# The Impact of Gambling Speed of Play on Executive Control Functions: Investigating Gambling Harm-Minimisation Approaches to Combat Impulsive Action and Impulsive Choice

Andrew Harris

Thesis submitted in partial fulfilment of the requirements of Nottingham Trent University for the degree of Doctor of Philosophy

September 2018

*“We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too”.*

John F. Kennedy - September 12, 1962, Rice University, Houston, Texas.

Abstract

Executive control functions are higher-order cognitive processes essential for exercising self-control over behaviour. These executive processes are the antithesis of impulsivity, which describes actions routinely and automatically triggered by environmental cues without planning and consideration of the consequences of those actions, and represents a construct intimately linked with disordered gambling behaviour. To prevent the potential harm that can be experienced during gambling, it is desirable that decisions and actions within a gambling context are governed by high-levels of executive control, as opposed to thought and actions that are triggered automatically and on impulse. Of interest to the present thesis is the way that technological developments have afforded increased sophistication of the structural characteristics of electronic gambling products, and how these interact with executive control processes during gambling. More specifically, this thesis aims to investigate how the increased speeds of play during gambling, afforded by electronic gambling products, impacts a gambler's ability to exercise self-control over motor actions.

An initial systematic critical review investigated the existing research findings pertaining to the impact of gambling speed of play on behaviour and cognition. Following an extensive literature search, 11 studies were selected for review based on several inclusion criteria. Some of the key findings stemming from the review were that games with higher event frequencies were more appealing to gamblers in general, and particularly appealing and enjoyed by problem and pathological gamblers. Faster games were associated with more difficulty quitting the game, and often resulted in more time and money being spent compared to slower games. Overall, the findings from the review suggest a link between increased speeds of play during gambling and reduced self-control, providing justification for the empirical chapters within this thesis that investigated the effects of gambling speed on executive control functions.

In a repeated-measures experiment, Experiment 1 identified that as the speed of play is increased during a slot machine gambling simulation, motor response inhibition performance, as assessed using an embedded go/no-go task, is inhibited amongst regular gamblers. This highlights how the structural characteristic of speed during gambling can impair a gamblers ability to exercise self-control during gambling, independent of the presence of a problem or pathological gambling disorder.

A second systematic critical review investigated the range of gambling harm-minimisation tools available during electronic gambling and their relative impact on thoughts and

behaviour during gambling. Several within-session tools were identified, including enforced breaks in play, pop-up messaging, behavioural tracking tools, monetary limit setting, and visual clock displays. One of the key findings included that the efficacy of pop-up responsible gambling messages in shaping thoughts and behaviour during gambling is dependent on the mode of delivery and content displayed in the messages. Yet to be investigated in depth within the gambling literature is the potential for the use of emotive content to be displayed in pop-up messages, which may serve to have a more powerful influence over thoughts and behaviour compared to non-emotive content.

Experiment 2 investigated the ability of new and existing gambling harm-minimisation tools to combat the loss of control over motor actions when gambling at high speeds of play, as demonstrated in Experiment 1. Pop-up responsible gambling messages containing either emotive or non-emotive content were compared to a structural change in the form of a forced discriminatory motor choice procedure and financial punishment intervention, in terms of their ability to facilitate motor response inhibition performance during slot machine gambling. Making structural changes to the slot machine that prevents prepotent response patterns developing and that requires greater levels of active attention over motor actions were successful in facilitating response inhibition performance amongst regular, non-problem gamblers. Changing the salience of no-go cues by financially punishing participants for erroneous motor responses increased motivation to exercise self-control and also improved response inhibition performance.

Experiment 3 built on the findings from Experiment 2 and aimed to investigate if inducing more cautious motor response patterns and greater control of motor outputs had wider benefits for cognitive control. It was found that inducing more cautious motor responses during an electronic slot machine simulator resulted in more deliberation and more accurate decisions in an information sampling task (see Clark et al., 2006), as well as a greater tolerance for delayed reward in a monetary delay discounting task (Kirby et al., 1999). It was also found that using emotional content in a pop-up responsible gambling message also facilitated performance on these choice impulsivity tasks, but this effect was independent of a transfer of cautiousness account.

This research has theoretical and applied implications to the field of gambling harm-minimisation. The research presented within this thesis suggests that making simple structural changes to electronic gambling products that prevent automatic response patterns developing are not only beneficial for motor control, but also have carry over benefits by reducing impulsive choice tendencies. In addition, the use of emotive content delivered via responsible gambling messages should be considered above the use of non-emotive content, as emotive content had a greater influence on decision-making processes amongst regular, non-problem gamblers.

# Acknowledgments

My thanks go out to my director of studies, Professor Mark Griffiths, for encouraging me to write, his editing of this thesis and related publications, and always having something positive to say about me as a colleague and a person. Thank you to both Dr Daria Kuss and Dr Mhairi Bowe in their supporting supervisory roles, you have both made yourself available to help me whenever I have needed it or just a chat (moan) and have provided me with invaluable opportunities to gain teaching experience. I look forward to joining you all on the psychology faculty this coming year.

I would also like to show my continued appreciation to Dr Adrian Parke for giving me my start in academia. You have always offered sound and reliable advice, which has continued throughout my PhD. I am pleased to call you my friend.

Thank you to my parents Sarah and Andy, brother Scott, and nephew Leo for their constant love and support. I love you all. Leo, you were barely 3 months old when I started my studies, now you are 7, and it has been amazing seeing you grow up into a wonderful, caring person.

My partner Georgina, I feel incredibly lucky to have met you. It would be an understatement to say that the best part of this PhD experience was meeting you, because in actual fact, it was the best day of my life. You are literally the most kind and caring person there is. You don't just brighten up my day but brighten up everyone's day when you are around. I'm incredibly proud of you for getting your PhD and lectureship recently, and despite the fact you have been incredibly busy and anxious yourself, you have always put everyone else first and never wavered in your kindness. The world would be a better place with more of you, but the fact there is only one makes me feel even more lucky to call you my partner. I love you. I would also like to thank your parents Richard and Linda for showing me love and support over the recent years, and also wish your brother Russ and Fiona a safe and fun trip on their year travelling the globe.

# Financial Support

The PhD was supported by a three-year fully funded Scholarship from the Nottingham Trent University Department of Psychology.

The author also received a £1500 research grant awarded by The Responsible Gambling Trust® (now GambleAware®). This funding was used to support Experiments 1, 2, and 3 of the thesis by providing participants money with which to gamble. The Responsible Gambling Trust had no other role or influence in the research contained within this thesis.

# Declaration

This thesis comprises the candidate's own original work and has not, whether in the same or different form, been submitted to this or any other University for a degree. All experiments were designed and analysed by the candidate, and all testing was conducted by the candidate. Any publications that have occurred as a result of this thesis are the candidate's own work.

*Research output stemming from the thesis*

*Publications*

- Harris, A., Kuss, D., & Griffiths, M. D. (in press). Gambling, motor cautiousness, and choice impulsivity: An experimental study. *Journal of Behavioural Addictions.*

- Harris, A., & Griffiths, M. D. (2018). The impact of speed of play in gambling on psychological and behavioural factors: A critical review. *Journal of Gambling Studies*, *34*(2),393-412

- Harris, A., Griffiths, M. D., & Parke, A. (2016). The case for using personally relevant and emotive messaging to facilitate self-control during gambling. *International Journal of Mental Health and Addiction, 16*(2),266-275.

- Griffiths, M.D., Harris, A., & Auer, M. (2016). A brief overview of behavioural feedback in promoting responsible gambling. *Casino and Gaming International* (May 2016 edition).

- Harris, A., & Griffiths, M. D. (2016). A critical review of the harm-minimisation tools available for electronic gambling. *Journal of Gambling Studies, 33*, 187–221.

*Conference papers and seminar presentations*

- Harris, A. (2017, September). *The interaction of gambling structural characteristics and executive control processes.* GambleAware, Covent Garden, London.

- Harris, A. (2017, January). *Facilitating executive control during gambling: The relationship between event frequency, motor impulsivity, and choice impulsivity*. Nottingham Trent University School of Psychology External Research Seminar Series, Nottingham.

- Harris, A. (2016, May). *Facilitating executive control during gambling: The relationship between event frequency, motor impulsivity, and choice impulsivity.* Nottingham Trent University Postgraduate Research Conference, Nottingham.

- Harris, A., & Parke, A. (2015, April). *Are executive functions affected by slot machine speed of play? The impact of reel speed on motor response inhibition.* Invited paper at Discovery Conference, Toronto, Canada.

# Contents

# List of Figures

# List of Tables

# Chapter 1. Introduction to Gambling and Problem Gambling in Great Britain and Thesis Overview

## *1. Defining gambling*

Most academic attempts to operationally define gambling propose that gambling is an activity in which something of value (predominately money) is risked on the outcome of an uncertain event (for example, see Ladouceur & Walker, 1998). Gambling activities are not homogenous and can be categorised based on several dimensions, including the degree to which specific forms of gambling involve luck and skill. Poker represents a form of gambling whereby in the long run the most skilful players will prosper over less-skilled players, even though the allocation of cards to players is random. Skilful players can prosper even with weak starting hands, highlighting the skill element involved in poker. Weaker players can also prosper in the short-term, owed to the chance element involved in the turn of a card. Conversely, gambling activities such as lotteries, roulette, and slot machine gambling, the latter representing the gambling activity of focus in this thesis, represent activities whereby the outcome is based predominantly or entirely on chance, despite strategies and 'systems' gamblers reportedly employ (Sundali & Croson, 2006).

Whilst gambling itself can be categorised as a form of risk-taking behaviour, it has been argued by Griffiths (1995) to represent a distinct form of risk-taking based on four additional features: (1) gambling involves the reallocation of wealth often in the absence of productive work; (2) the success of winners occurs at the expense of losers; (3) the outcome is determined by some degree of chance; and (4) losses are avoided by not participating in gambling.

In a similar light as alcohol, gambling has long been embedded in popular culture and yet represents an activity that can be taken to excess (Orford, 2001). For the vast majority of individuals, gambling represents an exciting and legitimate leisure pursuit and form of entertainment (Williams, Volberg, & Stevens, 2012). However, a minority of individuals go on to develop a gambling disorder, resulting in significant negative psychological and social consequences.

### *1.1 Defining pathological and problem gambling*

The clinical classification of pathological gambling has been through several changes in recent decades, highlight the evolving nature of this construct. Pathological gambling first appeared in the Diagnostic and Statistical Manual of Mental Disorders third edition (DSM-III; American Psychiatric Association (APA), 1980), where it was recognised as an impulse control disorder. Key aspects for diagnosis of this disorder in the DSM-III included the individual experiencing a progressive loss of control, with emphasis placed on the deleterious impacts of the gambling behaviour on familial, personal, and/or vocational pursuits. These early diagnostic criteria were criticised for their inclusion in DSM-III without robust and validated empirical evidence, rather, the initial diagnostic criteria were derived from the observations of clinical professionals (National Research Council, 1999).

Pathological gambling criteria were revised in the DSM-III-R (APA, 1987) to reflect its observed similarities with substance dependence. Whilst some of the underlying principles of pathological gambling, such as a progressive loss of control, remained present in the DSM-III-R, items were revised to reflect a pathological gambler's repeated unsuccessful attempts to control, cut back or stop gambling (APA, 1987).

Pathological gambling was included as an impulse control disorder in the DSM-IV (APA, 1994). For a diagnosis of pathological gambling according to the fourth edition, five or more criteria from a checklist of 10 items had to be endorsed by the gambler. Such items included reference to preoccupation with gambling, repeated unsuccessful attempts to cut down or stop gambling, deceiving others to conceal the extent of the gambling, an escalation of wager amounts to achieve desired excitement, and the loss of significant interpersonal relationships as a result of gambling. The DSM-IV also noted that the pathological gambling could be reflective of a manic episode, in which case, bipolar disorder would be the primary diagnosis. This demonstrates that even at this early stage, the comorbidity of pathological gambling with other psychological disorders was recognised, although the comorbidity issue first arose in the 1980 criteria, as one of the exclusion criteria was having anti-social personality disorder (see APA, 1980)

Pathological gambling's inclusion as an impulse control disorder in DSM-IV was criticised due to its important distinction from other impulse control disorders. For example, sufferers of the impulse control disorders kleptomania and pyromania report a sense of relief from overwhelming urges once the characteristic act has been committed, whilst conversely, pathological gamblers report distress upon cessation of gambling (Shaffer & Korn, 2002). In addition, the DSM-IV had a categorical approach to diagnosis, in which satisfying five or more of the diagnostic criteria leads to diagnosis of pathological gambling and less than five indicating the absence of pathological gambling. It is more widely recognised that disordered gambling represents a continuum of problems, with pathological gambling representing the high-ends of that continuum (Strong & Kahler, 2007). As a result, sub-clinical pathological gamblers, commonly referred to as problem gamblers, were overlooked based on the DSM-IV criteria, and yet still suffered significant negative psychological and social issues as a result of their gambling (Strong & Kahler, 2007). In this view, the difference between problem gambling and pathological gambling is a matter of degree, highlighting the need for understanding disordered gambling as existing on a continuum. However, an alternative perspective is the view of pathological gambling as a categorical disorder, rather than the extreme end of a continuum (Blaszczynski & Nower, 2002). Psychodynamic perspectives (see e.g., Rosenthal, 1992; Wildman, 1997), as well as the disease model of addiction (see e.g., McLellan et al., 2000) with its biological emphasis, argue that pathological gamblers are qualitatively distinct compared to non-pathological gamblers, on factors including personality, comorbidity, and biological correlates (Blaszczynski & Nower, 2002).

The fifth edition of the DSM (DSM-5; APA, 2013) was reflective of the shift in the mainstream conceptualisation of pathological gambling. Firstly, the diagnosis of pathological gambling was renamed as a 'gambling disorder'. One of the other major changes included the reclassification of the disorder from that of an impulse control disorder to a 'substance-related and addictive disorder' (i.e., a behavioural addiction), reflecting the recognition of the overlap in constructs between pathological gambling and substance addiction (Grant, Potenza, Weinstein, & Gorelick, 2010). Additional changes included removal of the 'illegal acts' criterion in the diagnosis, as well as a reduction in the number of required criterion for diagnosis from five to four (Rennert et al., 2014). Batstra and colleagues (2012) raised concern that this reduction in criterion could result in lower specificity, in danger of increasing false positive diagnoses. However, studies of the concurrent validity of DSM-IV pathological gambling reported consistently better diagnostic accuracy with the new cut-off of four and not five criteria (Stinchfield, 2003; Stinchfield, Govoni, & Frisch, 2005).

### *1.2 Gambling in Great Britain*

According to the most recent British Gambling Prevalence Survey (BGPS; Wardle et al., 2011) comprising 7756 individuals, 73% of the adult population (16 years of age or older) engaged in some form of past year gambling activity. This figure is similar to the 72% participation rates found in the 1999 survey (Sproston, Erens, & Orford, 2000) and an increase from the 68% figure obtained in 2007 (Wardle et al., 2007). A consistent finding from the BGPS is that the National Lottery is the most popular gambling activity with 59% of adults reporting playing the lottery within the past year prior to the survey. Controlling for National Lottery participation, 56% of adults' report engaging with some other form of gambling activity, a significant increase from 46% and 48% when compared to the 1999 and 2007 BGPS respectively. Gambling on slot machines remains one of the most popular forms of gambling in Britain, with 13% of adults reporting playing slot machines in the past year according to the BGPS 2010. Only betting on the National Lottery (59%), other lotteries (25%), buying scratchcards (24%), and betting on horse racing (16%) are more popular forms of gambling than slot machine gambling in Britain.

According to the BGPS (Wardle et al., 2011) problem gambling prevalence was 0.7% as assessed by the Problem Gambling Severity Index (PGSI; see Ferris & Wynne, 2001) and 0.9% according to the DSM-IV, where three or more, but less than five diagnostic criteria are met. Pathological gambling prevalence was 0.4% as assessed using DSM-IV criteria, where five or more diagnostic criteria are met. The BGPS (Wardle et al., 2011) reported that problem gambling rates were higher in men than women, more prominent in in younger adult age groups, and more prominent in Asian/Asian British and Black/Black British ethnicities. Overall, problem gambling rates were higher among those who were separated or divorced and/or had parents who gambled regularly.

More recently, Seabury and Wardle (2014; Wardle et al., 2014) published an overview of gambling behaviour in England and Scotland by combining the data from the Health Survey for England (n=8,291 aged 16 years and over) and Scottish Health Survey (n=4,815 16 years and over). Overall gambling participation rates were 65%. Problem gambling prevalence as assessed by the PGSI was 0.4%, and 0.5% when assessed using the DSM-IV criteria, equivalent to approximately 182,00 and 224,00 adults aged 16 years and over respectively. This is a reduction from 0.7% for PGSI assessed problem gambling and a reduction from 0.9% from the DSM-IV measurement obtained in the BGPS 2010. In his review of the 2014 EHS and SHS, Griffiths (2014) noted the disparity in these problem gambling rates between the BGPS and Health Surveys should be taken with caution, because the two survey approaches were not equivalent. For example, the BGPS solely focused on gambling behaviours, whilst the Health Surveys focused on a variety of health-related issues, gambling forming just a small part of the overall survey.

Similar problem gambling prevalence rates were found among data from the Adult Psychiatric Morbidity Survey which examined many types of psychiatric morbidity in a nationally representative sample of English (not British) adults aged 16 years (n=7,403; for a review, see Calado & Griffiths, 2016). Problem gambling prevalence assessed using the DSM-IV criteria was 0.7%, whereas 0.3% met the threshold of five or more criteria, indicative of pathological gambling.

### *1.3 Theoretical models of disordered gambling*

Three of the most prominent models of disordered gambling include the pathway model (Blaszczynski & Nower, 2002), the components model (Griffiths, 2005) and the syndrome model (Shaffer et al., 2004). Of note, the pathway model pertains specifically to gambling, whereas the components and syndrome models are models of addiction more generally.

#### *1.3.1 Pathway model*

Blaszczynski and Nower's pathway model (2002) argues that pathological gambling can develop along three distinct pathways, resulting in three subgroups of pathological gamblers: (1) behaviourally conditioned gamblers, (2) emotionally vulnerable gamblers, and (3) antisocial, impulsivist gamblers. The first pathway postulated by the model is behaviourally conditioned problem gambling. It is suggested that this subgroup may meet formal criteria for pathological gambling but are characterised by an absence of specific premorbid feature of psychopathology. This subgroup develops problem or pathological gambling via the effects of conditioning, cognitive illusions, and irrational beliefs, and it is suggested they will naturally fluctuate between regular, heavy, and excessive gambling. Blaszczynski and Nower (2002) also suggest behaviourally conditioned gamblers are characterised at the low end of the pathological dimension and show motivation to enter treatment and re-establish controlled levels of gambling post-treatment. Blaszczynski and Nower (2002) argue this subgroup share a similar profile to the 'cluster one' sample identified in the cluster analytical study conducted by Gonzalez-Ibanez and colleagues (1999) and the controlled gambling group in Blaszczynski's (1988) treatment outcome study. This gambler sub-type in these studies demonstrated minimal levels of psychopathology or within normal limits post-treatment.

The second subgroup suggested by the pathway model are emotionally vulnerable problem gamblers. Unlike behaviourally conditioned gamblers in the first pathway, Blaszczynski and Nower (2002) suggest this sub-group possess premorbid anxiety and/or depression, with a history of poor self-regulation and problem-solving skills, as well as experiencing adverse familial, developmental, and life events. In combination, these experiences and tendencies motivate the individual to gamble as a means of regulating emotional states and satisfying psychological needs through the effects of dissociation and arousal. Blaszczynski and Nower (2002) further argue that unlike the first pathway, the psychological vulnerability and dysfunction characteristic of the second pathway makes gamblers more resistant to treatment, meaning psychological intervention for their gambling should also focus on addressing their premorbid and underlying emotional difficulties. In support for this position for a sub-group of emotionally vulnerable gamblers, Steel and Blaszcynski's (1996) factorial structure design found a group of gamblers comprised mostly of females, with high levels of psychological distress, suicidal tendencies, history of mood disorders, and psychiatric history within the family. Furthermore, Gonzalez-Ibanez and colleagues' (1999) cluster analytical research found a subgroup of emotionally vulnerable gamblers occupying an intermediate position in terms of problem gambling severity when compared to both a less severe as well as a highly dysfunctional cluster of gamblers.

The third and final pathway comprised a sub-group of antisocial and impulsivist problem gamblers, described as "disturbed individuals with substantial psychosocial interference from gambling and characterised by signs suggestive of neurological or neurochemical dysfunction" (Blaszczynski &

Nower, 2002; p. 494). The model argues that this sub-group shares the psychological and biological vulnerabilities of the second pathway, but also possess impulsive and antisocial characteristics as a distinguishing feature. In addition, gamblers with maladaptive impulsive features have a tendency to engage in multiple behavioural problems outside of gambling, including but not limited to, high levels of irritability, boredom proneness, substance abuse, and encounters with criminal behaviour. Blaszczynski and Nower (2002) argued that for this subtype, gambling started at an early age and escalates rapidly in terms of severity and intensity, and that they are also reluctant to seek treatment and respond poorly to intervention. This description of the third pathway is supported by Steel and Blaszczynski (1996), who found levels of psychological distress amongst a sample of 115 gamblers was correlated with impulsive tendencies and antisocial personality characteristics. Furthermore, Gonzalez-Ibanez et al.'s (1999) cluster analysis identified a subgroup exhibiting similar features, including more intense gambling problems, impulsive tendencies, thrill seeking, and proneness to boredom.

