questions about this study.
- You are satisfied with the answers to all your questions.
- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw participation in the study without having to give a reason, and that doing so will not affect you now or in the future.
- You understand the difference between Research Participation and Research Observation, and that you may freely choose which Research Experience option you prefer
- You understand that you are free to change your Research Experience option from Participation to Observation at any time before the end of the study session, without having to give a reason, and that doing so will not affect you now or in the future.
- You understand that any data collected from you up to the point of your choice to participate as a Research Observer will be destroyed.

Regarding withdrawal during data collection:

- You understand that if you choose to end participation **during** data collection, any data collected from you up to that **point will be destroyed**.

Regarding withdrawal <u>after</u> data collection:

- You understand that your data is being collected anonymously and therefore cannot be removed once data collection has ended.

Regarding video recording:

I agree to have the computer screen recorded while I play the simulated slot machine game. I understand that no images or sounds of me will be recorded.

☐ Yes

☐ No

By signing this form, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

Research Participation vs. Research Observation

☐ Research Participation: I consent to provide data from my research experience to researchers for analysis.

☐ Research Observation: I do not consent to provide data from my research experience to researchers for analysis.

Your Signature Confirms:

☐ I have read what this study is about and understood the risks and benefits. I have had adequate time to think about this and had the opportunity to ask questions and my questions have been answered.

☐ I agree to participate in the research project understanding the risks and contributions of my participation, that my participation is voluntary, and that I may end my participation.

☐ A copy of this Informed Consent Form has been given to me for my records.

______________________________ ______________________________

Signature of Participant Date

Researcher's Signature:

I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

______________________________

______________________________

Signature of Principal Investigator Date

**Appendix H**

*Feedback Sheet: Psychology Research Experience Pool*

Thank you for participating in the study! Your participation and the data that you contribute are valuable for our research. This feedback sheet is intended to explain to you the purpose and hypotheses of the study in which you have just participated.

Gambling is an activity that lots of people enjoy, but for some it can get out of control and create financial and other problems. It is known that people who gamble excessively have difficulty doing tasks that require managing one's own thoughts and behaviors, known as "executive functions". We wanted to see whether people who have NOT developed a habit of excessive gambling differ in their performance on executive function tasks and if those differences might translate into different styles of playing a slot machine game. A style of play that has a lot of risk-taking (i.e. betting a lot of credits on each spin) might lead some gamblers in a direction toward excessive gambling.

In this experiment, you did two computerized tasks that psychologists use to measure executive functions, which vary from person to person. Executive functions are skills that allow us to monitor and control our own thoughts and actions, such as when we decide to think about something or to not think about it, or whether to do a behavior. We also had you tell us a little about yourself with some questionnaires. You may have been asked to play a home computer version of a popular slot machine game (but we would not have asked you to play the slots game if your questionnaire responses suggested that you are already heavily involved in gambling). We wondered if there might be a relationship between executive functions and risk-taking on the slot machine game. If that turns out to be true, it will help us to better understand why some people who gamble may develop a habit of gambling excessively. We also had you complete measures of emotion dysregulation and problematic internet use. The emotion dysregulation measure was included to help us develop a better understanding of how challenges with regulating emotions may be associated with their style of play on the slot machine task. The problematic internet use measure was administered to help begin to explore possible relationships between problem internet use and executive functions.

Electronic gambling machines (ie. “VLTs” or “slots”) can be addictive for some people. If you find that you play them often, spend a lot of money playing them, or spend a lot of time playing them, then that could suggest that you might be at risk for problems due to excessive gambling. Furthermore, if you believe that you might have a problem with excessive gambling, excessive internet use, or another mental health issue, then you can contact a professional through the Mental Health Helpline at 709-737-4668 or the Memorial University Student Wellness and Counselling Centre (UC 5000) at 709-864-8874.

We appreciate your participation in this experiment and hope that this has been an interesting experience. If you have any additional questions about this research or other research conducted in this lab, please ask the Primary Investigator (Vance MacLaren, maclaren@mun.ca, (709) 864-8496).

If you have any ethical concerns about your participation in this study (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at 709-864-2861.

Once again, thank you for your participation in this experiment. If you would like to learn more about electronic gambling machines, please see the following articles:

Harris, N., Newby, J., & Rupert, K. (2014). Competitiveness facets and sensation-seeking as predictors of problem gambling among a sample of university student gamblers. *Journal of Gambling Studies, 31(2)*, 385-396.

MacLaren, V. V. (2016). Video lottery is the most harmful form of gambling in Canada. *Journal of Gambling Studies*, *32*(2), 459-485.