*1.3.2 Components model of addiction*

According to the components model of addiction postulated by Griffiths (2005), all addictions are characterised by six underlying features: salience; mood modification; tolerance; withdrawal symptoms; conflict; and relapse. Within a gambling context, the salience component describes how gambling becomes a dominant feature of a person's life, where gambling dominates their thinking, feelings, and behaviours. This demonstrates how an individual does not necessarily have to be directly engaged in gambling for gambling to have influence over them. The component of salience is powerfully demonstrated by a quote obtained from an addicted slot machine gambler in Griffiths' (1995) study into slot machine addicts:

> *If I wasn't actually gambling I was spending the rest of my time working out clever little schemes to obtain money to feed my habit. These two activities literally took up all my time (Extract 1, p. 253).*

Mood modification refers to the subjective mood-altering experiences resulting from engagement in gambling. The nature of the induced mood states can vary greatly from person to person, as well as vary within an individual depending on subjective factors. For example, some individuals may engage in gambling as a way to escape stress and reduce anxiety (see, for example, the second pathway in Blaszczynski & Nower's (2002) model), whereas others may engage in gambling to achieve an arousing 'high' or 'buzz'. Griffiths (2005) argues it is possible for the same individual to experience both of these polarising effects, depending on the subjective psychological state of the individual. For example, after a long stressful day at work, an individual may engage in gambling as a means to destress and escape from the day's problems. Alternatively, the same individual may use gambling as a means to raise mood levels during periods of low mood and/or boredom. Gambling may therefore be conceptualised as a form of self-medication that allows an individual to achieve desired mood-states.

The tolerance component refers to the need for increasing amounts of an activity to achieve the same desired effect (e.g., mood modification). Within a gambling context, this may refer to the need for a gambler to bet larger amounts of money and/or spend longer durations gambling to achieve the same mood-modifying effects that were previously achievable from smaller wagers or shorter play durations. This concept is supported empirically by Griffiths (1993) who demonstrated that after an initial increase in heart rate at the start of gambling for regular and non-regular gamblers, the heart rates of regular gamblers decreased towards base-rate quickly, whereas heart rates of non-regular gamblers remained elevated. This objectively demonstrated that the regular gamblers in Griffiths' (1993) study had developed tolerance towards the physiological highs associated with gambling, and it was argued those regular gamblers would have to gamble faster or more often to experience the same desired effects.

Withdrawal symptoms refer to the distressing psychological and/or physical effects experienced when the appetitive behaviour of choice is discontinued or suddenly reduced (Griffiths, 2005). The psychological withdrawal effects may consist of mood-swings or increased irritability as examples, whereas the physical symptoms may consist of nausea, sweating, headaches, and sleep disturbances. Withdrawal symptoms are more classically associated with withdrawal from substance addiction (see Orford, 2001), although studies have identified that the majority of pathological gamblers report at least one side effect during the withdrawal period from gambling (Griffiths & Smeaton, 2002; Rosenthal & Lesieur, 1992).

The conflict component of Griffiths' (2005) model refers to both the intrapsychic and interpersonal conflicts experienced by the gambler as a result of their gambling behaviour. The persistent choosing of the short-term pleasure and relief offered by gambling often leads the individual to disregard adverse and long-term consequences, resulting in the compromising of personal relationships, work and/or education, and other social activities (Griffiths, 2005). The gambler may also experience internal conflict in the sense that they know their behaviour is excessive and causing damage, and yet find it difficult to cut down or stop. This internal conflict and discomfort can then paradoxically result in increased gambling as a means to escape this discomfort, at least in the short-term.

The final component, relapse, refers to the process whereby a gambler returns to gambling following a period of attempted abstinence. It is not uncommon to find gamblers resuming behaviour similar to that of their most intensive periods of gambling after several years of abstinence (Griffiths, 2005).

Griffiths (2002) argued that all of these components are needed in order for the behaviour to be defined as an addiction. It could be argued that the absence of one or more of these components is likely indicative of an excessive healthy enthusiasm. Griffiths (2002) claimed that the difference between an excessive healthy enthusiasm and an addiction is that healthy enthusiasms add to an individual's quality of life, whereas addictions take away from it.

*1.3.3 Syndrome model of addiction*

In their syndrome model of addiction, Shaffer and colleagues (2004) claimed that '[a] syndrome is a cluster of symptoms and signs related to an abnormal underlying condition' (p.367). This suggests the syndrome can be expressed in several ways, including substance abuse and pathological gambling, but that there is a shared set of biopsychosocial antecedents acting as risk-factors. As well as possessing neurobiological and genetic predisposing risk-factors, Shaffer and colleagues (2004) argue that throughout the developmental process, individuals encounter and develop neurobiological and psychosocial elements that influence behaviour, some of which acts as risk-factors for the development of addiction (e.g., modelling a parent who gambles to excess), whilst others act as protective factors (e.g., strong social support networks). The model also emphasises the important role that exposure and opportunity to engage with objects of addiction has in the development of addiction. Shaffer et al. (2004) suggest that interacting with these objects of addiction exposes at-risk individuals to the neurobiological consequences of addiction, such as activation of reward circuitry within the brain, consequences shared amongst all forms of addiction, but also exposes individuals to outcomes specific to certain forms of addiction (e.g., the behaviour elicited by specific psychoactive substances).

Shaffer et al. (2004) argue that addiction is object non-specific, essentially positing that addiction itself is not inextricably linked to a particular substance or behaviour. In support of this, observations of both treatment-seeking and non-treatment-seeking individuals demonstrates that recovering addicts commonly switch from excessive consumption of one behaviour to another (Anglin & Hser, 1990). However, evidence from a gambling context challenges this position of object non-specificity. It is observed that the proportion of pathological gamblers compared to non-problem gamblers is higher dependent on the type of activity in question. For example, a consistent finding from multiple empirical accounts have identified higher rates of pathological gambling are found within slot machine gambling compared with lottery gambling (e.g., Gotestam & Johansson, 2003; Lund, 2006), suggesting specific structural characteristics of gambling may facilitate the transition from controlled gambling to addiction.

Indeed, one of the shared limitations of all three theoretical models is the lack of explicit consideration for the role of gambling structural characteristics in the transition from healthy to disordered gambling. For example, structural mechanisms of gambling games likely impact the classical and operant conditioning phases that Blaszczynski and Nower (2002) argue are shared by all three gambler subtypes in their pathways model. Structural features such as the speed of play, jackpot sizes, and pay-out ratios are examples of varying characteristics that may contribute to the reinforcing excitement and arousal experienced within the gambling game, whilst other characteristic may contribute to the acquisition of maladaptive gambling cognitive schemas and illusions of control (Griffiths, 1994). Furthermore, the components model lacks discussion on the roles of gambling structural characteristics in the development of pathological gambling, although it is acknowledged that Griffiths discusses these at length elsewhere (e.g., Griffiths, 1993; Griffiths & Auer, 2013; Parke & Griffiths, 2006, 2007). For example, it may be argued that specific gambling features such as ambient characteristics (sound and light) contribute to the salience component of addiction, or that different gambling event frequencies (time delay between the next available bet) are more adept at modifying mood.

Structural characteristics research aims to address these issues regarding how the features of gambling games impact an individual as an agent during gambling. Such research acknowledges the important role that genetic and biological vulnerability likely play in the development of a gambling disorder, but also challenges the assumption that the development of disordered gambling is object non-specific. In this sense, structural characteristics research arguably falls within the realm of gambling harm-minimisation, challenging gambling industry representatives to consider the role that gambling features have in the development of a gambling disorder and to modify games in ways that are conducive to safer and responsible gambling. Showing the link between structural characteristics and problematic gambling behaviour of course should stem from carefully controlled empirical research.

## 1.4 Overview of the following chapters

### *1.4.1 Chapter 2. The impact of speed of play in gambling on psychological and behavioural factors: A systematic critical review*

The structural gambling feature of focus for the present thesis is event frequency. Event frequency refers to the number of gambling events available for betting within a given time frame. Within this thesis, the term event frequency is used synonymously with ‘speed of play’. Although speed of play could refer to the gambling game itself or the behaviour of the gambler, within this context, it is used to describe the maximum speed of the gaming machine. The empirical chapters within this thesis will examine this speed characteristic within slot machine gambling – a type of gambling that offers some of the highest known event frequencies. There has long been an assumption within gambling research that faster speeds of play and high event frequencies are associated with problematic gambling behaviour (McCormack & Griffiths, 2013). The research conducted in Chapter 2 in the form of a critical review was to identify if there was an empirical basis to support this assumption, and to assess how speed of play in gambling has an impact on psychological and behavioural variables. Although the reviewed studies comprised disparate methodologies, a consistent finding was that increased speeds of play in gambling are associated with deleterious impacts on behaviour and cognition. Less clear were the mechanisms that led to a loss of self-control during gambling at higher event frequencies, providing rationale for the empirical chapters within this thesis that investigated how speed of play impacts executive control processes within the brain. A version of this thesis chapter was published in the Journal of Gambling Studies (Harris & Griffiths, 2018).

*1.4.2 Chapter 3. Automatic versus executive control processes*

Chapter 3 of the thesis acquaints the reader with relevant theoretical and empirical accounts regarding executive control processes. The chapter discusses the differences between automatic and controlled processes and argues why automaticity is not desirable within a gambling context. The main focus of the chapter is behavioural response inhibition, which is regarded as the hallmark feature of executive control. Response inhibition allows individuals to overcome strongly conditioned and habituated responses to allow self-guided behaviour towards chosen goals and to keep individuals safe from potential harm (Aron, Robbins, & Poldrack, 2014). Response inhibition theory is introduced, as well as a discussion of the key role that response inhibition has in disordered gambling, using empirical evidence to support this claim. The chapter also presents evidence demonstrating that executive control capacity is not rigid, and that a range of contextual factors can impact response inhibition performance, including arousal, motivation, and event frequency – factors which are all pertinent to gambling.

*1.4.3 Chapter 4. Evaluation of methodology and materials*

Chapter 4 provides a critical evaluation and justification of the laboratory-based experimental methodology used within the thesis. A detailed description of the slot machine simulator used throughout the experimental chapters in the thesis is provided, including information on the various speeds of play, number of gambling events (trials), pay-out structure, and the integration of a response inhibition test within the slot machine simulation. The chapter also presents and discusses the psychological measurements used throughout the experiments, and where relevant, what alternative measures were also considered. In cases where scales and cognitive tests have been adapted from their original format, justifications for these changes are provided.

*1.4.4 Chapter 5. The relationship between gambling event frequency, motor response inhibition, arousal, and dissociative experience*

Chapter 5 comprises the first of three experimental studies. In this first experiment, the motor response inhibition performance of 50 regular non-problem gamblers was assessed during exposure to slot machine gambling at various event frequencies in a repeated-measures design. The results indicated that increased speeds of play were detrimental to response inhibition performance, as assessed using a go/no-go task embedded within the slot machine. Gamblers were less able to withhold prepotent responses when instructed to do so at faster game speeds. Furthermore, faster games were associated with faster reaction times to gambling stimuli, elevated levels of subjective arousal, increased enjoyment, but less dissociative experiences, the latter being associated more with slot machines with slower speeds of play. Increased arousal and faster reaction times were significant and negative predictors of response inhibition performance at fast speeds, but as speed of play decreased, the relative predictive strength of arousal on response inhibition performance decreased, with levels of dissociative experience becoming the dominant predictor of response inhibition performance at the slowest speed of play.

*1.4.5 Chapter 6. A critical review of the harm-minimisation tools available for electronic gambling*

In light of the results obtained in the first experiment, the subsequent experiments assessed the ability of harm-minimisation tools to facilitate response inhibition performance during gambling. First, research in the form of a critical review was conducted and presented in Chapter 6, with the purpose of gaining further knowledge regarding the range of harm-minimisation tools available in electronic gambling and their associated efficacy in facilitating cognition and behaviour *during* gambling. Several categories of harm-minimisation tools were identified, including, but not limited to, breaks-in-play, pop-up messages, and limit setting approaches. One of the key findings of the review was that the use of pop-up messages to deliver responsible gambling information during play is a widely used and accepted form of harm-minimisation. However, the efficacy of pop-messages in facilitating responsible gambling appears dependent on the mode of display (i.e., static versus dynamic presentation), as well as type of content presented (i.e., informative versus self-appraisal content). Pop-up messages were one of the harm-minimisation approaches tested in future empirical chapters within this thesis for several reasons stemming from the critical the review: (i) pop-up message research has been prominent in the recent decade, with evidence suggesting dynamic messages have some (although inconsistent) positive impact on gambling cognitions and behaviour; (ii) not all avenues regarding the best type of content to be displayed in pop-up messages have been explored; (iii) it is less known *how* pop-up messages impact psychological and behavioural factors and if they impact executive control processes; and (iv) if pop-ups are widely used and accepted as a form of gambling harm-minimisation, then it should follow that the approach continues to receive scientific examination and scrutiny. A version of this chapter was published in the Journal of Gambling Studies (Harris & Griffiths, 2017).

#### *1.4.6 Chapter 7. The case for using personally relevant and emotionally stimulating gambling messages to facilitate responsible gambling behaviour*

Chapter 7 presents a conceptual argument regarding the role that emotion has in decision-making processes. Whilst drawing on available empirical research from health-related behaviours outside of a gambling context, the chapter extrapolates such findings to posit that the use of emotion in responsible gambling messages should be tested as a potential fruitful approach to harm-minimisation within gambling. The argument stems from empirical findings demonstrating that emotional and personally relevant information are more eye-catching, more likely to be processed at a semantic level, and therefore, more likely to influence thoughts and behaviour within a gambling session. Such approaches need to be tested for their efficacy, as well as potential inadvertent perverse effects, before the approach can be implemented as a legitimate harm-minimisation approach. A version of this chapter was published in the International Journal of Mental Health and Addiction (Harris, Parke, & Griffiths, 2018). The second and third experiments of the thesis incorporates the use of emotional content within gambling messages as one of the harm-minimisation tools tested with the aim of facilitating aspects of executive control during gambling.

#### *1.4.7 Chapter 8. The efficacy of new and existing harm-minimisation tools in facilitating response inhibition during gambling*

Chapter 8 reports the second experiment of the thesis. The first experiment identified that fast speed of play during slot machine gambling was significantly detrimental to response inhibition, and the second experiment investigates if existing and original harm-minimisation approaches can combat this loss of motor control. Four harm-minimisation approaches (plus a control condition) were tested for their ability to facilitate the response inhibition performance of 60 regular non-problem gamblers whilst gambling on a slot machine simulator in a between-participants design. The harm-minimisation approaches included two types of pop-up message (one presenting informative content, the other emotional content), a structure change condition whereby activating the 'spin' button on the machine required a discriminatory motor response to be made, and a 'punishment' condition, where participants were briefed that erroneous motor responses would result in a small financial loss.

Relative to a control condition, only changing the structure of the spin button and the financial punishment condition were successful in facilitating self-control during gambling, evidenced by increased response inhibition performance on an embedded go/no-go task.

*1.4.8 Chapter 9. Impulsivity transfer effects*

Chapter 9 serves as the introductory chapter for the third experiment of the thesis. The chapter highlights how the construct of impulsivity is now regarded as multifaceted, comprising both motor and cognitive sub-domains. Arguments are presented with reference to empirical research findings that challenge the extent to which sub-domains of impulsivity are related or distinct. There is a sufficient body of research (see e.g., Arce & Santisteban, 2006; Stevens et al., 2015; Verbruggen, Adams, & Chambers, 2012) to suggest that different facets of impulsivity are indeed related, sharing cognitive resources and neurocircuitry. Linking these findings to previous empirical chapters within the thesis raises the issue that if increased speeds of play interfere with the motor aspect of impulsivity, then it may follow that the structural characteristic of speed may also impact wider aspects of impulsivity pertaining to impulsive choice, key to self-control during gambling. This issue is addressed in the third experiment in a more positive light, namely, if specific harm-minimisation tools can facilitate response inhibition performance as demonstrated in the second experiment, then the same tools may facilitate adaptive impulsivity transfer effects to wider aspects of cognition.

*1.4.9 Chapter 10. Gambling, motor cautiousness, and choice impulsivity: An experimental study*

The third and final empirical study of the thesis is reported in Chapter 10. The study experimentally investigated the extent to which inducing motor cautiousness during a high-speed slot machine gambling simulation has transfer effects to the choice component of impulsivity, namely, reflection impulsivity and delay discounting. A total of 70 regular non-problem gamblers participated in the between-participant experimental design. Original structure change approaches shown to be successful in facilitating response inhibition performance in the second experiment were again successful in this domain, but also demonstrated that they facilitated performance in a reflection impulsivity task and delay discounting task. Relative to a control condition, participants in the structure change condition deliberated over decision for longer, made more accurate probabilistic decisions, and showed greater preference for larger delayed hypothetical rewards over smaller immediate hypothetical rewards. Pop-up messages were again unsuccessful in facilitating motor response inhibition. However, pop-up messages, dependent on their content, did facilitate reflection impulsivity and delay discounting performance relative to a control condition, independent of a motor cautiousness transfer effect. The discussion proposes that the harm-minimisation tools tested here can have both a 'direct' impact on the choice component of impulsivity, as well as an 'indirect' transfer of cautiousness route to improved decision-making during gambling. Chapters 9 and 10 were combined to produce an empirical research paper published in the Journal of Behavioural Addictions (Harris, Kuss, & Griffiths, in press)

*1.4.10 Chapter 11. Summary of findings and conclusions*

Chapter 11 summarises the research questions and aims of the thesis, as well as the main findings and conclusions from the empirical chapters. The chapter also presents discussion on the applied implications of the key findings and potential for follow-up and future research, as well as acknowledges the caveats of the thesis overall.

# Chapter 2. The Impact of Speed of Play in Gambling on Psychological and Behavioural Factors: A Critical Systematic Review

### *2. Chapter overview*

There has long been an assumption within gambling research that faster speeds of play are associated with problematic gambling behaviour (McCormack & Griffiths, 2013). The purpose of the present chapter, which takes the form of a critical systematic review, was to identify if there was an empirical basis to support this assumption, and if so, to assess how speed of play in gambling has an impact on psychological and behavioural variables.

### *2.1 Introduction*

Games with fast speeds of play are frequently associated with problem gambling. For example, it has frequently been observed that problem gamblers seeking intervention or treatment for their disordered gambling often report rapid forms of gambling (such as electronic game machines [EGMs]) as a primary cause of their disordered gambling (e.g., Griffiths, 2008; Meyer, Hayer & Griffiths, 2009; Turner & Horbay, 2004). In the psychological gambling literature, speed of play is inextricably associated with event frequency, a structural characteristic referring to the number of gambling events within a given time period and operationalized as the time interval between successive wagers on any given gambling game (Griffiths & Auer, 2013). For example, the event frequency of a bi-weekly lottery is twice a week, whereas the event frequency on an EGM that spins 12 times a minute is five seconds. A fast speed of play has been identified as one of the key features that appeal to gamblers and is therefore more likely to be associated with both higher levels of gambling participation generally, as well as gambling-related harm (Parke & Griffiths, 2007). Of concern is evidence suggesting games with fast speeds of play, such as EGMs, are particularly appealing to problem gamblers (Griffiths, 2008).

Several theoretical propositions exist that attempt to account for the relationship between high event frequency gambling participation and disordered gambling. For instance, the rapid sequencing of gambling stimuli accompanied with reward (i.e., 'the constant cycling of player action'; Dow-Schull, 2012) means that that fast, rhythmic, and continuous nature of EGM gambling facilitates an immersive state of lowered conscious awareness for peripheral information. This may give rise to the gambler experiencing a dissociative state, and it has been argued that such psychological states, facilitated by games with fast speeds, are pleasurable to the gambler (Griffiths et al., 2006). During such dissociative experiences, the need for more conscious and deliberate decision-making is limited, providing negative reinforcement to gamble by reducing tension and escaping wider psychological distress that may be experienced in everyday life (Fang & Mowen, 2009). However, Norman and Shallice (1986) argue that there are specific situations where the routine activation of behaviour, at the expense of top-down executive control, is maladaptive. Unsurprisingly, among the situations Norman and Shallice (1986) identify include those where potential danger can be experienced, or situations that require planning and decision-making. Given that gambling is a situation requiring the constant updating of goals and adjustment of behaviour, as well as a situation where harm may be experienced, it may be maladaptive for gambling features such as speed of play to facilitate dissociative experiences.

The appeal of games with fast speeds of play, particularly amongst problem gamblers, may also be explained by Gray's (1970) Reinforcement Sensitivity Theory. The theory postulates that the Behavioural Approach System (BAS) motivates behaviour to seek out reward (Gray, 1981, 1991). The subsequent reward, which is exciting and pleasurable to the individual, reinforces the behaviour and consequently leaves individuals highly sensitive to potential rewards and makes extinction of the behaviour difficult. Pickering and Gray (1999) argue that dopaminergic fibres ascending from both the substantia nigra and ventral tegmental areas of the brain, that innervate the basal ganglia, together with motor, sensorimotor, and prefrontal regions, are assumed to drive this system. It has been demonstrated that those with abnormalities in dopaminergic functioning, as well as ventro-medial prefrontal cortex structures, are at risk of developing problem gambling due to abnormalities in the way reward and punishment is processed (Goudriaan et al., 2004). Therefore, it is perhaps unsurprising that gamblers with increased sensitivity to reward will be attracted to games with high event frequencies, as such games are more likely to provide increased levels of reward in a relatively shorter period of time.

Alternatively, sensitivity to punishment or loss is seen as a protective factor in the persistence of risk-taking behaviour (e.g., Gray, 1991). Games with high event frequencies also deliver relatively higher rates of loss, and therefore conceptually, one could predict that such factors result in fast games being avoided for gamblers with higher levels of punishment sensitivity. Paradoxically, research demonstrates that this is not the case for gamblers with high levels of sensitivity to reward and punishment. For example, Gaher and colleagues (2015) argue that the increased sensitivity to punishment results in further gambling to alleviate the negative mood state caused by the loss, which results in loss-chasing behaviours. As a result, reinforcement sensitivity theory is able to predict that those high in either reward sensitivity, and/or punishment sensitivity, would be attracted to and persist on games with fast speeds of play for different reasons.

The rapid and continuous pace of play afforded by gambling games with high event frequencies may potentially interfere with a gamblers' ability to process new information, update goals, and/or make adjustments in their behaviour to avoid undesirable consequences. Response modulation is a cognitive process whereby the individual disengages attention on the ongoing activity to re-evaluate and adjust behaviour according to the current reinforcement rate of the behaviour in question (Derevensky, Merrick, & Shek, 2011). Behavioural perseverance despite negative consequence is a hallmark sign of a wide range of clinical disorders including psychopathy (Newman, Patterson, & Kosson, 1987), borderline personality disorder (Davey, 2008), and disordered gambling (Thompson & Corr, 2013). Consequently, if a gambler is not afforded the opportunity to pause and reflect between gambling events, it is less likely that they will respond adaptively to punishment (e.g., financial loss). High event frequency games allow less opportunity for such reflection and adaptation of behaviour and are therefore more likely to lead to behaviour symptomatic of problem gambling. In support of this notion, experimental evidence suggests that when problem gamblers are forced to pause for five seconds between events, they do not persist in gambling longer than non-problem gamblers (Corr & Thompson, 2014; Thompson & Corr, 2013). However, it is unclear whether this effect is due to increased reflection time, or more simply, that the pause made the game less enjoyable. Both factors are not necessarily mutually exclusive.

Whilst these theoretical models have high face validity in explaining why fast speeds of play are associated with disordered gambling, a significant problem remains in that the empirical relationship is largely correlational. The argument can be made that a weak empirical association between fast speeds of play and disordered gambling is potentially harmful to scientific research into this relationship, as it assumes an extensive knowledge-base has already been established. Therefore, one of the goals of the present chapter is to identify the gaps in the current understanding relating to the impact of high event frequency on gamblers across the entire spectrum of problem gambling behaviour. An additional reason for carrying out the present review is to collectively establish what is already known in terms of the psychological and behavioural factors that high event frequency games impact. This is to facilitate the development of gambling harm-minimisation approaches which focus on specific factors that enhance a gamblers' self-control. As far as the authors are aware, no previous literature review has ever examined speed of play in gambling as the single focus although more general reviews of structural characteristics in gambling have devoted small sections of such overviews to theoretical descriptions of event frequency (e.g., Griffiths, 1993; McCormack & Griffiths, 2013; Parke & Griffiths, 2006, 2007).

### *2.2 Method*

#### *2.2.1 Search strategy*

An in-depth literature review was carried out comprising three concurrent phases: (i) search of online electronic databases; (ii) use of professional contacts in the field of gambling to share personal collection of papers related to harm-minimisation in gambling; and (iii) 'snowballing' - a method in which reference lists from published papers are viewed and relevant papers pursued. Electronic databases included the use of the authors' Library One Search (an all-encompassing database search engine, including, but not limited to: *Academic Search Elite, PsychArticles, PsychInfo, Science Direct,* and *Scopus*) as a primary source, along with *Google Scholar* being used as a more general search engine. The general search terms used were 'gambling', 'gaming', 'electronic gambling', and 'online gambling', with more specific search terms comprising 'gambling speed of play', 'gambling event frequency, 'responsible gambling', 'gambling harm-minimisation', and 'gambling tempo'.

#### *2.2.2 Inclusion criteria*

To be included as an output to be evaluated, the published paper had to have: (i) been written in the English language; (ii) reported a study where speed of play was an independent/dependent variable, a predictor/outcome variable, or an area of interest for qualitative studies (e.g., observational studies, interview studies, etc.); (iii) been published within the last 25 years (1991-2016); and (iv) been subjected to peer-review. It was assumed that those studies that had undergone peer-review would be more scientifically rigorous than anything in the 'grey' literature.

#### *2.2.3 Search results*

Once the initially retrieved papers had been filtered according to title and abstract content, a more in-depth assessment was conducted using the inclusion criteria as guidance. The remaining papers were then categorised according to the type of study reported: experimental or qualitative. Using this method, a total of 11 studies remained for critical review comprising nine experimental studies and two qualitative studies (one focus group interview study and one observational study). A summary of the reviewed papers can be found in Table 2.1. The studies are critically reviewed in chronological order.

**Table 2.1.** Summary *of the papers selected for review.*

| Author(s) (Year) | Country | Main Aims | Sample (N) (Design/Method) | Key Findings |
|---|---|---|---|---|
| **Experimental Research** | | | | |
| Griffiths (1994) | United Kingdom | Assessed the cognitive biases demonstrated by regular non-problem gamblers and non-regular non-problem gamblers. Speed of play acted as a dependent variable. | 30 (29 males) regular non-problem gamblers and 30 (15 male) non-regular non-problem gamblers. Mean age= 23.4 years.<br><br>(Live gambling arcade experiment). | Regular gamblers gambled significantly more times per minute (8) compared to non-regular gamblers (6). |
| Loba, Stewart, Klein & Blackburn (2002) | Canada | Experimental study to determine which gaming structural manipulations, including speed of play, might help reduce the risk of abuse of VLTs by pathological gamblers. | 60 (38 male) regular VLT players, with 29 being classed as a pathological gambler and 31 as non-pathological gamblers, as determined by the SOGS. Mean age=34.7 (SD=11.6)<br><br>(Laboratory-based experiment using commercially available VLT). | Compared to non-pathological gamblers, pathological gamblers' ratings of enjoyment, excitement, and tension-reduction was significantly reduced when speeds of play were reduced, as well as when sound was turned off during the game. Pathological gamblers reported significantly more difficulty in stopping gambling than non-pathological gamblers when speed of play was increased accompanied by sound. |
| Blaszczysnki et al. (2005) | Australia | Investigated the impact of structural manipulations, including speed of play, on subjective gambling experience in a live gambling setting. | 400 participants of various non-problem and problem gambling statuses.<br><br>(Naturalistic EGM experiment). | Satisfaction ratings were reduced significantly when both social and problem gamblers played the machines modified to produce a 5 second event |

**Table 2.1.** Summary *of the papers selected for review.*

| | | | | |
|---|---|---|---|---|
| | | | | frequency compared to 3 second event frequency. There was a non-significant impact of slowing the event frequencies on self-reported enjoyment levels. |
| Delfabbro, Falzon, & Ingram (2005) | Australia | Investigated the impact of parameter variation, including speed of play (experiment 3 of 3), on a simulated EGM, in terms of their impact on subjective gambling experience and observable gambling behaviour. | 24 gamblers (15 male) with various gambling experiences, participation rates, and problem gambling statuses. Mean age of participants in this section of the study (experiment 3) was 47.92 (SD= 15.6), with 10 of the gamblers being classed as a problem gambler using the SOGS.<br><br>(Laboratory-based experiment using simulated EGM). | Faster speeds of play (3.5s evet frequency) yielding a significantly higher excitement rating than slower speed games (5s event frequency). Preference ratings were again, significantly higher for faster speed machines. No significant impact of speed of play on the amount spent gambling, but the total amount of games played was significantly higher in the fast speed condition. |
| Sharpe at al. (2005) | Australia | Investigated the impact of structural manipulations, including speed of play, on gambling behaviour in a live gambling setting. | 779 gamblers, from which, 634 participants provided SOGS scores. Twenty percent of the sample were classed as problem gamblers for having scored five or more on the SOGS, all other participants were grouped as non-problem gamblers. Participant mean age was 46.1 (SD= 17.9) years.<br><br>(Naturalistic EGM experiment). | The speed manipulations (3.5s and 5s) had little effect on gambling behaviour. There was no statistical significance in terms of the difference in time spent on the gaming machines, number of bets placed, amount lost, number of lines or credits played, and alcohol and cigarette consumption, as a result of manipulations in speed of play. |
| Ladouceur & Sevigny (2006) | Canada | Investigated the impact of video lottery game speed on gamblers' levels of concentration, motivation, self-control, and the amount of games played. | 43 (22 female) regular and non-regular non-problem gamblers.<br><br>(Laboratory-based VLT simulation experiment). | Gamblers in the 5 second condition played more games and underestimated the number of games they had played compared to participants in the |

**Table 2.1.** Summary *of the papers selected for review.*

| | | | | |
|---|---|---|---|---|
| | | | | slow (15s) speed condition. Speed of play did not however, have a statistically significant impact on participant levels of concentration during gambling, motivation to continue gambling, or time and money spent gambling. |
| Linnet et al. (2010) | Denmark | Investigated the effects of event frequency on the behaviour and experiences of problem and non-problem gamblers. | 15 (10 male) pathological gamblers and 15 (8 male) non-problem gamblers.<br><br>(Laboratory-based experiment using a commercially available VLT). | Pathological gamblers reported significantly higher levels of excitement in the fast (2 second) condition compared to non-problem gamblers. This significant effect was not maintained in the slower (3 second) condition. Pathological gamblers also reported significantly higher desire to play again than non-problem gamblers in the 2 second condition. Pathological gamblers spent more time gambling than non-pathological gamblers in both the 2 second and 3 second condition. Significantly more pathological gamblers (60%) continued gambling until they were told to stop in the 2 second condition compared to non-pathological gamblers (6.7%). |
| Choliz (2010) | Spain | Investigated impact of different reward delays, and therefore, event frequency, on gambling behaviour among treatment seeking problem gamblers. | 10 treatment seeking problem gamblers.<br><br>(Laboratory-based experiment using a simulated slot machine). | More games were played in the 2 second (immediate reward) event frequency condition (56) when compared to the 10 second (delayed reward) condition (39). |

**Table 2.1.** Summary *of the papers selected for review.*

| | | | | |
|---|---|---|---|---|
| Mentzoni et al. (2012) | Norway | Investigated the impact of various bet-to-outcome-intervals (BOI; and therefore, speed of play) on subjective gambling experience, illusions of control, and observable gambling behaviour. | 62 undergraduate students (31 male) with a mean age of 20.8 year (SD=3.26. Three participants were probable pathological gamblers, 27 had some problems with gambling, and 32 had no problems with gambling, as indicated by the SOGS.<br><br>(Laboratory-based experiment using computer simulated slot machine). | No overall main effect of BOI on average bet size, illusion of control, or subjective enjoyment ratings, and no evidence that the faster game was preferred by the participants. Results did however, indicate an interaction effect, at-risk pathological gamblers made significantly higher average bet sizes than non-problem gamblers in the short (fast speed) BOI condition. |
| | | | | |
| **Qualitative Research** | | | | |
| Griffiths (1991) | United Kingdom | General aims of the research were to observe amusement arcade cliental and their behavioural characteristics. | Gamblers visiting 33 UK-based amusement arcades.<br><br>(Observational field study). | Common amongst regular gamblers was that they played at very fast speeds of up to 100 times in 10 minutes. Fast-paced gamblers appeared to be on ‘automatic pilot’, a state which was only halted temporarily when the ‘nudge’ feature of the slot machine came into play. |
| Thompson, Hollings, & Griffiths (2009) | United Kingdom | Qualitative investigation to enhance understanding of how structural characteristics of gaming machines interact with the gambler. | 48 gamblers, with statuses ranging from non-problem to current problem gambler.<br><br>(Series of interviews and focus groups). | Speed of play was identified as a core structural characteristic that drives gambling behaviour, and faster games reported to enhance the gambling experience. |

## ***2.3 Results***

### *2.3.1 Experimental studies*

Griffiths (1994) conducted an ecologically valid gambling experiment in the UK using slot machines in a gambling arcade to assess both the cognitive biases by regular non-problem gamblers (N=30, 29 males) and non-regular non-problem gamblers (N=30, 15 males), as well as their overt gambling behaviour (mean age = 23.4 years). Cognitive biases were assessed using the 'thinking aloud' method where gamblers' verbalisations are recorded and categorised (Ericcsson & Simon, 1980). Overt gambling behaviour variables included total plays, time spent gambling, and speed of play. Results relating to speed of play demonstrated that on average, regular gamblers played significantly faster (eight gambles per minute) compared to non-regular gamblers (six gambles per minute). The mean speed of play rate was reduced in the thinking out loud condition for non-regular gamblers from 6.5 to 5.3 gambles per minute, and increased in the thinking out loud condition for regular gamblers from 7.5 to 8.4 gambles per minute, although both of these differences were not statistically significant.

Because cognitive biases were the main focus of this experiment and not speed of play, and the fact that speed of play was used as one of several dependent variables, knowledge gained in terms of the impact of speed on the gambler is limited. However, the study did provide empirical evidence that regular gamblers play on slot machines significantly quicker than non-regular gamblers ($p<0.01$). Reasons for this may simply be due to the fact that regular gamblers are more familiar with the gambling product and consequently, the game mechanics, allowing them to operate the games at a faster pace through familiarity and competence. This was supported by the verbalisations from both regular and non-regular gamblers in the 'thinking aloud' condition. Compared to regular gamblers, non-regular gamblers made significantly more verbalisations that were classed as 'confused questions' ($p<.001$) and 'confused statements' ($p<.001$), suggesting that the lower level of competence may slow down the speed of gambling for non-regular gamblers.

Loba, Stewart, Klein, and Blackburn (2002) conducted a laboratory-based experiment in Canada using commercially available video lottery terminals (VLTs) to examine the effects of structural characteristic manipulations on subjective game experiences. Participants comprised 60 regular VLT players (38 males), with 29 being classed as a 'pathological gambler' and 31 as 'non-pathological' gamblers, as determined by the SOGS (Lesieur & Blume, 1987). Participants were on average 34.7 years of age (SD=11.6). Game manipulations included increasing and decreasing the speed of play for a video poker and 'reel spin' game, as well as other sensory manipulations such as sound/no sound, stop button/no stop button, and display counter/no display counter. Results indicated that when compared to non-pathological gamblers, pathological gamblers' ratings of enjoyment, excitement, and tension-reduction was significantly reduced when speeds of play were reduced, as well as when sound was turned off during the game. Of note, pathological gamblers reported significantly more difficulty in stopping gambling than non-pathological gamblers when speed of play was increased accompanied by sound.

However, it is not made clear to what extent the game speeds were increased or decreased relative to a control condition, as no information on VLT event frequency was provided. This is an important omission, as it is not known if the pathological gamblers were sensitive to small changes in event frequency, or if in fact the speed manipulations were large. In addition, the use of dichotomous participant groupings, non-pathological vs pathological gamblers, overlooked the fact that pathological gambling behaviour is viewed along a continuum of problematic behaviours and intensities, where several intermediate levels of risk between non-pathological and pathological gambling exist (Currie & Casey, 2007). In terms of the impact of speed of play on self-reported gambling experiences, it is important to acknowledge that speed of play was manipulated concurrently to other multiple structural game changes. This makes it difficult to ascertain the proportional impact of each manipulation on reported gambling experiences, and therefore does not shed light on the impact of speed of play on gambling experiences in isolation. However, it is understandable why speed was not isolated in Loba et. al.'s experimental procedure given the already lengthy experiment duration (two hours).

Sharpe and colleagues (2005) conducted a naturalistic experiment, in which various structural manipulations to eight gaming machines in gambling venues and hotels in the New South Wales region of Australia were made. Participants comprised 779 gamblers, from which 634 participants provided SOGS scores. Participant mean age was 46.1 years (SD=17.9), and the mean SOGS score was 2.43 (SD=3.43) out of 20. One-fifth (20%) of the participants were classed as problem gamblers having scored five or more on the SOGS. All other participants were grouped as non-problem gamblers due to sub-categories of 'at-risk' gamblers being too small for reliable statistical analysis. Speed of play was one of the independent variables, being manipulated at two levels: 3.5-second, and 5-second event frequencies, with maximum bet size and maximum size note acceptors as the two other structural characteristics being experimentally manipulated.

The speed manipulations had little effect on gambling behaviour. There was no statistical significance in terms of the difference in time spent on the gaming machines, number of bets placed, amount lost, number of lines or credits played, and alcohol/cigarette consumption, as a result of manipulations in speed of play. However, it is not possible to tell from this study whether reductions in speed of play would be differentially effective for problem gamblers as compared to at-risk gamblers, because there were insufficient numbers of at-risk gamblers included in the study. In addition, that fact that gambling behaviour was being observed by the researchers may in turn have produced demand characteristics, possibly resulting in gamblers behaving in a more controlled and moderate manner, gambling more slowly and deliberately as a result. Of the three proposed modifications, only a reduction in maximum bet size to $1 demonstrated evidence for a potential reduction in harm associated with gambling, because those gambling on $1 maximum machines played for less time, made fewer bets, lost less money, and consumed less alcohol and cigarettes during play.

Blaszczysnki and colleagues (2005) similarly demonstrated that a reduction in speed of play on EGMs from a three-second to five-second event frequency had no impact on a gambler's intentions to continue playing. They conducted a live experiment in hotels and clubs in the Sydney region of Australia, comprising more than 400 participants of various non-problem and problem gambling statuses who played on modified experimental and non-modified gaming machines. As well as manipulating speed of play, experimental machines were modified to limit the maximum bet size and reduce the high denomination note acceptors compared to control machines. Limiting the maximum bet size and note acceptor modifications had a non-significant impact on self-reported satisfaction and enjoyment levels for both social and problem gamblers. However, satisfaction ratings were reduced significantly when both social and problem gamblers played the machines modified to a five-second event frequency, when compared to the unmodified machines with three-second event frequencies. There was a non-significant impact of slowing the event frequencies on self-reported enjoyment levels, although Blaszczynski et al. (2005) report this as a trend towards reduced enjoyment levels given the *p*-value of .065. There was no interaction effect between levels of enjoyment of three- and five-second event frequencies and problem gambling status, although overall, problem gamblers rated all EGMs as less enjoyable than social gamblers. While satisfaction ratings reached statistical significance, the largest difference in satisfaction and enjoyment scores between the modified and control machines was just 8.75%, suggesting a small effect size.

Despite the seemingly negative impact of reducing speed of play on satisfaction and enjoyment levels, this did not impact gamblers' intentions to continue gambling on EGMs, as respectively, 54% and 53% reported intentions to continue play on the control and experimental machines. Speed of play was the only modification to the machines that gamblers were able to identify, although detection rates were low, with only 14% of gamblers able to identify the modifications. This suggests that reasons for the reduced satisfaction and enjoyment ratings were subconscious, at least for the majority of the gamblers in this experiment. An alternate explanation could be that the overall effect of reduced satisfaction and enjoyment was driven only by those gamblers that were able to detect the reduced speed modification. Further post-hoc statistical analysis would be required to provide evidence for such claims.

Delfabbro, Falzon and Ingram (2005) conducted three laboratory-based experiments in South Australia assessing the impact of parameter variation on simulated EGMs in terms of their impact on subjective gambling experience and observable gambling behaviour. The EGM manipulations included reinforcement magnitude and frequency (Experiment 1), sound and screen illumination (Experiment 2), and outcome display and speed manipulation (Experiment 3). The speed of play in Experiment 3 was manipulated at two levels to provide machines with both a 3.5- and five-second event frequency. Participants exposed to the speed of play manipulations were 24 gamblers (15 males) with various gambling experiences, participation rates, and problem gambling statuses. The mean age of participants in Experiment 3 was 47.92 years (SD=15.6), with 10 of the gamblers being classed as a problem gambler using the SOGS. Participants were asked to play for three minutes on each of the four machines programmed with the varying parameter settings (credit display/fast speed, credit display slow speed, dollar display fast, and dollar display slow). After this mandatory exposure, participants were given a free choice to continue gambling on one of the four machines.

Speed of play was shown to significantly influence excitement ratings, with faster speeds yielding a significantly higher rating than slower speed games. Preference ratings were again, significantly higher for faster speed machines. Display type (dollars vs. credits) did not significantly impact excitement or preference ratings. There was no significant impact of speed of play in terms of the amount spent gambling on the machines overall, but the total amount of games played was significantly higher in the fast speed condition. Control measures indicated that these differences in subjective experience ratings and gambling behaviour could not simply be attributed to specific machines yielding a higher return to player or win rate, indicating the effects were driven by the speed manipulations alone. Neither gender, nor problem gambling status, interacted with the manipulations to produce significant effects, although these small sub-sample comparisons may not be reliable given the low number of participants in each category (e.g., Experiment 3 comprised just 10 problem gamblers).

Ladouceur and Sevigny (2006) investigated the impact of VLT game speed on gamblers' levels of concentration, motivation, self-control, and number of games played. Participants comprised 43 gamblers (22 females) from the Quebec City region of Canada. Gambling participation rates ranged from 0-24 times over the past six months, with an approximate overall mean average of three times in the past six months. A majority of the sample (n=32) scored zero on the SOGS, six had a score of one, and five had a score of two, indicating the sample did not contain any problem or at-risk gamblers. Speed of play was manipulated at two levels, with one group being exposed to a VLT game with a five-second event frequency, the other group a 15-second event frequency. Gamblers in the five-second condition played more games and underestimated the number of games they had played compared to participants in the slow speed condition. However, speed of play did not have a statistically significant impact on participant levels of concentration during gambling, motivation to continue gambling, or self-control in terms of time and money spent gambling. The authors concluded that the slower speed VLT game did not appear to have any positive impact in terms of facilitating more controlled gambling behaviour among the participants studied.

The use of both a five-second event frequency for the 'fast' condition and 15-second event frequency for the 'slow' condition is questionable, particularly given that event frequencies on electronic gaming machines can reach three seconds for offline EGMs, and even higher in their online form. Consequently, a five-second event frequency would arguably be considered slow for specific forms of EGM gambling. Motivation to continue playing was extremely low in both speed conditions, with mean motivation scores of 2.6 and 2.5 out of 10 being recorded in the fast and slow conditions respectively. Enjoyment ratings of both games were also arguably very modest, with mean enjoyment ratings 2.7 and 2.5 out of 4 for the fast and slow condition respectively. Of note, was that 67% of participants in the slow condition reported that they would like the game to go faster (compared to just 33% in the fast condition). Taken together, it could be argued that the gambling in this experimental study failed to replicate the exciting and arousing nature of real-world gambling, although it is acknowledged that this is often a trade-off for high-levels of experimental control. In addition, mean participation rates in gambling were very low for this sample, with mean participation rates equating to just once every couple of months, meaning that the gamblers were already participating at highly controlled levels, potentially masking the effects of the speed modification, and failing to be representative of gambling behaviour typically exhibited by more regular gamblers.

Linnet et al. (2010) conducted a laboratory-based experiment in Denmark to investigate the effects of event frequency on the behaviour and experiences of problem and non-problem gamblers. The study comprised 15 pathological gamblers (10 males) and 15 non-problem gamblers (eight males). Event frequency on a popular and commercially available slot machine was manipulated at two levels to produce a two-second and three-second event frequency slot machine. The dependent variables included self-reported excitement levels, desire to play again, and time spent gambling.

Pathological gamblers reported significantly higher levels of excitement in the two-second condition compared to non-problem gamblers. This significant effect was not maintained in the three-second condition. Pathological gamblers also reported significantly higher desire to play again than non-problem gamblers in the two-second condition, but again, this effect was not maintained in the three-second condition. Pathological gamblers spent more time gambling than non-pathological gamblers in both the two-second and three-second condition. In addition, significantly more pathological gamblers (60%) continued gambling until they were told to stop in the two-second condition compared to non-pathological gamblers (6.7%). In the three-second condition, twice as many pathological gamblers (40%) continued gambling until stopped compared to non-pathological gamblers (20%), although this effect did not remain statistically significant.

Overall, the results supported the notion that the behaviour and gambling experiences of pathological gamblers differs significantly from non-pathological gamblers at the faster two-second event frequency, but that their behaviour and experience was more similar at the slower three-second event frequency. However, upon close examination of the statistics, pathological gamblers report approximately 40-60% higher ratings of excitement and desire to continue gambling compared to non-pathological gamblers in the three-second condition. While these figures did not differ at a statistically significant level, this lack of statistical significance is likely due to the small sample size of just 15 for each problem gambling status, and represents a significant limitation of the study. An additional limitation of the experimental procedure was that the experimenters were not able to control payback and win percentages across the two slot machines. As a result, the researchers were not able to control for extraneous variables such as emotion as a result of wins and losses, which has been demonstrated to be an important determinant in a range of gambling behaviours, including size and frequency of bets (Harris & Parke, 2015, 2016).

Choliz (2010) manipulated reward delay, and therefore, event frequency in a repeated-measures laboratory experiment conducted in Spain. The sample comprised 10 problem gamblers recruited from gambling treatment services, and they took part in a simulated slot machine study. Whilst controlling for reel speed, the experimenter manipulated the reward delay at two levels: a two-second, and 10-second delay. While the reward delay was the main variable of interest, it is important to note that as a result of this experimental manipulation, event frequency duration coincided with the reward delay, to produce a condition with a two-second and 10-second event frequency.

Key results indicated that more games were played in the two-second event frequency condition (n=56) when compared to the 10-second condition (n=39). Choliz (2010) reported that this difference could not be attributed to volume or frequency of winning outcomes because there were no significant differences in gambling outcome across the two conditions. However, it is questionable whether results were driven by the reward delay or the event frequency. It may have been the case that fewer games were played in the ten-second condition due to each game cycle taking longer to complete, and participants may simply be constrained for time resulting in fewer games being played. Caution must also be taken relating to the reliability of results given the small sample of just 10 participants.

In a Norwegian laboratory-based experiment using a computer-simulated slot machine, Mentzoni and colleagues (2012) investigated the impact of various bet-to-outcome-intervals (BOIs) on subjective gambling experience, illusions of control, and observable gambling behaviour. The authors define BOI as the time delay between the initiation of the bet and receiving the outcome of that bet. However, there was an important distinction overlooked by Mentzoni et al. (2012) between event frequency and BOI. It is possible to have a short BOI structure within a relatively slower event frequency if the outcome of the event does not signify the point at which a new game cycle or bet can begin. For example, a slot machine may spin for two-seconds and reveal the outcome of the wager immediately following the reel spin, but there may be a further one-second delay before a new wager can be made. In this hypothetical example, the machine would have a two-second BOI, yet a three-second event frequency. This distinction is not made by the authors, so it has to be assumed that BOI and event frequency are of the same length of time in this study.

A total of 62 undergraduate students (31 males) with a mean age of 20.8 years (SD=3.26) participated in the between-participants experiment. Three participants were probable pathological gamblers, 27 had some problems with gambling, and 32 had no problems with gambling, as indicated by the SOGS. Of note, the three participants scoring five or more on the SOGS were excluded from further analysis. Participants were allocated to one-of-three BOI condition: 400ms; 1700ms; and 3000ms respectively. The results showed no overall main effect of BOI on average bet size, illusion of control, or subjective enjoyment ratings, and therefore, little evidence to support the notion that speed of play leads to more intensive and risky gambling, and no evidence that the faster game was preferred by the participants. However, results did indicate an interaction effect in that at-risk pathological gamblers made significantly higher average bet sizes than non-problem gamblers in the short BOI condition. The differences in bet sizes between these two sub-groups did not reach statistical significance in the moderate or long BOI condition. This may indicate that at-risk gamblers may be particularly susceptible to elevated risk-taking in games with high event frequencies and short BOIs.

To reiterate, one of the limitations of this study was the lack of distinction between BOI and event frequency, so it is not possible to ascertain whether the short BOI or high event frequency resulted in at-risk gamblers escalating their average bet sizes. Further research would be required to control for this distinction. In addition, the absence of a meaningful sample size of pathological gamblers means results cannot be extended to account for the behaviour of those at the extreme end of the problem gambling continuum.

### *2.3.2 Qualitative studies*

Thompson, Hollings and Griffiths (2009) conducted a qualitative investigation into EGM gambling, with one of their key objectives being to gain an enhanced understanding into how structural characteristics of machines interact with the gambler. Forty-eight gamblers, with statuses ranging from non-problem to current problem gambler, participated in a series of interviews and focus groups across several regions of the UK. Throughout the investigation, speed of play was identified as a core structural characteristic that drives gambling behaviour. The instantaneous nature of machine play, and the real-time risk involved was found to be a key motivation for many players. These factors were enhanced by the speed of machine gambling compared to some of the other forms of gambling. Two of the recovering problem gamblers stated how they preferred electronic roulette in its' virtual form (played via 'fixed odds betting terminal' machines) because less time is wasted counting and raking chips compared to 'live' roulette:

> *"I played roulette on the table and it wasn't quick enough for me. I was too impatient, I couldn't wait. So I'd play the machines" (Problem gambler).*
> *"They're very fast. A gambler's trait is impatience and there's no waiting around … It's just you and the machine, pressing the button" (Problem gambler).*

The authors highlighted how several problem gamblers likened rapid machine play to taking drugs:

*"I like the instant fix, the constant fix" (Problem gambler).*

Several gamblers reported using the 'autoplay' feature to facilitate faster play. Other ways a minority of gamblers reported trying to increase the game speed was by playing multiple machines simultaneously or betting on multiple lines. Findings demonstrated that the majority of problem gamblers reported a preference for simpler games, such as three-reeled slots, with no bonus boards, as it was these simple machine variants that allowed for faster rates of play and therefore, more opportunities to win. A smaller proportion of problem gamblers along with regular gamblers reported that they preferred slower and more complex games with a larger skill element. These were the players who reported gambling to kill time. Additionally, the slower pace and increased complexity allowed for longer periods of gambling:

*"You've got to do more so it makes your money last longer" (Regular gambler).*

From this qualitative study, it appears that there is a tendency for those with elevated levels of problem gambling to prefer games of a rapid nature to maximise excitement and wins. However, regular non-problem gamblers had a tendency to report a preference for more complex and slower games to allow them to play for longer. The authors' reported the particularly fruitful nature of the one-to-one interviews where problem gamblers were able to disclose more personal and experiential information in a confidential manner. This was not the case in the focus groups, therefore, this part of the study may have suffered from well-reported limitations of focus group research in that those with more dominant personality and communication styles may have overrepresented the views of the majority.

In a different type of qualitative study, Griffiths (1991) conducted a longitudinal observational study across 33 inland and coastal amusement arcades over a 28-month period. Although no specific hypotheses were made because of the exploratory nature of the observations, one of the general aims of the research was to observe amusement arcade clientele and their behavioural characteristics. Relating to the present aims of this review, Griffiths observed that a commonality amongst regular gamblers was that they played at very fast speeds of up to 100 times in 10 minutes. The study described these fast-paced gamblers as being on 'automatic pilot', a state which was only halted temporarily when the 'nudge' feature of the slot machine came into play. These observations suggest an altered state of conscious awareness and narrowing of attention was produced for regular gamblers playing EGMs at fast speeds. The findings also suggest that specific game characteristics such as ‘nudge’ features have the potential to break lowered conscious and autopilot states.

However, Griffiths (1991) did not define regular gamblers (except that he recognised regular patrons over the course of the longitudinal study) and given the non-intrusive observational nature of the research, it was not possible to obtain the players’ problem gambling status. As a result, it is difficult to ascertain if the rapid pace of play observed in regular gamblers was a result of any underlying gambling problems, or the structural features of the games themselves inducing a rapid play style. Of note, while it was observed that specific game features (i.e., nudges) appeared to break dissociative states, it might be the case the benefits of this are offset by the increased illusion of control, which has shown to be a predictor of problem gambling behaviour (Fu & Yu, 2015).

### *2.4 Discussion*

Based on the studies reviewed, there appears to be an overall trend from the experimental findings that games with high event frequencies are perceived as more exciting and more enjoyable by gamblers, which is likely to be one of the core factors accounting for the popularity of EGMs. This is a finding that applies to gamblers across the entire problem gambling continuum. This evidence is supported and complemented by the qualitative data surrounding speed of play, where the reasons gamblers show a preference for such fast games include the instant gratification they provide, and the lack of waiting around between gambling events which appeals to the gamblers’ ‘lack of patience’. However, while both problem and non-problem gamblers rate faster games as more enjoyable when compared to slower game speeds, some studies (e.g., Linnet et al., 2010) demonstrate that enjoyment ratings for fast games are significantly higher amongst problem gamblers. Furthermore, some studies found that problem gamblers also report a significantly higher desire to continue gambling on faster games when compared to the same ratings made by non-problem gamblers, as well as problem gamblers also reporting a greater reduction in tension when playing faster games. Taken together, these findings appear to support previous notions that games with fast speeds are particularly appealing to those displaying signs of disordered gambling (e.g., Griffiths, 2008).

In terms of the behavioural impact of speed of play, results demonstrated a varied set of findings. Several studies reported that games with faster speeds of play resulted in more games being played compared to slower games (e.g., Loba et al., 2002; Delfabbro et al., 2005; Ladouceur & Sevigny, 2006), which is perhaps unsurprising given the fact that a higher event frequency affords the gambler the opportunity to make more bets in a given period of time compared to games with slower event frequencies. Several studies also found that problem gamblers reported more difficulty in stopping gambling compared to non-problem gamblers at fast speeds of play (an effect that disappeared when game speed was slowed) or that problem gamblers were significantly more likely to continue gambling until asked to stop at fast speeds compared to non-problem gamblers (an effect that was also found at slower speeds, although to a lesser extent). One study showed that speed interacted with problem gambling status, demonstrating that problem gamblers significantly increased their average bet sizes in games with fast speeds (Mentzoni et al., 2012). Taken together, these results suggest problem gamblers have more difficulty in exercising self-control compared to non-problem gamblers regardless of speed of play, but that this effect is exacerbated with fast game speeds. However, several studies showed that speed of play had no impact on variables including both the amount of time and money spent gambling, number of bets placed, desire to continue gambling, and illusion of control. The trend appears to point towards an overall deleterious impact of speed of play on gambling behaviour and self-control, but results are inconsistent. This inconsistency is most likely due to the relatively small amount of studies conducted investigating speed of play, the varied methodologies used among this small sample, and the methodological limitations they possess (particularly the relatively small sample sizes). Coupled with this, the present review clearly demonstrates that there is a lack of studies with longitudinal designs and that those studies with small sample sizes include relatively few individuals with gambling problems making it difficult to provide any definitive conclusions regarding the impact of speed of play on both problem and non-problem gamblers and/or the differences between them.

The examination of the impact of speed of play on gambling behaviour in a real gambling venue, using commercially available gambling products, has the advantage of assessing gambling behaviour in its' natural environment. While this adds a great deal of ecological validity to the findings, a drawback is that tight experimental control measures are sacrificed. For example, it has been found that the structural changes made to machines in such studies are often not made in isolation. That is to say, speed of play was not the only variable manipulated, making it more difficult to ascertain casual influence on gambling behaviour. Of note, several of the laboratory-based studies also fall victim to this limitation, but as a whole, experimental research in the laboratory environment has the added advantage of implementing higher levels of experimental control and more easily isolating the impact of speed of play on gambling behaviour. Whilst it is acknowledged that gambling comprises a wide range of structural and situational characteristics (McCormack & Griffiths, 2013; Parke & Griffiths, 2007), a more parsimonious approach is essential to learn more about specific structural characteristics (in this case speed of play) and its' influence on the gambler.

Another factor potentially driving the inconsistent findings is the nature of the speed of play manipulation in this body of research. As a case example, the ‘fast’ speed of play condition in Ladouceur and Sevigny’s (2006) experimental study consisted of a five-second event frequency, whereas this would not even qualify as the slow condition in both Mentzoni et al.’s. (2012) and Linnet et al.’s. (2010) experiments, and only matched the speed of the slow condition in Delfabbro, Falzon, and Ingram’s (2005) experiment. This has important implications in the way results are interpreted and reported. It may be more beneficial for research findings to be interpreted in terms of the event frequency itself (measured in seconds, for example), rather than any subjective interpretation of what makes for a ‘fast’ or ‘slow’ condition. This way, results can be standardised and made to be more comparable across studies and also has the added advantage of helping to ascertain speed thresholds where self-control becomes facilitated or degraded. It would also be advisable for speed manipulations to be anchored and manipulated proportionally around industry standard event frequencies, which occur approximately every three seconds on EGMs, allowing event frequency speed results to be assessed against existing industry benchmarks. Furthermore, there are relatively few studies that manipulate speed comparable to the faster pace of games found on online gambling platforms, emphasising the need for investigations evaluating the impact of both decreases and increases in speed of play.

There is also the argument that the impact of speed of play may not be immediately visible by assessing direct and overt gambling behaviour in some cases. The impact may be more subtle, and not captured within a relatively short experimental session, where the effects of speed on behaviour may take impact over a more sustained period of time by influencing executive functions vital for self-control not assessed in these studies. For example, these studies did not assess core executive functions such as response inhibition, reflection impulsivity, or response modulation, functions which act as the antithesis to a more impulsive style of response, and functions that act as predictors of risk-taking behaviours (Mahmood et al., 2013). Emerging evidence has demonstrated that executive control capabilities can be influenced by structural characteristics in a gambling context, characteristics that include stake size (Parke, Harris, Parke, & Goddard, 2015), as well as speed of play (Harris & Griffiths, 2016). Furthermore, evidence suggests that facilitating response inhibition in a gambling context leads to a preference for less risky gambling-related decisions (Verbruggen, Adams, & Chambers, 2012). Furthermore, if structural gambling features such as speed have the potential to interfere with executive inhibitory processes, this could explain why some gamblers find quitting such games more difficult, even in the face monetary loss, potentially leading to excessive losses and time spent gambling.

The present review chapter identified just one study utilising a qualitative self-report approach, the findings from which supported the empirical studies in which gamblers frequently report a preference and increased levels of enjoyment in games with high event frequencies. Obtaining first-person perspectives may offer fruitful information not otherwise available to gambling harm-minimisation research studies via the experimental method. Interviews and focus groups may provide insights into alternative ways of facilitating self-control during gambling, without excessively slowing down the speed of the game, which has been shown to have a consistent detrimental impact on the enjoyment of gambling. For example, gamblers report the need for ‘a constant fix’, so one avenue of exploration may be to find ways of providing breaks in play to facilitate self-control and allow for response modulation, but whilst simultaneously making the time between gambling entertaining, such as the use of non-gambling mini-games. It is also advisable that gamblers are involved in the design process of such measures, much the same way that gambling focus groups were used to help create persuasive system designs to facilitate monetary limit adherence tools in a study conducted by Wohl et al. (2014).

### *2.5 Conclusions*

Despite much reference to problem gambling being associated with games with high event frequencies (e.g., EGMs), research actually investigating the impact of speed of play on gamblers is in its relative infancy. The majority of the limited empirical evidence points towards the notion that games that have a faster speed of play are more enjoyable and desirable by an array of gamblers, but that this comes at the cost of impaired self-control. The increased number of bets placed, increased time spent gambling, and the reduced ability or willingness to stop gambling during fast games, appears particularly applicable to, but not limited to, problem gamblers. This suggests close attention should be paid towards implementing measures to facilitate self-control during rapid forms of gambling. Slowing down game speed has shown some (but inconsistent) support for reducing risk-taking and facilitating self-control, although evidence suggests this would likely reduce gambling enjoyment and detract from the experience of gambling. As a result, potential perverse and unintended consequences may result from slowing game speeds, in the form of compensatory behaviours or a migration to other products. For example, if game speed is slowed, this may result in gamblers making higher volume bets to compensate for the reduced event frequency, or playing multiple products simultaneously to essentially allow for the same volume of gambling in the same period of time. Alternatively, slowing game speed on EGMs may result in gamblers migrating to online forms of gambling, where speeds of play can be much faster, and where the online environment itself can give rise to increased risk-taking and reduced inhibitions (Suler, 2004).

As an alternative, researchers should investigate ways of implementing harm-minimisation tools that have the effect of making gambling safer by facilitating self-control, but that are less conducive to detracting from the overall enjoyment and experience of gambling such as slowing game speeds. One possibility mentioned is the use of non-gambling mini-games during breaks in play to both provide a chance to take a break and modulate behaviour, but maintain entertainment levels. Existing research also suggests that while breaks in play in isolation may be detrimental to gambling behaviour by increasing cravings and negative subjecting emotion (Blaszczynski et al., 2016), when breaks are accompanied by responsible gambling messages that are not overly paternalistic and allow gamblers to engage in self-appraisal (Monaghan & Blaszczynski, 2010), or allow a gambler to focus on external emotional factors (Harris, Parke, & Griffiths, 2016), gambling behaviour is shaped more positively.

Therefore, rather than slow down the speed of the game (which would likely decrease the pleasure of gambling for those without any problems), gambling operators should utilize gambling tools that promote responsible gambling (Harris & Griffiths, 2016). There is now growing empirical evidence that some responsible gambling tools can help decrease the time and money spent playing among individuals who gamble intensely on games with fast speeds of play including pre-commitment tools such as limit-setting features (Auer & Griffiths, 2013) and personalised feedback based on actual gambling behaviour (Auer & Griffiths, 2015, 2016). Unfortunately, such tools can only be used on those gambling games where playing behaviour can be electronically tracked such as those online and/or those that require a loyalty card or player card to gamble. However, some operators in some countries (such as *Norsk Tipping* in Norway, *Svenska Spel* in Sweden, and *Casinos Austria* in Austria) use mandatory player cards that tracks all gambling behaviour both online and offline and such a system could be implemented by other operators in other countries.

Finally, further research is required to ascertain the psychological mechanisms that mediate the relationship between speed of play and overt gambling behaviour. It is possible that the total impact of high event frequencies on the gambler is not immediately captured within short, single-session experimental procedures (which is why, as mentioned above, longitudinal research is needed), or that it is not immediately observable using overt gambling behaviour as a measure. What may be required is the use of proxy measures deemed essential for the application of self-control, particularly relevant in a gambling context. Such measures may include core executive functions that act as the antithesis to impulsivity, for example response inhibition and response modulation.

# Chapter 3. Automatic versus Executive Control Processes

### *3. Chapter overview*

The present chapter acquaints the reader with relevant theoretical and empirical accounts regarding executive control processes. The chapter discusses the differences between automatic and controlled processes and argues why automaticity is not desirable within a gambling context. The main focus of the chapter is behavioural response inhibition, which is regarded as the hallmark feature of executive control. Response inhibition allows individuals to overcome strongly conditioned and habituated responses to allow self-guided behaviour towards chosen goals and to keep individuals safe from potential harm (Aron, Robbins, & Poldrack, 2014). Response inhibition theory is introduced, as well as a discussion of the key role that response inhibition has in disordered gambling.

### *3.1 Introduction*

In psychological terms, automatic processes are argued to be fast, require minimal or no effort, and are considered 'bottom-up' and involuntary as they are triggered easily by environmental cues (Stevens et al., 2015). In contrast to automatic processes, executive control processes are considered relatively slower, more effortful, are goal-driven, and are therefore more voluntary and 'top-down' in nature (Stevens et al., 2015). Categorising all mental processes as automatic or controlled however, may represent a false dichotomy, as many theorists assume that all cognitive processes vary in the degree to which they involve automatic and controlled processing (e.g., Kahneman, 2003; Norman & Shallice, 1986).

Many situations involve the transformation of once complex actions into more automatic process through rehearsal and practise. One advantage of this is that it frees the individual from having to consciously process everyday actions, as conscious processing is relatively effortful and time-consuming (Hassin et al., 2009). A salient example of this would be reading, essential for everyday life, and a skill which for the vast majority of adults has been converted from an effortful and conscious task, to a more automatic and fast process (Augustinova & Ferrand, 2014). The ability to respond rapidly and automatically to environmental stimuli based on limited information is essential for the survival and success of organisms, like retracting our bodies away from potential or real threats, or at the more social level, allows individuals to react to their opponent's actions in a sporting context (Zamorano, et al., 2014).

Whilst rapid and automatic processing and response styles have evolutionary benefits, Norman and Shallice (1986) identify several types of situations in which the routine activation of behaviour may become maladaptive and suboptimal for performance. Such situations include those that involve planning or decision-making; those that involve error correction or troubleshooting; situations where responses are not well-rehearsed or contain novel sequences of actions; dangerous or technically difficult situations; and situations that require the overcoming of a strong habitual responses or resisting temptation (Norman & Shallice, 1986). In such situations, the inhibition of our instinctive reactions or automatic responses is essential to achieve a specific goal (Zamorano et al., 2014), as well as keep individuals safe from potential dangers.

The act of gambling, with its potential to cause harm through excessive and uncontrolled play, falls under the situational criteria in which Norman and Shallice (1986) argue that automatic behaviours may become maladaptive. To minimise or protect the individual from experiencing harm during gambling, it is desirable that decision-making and subsequent actions are made via executive control processes, defined as a set of higher-order cognitive processes that are necessary for the cognitive control of behaviour, involving the selecting and successfully monitoring of behaviours that facilitate the attainment of chosen goals (Diamond, 2016). Executive control processes involve the organising, monitoring, biasing, and altering of more 'basic' cognitive processes such as the detection of stimuli, response selection, and motor programming (Verbruggen, McLaren, & Chambers, 2014). These processes are essential to allow individuals to overcome and supress habituated actions that are environmentally conditioned and triggered and therefore, allow individuals to adjust their decision-making strategies when change is required to achieve our goals (see e.g., Miller & Cohen, 2001; Norman & Shallice, 1986).

Executive control also comprises working memory, problem solving capacity, and attentional control (Chan, Shum, Toulopoulou, & Chen, 2008; Diamond, 2016). However, the process of overcoming automatic and habituated responses refers to *behavioural inhibition*. Behavioural inhibition itself is comprised of three interrelated processes (Barkley, 1997; Oosterlaan, Logan, & Sergeant, 1988). The first, and the focus of this thesis, is response inhibition, defined as the ability to inhibit the initial prepotent (dominant) response to a stimulus. Behavioural inhibition also includes the ability to cancel an already initiated response and therefore, permitting a delay in the decision to respond. Finally, behavioural inhibition also pertains to the ability to self-direct responses in light of competing events and responses, referred to as interference control (Barkley, 1997; Oosterlaan, Logan, & Sergeant, 1988).

### *3.2 Response inhibition*

Response inhibition plays a central role in theorising about human cognition and is regarded as the hallmark of executive control (Macleod, 2007). Response inhibition can be further subdivided conceptually into the suppression of thoughts, emotions, decisions, and motor action (Aron, Robbins

& Poldrack, 2004; Baddeley, 1996). The ability to stop undesirable habituated and automatic actions allows individuals to respond appropriately to changes in the environment and prevents individuals from becoming slaves to their environment and past experiences. The role of inhibitory processes in paradigms including go/no-go and stop-signal tasks is still under investigation within psychological research (see e.g., Verbruggen & Logan, 2008; Verbruggen et al., 2014), although there is general consensus that the intentional stopping of a prepotent action requires inhibition processes (Logan & Cowan, 1984; MacLeod et al., 2003; Verbruggen, Liefooghe, & Vandierendonck, 2004).

Response inhibition performance is often conceptualised using the "horse race" analogy, where 'go' processes race with 'stop' processes to reach an output buffer to determine if an action is performed or withheld (Logan & Cowan, 1984). This race model (Logan & Cowan, 1984) assumes independence between the go and stop processes, although modern neuroscience evidence suggests complete independence between to the two systems is unlikely (Verbruggen & Logan, 2008). Whilst performing and withholding actions both involve an interaction within the basal ganglia, discrete pathways have been identified for going and stopping processes. A motor response can be activated via a direct cortical-subcortical pathway involving the activation of 'go' cells in the striatum which inhibit structures within the globus pallidus, which in turn reduces thalamic inhibition, allowing a response to be executed (Nambu, Tokuno, & Takada, 2002). This signal to perform an action however, can be stopped via activation of an indirect pathway (Nambu et al., 2002). In the indirect pathway, 'no-go' striatal cells are able to inhibit the external segment of the globus pallidus, reducing tonic inhibition between internal and external segments of the globus pallidus, leading to increased inhibition of the thalamus and therefore, allowing for selective inhibition of particular responses (Aron & Verbruggen, 2008). Aron (2011) identifies a drawback of this indirect pathway is that it is relatively slow, often making it difficult to inhibit prepotent response tendencies.

### *3.2.1 Problem gambling and response inhibition*

As discussed in Chapter 1, conceptualisation and definition of pathological gambling have shifted from that of an impulse control disorder to a behavioural addiction (see APA, 2013). However, impulsivity, argued to be the antipodes of the response inhibition element of executive control (Bickel et al., 2012), remains a core construct in disordered gambling. Several cognitive behavioural and neuroimaging studies identify deficits in response inhibition performance amongst problem gamblers. A range of evidence exists demonstrating the behavioural and cognitive risk-factors for developing disordered gambling, although two mainstream approaches exist that propose the reasons gamblers struggle to cease gambling within a gambling session. These approaches highlight the key role of decision-making deficiencies (for a review, see Clark, 2010) and inhibition dysfunction (for a review, see van Holst et al., 2010). The latter, which is the focus in Experiments 1 and 2 of the present thesis, refers to a tendency to respond rapidly to rewards and punishment without sufficient consideration and evaluation of the consequences. Most commonly, behavioural assessments of response inhibition utilise tests including the go/no-go task, the stop signal task, the Stroop test, and the continuous performance test.

Fuentes et al. (2006) studied the response inhibition performance of pathological gamblers with and without comorbid disorders and compared this to healthy controls. Inhibition was assessed using a simple visual reaction test (SVR) and simple choice auditory reaction test (SCA), in which participants must respond to specific basic shapes and avoid responding to others (SVR) and respond to high auditory tones while supressing responses to low auditory tones (SCA). Results indicated that pathological gamblers with and without comorbidities made more incorrect responses on both the SVR and SCA tasks when compared to a healthy control group. Response times during these tasks however, did not differ significantly between groups, and therefore decreased reaction time which typically leads to erroneous responses (Dickman & Meyer, 1988) was not found for pathological gamblers. However, Fuentes et al. (2006) argue that the SVR and SCA measure more than inhibition performance, and that they require constructs including attentional processing and stimulus-response processing. Therefore, apparent deficits in motor response inhibition on these tasks may be attributed to impaired information processing and integration due to the lack of difference in task reaction times between the pathological gambling and healthy control groups.

Goudriaan et al. (2006) conducted a battery of response inhibition tests on pathological gamblers, alcohol dependent subjects, a Tourette syndrome group, and a healthy control group. On a circle tracing task, the pathological gambling and Tourette's syndrome group completed the circle faster when compared to times of the control group, showing poor inhibition of an ongoing response. The researchers also found that the clinical groups were more prone to interference effects in a Stroop colour word test, and also demonstrated slower stop-signal reaction times in a stop-signal task, indicating poorer inhibition performance across the clinical groups. It was also found that poorer inhibition performance on the stop-signal task predicted relapse at a one-year follow-up for pathological gamblers.

Kertzman and colleagues (2008) demonstrated that pathological gamblers without comorbid disorders demonstrated a greater number of commission errors on a go/no-go task and continuous performance task when compared to a healthy control group. Pathological gamblers had an overall longer reaction time compared to healthy controls, which is counterintuitive in speed-accuracy trade-off paradigms, where longer response times usually relate to more accurate performances. Kertzman et al. (2008) therefore argue that the longer reaction times for pathological gamblers, accompanied with worse inhibition performance, suggests pathological gamblers may possess deficits in the organisation of stimulus-response schemata, and this is observed as inhibition deficiencies.

In their assessment of cognitive flexibility and response inhibition in gamblers with varying degrees of severity, Odlaug and colleagues (2011) identified that pathological gamblers possess significantly greater response inhibition and cognitive flexibility deficits when compared to at-risk gamblers and healthy controls. They found that pathological gamblers had significantly slower stop-signal reaction times in a stop-signal task indicative of poorer response inhibition performance. Furthermore, and consistent with previous cognitive/behavioural findings (see e.g., Kertzman et al., 2008), pathological gamblers had overall slower reaction times to go-trials in this paradigm, suggesting the poorer response inhibition performance was not a result of a faster response tendency. However, Odlaug et al. (2011) did find that the pathological gambling group were on average older than the at-risk and control groups, therefore suggesting that this reduction in response times on go-trials may have resulted from age-effects, where response times typically degrade with age (Birren & Fisher, 1995). Response inhibition performance was still worse overall for the pathological gambling group even when groups were age-matched.

Within this experimental investigation, at-risk gamblers did not differ significantly from a healthy control group in terms of response inhibition performance, suggesting inhibition deficits may be characteristic of more intense forms of problem gambling. However, the authors noted that the at-risk group was arguably too heterogeneous, encompassing a wide range of gamblers across the problem gambling spectrum. Therefore, the fact that the at-risk group showed no response inhibition deficits relative to healthy controls may be a result of an overall mild symptomology in this group. Follow-up studies with further sub-divisions of the at-risk group would be required to assess response inhibition deficits within sub-clinical problem gambling groups.

Kertzman et al. (2011) assessed inhibition and decision-making under risk within a group of pathological gamblers, as well as assessing the relationship between the two constructs. Stroop task performance was significantly worse within the pathological gambling group, with increased response times relative to a healthy control group, indicative of poorer interference control. In addition, pathological gamblers made more omission errors in later trials of the go/no-go task, and response times where overall elevated, again suggesting pathological gamblers possess impairments in response conflict resolution (van Holst et al., 2010). However, notably, the performance on the two inhibition tasks did not predict performance on the Iowa Gambling Task (IGT) – a paradigm used to measure decision-making under risk – and overall, there was a lack of association between performance on the two inhibition tasks (Stroop and go/no-go task). This confirms that these various tests of inhibition represent different sub-components of inhibition (interference control and motor response inhibition) and that impairment in one of these domains does not automatically imply impairment in the other within pathological gambling groups. It also suggests that decision-making under risk is not predicted by inhibition ability, suggesting that impulsive choice and impulsive action represent dissociable constructs. This also highlights the needs for research more closely examining the different inhibition deficits in gamblers, and the situations which give rise to difference aspects of impulsivity.

Brevers et al. (2012) found evidence that poor response inhibition performance was indicative of the more severe forms of problem gambling. Compared to a non-gambling control group, problem gamblers performed significantly worse on an impulsive choice task (delay discounting paradigm), but not in a stop-signal task measuring response inhibition. However, a pathological gambling group performed similarly to problem gamblers on the delay discounting task, but performed significantly worse on the response inhibition task. This suggests that poorer response inhibition may be influential in the transition from regulated to disordered gambling, and that response inhibition may represent a developmental pathway for more severe forms of disordered gambling.

The overall pattern of results from relatively recent examinations of response inhibition amongst problem gamblers is consistent with the notion that problem gamblers reliably show inhibitory deficits relative to healthy controls. This is often characterised by slower overall performance in Stroop tasks, indicating problem gamblers are prone to interference effects due to impaired interference control. In addition, problem gamblers reliably show a greater number of commission errors in go/no-go and stop-signal paradigms, indicative of impaired ability to withhold or cancel motor responses when required. Perhaps less intuitive is the repeated finding that deficits in response inhibition performance is not a result of a rapid response style. In fact, problem gamblers demonstrate longer reaction times in response imbibition tests, suggesting that poor response inhibition performance in this group may be a result of impairment in response conflict resolution. Further evidence to support this approach is that studies including Kertzman et al. (2011) show that more omission errors in the go/no-go task are made by problem gamblers suggesting impairments in response conflict resolution (see also van Holst et al., 2010).

Whilst behavioural tests of response inhibition such as the go/no-go task and stop-signal task are widely used and represent valid and reliable measures, these tasks are arguably novel and lack context specificity. However, Brevers et al. (2017) found no evidence for preferred gambling activity stimuli on proactive or reactive inhibitory control. Poker players demonstrated no additional response inhibition deficits when exposed to poker-related cues compared to neutral cues. The authors argued that this finding, which ran contrary to their hypothesis, may have resulted from the lack of expectancy and availability of poker gambling during or following the experiment. He and Noel (2017) suggest this lack of availability of gambling prevented the poker cues from fully activating motivational-approach behaviours. Support for the need for context-specificity in response inhibition research related to appetitive behaviours, is the finding that the perceived availability of the appetitive behaviour of choice increases cravings in smokers (Droungas et al., 1995) and social drinkers (Papachristou, Nederkoorn, Corstjens, & Jansen, 2012). Stimulus availability has also been shown to increase neural cue reactivity in neural structures such as the amygdala and caudate nucleus that are implicated in reward circuitry and appetitive motivation (Jasinska et al., 2014). Therefore, it may be argued that the lack of gambling availability in typical tests of response inhibition may actually mute context-specific response inhibition deficits in gamblers across the entire problem gambling spectrum, ranging from non-problem to pathological gamblers.

Furthermore, one of the key limitations of research investigating the role of response inhibition in problematic gambling behaviours is the lack of comparison between regular non-problem gamblers and non-gamblers. Whilst control groups often consist of either healthy non-gamblers or regular non-problem gamblers, in depth analysis of their quantitative and/or qualitative differences in response inhibition capacity is lacking. This will likely provide insight into the effects of gambling parameters on executive control in the absence of psychopathology, and may provide information on potential intermediate cognitive deficiencies, which may lead to disordered gambling. If regular non-problem gamblers are consistently used as a control group for comparison against problem and pathological gamblers, then it may lead to the assumption that impairment does not exist in regular gamblers due to the framing effect of being assessed against disordered gamblers. It is important to assess response inhibition capacity in regular gamblers as a result of varying gambling parameters to examine the impact that specific structural characteristics of gambling have on self-control. Knowledge gained from this can help inform responsible gambling strategies that act as a preventive approach to gambling-related harm. The strategic approach to tackling this harm is of pertinent importance, as is where to focus efforts to reduce such harm. Adams, Raeburn, and de Silva (2009) argued that in a society demonstrating relatively stable consumption, it is justifiable that attention should be directed towards the treatment of those suffering with a gambling problem. However, such concentration of effort – as Adams and colleagues (2008) go on to argue – is less urgent in a rapidly changing environment that is demonstrating escalation of risk. Instead, effort would be best directed towards attending to the situation itself;

*'…when a submerged rock pierces a hole in the bottom of a boat, it makes little sense to attend solely to those who have been injured and it makes considerably more sense to focus a good deal of energy upon stemming the flow of water through the hole'* (Adams, Raeburn, & de Silva, 2008, pp. 869).

### ***3.3 Factors that influence response inhibition performance: Arousal, motivation, and task demands***

Recent empirical evidence suggests that executive control functions, including behavioural inhibition, can be influenced by a variety of factors that interact with proximal and distant brain mechanisms that bring about changes in response inhibition performance (e.g., Leotti, & Wager, 2010; Weinbach et al., 2015; Zamorano et al., 2014). Important for the current thesis is the fact that such evidence also suggests that response inhibition is not a stable individual trait but is both positively and negatively shaped by contextual factors.

#### *3.3.1 Behavioural inhibition and arousal*

An example of one such system that is influenced by contextual factors, and may play a key role in response inhibition, is arousal. Presentation of alerting cues, such as an external audio or visual cue, can be used to increase phasic arousal to induce a state of raised alertness (Weinbach et al., 2015). Aston-Jones and Cohen (2005) argue that this alerting process is modulated by the distribution of norepinephrine (NE) from the locus coeruleus in the brain stem. Evidence for the role of NE in the alerting effect is derived from research showing that administering NE inhibiting drugs to healthy adults (Coull, Nobre, & Frith, 2001) and animals (Witte & Marrocco, 1997) reduces alerting effects.

Classic views of the role of arousal in response inhibition performance suggest that increased arousal leads to an increased alert state accompanied by a readiness to respond (Derryberry & Rothbart, 1988). This alerted state leads to reduced reaction time (i.e., faster responses) to cues, which means that responses are made based on information that is more limited and are therefore, associated with a greater error rate (Derryberry & Rothbart, 1988; Posner & Peterson, 1990). In this view, increased arousal leads to an increased readiness to respond (consistent with fight/flight theories of arousal, (e.g., Porges, 2001), which in turn gives rise to an impulsive response style and can impair the ability to exercise response inhibition.

Increased arousal has also been shown to impair other aspects of behavioural inhibition, namely, interference control. Studies utilising the flanker task paradigm have demonstrated that following alerting cues, participants show greater interference from irrelevant distractors compared to when no alerting cue was given (Macleod et al., 2010; Redick & Engle, 2006; Weinbach & Henrik, 2012). This effect has been argued to represent a direct negative effect of arousal on behavioural inhibition and that this flanker interference effect is explained by the role arousal plays in impairing frontal brain regions necessary for top-down cognitive control (Callejas et al., 2005; Fan et al., 2009).

However, an alternative explanation is that increased levels of arousal caused by alerting cues does not directly impair executive control per say, but rather gives the impression of impaired executive functioning via an indirect effect. Recent empirical evidence suggests that this indirect effect occurs due to increased arousal leading to response thresholds being reduced, leading to response decisions being reached faster (Nieuwenhuis & de Kleijn, 2013). This account can be explained using the horse race model of inhibition (Logan & Cowan, 1984) whereby increased arousal caused by alerting cues further bias the race in favour of making a response, where the executive control processes necessarily for inhibiting the response are relatively slower, the end result being a perceived reduction in inhibition performance.

In contrast, emerging evidence suggests that increased arousal resulting from alerting cues can improve inhibition performance in behavioural inhibition tasks. Previously, increased flanker interference has been explained by suggesting increased arousal leads to an increased level of processing of salient information within the visual field, which increases processing of task-irrelevant information in the flanker task (Weinbach & Henik, 2014). However, it has been suggested that via the same mechanism, alerting can reduce distractor interference when task-relevant information is made more salient than peripheral information (Weinbach & Henik, 2014). Weinbach and colleagues (2015) demonstrated that increasing arousal induced by alerting cues in a stop signal paradigm resulted in faster responses to go stimuli, and yet this increased response speed did not result in increased error rates on stop signals, suggesting alerting enabled response inhibition performance to remain stable despite greater processing speeds. Neurological evidence also suggests that high levels of alertness reduced activation in the primary visual cortex, suggesting less cognitive effort is required for increased aroused states to process perceptual information (Fischer, Plessow, & Ruge, 2013).

Taken together, the impact of arousal on behavioural inhibition appears inconsistent, arguably due to contextual factors and variables of interest. For example, a large body of research examining the flanker effect demonstrates arousal negatively impacting interference control, whereas there is some evidence for a positive effect of arousal on stop signal performance which is a measure of response cancellation. However, it may be erroneous to assume that arousal differentially impacts these two processes given that response cancelation and interference control both represent aspects of behavioural inhibition that share neural correlates (Diamond, 2016). However, recent theoretical propositions propose that perceptual processing, which is susceptible to the effects of arousal, may represent a single underlying process that plays a key role in behavioural inhibition (Verbruggen, Mclaren, & Chambers, 2014). In this view, inhibition performance can be enhanced by increased arousal if this is also met with task-relevant information being made salient, facilitating perpetual processing of essential information. Conversely, this theory also predicts that if increases in arousal are accompanied with task-irrelevant or distracting information, then arousal may impair inhibition performance.

Importantly, when considering the role of arousal on inhibition performance, it may be over simplistic to refer to the effects of increased or decreased arousal on task performance without considering the demands of the specific task in question, making cross-study comparisons challenging. As well as behavioural inhibition performance discussed here, arousal has been intimately linked to theories on sleep, stress, attention, anxiety and motivation (Aston-Jones & Cohen, 2005). In most cases, performance is improved when arousal is optimal for the task-specific demands. Classic ‘inverted-U’ theories of arousal hold that performance is impaired when arousal falls below or surpasses this optimal level of arousal (Yerkes & Dodson, 1908). As a result, without controlling for task demands, the value gained from cross-study comparison of the role of arousal on performance is limited, as it may be due to the nature and cognitive demands of the task itself that determines whether performance will benefit from increases or decreases in arousal, which includes behavioural inhibition research. One of the key aims of the present thesis is to investigate how arousal is manipulated by changes in the structural characteristics of electronic gambling, and in turn, how this change in arousal impacts a gambler’s ability to exercise motor response inhibition within a gambling context.

### *3.3.2 Behavioural inhibition and motivation*

Several studies identify that behavioural inhibition varies within subjects as a result of experimental manipulations- evidence that runs contrary to the view that assumes inhibition represents a fixed and stable ability (Leotti & Wager, 2010). Within a stop-signal paradigm, research has demonstrated that systematically adjusting the ratio of go to stop-signals that change stop-signal expectancy, as well as adjusting the salience of stop-signals, are factors that contribute to behavioural inhibition performance (van den Wildenberg, van der Molen, & Logan, 2002; van der Schoot, Licht, Horsley, & Sergeant, 2005).

The role of subjective motivation on response inhibition performance is arguably less investigated. Motivation likely plays an important role in behavioural inhibition tasks such as the go/no-go task and the stop-signal task, as instruction on these tasks usually involves asking the participant to respond both as fast as possible on go-trials, but also as accurately as possible, which pertains to correctly inhibiting responses on no-go-signals. Therefore, the probability of successful inhibition is likely driven by the subjective weighted value and motivation placed on either speedy responses or successful inhibition (Leotti & Wager, 2009).

In a series of experiments conducted by Leotti and Wager (2009), it was indeed demonstrated that subjective speed-accuracy trade-off strategy was correlated with stop-signal reaction-time (SSRT). Furthermore, the researchers also demonstrated that participant stop-go trade-off value was adjusted by experimentally manipulating the reward associated with either fast responses or accurate inhibition. When the participants were rewarded for accurate inhibition, motivation for stopping increased resulting in greater inhibition performance. One of the explanations for this phenomenon put forward by Leotti and Wgaer (2009) is that go and stop pathways in the brain (see Frank, Seeberger, & O'Reilly, 2004) are differentially activated by mental preparation which is influenced by motivation, resulting in increased/decreased potentiation of the two pathways.

Langford, Schevernels, and Boehler (2016) conducted an electroencephalographic (EEG) experiment investigating the effects of motivational context on proactive response inhibition in human subjects within a stop-signal paradigm. They found that N1 amplitudes – a type of event-related electrical potential (ERP) associated with visual evocation (Wascher, Hoffman, Sanger, & Grosjean, 2009) – were enhanced for go-stimuli within trials where successful inhibition was associated with reward. This indicates an enhanced level of attention, even for go stimuli, when compared to trials where the motivational influences of rewards were not present. Furthermore, their findings indicated a lack of covariation between reaction time and N1 amplitude, consistent with the notion that the contextual effect of motivation can increase on-task attention allocation that overrides the relationship between attention and response speeds, meaning attention levels might directly affect response inhibition performance.

The motivational influences of reward have been demonstrated to increase speeded responses within a go/no-go paradigm. Chen and Kwak (2017) demonstrated that when the speed of go-responses were rewarded by points, participants significantly increased the speed of their responses. This also resulted in a speed-accuracy trade-off, in which this increase in speed resulted in a reduced ability to correctly inhibit responses on no-go-trials, which were subsequently punished by subtracting points from the participant. However, this effect was only present in conditions in which go-signal probability was high, meaning that perceived risk had a modulating effect on the impact of motivation on speeded responses. Chen and Kwak (2017) also demonstrated that individual levels of impulsivity, as assessed by the BIS-11 (Patton, Stanford, & Barratt, 1995) and a delay discounting task, were predictive of poorer response inhibition performance overall. However, importantly, these individual effects were only present in conditions in which the potential reward magnitudes were low, or when the percentage of go-trials were very high (80%) or very low (20%). This suggests that the relationship between inhibition performance and individual risk-taking tendencies are strongest when there is less conflict associated with a decision to perform or withhold an action. In addition, their results indicated that individual risk-taking tendencies were associated with poorer inhibition performance as reward magnitudes increased, but this relationship was only present when go-trial probability was low (20%). This suggests that individuals who may be more susceptible to high-risk behaviours such as gambling may lack an ability to adjust behaviour in favour of successful inhibition in the presence of reward in situations where risk is high.

Motivation therefore plays a vital role in response inhibition. Taken together, these empirical studies suggest that when motivation is anchored to withholding responses, more successful inhibition will follow. While this has been demonstrated in arguably novel experimental paradigms, within a gambling context, the potential to win money acts as a powerful motivation to gamble, where money can only be *won* by the act of gambling and not refraining from gambling. The issue therefore arises that for gamblers, motivation is biased towards performing an action (gambling), which is positively reinforced with the potential to win money. The contextual factors of gambling are therefore likely to impair a gambler's ability to refrain from or stop gambling within a gambling session by exercising response inhibition. With provocation, the inhibitory system of gamblers may be overwhelmed by these intense motivational drives, leading to stimulus-driven behaviours at the expense of top-down executive control. Experiment 2 of the thesis investigates how changing the motivational value of withholding motor responses within a gambling context can impact response inhibition, and how such measures compare to other new and existing harm-minimisation tools aimed at facilitating self-control and responsible gambling.

### *3.3.3 Behavioural inhibition and speed*

One of the core aims of the thesis is to examine how structural characteristics of electronic gambling interact with executive control processes. More specifically, the investigation will examine how manipulating the speed of play in electronic gambling effects a gambler's ability to exercise motor response inhibition. Research suggests faster event frequencies in gambling lead to a faster speed of play for gamblers, despite no requirements for them to gamble faster. This has been demonstrated empirically on numerous occasions within a gambling context (for a review, see Harris & Griffiths, 2018). For example, in their experimental studies, Choliz (2010), Delfabbro et al. (2005), and Ladouceur and Sevigny (2006) found that increasing the speed of play of gambling resulted in faster gambling behaviour (although see Sharpe et al. [2005] for a null effect). This has important implications for self-control because movement speed is one of the most important factors influencing sensorimotor variability that is associated with risk during a movement (Trommershauser, Maloney, & Landy, 2003). Increased speed of responses is naturally associated with greater risk of failure in a vast amount of task performance, as is consistently demonstrated in speed-accuracy trade-offs in healthy participants (Ratcliff & Tuerlinckx, 2002). Furthermore, a negative correlation between response time and commission errors is typically found in a range of clinical sub-groups characterised by impulsive tendencies, including psychopaths (Newman & Schmitt, 1998), patients with borderline personality disorder (Rentrop et al., 2008) and juvenile delinquents (Lemarquand et al., 1998).

When comparing the role of inter-stimulus-intervals (ISI) in response inhibition tasks afforded by EEG and functional magnetic resonance imaging (fMRI), Zamorano et al. (2014) found that when ISI was short (i.e., a fast condition), this resulted in faster overall reaction times to go stimuli, as well as a greater error rate on no-go trials. Furthermore, their results indicate that short ISI duration (fast speeds) put greater demand on automatic inhibition processes, whereas a longer ISI shifts demands onto more top-down interference control processes.

These findings highlight the notion that changes in event frequencies can alter the relative contribution different mechanisms have in exercising response inhibition, but also that automatic response inhibition required at shorter ISIs are associated with greater error rates. Therefore, within a gambling context, if speed of play is increased, this is likely to have negative ramifications for self-control, which increases the chances of experiencing gambling-related harm via an inability to carefully consider actions, withhold motor responses, and cease gambling.

### *3.4 Chapter summary*

Automatic behaviours can be considered to be rapid in execution, requiring minimal effort to perform, and are typically triggered by environmental cues. Whilst the automatic execution of behaviour presents several evolutionary benefits, the absence of top-down executive control and lack of careful consideration of behaviour may become maladaptive within a gambling context, leading to the potential to experience gambling-related harm. Gambling is therefore an activity where high-levels of cognitive control over behaviour is desirable to prevent stimulus-driven prepotent actions dominating behavioural output. Response inhibition is considered a quintessential feature of executive control, a feature that allows individuals to overcome strongly conditioned and habituated responses to allow self-guided behaviour towards chosen goals and to keep individuals safe from potential harm.

Impaired response inhibition is consistently demonstrated as a hallmark feature of disordered gambling. Compared to non-gamblers and non-problem gamblers, problem and pathological gamblers perform reliably worse on behavioural inhibition tests, including tests of response inhibition most commonly assessed using go/no-go and stop-signal paradigms. Typically, problem and pathological gamblers demonstrate an impaired ability to withhold prepotent responses when instructed, leading to the execution of undesired and maladaptive actions. Arguably counterintuitive, this poor response inhibition performance is more often associated with slowed reaction time, suggesting impaired response conflict resolution, as opposed to a more rapid response styles amongst this clinical population. However, receiving considerably less attention is the consideration of how the structural characteristics of gambling itself may contribute to a loss of self-control *during* gambling. In-depth examination of the impact of these features is therefore required on regular gamblers in the absence of the confounding effects of psychopathology. Understanding the link between the structural characteristics of gambling and factors conducive for self-control can therefore inform preventive responsible gambling approaches aimed and containing or reducing the prevalence of problem and pathological gambling.

Executive control capacities, such as an individual's predispositional response inhibition capability, is often regarded as a risk-factor for the development of problem gambling behaviour. However, emergent evidence suggests the executive control domains, including response inhibition performance, are susceptible to contextual factors that interact with proximal and distant brain mechanisms that bring about changes in response inhibition performance. Factors discussed here that received empirical support for their influence on response inhibition performance pertinent to gambling include levels of arousal, motivation, and the event frequency of stimuli presentation. Experiments 1 and 2 of the thesis examine these factors within a gambling context. Based on theoretical and empirical accounts extrapolated from non-gambling contexts, it is predicted that the increased speed of play afforded by electronic gambling technology could interact with response inhibition capacity, where increased speeds of play may put greater demands on response inhibition resources, which may be detrimental to motor control.

# Chapter 4. Rationale for Methodology and Assessment Tools

***4. Chapter overview***

The present chapter provides a critical evaluation and justification of the laboratory-based experimental methodology used within this thesis. The chapter also presents and discusses the psychological measures and assessments used throughout the experiments, and where relevant, what alternative measures were also considered. In cases where scales and cognitive tests have been adapted from their original format, justifications for these changes are provided.

***4.1 The laboratory-based experimental approach to gambling research***

*4.1.1 General limitations*

Often, when individuals engage in gambling behaviour, they do so in amusement and leisure settings, which are laden with gambling-related cues and reinforcers. However, increasing numbers of gamblers are turning to online and smartphone technologies as their preferred gambling platform (see Wardle et al., 2007, 2011), which present their own set of influences over gambling, including the reduced behavioural inhibition facilitated by online play (Dong & Potenza, 2014). Laboratory-based gambling may be seen as a stark contrast to these real-world gambling environments, where the laboratory may be perceived as relatively bleak and lacking in the visual and auditory experience that contribute to the excitement of gambling.

*4.1.2 Intention to gamble*

Individuals usually engage in gambling behaviour based on urges and desires to gamble. The modern ubiquitous nature of electronic gambling means that individuals can engage in gambling with relative ease, with varying degrees of planning. For example, prior to internet gambling, gamblers would be required to plan a journey to a live gambling venue, gather funds to gamble with, and ultimately make that journey, allowing some temporal separation between the decision to gamble and actually engaging in gambling. Modern technology reduces this temporal separation between urges and engagement, which likely facilitates impulsive behaviour. When participants agree to engage in laboratory-based studies, it usually consists of a sign-up procedure, where potential participants agree to take part sometime in the near future. Of course, this has practical benefits for the researcher in that planning and preparation for the experiment can take place. However, the drawback is that participants will be committed to gambling at a specified time, regardless of their intentions to gamble or not, likely having confounding effects on gambling behaviour.

*4.1.3 Risk and reward*

Often reported as a limitation of experimental gambling research is the muted or alleviated risk to participants. Due to ethical restrictions, it is often the case that participants in laboratory-based gambling experiments gamble with non-monetary units (e.g., points or credits) or gamble with varying, although often modest, amounts of 'house' money provided by the experimenter. Whilst at face value this may appear objectively to be risk-free for the participant, it can be argued that the level of risk may be subjective, depending on how the monetary stake provided in the experiment is viewed by the participant. For example, in previous studies such as Parke et al. (2015), effort is often made to instil a sense of ownership in the participant over the initial monetary stake through a carefully constructed briefing, emphasising that '*this money is yours to gamble with'*. If this is successful in instilling a sense of ownership, then it can be argued that participants do perceive potential risk.

Research is often restricted by budgets, meaning that the maximum amount that participants can win is controlled and limited. However, real-world gambling affords the opportunity to win large amounts of money on the roll of a dice or spin of the reels, potentially exceeded thousands or even millions of pounds in the case of progressive jackpots, which acts as a strong behavioural reinforcement. The reduced potential monetary gains in experimental gambling research may therefore reduce the external validity of behavioural findings.

*4.1.4 Expected manipulation*

There is a degree of participant expectation in psychological research that their behaviour will be closely scrutinised and that manipulation is taking place. This may result in participants behaving over cautiously or unnatural. This may be especially true if participants consist of psychology students. Problematic for gambling research is if the participant feels that the game is not random and gambling outcome is being controlled, which will likely result in unrealistic gambling behaviour being presented. As with the present thesis experiments, attempts can be made to reduce this manipulation expectancy via a framing effect and moderate levels of deception. For example, participants in these experiments will be informed they are taking part in a 'gambling experience', and that their retrospective opinion of the game will be questioned following the gambling session. Contrary to this would be telling participants they were taking part in a psychological experiment where cognitive and behavioural variables will be assessed. The former attempts to relax participants, and through mild but ethical deception, reduces participant self-consciousness over behavioural and cognitive variables of interest, more likely resulting in naturalistic participant behaviour.

*4.1.5 Advantages of laboratory studies*

An experimental laboratory-based approach enables high-levels of control over extraneous variable that may confound the impact of the independent variables of interest. Key variables that are able to be controlled as a result of the experimental approach include the emotional effects of gambling outcome (wins/losses), the arousing effects of the 'near miss' phenomena (for example, see Foxall & Sigurdson, 2012), age and trait impulsivity effects on response inhibition, as well as gambling session duration. Manipulation of the independent variable of speed of play of slot machine gambling would not have been feasible without using an experimental paradigm. Whilst different speeds of play on slot machines exist in online and high street gambling venues, it would not have been temporally practical or controlled to measure executive function capacity across these different domains and platforms. Furthermore, to test response inhibition *during* gambling, it is more temporally viable and cost-efficient to create an experimental gambling paradigm which incorporates psychological tests within an experimental software package in the laboratory.

*4.1.6 Convergence of laboratory-based and real-world gambling research*

Whilst several limitations of laboratory-based gambling research have been identified, several procedural factors have been proposed to minimise these limitations. Importantly, despite the well-known limitations of experimental gambling studies, research has identified that results from both the laboratory and naturalistic settings show a high level of convergence (Anderson, Lindsay, & Bushman, 1999).

***4.2 The slot machine simulation***

In order to fulfil the requirements of having high levels of experimental control, as well as afford the opportunity to manipulate the gambling structural characteristics of interest, a simple slot machine simulator was created using the programming software Psychopy® (Peirce, 2007). The slot machine was chosen as the gambling game of choice for this thesis as this form of gambling represents the fastest known form of gambling, in terms of duration between gambling events. Using a simulation allowed speed of play to be manipulated and also allowed for several important extraneous variables to be controlled. For example, using the purpose built slot machine simulator allowed gambling outcome to be controlled, which includes the volume and frequency of wins/losses. It also allowed the size of bets to be controlled, as well as arousing features including the 'losses disguised as wins' (Leino et al.,2016) and 'near miss' phenomena (Clark et al., 2009a) to be controlled. Using a slot machine simulator also allowed a responses inhibition test to be embedded into the game, and therefore the response inhibition task used in these studies can be considered an 'online' measure of response inhibition (the following section, titled 'Assessing behavioural response inhibition', will discuss the response inhibition task in greater detail).

In all conditions in Experiments 1, 2, and 3, the slot machine simulators had 90 trials (gambling events) in each. In Experiment 1, speed will be manipulated as the independent variable of interest, resulting simulators with a 1.5s (fast condition), 3s (moderate condition), and 4.5s (slow condition) event frequency. In Experiment 1, a further two conditions are tested; moderate speed with pauses, and slow speed with pauses. In these conditions, the simulator provides a mandatory brief pause in play between the end of one reel spin and the opportunity to spin the reels again. The moderate speed with pauses condition has a 1.5s reel spin, followed by a 1.5s delay or pause before gambling is again permitted, totalling a 3s event frequency. In the slow with pauses condition, the machine has a 1.5s reel spin, followed by a 3s pause until the reels can be spun again, totalling a 4.5s event frequency. Experiments 2 and 3 of the thesis use only the fast speed slot machine (1.5s event frequency).

***4.3 Assessing behavioural response inhibition***

The go/no-go task (see Donders, 1969) comprises a series of stimuli presented in a stream, usually requiring participants to perform a binary decision dependent on the stimulus being presented. One type of stimuli (a go trial) requires participants to perform an action, usually in the form of a button press, whilst the other type of stimuli (a no-go trial) requires participants to withhold the response. Go trials are usually in the majority, typically between a 15:1 and 4:1 ratio to no-go trials (Kertzman et al., 2008). The first part of the task is typically comprised of a 'training phase', consisting of a long series of go trials to allow response prepotency to develop. Combined, these features of the task will bias responses towards performing a specific action and therefore, places greater demands on the executive control system to withhold that action when no-go trials are present (Simmonds, Pekar, & Mostofsky, 2008), making the go/no-go task a useful tool to assess inhibitory control and action monitoring (Menon et al.,2001). Reaction time to respond to go trials, as well as response accuracy on no-go trials, are typical dependent variables obtained via a behavioural go/no-go task.

Within a gambling context, the stimulus-response pairing of the lighting up of the gamble/spin button (stimulus) and the subsequent action of pressing the spin button (gambling), is kept constant. As a result of this consistent stimulus-response pairing, gambling decisions may become habituated and become automatic at the expense of top-down executive control. Within a stop-signal paradigm, which is also a common tool to assess inhibitory control processes (for a review, see Alderson, Rapport, & Kofler, 2007), a consistent stimulus-response mapping can never occur. This is due to the fact that at any one time, the stimulus can be both associated with performing an action or withholding that action, as the stimulus is held constant but the signal to withhold a response follows the stimulus itself in close temporal proximity. Therefore, it was deemed more appropriate that the assessment of motor response inhibition for the experiments presented here followed the principles of a go/no-go task, because it is more representative of gambling on electronic slot machines. This is due to the fact that the lighting up of the gamble/spin button on such gaming machines is never paired with a requirement to stop gambling in a real-world setting. As a result of using separate stimuli for go and no-go cues in this gambling experiment (i.e., a green spin button for go trials and red for no-go trials), it allows any naturally habituated patterns of motor responses to develop during the training phase of the test, and is therefore, a simulation more representative of real gambling compared to a simulation where a stop signal paradigm is implemented.

### *4.3.1 Withholding vs. cancellation*

Although this appears to be a small procedural difference, critically, there is a further distinction to be made between the two aforementioned behavioural inhibition paradigms. This distinction concerns the difference between the *withholding* of a motor response and the *cancellation* of a motor response. The go/no-go task assesses the former, while the stop signal task assesses the latter. Go/no-go performance implicates response choice selection as well as action restraint, whereas stop signal performance involves the cancellation of an already selected response (action cancellation; Dalley, Everitt, & Robbins, 2011). Evidence for the dissociation between the two processes includes findings that serotonergic neurotransmitter manipulations impact go/no-go performance, whilst having no effects of stop signal performance (Eagle et al., 2007), suggesting differential sub-processes depending on the programming of the action (Dalley, Everitt & Robbins, 2011).

Other measures, including the Continuous Performance Test (CPT; Rodriguez-Jimenez et al., 2006), have been used for the assessment of response inhibition in pathological gamblers. However, when the results from CPT and go/no-go studies have been compared, different findings have been reported. For example, Rodriguez-Jimenez and colleagues (2006) found no impairment in the response inhibition performance of pathological gamblers conducting the CPT. In contrast, when compared to healthy controls, pathological gamblers have shown impairments in response inhibition performance on the go/no-go task (Fuentes et al., 2006; Goudriaan et al., 2005). It has been argued that this inconsistent finding may relate to the ratio of go to no-go signals in the respective tasks, which may alter the salience of the no-go signals (Braver et al., 2001). Unlike in the CPT, the no-go signals in the go/no-go task are relatively infrequent, with go to no-go trial ratios usually around 4:1 (Simmonds et al., 2008), therefore increasing the tendency towards making a rapid response to go trials, as opposed to withholding such responses (Kertzman et al., 2008). Consequently, the go/no-go task appears a more appropriate tool to evaluate inhibitory control and action monitoring (Menon et al., 2001), in which erroneous responses to no-go stimuli in the task are representative of impaired response inhibition (Berwid et al., 2005).

One of the main aims of the present study is to assess a gambler's ability to *withhold* impulsive motor actions at different gambling speeds of play, as opposed to *cancelling* an already initiated response. From the perspective of self-control in gambling, it may be argued that withholding undesired responses completely is more desirable than having to cancel undesired actions that have already been initiated, therefore, providing further justification for the use of a go/no-go behavioural measure.

### *4.3.2 The Go/No-Go Task*

Several research studies have identified an association between pathological gambling and impaired response inhibition performance. For example, Kertzman et al. (2008) found that compared to healthy controls, pathological gamblers performed significantly worse on a go no/go task in terms of response inhibition performance. Billieux and colleagues (2012) also found response inhibition impairments in treatment-seeking pathological gamblers compared to healthy controls. Poor response inhibition during adolescence has also been shown to predicts later substance dependence (Nigg et al., 2006), and response inhibition deficits have been observed in impulse control disorders including attention deficit hyperactivity disorder (Nigg, 2001) and substance abuse disorders (Bechara, Noel, & Crone 2006).

Weafer, Baggott, and de Wit (2013) conducted an assessment of the reliability of various behavioural measures of impulsive choice and impulsive action. From their sample of 128 healthy adults, reliability estimates for commission errors (i.e., failing to withhold motor responses) on the go/no-go task was moderate to high ($r=.65$, $p<.001$). The researchers also found that day-to-day fluctuations in mood did not significantly influence performance on the go/no-go task, supporting its use as a reliable behavioural assessment of impulsive action.

Several dependent variables can be obtained from the go/no-go task. They include mean reaction time to respond to the go stimuli, measured in seconds or milliseconds, and percentage of commission errors (i.e., the percentage of unsuccessfully inhibited responses on no-go trials). As with research data from the CPT that suggests a more rapid response style is associated with impulsive and erroneous decision-making, the same pattern of results also applies to the go/no-go task (Simmonds et al., 2008). Some variations of the go/no-go task also allow for a measure of the percentage of omission errors. Omission errors are erroneous responses on go trials that require a discriminatory choice of more than one response. For example, a go trial may require a participant to press either a left arrow key in response to an image of a left-pointing arrow, or press the right arrow key in response to an image of a right-pointing arrow (see e.g., Parke et al., 2015). Failure to select the correct response on such go trials is referred to in the literature as an omission error, which is representative of inattention. However, the design of the Experiment 1 and the majority of conditions in Experiments 2 and 3 requires participants to make only a single response on go trials, meaning omission errors are not assessed.

The stimuli used in go/no-go tasks have been varied and have included a variety of visual imagery including colours (e.g., Fillmore, 2003); shapes, such as arrows (e.g., Parke et al., 2015), as well as emotional imagery such as faces (e.g., Schulz et al., 2007), and the test has also been conducted using audio stimuli (e.g., Gondan, Gotze, & Greenlee, 2010). The go/no-go task in Experiments 1, 2 and 3 here use colour to cue go and no-go trials, with green spin buttons representing go cues and red spin buttons representing no-go cues. One condition within Experiments 2 and 3 of the thesis use both colour and directional arrows as the go and no-go stimuli. Task variants may also include ‘simple’ or ‘complex’ designs. Simple variants include no-go stimuli that are kept constant, while complex designs involve changing the no-go stimuli depending on context, which in turn requires frequent updating of stimulus-response associations in working memory. The go/no-go task in the present study meets the criteria for a ‘simple’ design, as the no-go cue (red spin button) is kept constant throughout.

The number of trials used to formulate a go/no-go task have varied greatly. For example, in their meta-analysis of fMRI studies utilising a go/no-go paradigm, Simmonds, Pekar, and Mostofsky (2008) reported that the number of trials used within a go/no-go task have varied between 48 and 1260. However, consideration must be given to potential fatigue effects that may be associated with lengthy experimental procedures and the confounding effect this may have on response inhibition performance. For example, fatigue due to sustained attention in later stages of lengthy experimental procedures may manifest as poor response inhibition performance, giving the potential false impression that the participant is demonstrating higher levels of motor impulsivity. Also, of importance when selecting the number of trials in a go/no-go task, is consideration of the type of experimental design being implemented, namely, between-subjects or repeated-measures designs, because this will directly impact the overall workload of the participant. As Experiment 1 of the thesis is a repeated-measures design comprising five conditions (i.e., five go/no-go tasks), the number of trials in each go/no-go task are relatively conservative at 90 trials in each condition. This results in the tests being completed in approximately 5-15 minutes depending on participant response latency and the experimental conditions that manipulate speed of play and therefore, the speed of the go/no-go task.

The go/no-go task to be used in the present series of studies have two noteworthy modifications from more typical versions of the task. First, the test is embedded into, and forms part of, a slot machine simulator. In essence, the present study, while utilising the principles of a go/no-go task, is a more naturalistic measure of response inhibition as participants will not be instructed that they are performing a response inhibition task. The slot machine is activated by pressing the ‘spin’ button, which is performed by pressing the spacebar on a standard computer keyboard. The spin button is also visually displayed on a computer screen containing the visual display of the simulator. The spin button on the display is either green or red, and participants are instructed to restrain from pressing the spin button when it is red. This method was chosen to enable the moment-by-moment capture of the impact of varying gambling speeds of play on motor response inhibition. Consequently, it provides greater insight into the impact gambling parameters have on a gambler’s executive control capacity within a gambling session.

The experiments also assess psychological factors pertinent to gambling and that are also associated with response inhibition performance. One such factor is arousal. Arousal within a gambling session can be tonic and last over a sustained period of time, but can also fluctuate rapidly in response to stimuli, known as phasic arousal (Howells, Stein, & Russell, 2012). In essence, the impact of gambling on arousal has the potential to decrease rapidly following a gambling session, meaning assessing response inhibition via a go/no-go task that follows a gambling session provides the arousing nature of gambling time to fluctuate and potentially dissipate, losing valuable insight into the role of arousal in response inhibition performance within a gambling context. Therefore, embedding the task into the gambling simulation allows for an ‘on-task’ or ‘online’ measure of motor response inhibition and provides insights into inhibitory control capacity during gambling at varying gambling event frequencies.

The second significant modification of this go/no-go task is that it is common for participants to be instructed to respond as rapidly and accurately as possible on go/no-go tasks. One of the principal aims of the present study is to examine the impact of speed of play of gambling on psychological and behavioural factors in gamblers, which includes an examination of how the speed of the game impacts gambling speed and response times. Therefore, instructing participants to respond rapidly would likely induce more commission errors on the embedded go/no-go task, as well as falsely increase the rate at which the gambler feels compelled to gamble on the simulator as a result of the experimental manipulations. Not instructing gamblers to respond rapidly keeps the experiment more naturalistic and representative of real-world gambling. This also keeps the purported emphasis to participants that the experiments are a ‘gambling experience’, rather than a cognitive test battery.

### *4.4 Assessing valence, arousal, and perceived self-control*

Lang (1980b) states that emotional responses can be assessed in at least three different systems, including affective reports, physiological reactivity, and overt behavioural acts. Selecting among available affective report measures poses a challenge in light of the large number of tools that have been devised. Wundt (1896; cited in Bradley & Lang, 1994) proposed that the affective experience of stimuli, including objects and events, can be described using three dimensions originally labelled as pleasure, tension, and inhibition. Although these categories proposed by Wundt (1896) were theoretical in nature, empirical investigation repeatedly confirms that valence, arousal, and dominance are pervasive in the influence of human judgments for a wide range of stimuli and events (Bradley & Lang, 1994).

A widely used tool for the assessment of the three identified dimensions of affective response is the Semantic Differential Scale (SDS; Mehrabian & Russel, 1974). The SDS comprises 18 bipolar pairs of adjectives that are each rated along a nine-point scale. Factor analysis is then conducted on the resulting 18 ratings to formulate scores on the sub-dimensions of pleasure, arousal, and dominance. While the SDS provides informative data, it is not without procedural drawbacks in experimental designs. The SDS can be lengthy and time consuming to administer because it requires participants to make 18 different ratings for each stimulus or event experienced in an experimental session. This limitation is amplified when repeated-measures experimental designs (such as Experiment 1 of the thesis) are conducted. The SDS has also been criticised for its difficult application to non-English speaking cultures, and individuals that lack linguistic sophistication (Bradley & Lang, 1994). Additionally, it can be argued that the use of 18 adjectives, of varying complexity, requires the participant to understand the operational meaning of such adjectives. For example, while it would be a fair assumption for English speakers to have a reasonable grasp of the approximate meaning of the adjective pair '*unhappy-happy*', it may be less fair to assume understanding of debatably more complex adjective pairs such as '*melancholic-contented*'. Using the latter pair as an example, it may also be contended to what extent these words actually represent dichotomous ends of a semantic scale.

### *4.4.1 Self-Assessment Manikins*

As a result of these limitations, particularly the need to avoid an excessively lengthy and potentially fatiguing repeated-measures procedure, a self-assessment tool able to quantify the affective reactions to gambling events, namely valence, arousal, and dominance, in a less time-consuming way was required. These issues were addressed by Lang (1980b; Hodes, Cook & Lang, 1985) who formulated a language-free, picture-based instrument to measure the self-reported valence, arousal, and dominance associated with various forms of stimuli and events. The tool is known as the Self-Assessment Manikin (SAM), is capable of being administered both electronically and in pen-and-paper format. For the valence SAM scale, extreme end points of the scale are represented by an intensely smiling, happy figure at one end, and an intensely unhappy, frowning figure at the opposite end, with the midpoint portrayed as a neutrally-valenced figure. The arousal SAM scale at the highly aroused end of the scale is portrayed as a wide-eyed figured with a large, non-regular shape exceeding from the trunk of the body, representing a large amount of nervous system activity, whilst the opposite end of the scale is portrayed as a closed-eyed figure with a minimally visible shape around the trunk area, representing a relaxed, minimally-aroused state. The dominance dimension of the SAM represents changes in perceived control and autonomy, and the figure on the dominance scale changes in size from very small at one end of the scale, and a much larger figure at the opposite end of the scale, indicative of maximum control and autonomy (Bradley & Lang, 1994). Figure 4.1 illustrates the three SAM scales in their 9-point versions to be used in the present study.

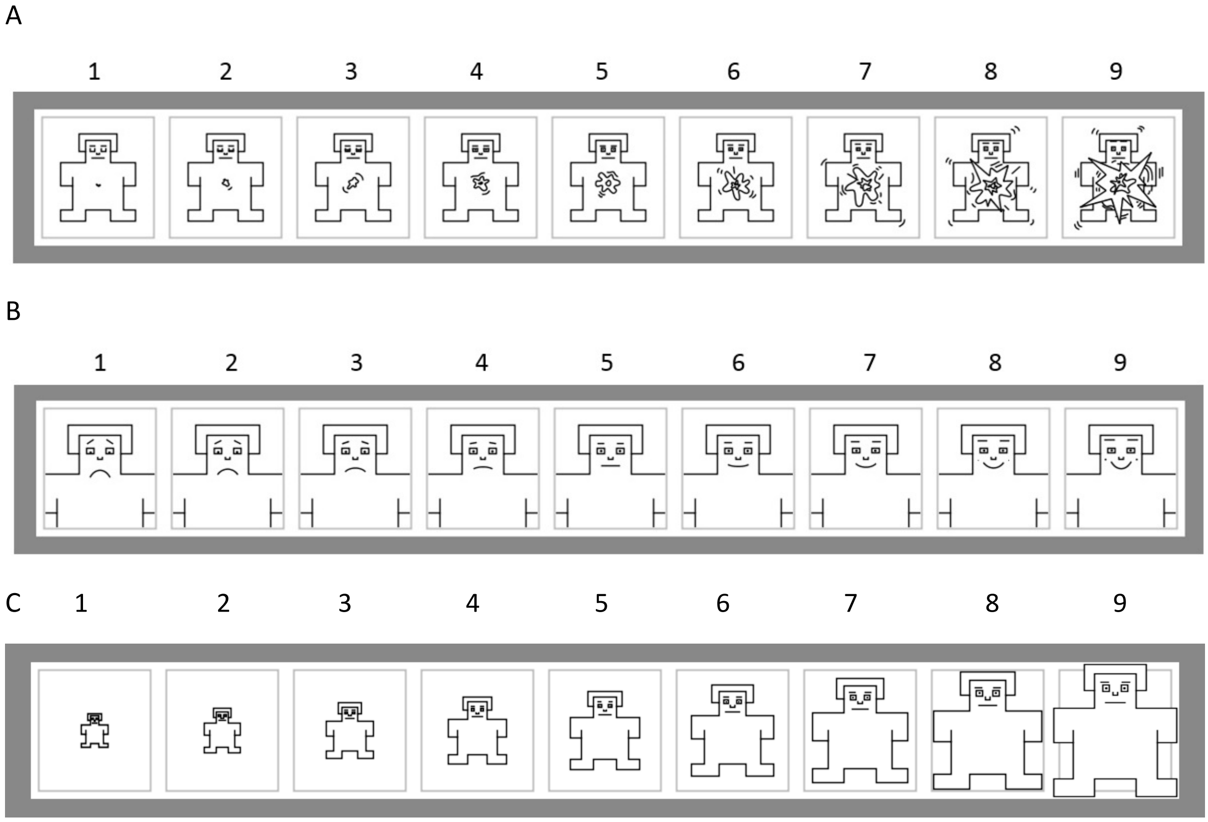


***Figure 4.1.*** The Self-Assessment Manikin (SAM) used to measure the affective dimensions of arousal (A), valence (B), and dominance (C). To increase the SAM's capability of detecting smaller changes as a result of experimental manipulations in each of these affective dimensions, 9-point scale versions were used. Notably, the SAM is also available in 5-point and 7-point versions, as well as a full figure version of the valence scale, as opposed to the portrait version used here.

Pencil and paper versions of the SAM requires participants to mark an 'X' on the figure most representative of their current levels of valence, arousal, and dominance. The current version of the

SAM, which is presented to participants electronically, is accompanied with a numerical scale next to each figure on each scale. Participants must select the relevant figure by pressing the figure's corresponding number using the number scale on a standard computer keyboard.

In an attempt to validate the SAM as a tool for assessing affective responses to stimuli, Bradley and Lang (1994) compared participant responses to affective pictures using both the SAM and the lengthier and widely used Semantic Differential Scale (SDS). Their results showed a near perfect correlation between the two tools for the arousal and valence components. However, the dominance component as assessed by the SAM, was seemingly better suited to capture the control experienced by the participant when compared to the SDS. Bradley and Lang (1994) argued this by using the picture of the snake used as a stimulus in their study as an example. The dominance rating was high for this picture when measured using the SDS, which appears counterintuitive given the general fear associated with this animal and likely lowered state of control experienced by humans. Therefore, the SDS may confuse participants as to which side of the dynamic relationship they are rating, leading to the snake's dominance being rated as opposed to their own view as the scale intends. However, dominance ratings for the same picture were low when made using the SAM, suggesting that because the SAM figure is human-like in appearance, it correctly guides participants to rate their first-person experiences in response to the stimuli being presented. Overall, these empirical results suggest the SAM is an appropriate tool for use in capturing self-report valence and arousal and is comparable to lengthier and more widely used tools (e.g., the SDS) for capturing these affective dimensions. Furthermore, it can be argued to represent a more valid measure of the dominance component of affective responses to stimuli when compared to the SDS.

The SAM has been used effectively to assess emotional responses in a variety of situations, including reactions to pictures (Lang et al.,1993), sounds (Bradley, 1994), pain-eliciting stimuli (McNeil & Brunetti, 1992), and (in line with the present study) emotional responses to manipulated structural characteristics of gambling (Parke et al., 2015). The tool has also been used with a wide variety of clinical populations, including those with psychopathy (Patrick, Bradley, & Lang, 1993), anxiety (Cook et al., 1988), borderline personality disorder (Herpetz et al., 1999), and substance abuse disorder (de Arcos et al., 2005). It has also been used to assess affective responses to events in non-clinical specialist populations, including children (Greenbaum et al., 1990), and regular non-problem gamblers (Parke et al., 2015).

Physiological approaches were also considered for the measurement of arousal in the experimental gambling context. Whilst the advantages of physiological measures of arousal, such as galvanic skin response measures and heart rate variability measures, include their consideration as objective measures of arousal, some of the main limitations associated with such approaches ultimately led to the selection of a self-report approach. The first factor leading to the exclusion of physiological measures of arousal is the lack of control over the participant's sleep-wake cycle, a factor widely reported as influencing physiological arousal (see e.g., Harrison and Horne, 2000). Secondly, the use of external measuring instrumentation becomes an intrusive factor that can affect the participant's reaction because they are not being tested in a neutral environment. Of importance to the ecological validity of the study, is that the gambling simulation is portrayed as a gambling experience, rather than a battery of tests, to maximise external validity.

The validity of self-report measures of emotional responses is an ongoing debate. Whether self-report measures of emotional responses are valid or not is arguably a false dichotomy, because the extent to which self-report is valid is dependent upon the type of self-report measure being used (Robinson & Clore, 2002). More specifically, empirical evidence suggests that self-reports of current emotional experiences are likely to be more valid than self-reports of emotion made retrospectively from the relevant experience (Robinson & Clore, 2002). Consequently, the use of the SAM – which is able to be administered and completed quickly and immediately following a gambling experience – is ideally placed to capture the participant's emotional responses to that gambling experience. In their review of self-report, physiological, and behavioural approaches to assess emotion, Mauss and Robinson (2009) concluded that there is no 'gold standard' assessment of emotional responses. They concluded that experiential, physiological, and behavioural measures are all relevant to understanding emotion and cannot be assumed to be interchangeable.

### *4.5 Assessing dissociation*

The construct of dissociation has been used to refer to a discontinuity between elements of thought and action that are usually connected (Allcock et al., 2006). Dissociation is associated with a lowered state of conscious awareness, where individuals are no longer able to exert control over their actions, thoughts, or feelings. An individual might feel compelled to do something and be unable to prevent themselves from stopping, or feeling that they are compelled to undertake a specific action (Dell, 2001). In a gambling context, those that report being in a state of dissociation have described it as being outside of oneself and losing track of time and money spent during gambling (Monaghan, 2008). The exercise of executive-(self)-control can be argued to represent the antithesis of automatic processes, or the lowered conscious state that dissociation represents.

While dissociative states may have some positive effects for the individual, for example, escaping emotional distress, Norman and Shallice (1986) argue that there are several conditions under which the routine activation of behaviour, at the expense of cognitive control, would be inappropriate. These conditions identified by Norman and Shallice (1986) include situations that require planning and decision-making and situations with potentially dangerous consequences. Given the negative consequences that can occur during gambling if self-control and self-awareness are diminished, then assessing the impact of structural features of gambling on levels of dissociation is essential from a harm-minimisation perspective.

Defining the construct of dissociation has been controversial, and the term has been used to describe a number of both pathological and normal processes. Broadly speaking, the term dissociation is used to describe three domains: (i) multiple mental process that are disjointed and not consciously accessible; (ii) psychological disengagement from the 'self' or the environment; and (iii) as a defence mechanism to escape emotional distress (Cardena, 1994). Some have argued that dissociative experiences are discrete states that are rarely experienced by healthy individuals, while others argue that dissociative experiences are continuous, vary in intensity, and are common, which is also the modern mainstream view (for example, see Waller, Putnam & Carlson, 1996).

Current research on appetitive behaviours commonly report the use of two main self-report instruments for assessing the construct of dissociation (Allcock et al., 2006). These are the Dissociative Experiences Scale (DES; Bernstein & Putnam, 1986) to assess general dissociative tendencies in life, and Jacobs' (1988) scale assessing the level of dissociative experience while engaging in a potentially addictive activity, including gambling.

### *4.5.1 Criticisms of the Dissociative Experiences Scale*

Dissociation as a construct has been criticised for being a vague and relatively ill-defined concept, and that it is hard to operationalise, particularly within a gambling research context (Allcock et al., 2006). Regarded as perhaps the most widely used instrument to measure dissociation, criticisms of the DES have highlighted that about two-thirds of the items can be explained in term of cognitive control functions, such as distribution of attention, memory recall, and the use of imagination. This implies that relatively common everyday phenomena such as 'absent-mindedness' (i.e., lapses in cognitive control) would predict higher scores on the DES (Frankel, 1996). Similarly, the DES has been criticised due to the fact that one of its' major components assesses absorption in imaginative activities (Allcock et al., 2006). Consequently, relatively normal everyday phenomena such as fantasy proneness would predict higher DES scores (Rauschenberg & Lynn, 1995). This proposition has been supported empirically, with moderate levels of correlation being found between the three dissociation subscales of the DES, everyday cognitive lapses, and fantasy proneness, in a non-clinical (student) sample (Merckelbach, Muris & Rassin, 1999).

*4.5.2 Jacobs' (1988) Four-Item Dissociation Scale*

Jacobs' (1988) four-item scale operationalises the dissociation component of his General Theory of Addictions (Jacobs, 1986). It assesses four dissociative-like states experienced by an individual during or immediately after a period of appetitive indulgence, and therefore, was deemed more appropriate as a measure of within-session gambling dissociation than the DES in the present study, as the latter is focused on dissociative experiences in life more generally.

Within Jacobs' scale, Item 1, *"After (activity noted) have you ever felt like you had been in a trance?"* is designed to assess to what extent an individual experiences a blurring of reality. Item 2 *"Did you ever feel like you had taken on another identity?"* is designed to assess the extent to which an individual experiences a shift in persona. Item 3 *"Have you ever felt like you were outside yourself - watching yourself (doing the given activity)?"* captures the extent to which an individual has an out-of-body experience. Finally, Item 4 "Have you ever experienced a memory blackout for a period when you have been (doing the given activity)?" assesses the extent to which an individual experiences amnestic states. The scale's responses are made on a five-point scale, ranging from 1 ('not at all') to 5 ('all the time'). Whilst the convergent reliability and validity scores of this questionnaire are not available, the measure has been adapted and used in research focusing on eating disorders (Jacobs, 1988), alcohol and other drug use (Jacobs, 1988; Rosenthal, & Lesieur, 1992), as well as gambling (Diskin, & Hodgins, 1999; 2001; Gupta, & Derevensky, 1998).

Variations of the original four questions have also been introduced. For example, the introduction of a fifth question assessing if an individual has experienced a loss of awareness of time while gambling has been implemented in several gambling studies (e.g., Diskin & Hodgins, 2001; Gupta & Derevensky, 1998). Blaszczynski et al. (2015) also modified the questions to assess dissociation during video lottery terminal gambling. The frequency of dissociative experiences reported across studies employing Jacobs' measure has been highly consistent (e.g., Jacobs, 1988; Lesieur, & Rosenthal, 1994). Furthermore, large correlations between pathological gambling and dissociation assessed using Jacobs' questionnaire have been found (Rosenthal & Lesieur, 1992).

Five items were used in the present study, including the original four items proposed by Jacobs (1988), with the addition of a fifth item assessing the experience of time loss (see e.g., Gupta & Derevensky, 1998). It was deemed appropriate to add this fifth item due to evidence suggesting that problem gambling is not only associated with excessive monetary spend, but also with excessive time spent gambling (Heiskanen, 2017). Of note, in Blaszczynski et al.'s (2015) study, the Cronbach's alpha was 0.79 for the 4-item scale and 0.69 for the scale including the additional question concerning time perception. As seen in Blaszczynski et al.'s (2015) study, the questions in the present studies were further adapted to extract self-report levels of dissociation associated with the gambling session participants had just completed. Five-point scales were used for each question where responses could range from 1 ('not at all') to 5 ('all the time'), with a mid-way point of 3 ('occasionally').

### *4.6 Assessing choice impulsivity*

In-depth examination is ongoing regarding the construct of impulsivity, its components, and boundaries (Gullo, Loxton, & Dawes, 2014). At the broadest level, impulsivity may be categorised into two relatively distinct domains, impulsive action and impulsive choice (Arce & Santisteban, 2006; Diergaarde et al., 2008). Further sub-factors that have been argued to constitute impulsivity have included withholding/cancellation of motor responses, choice, reflection, and decision-making (Fineberg, et al., 2014), identifying the need to treat the construct of impulsivity in a parsimonious way. Given Evenden's (1999) definition of impulsivity as a predisposition towards rapid and unplanned reactions to stimuli with diminished regard for the consequences of such actions, then tools assessing an individual's ability to plan and consider future consequences are essential in understanding impulsivity.

The inclusion of measures of choice impulsivity as a means of capturing impulsivity during gambling is supported by evidence which shows that those who demonstrate impulsive behaviour at the clinical level also have elevated levels of choice impulsivity (Patros et al., 2016). Such clinical sub-groups include those with bipolar disorder, borderline and anti-social personality disorder, as well as those with addictions including gambling (Ahn, et al., 2011). Including choice impulsivity measures resulting from gambling is also critical because choice impulsivity is related to many detrimental behaviours, including gambling persistence (Leeman & Potenza, 2012), suicide (Dombrovski, et al., 2011), risky sexual behaviours (Johnson & Bruner, 2012), substance abuse (Kollins, 2003), and violence (Cherek & Lane, 1999).

Several tools exist that assess and quantify the planning and consideration of future consequences, identified as a quintessential feature of choice impulsivity. This process of deliberation is more often referred to as delay discounting or temporal discounting (Fineberg et al., 2014). Delay discounting tasks involve choices between smaller and more immediate real or hypothetical rewards, or larger-later (or delayed) real or hypothetical rewards. A greater tendency to opt for the smaller more immediate reward is indicative of higher levels of impulsivity, because larger delayed rewards are discounted at a steeper rate (Reynolds, 2006). Subjective values, needs, and reward sensitivity is likely to play a part in discounting rates, as well as a variety of situational influences such as sleep deprivation (Reynolds & Schiffbauer, 2004) and mood (Weafer et al., 2013). Such state influences on choice impulsivity may also include structural and situational factors in gambling. In essence, delay discounting rates are not simply an assessment of trait impulsivity but can be influenced by a variety of situational factors, making delay discounting tasks ideal in assessing further situational and psychological influences on impulsivity levels.

*4.6.1 The Monetary Choice Questionnaire (MCQ)*

The MCQ (Kirby et al., 1999*)* is a 27-item assessment of delay discounting, where each item requires a choice between a smaller hypothetical monetary reward immediately, or a larger hypothetical monetary reward following a delay ranging from 7 to 186 days (see Appendix A). For example, *"Would you prefer $19 today, or $25 in 53 days?"* (item 3 of the MCQ). The 27 items are sub-divided into three magnitude conditions: small ($23-35), medium ($50-60), and large ($75-85). This allows for secondary analysis of discounting rates for each magnitude condition if desired.

The MCQ was developed by assuming a hyperbolic model (see e.g., Green & Myerson, 1996; Liabson, 1997) and works by determining the values of smaller-immediate, larger-delayed, and delay to larger rewards based on specified discounting (*k*) ranging from .00016 to .25, with larger *k*-values indicating higher levels of choice impulsivity. The *k*-value, which is based on a hyperbolic discounting function, is summarised in the following equation, $V=A/(1_{+}kD)$, in which V= the value of the delayed reinforcer (present value of the reward or indifference point), is equal to the amount of the reinforcer (A), divided by the delay to the reward (*k*D). *K* is therefore, a free parameter that describes the steepness of the discount function (the degree to which value is affected by the delay).

The advantage of using a *k*-value to assess delay discounting is that it has been shown to be relatively stable and has a very good test-retest reliability (Kirby, 2009). Kirby (2009) showed that repeated testing using similar test situations resulted in individuals scoring similar discounting rates, as assessed using *k,* up to one year later (test-retest reliability =.71) using a self-report assessment of delay discounting. However, Hamilton et al. (2015) report that estimating delay discounting using *k*-values has a tendency to overestimate indifference points when delays are short and long, though the overall fit of the curve using this mathematical model is good. Furthermore, pre-programmed resources have been developed to allow researchers to quickly calculate individual and group level *k*-values to allow for efficient statistical comparisons (see e.g., Kaplan, Lemley, Reed, & Jarmolowicz, 2014).

Whilst the MCQ used in Experiment 3 of the present thesis uses hypothetical monetary rewards, some research suggests that discounting rates are steeper (i.e., individuals show greater levels of impulsivity) when real money is used in the procedure (Kirby, 1997). However, the validity of the comparison of real versus hypothetical rewards is questionable given the large methodological differences across studies, as well as the fact that steeper discounting rates for real monetary rewards are inconsistent (for a review, see Lawyer et al., 2011). Furthermore, a large meta-analysis investigating delay discounting research found no differences in convergent validity between real and hypothetical rewards (Duckworth & Kern, 2011). Consequently, it is reasonable to conclude that the use of hypothetical rewards in the delay discounting task in Experiment 3 of the thesis is sufficiently able to capture the delay discounting aspect of choice impulsivity. Additionally, the use of hypothetical rewards has a practical significance in the sense that it allows research to be conducted at a reasonable cost because the use of real monetary values that match those presented in the MCQ would amount to a significant financial expenditure per participant.

The type of stimuli (or commodity) used in a delay discounting task is also of significance, given the fact that discounting rates across different commodities have been reported. For example, primary consumable items such as food and alcohol are discounted at higher rates than leisure items such as books, music, and money (Charlton & Fantino, 2008), although the extent of discounting across different hypothetical commodities are highly correlated (Odum, 2011). There is also an emphasis to ensure that the reward modality in delay discounting tasks are relevant to the population being studied (Hamilton et al., 2015). This ensures the choices in the tasks are both contextually relevant and relate to the appetitive behaviour of study, as well as ensuring decisions are not novel. Therefore, the use of the MCQ to study delay discounting in gambling, where money is the commodity available, has high face validity.

When considering task modifications from standardised procedures, it is important to consider the added benefit of task modification versus how such modifications reduce convergent validity. To maximise contextual and cultural relevance in the MCQ in the present study, the only modification that was made to the 27-item MCQ was that all items where modified to give the monetary values in pounds sterling rather than US dollars, given that the study took place in the UK. Therefore, participants are more likely to appreciate and understand the relative values of the hypothetical rewards being presented, without detrimental impact on the convergent validity of findings.

Further strengths of the MCQ and reasons for its inclusion as a tool to assess choice impulsivity in the present study, is that the test is widely used, allowing cross-study comparisons of research data. Furthermore, the test has been shown to be sensitive to experimental manipulations (Hamilton et al., 2015). In addition, the test is relatively easy to understand and administer, and can be completed as a pen-and-paper task, or in this case, be completed electronically and incorporated as part of a battery of tests. Finally, the MCQ (despite comprising 27 items), can be completed relatively quickly, an essential factor enabling participants to complete the task whilst psychological states resulting from the gambling experimental manipulations are still active and influential.

One of the drawbacks of using the MCQ is the reported potential for ceiling effects among the most impulsive individuals, as well as limited modifiability of the scale items (Hamilton et al., 2015). Preliminary statistical analysis, including a frequency of scores analysis and an assessment of the data's normal distribution, can be conducted to assess for ceiling effects, and if present, is reported alongside the main statistical findings (alongside a caveat). In terms of the limited modifiability of the MCQ, the minor modification of US dollars to sterling was the only modification required for the present study, and therefore, limited modifiability of the MCQ is not seen as a precluding factor for the purposes of the present thesis.

*4.6.2 The Information Sampling Task (IST)*

The IST is a tool that has been used to study aspects of choice impulsivity pertaining to the quality of decisions under uncertainty. Referred to as 'reflection impulsivity', this aspect of choice impulsivity refers to the tendency to gather and evaluate information before making a decision based on that information (Kagan, 1966). An impulsive response style, at the expense of information gathering and deliberation, is often correlated with poorer performance on reflection impulsivity tasks (Messer, 1976). For example, the Matching Familiar Figures Test (MFFT; Kagan et al., 1964) is widely used as a measure of reflection impulsivity. Although now relatively dated, a review conducted by Messer (1976) identified the strong tendency for impulsive response styles (i.e., less deliberation time) to be associated with inaccurate decision-making.

The IST has several advantages over the MFFT, including the fact that the tool is not only able to gather information on decision time and quality of decisions, but in addition, quantifies the amount of information gathered by a participant before a decision is made. The fact that choices in the IST are made under uncertainty, as opposed to having the correct answer present as in the MFFT, arguably makes decision-making in the IST more representative of everyday decision-making processes, including those within a gambling context.

Classic versions of the IST (see e.g., Clark et al., 2006) involve participants being presented with a 5x5 grid of closed boxes. Clicking on a box reveals one of two colours and participants can open as many boxes as they wish to gather information to make a prediction on which of the two colours is in the majority within the 5x5 grid. Based on the number of boxes opened, the colours of those boxes, and the decision made by the participant as to which colour is in the majority, the probability that the participant's decision is correct can be calculated, often referred to in the literature as 'p-correct' (see e.g., Clark et al., 2006; Parke et al., 2015). However, the participant starts with a number of potential points that can be won for correct responses, but sampling (i.e., opening) a box results in the maximum points available being reduced for every box that is sampled. Participants are also penalised points for incorrect decisions (Clark et al., 2006). The participant must therefore weigh up the quality of information available on which to base their decision against the potential returns/penalties for correct/incorrect responses.

Whilst p-correct is often the main variable of interest in the IST, other dependent variables include the number of boxes opened and the time taken to make a decision, both of which provide additional information on how decisions were made. Longer deliberation and a greater number of boxes sampled is indicative of greater levels of reflection, whilst quick decisions based on limited information is indicative of greater levels of impulsive decision-making.

Research into appetitive behaviours using the IST has highlighted significantly reduced levels of reflection among samples of chronic cannabis users (Clark et al., 2009b), and amongst current users of opioids and amphetamines (Clark et al., 2006). Alcohol-dependent individuals have also demonstrated lower levels of reflection on the IST relative to a healthy control group (Lawrence et al., 2009). Although less researched, binge drinking is also associated with poorer performance on similar behavioural tasks (for example, see Henges & Marczinski, 2012). In a gambling context, Lawrence and colleagues (2009) also demonstrated that problem gamblers tolerated more uncertainty in their decisions on the IST when compared to healthy controls.

However, it remains less clear whether reflection impulsivity is a cause or consequence of appetitive behaviours, although the two views are not necessarily mutually exclusive. Combining the fact that problem gambling has been described as a prototypical model of addiction that is not confounded by the harmful effects of substance abuse (Bechara, 2003; Potenza, 2006), and that problem gamblers show deficits in reflection impulsivity (Lawrence at al., 2009), has led to the view that factors including reflection impulsivity represent pre-existing vulnerability factors in addictions (Dalley et al., 2007; Verdejo-Garcia, Lawrence, & Clark, 2008). Whilst acknowledging the likely role of such factors in the uptake of appetitive behaviours, the present study predicts that the reflection impulsivity of healthy individuals can be influenced by contextual factors, namely, structural characteristics of gaming machines. Therefore, it is predicted from an experimental standpoint that differences in reflection impulsivity will be detected using the IST as a result of manipulations to structural characteristics in gaming machines.

The IST in the present study has been modified to allow it to be easily integrated into the experimental software package *Psychopy* (Peirce, 2007), and to reduce the novelty of the task by converting its format into a more widely recognised probability task. The design of this version of the IST was based upon the classic 'urn problem' (see also, Parke et al., 2015). An urn (instead of a grid) contains 19 unseen balls (instead of boxes), and each ball is coloured either black or red. Participants are required to determine whether black or red balls are in the majority. Participants can gather information by selecting to remove a ball without replacement from the urn to reveal its colour. Points are awarded in the IST for correct predictions regarding which colour is in the majority. For each IST trial, participants begin with 95 points, and have 5 points removed for each ball taken from the urn. For example, if a participant removed 3 balls from the urn, and correctly predicted that red was in the majority they would win 80 points for that particular IST trial (see Figure 10.1 in Chapter 10, Experiment 3, for example illustrations). However, if participants make an incorrect prediction, then they are penalised 95 points for that trial. Participants are informed that all of the points that they accumulated over the IST trials will be totalled, and the participant who accumulates the most points receives a £100 cash prize, thus reducing the novelty of the task given the potential for significant financial reward.

The final modification to this version of the IST, is that during the experiment, participants are not provided with feedback regarding whether their predictions in each IST trial were correct or not. This is to prevent any inter-trial contamination effects. For example, if one participant guesses correctly in the first trial, this may be accompanied with increased positive valence, which could impact performance in subsequent IST trials. Alternatively, if one participant repeatedly makes incorrect decisions, feedback on this may influence them to make riskier but potentially higher yield guesses in the remaining trials. Therefore, not providing feedback after each trial has the advantage of controlling for such extraneous variables.

Each participant completes five IST trials, each of which present a different and random pre-programmed combination of red/black balls to be removed from the urn. P-correct values can vary between 0-100%, although these extreme values are unlikely. For example, to obtain a score of 0%, participants would have to sample 10 (or more) of the 19 balls, at least 10 of them would have to be the same colour, and then the participant would have to guess the majority was the opposite colour. Consequently, p-correct scores most likely vary between 50-100% accuracy, although achieving a score of 100% would require the participant to sample enough balls from the urn until they have at least 10 of either red or black, but this would conversely result in the number of available points for correct answers being significantly reduced.

## 4.7 Assessing trait impulsivity

### *4.7.1 Barratt Impulsivity Scale-11*

Unlike Experiment 1 of the thesis, Experiments 2 and 3 are between-participant designs, which requires the management of between-group differences in trait impulsivity. The Barratt Impulsivity

Scale (BIS-11; Patton Patton, Stanford, & Barratt, 1995) is a self-report questionnaire designed to assess the personality and behavioural construct of impulsiveness. The BIS-11 is the most widely cited instrument for the assessment of impulsiveness and has been used to advance understanding of this construct and its relationship to a range of clinical disorders (for a review, see Stanford et al., 2009).

The BIS-11 is a 30-item questionnaire capable of providing an overall impulsivity score, as well as measures scores on sub-components of impulsivity, including attentional, motor, and non-planning impulsivity (see Appendix B). Eight of the 30 items focus on attentional impulsivity, and 11 items are used to assess both motor and non-planning impulsivity respectively. All items are rated using a 1-4 scale, with higher scores indicative of greater levels of trait impulsivity.

Among the main reasons for selection and use of the BIS-11 in this thesis are the availability of normative data and of a large range of translations, as well as the considerable amount of previous research using this scale in a variety of clinical populations (Bari, Kellermann, & Studer, 2016). However, whilst the BIS-11 is the most widely cited tool for assessing trait impulsivity, it is not without its criticisms. Reise and colleagues (2013) for example, conducted an assessment of the BIS-11 structure among a large community sample (*N*=691). Amongst their findings was a lack of empirical support for the three sub-components of impulsivity aforementioned, and instead have proposed a more streamline two-factor model encompassing (i) an inability to wait for reward, and (ii) rapid response style. Furthermore, as with many self-report approaches, scores on the BIS-11 are likely to be influenced by subjective interpretation of the items and participant’s ability to reflect and report accurately on their behaviour.

# Chapter 5. Experiment 1. The Relationship Between Gambling Event Frequency, Motor Response Inhibition, Arousal, and Dissociative Experience

### *5. Chapter overview*

Chapter 2 identified an association between increased gambling event frequency and psychological and behavioural indicators of a loss of self-control. However, this association has been shown to be inconsistent, and is more often found amongst groups of problem and pathological gamblers when these clinical groups are compared to non-gambling control groups. Receiving less attention is the potential impact of gambling event frequency on non-problem regular gamblers, as well as the underlying cognitive processes that may give rise to reduced self-control within a gambling session. Reduced self-control may not be readily observable in typical overt behavioural measures found in existing studies examining speed of play in gambling. These measures, such as time and money spent gambling, may represent a loss of self-control at the more extreme end of the spectrum, potentially overlooking intermediate stages of reduced self-control, as well as the cognitive mechanisms giving rise to this reduction in self-control.

Several research studies have been discussed in Chapter 3 that highlight response inhibition as a core construct in problematic gambling behaviour. Response inhibition is frequently shown to be impaired in those with a gambling disorder, meaning maladaptive actions are executed due to reduced inhibition capacity. It is argued therefore, that a reduction in response inhibition capacity can give rise to impulsive tendencies that may lead to problematic gambling behaviour. As a result, it is important to investigate if structural characteristics of gambling are conducive to impaired response inhibition, and to shed let on potential causal mechanisms, independent from predispositional vulnerability, in the transition from controlled to problematic gambling behaviours. This investigation is motivated by an extrapolation of results from wider cognitive psychological research that illustrates that both the speed at which stimuli are presented to an individual, as well as individual levels of arousal, represent situational and psychological factors that can influence response inhibition performance.

### *5.1 Research aims and hypotheses*

The first aim of Experiment 1 is to experimentally investigate the impact of gambling speed of play on a gambler’s ability to withhold motor responses during gambling. It is hypothesised that as event frequency increases on electronic slot machine simulators, response inhibition performance will decrease (H1).

The second aim of Experiment 1 is to investigate the psychological factors that predict the relationship between gambling event frequency and response inhibition performance. It is hypothesised that subjective arousal will increase at faster speeds of play (H2), and that increased arousal will be predictive of poorer response inhibition performance (H3).

The third aim of Experiment 1 is to investigate if the inclusion of brief pauses in play between gambling events allow for adaptive response modulation (i.e., allow gamblers to adapt their behaviour to avoid erroneous responses). Existing research demonstrates that the imposition of a simple short delay between gambling events in a computerised card game strengthens inhibitory control processes (Thompson & Corr, 2013). However, the inclusion of brief pauses in play as a means to facilitate inhibitory control processes is yet to be investigated in gambling games with high event frequencies such as slot machine gambling. It is predicted that providing a short pause following presentation of a gambling result will provide a refractory period to allow executive control systems to exercise control over actions, actions that may otherwise be automatically and impulsively executed by the provision of a new gambling event. Therefore, it is hypothesised that inclusion of brief pauses in play during slot machine gambling will improve response inhibition performance by facilitating proactive motor control, demonstrated by an increased reaction time (H4).

## *5.2 Method*

### *5.2.1 Design*

A repeated-measures experiment was conducted to assess the impact of slot machine event frequency on motor response inhibition performance. An electronic slot machine simulator was designed using a combination of the graphical user interface and coding function available on *Psychopy* (Peirce, 2007) experiment builder (see figure 5.1). The slot machine was a three-reeled design, with a single pay line, consisting of five speed of play conditions: Fast; Moderate; and Slow slot machine event frequencies (1.5s, 3s, and 4.5s event frequencies respectively); Moderate event frequency with a brief pause in play (fast spin of 1.5s plus 1.5s pause in play, totalling 3s event frequency); and Slow event frequency with brief pause in play (fast spin of 1.5s plus 3s pause in play, totalling 4.5s event frequency). Each condition of the slot machine simulator had 90 trials (gambling events). Each slot machine condition was programmed to give the illusion of randomness. However, the slot machines were pre-programmed to control for volume, frequency, and range of wins, as well as number of near misses (see Clark et al., 2009a). However, there was a four percent variance in payback percentages among the five conditions to ensure participants did not win or lose the exact same amount in every condition, and therefore, reinforcing the illusion of randomness (see Figure

5.2). The slot machine pay-back percentages ranged from 92%-96%. This variance was considered small and not able to produce a significant enough change in valence as a result of increased/decreased monetary wins/losses, and therefore, was not considered to represent a confounding variable.

A behavioural measure of response inhibition, in the form of a go/no-go task (see figure 5.1), was built into the slot machine simulator, and immediately following each session of gambling, participants were given various electronic scales to complete to measure subjective arousal, dissociation, valence, and perceived self-control. All scales were presented and completed using the *Psychopy* experiment builder. Reaction time was also measured, which is a standard function in the experimental software.


***Figure 5.1.*** Image taken from the electronic slot machine simulator programme. A three-reeled slot machine simulator with a single pay line was designed using *Psychopy* experiment builder. The machine is activated using the space bar on the participant's keyboard when the visual display spin button changes from grey to either green or red (though participants are instructed to withhold responses when the button is red).

*5.2.2 Participants*

A sample of 50 (36 male), non-problem, regular gamblers were recruited from amusement arcades and sports teams in the Lincolnshire, UK, region. These areas were targeted during the recruitment process as they were identified as areas likely to contain a high density of gamblers. All participants were classed as regular gamblers, defined for the purposes of this study as an individual who had gambled at least once per month over the past 12 months. Participant mean age was 29.88 years

(SD=9.13), with ages ranging from 19-58 years. A short screening questionnaire was administered to both ensure participants reported regular participation in gambling, as well as to ensure participants had never suffered with a gambling problem, nor currently suffering with a gambling problem. An affirmative answer on either count of problem gambling resulted in participants being excluded from participation. Of note, two participants were excluded from participation following the screening questionnaire, as they reported having previously experienced problem gambling.

*5.2.3 Materials*

*5.2.3.1 Behavioural response inhibition task*

The electronic slot machine simulator consisted of 90 trials (gambling events) per condition. The machine was activated by pressing the 'spin button' which was the spacebar on a standard keyboard. The spin button on the slot machine simulator visual display varied in colour from green to red, with green trials indicating participants could spin the machine and continue gambling, but red indicating that they need to withhold their motor response. Response inhibition was therefore assessed with an 'online' behavioural go/no-go task, as the task was embedded into the gambling simulator. The first 30 trials of each condition were all green 'go' responses, often referred to as a 'training phase' in classic response inhibition tasks (for a review, see Simmonds et al., 2008). The purpose of the first 30 trials all being 'go' trials was to allow any prepotent patterns of motor responses to develop. The remaining 60 trials in each condition consisted of a random 4:1 ratio of green 'go' to red 'no-go' trials.

*5.2.3.2 Dissociation*

Dissociative experience was assessed using a modified version of Jacobs' (1988) Four Item Dissociative Experience Scale. The original scale was modified in two ways for the present study. First, the original four items were modified to ask participants to reflect on the gambling session they had just participated in, as opposed to gambling experience in general. For example, the question 'When gambling, how often do you feel like you have been in a trance?' was modified to read 'Thinking back to the gambling session you have just completed, how often did you feel like you were in a trance?' The second modification of the scale was the addition of a fifth item, asking participants about their perception of time during the gambling session, an item incorporated into previous experimental gambling research (see Gupta & Derevensky, 1988; Blaszczynski et al., 2015). All five items were self-report on a five-point Likert-scale, anchored at 1, 'never', and five, 'all the time'. Midpoint of the scale, 3, indicated 'occasionally'.

*5.2.3.3 Subjective arousal and valence*

Participant subjective levels of arousal and valence during each experimental condition were assessed using the Self-Assessment Manikin (SAM; Lang, 1980b). The SAM is a non-verbal pictorial assessment technique that directly measures the pleasure and arousal associated with a person's affective reaction to a wide variety of stimuli (see figure 4.1 in Chapter 4). The SAM was chosen to measure valence and arousal as it is a method that has been demonstrated as an easy to administer, non-verbal method for quickly assessing the arousal and pleasure associated with an individual's reaction to an event or stimuli. SAM scores measuring experience of arousal are highly correlated with scores obtained using the verbal and lengthier semantic differential scale (Bradly & Lang, 1994). They have also been used to measure emotional responses to a wide range of stimuli, including both pictures (e.g., Lang et al., 1993) and sounds (e.g., Bradly, 1994), as well as administered successfully among a range of clinical populations, as well as children and non-English speakers (Bradley & Lang, 1994). Full body versions of the SAMs were used for both the valence and arousal scale (portrait-only versions are available for the valence scale), and both scales were presented in their nine-point scale versions (see figure 4.1 in Chapter 4).

*5.2.3.4 Perceived self-control*

Participants' perceived level of self-control was assessed using a single-item nine-point Likert scale questionnaire. Perceived self-control was assessed to ascertain to what extent participants felt they were exercising self-control during the various gambling conditions. Participants were asked, 'To what extent do you feel you were in control of your actions during the last gambling session?' Responses were anchored at 1, 'no self-control', and 9,'maximum self-control'. The midpoint of the scale, 5, indicated 'moderate levels of self-control'. Perceived self-control was assessed using this separate question as opposed to the dominance SAM discussed in Chapter 4. This was due to concerns that scores on this item could vary greatly because of subjective interpretation of the dominance item. For example, participants could interpret dominance as their perceived performance during gambling in terms of money won/lost, as opposed to the item's intention of measuring control over the situation. Furthermore, the present study was concerned with how actual levels of motor control compared to perceived levels of motor control, and therefore, it was deemed more accurate to use an item that was explicitly clear which component of self-control participants should rate.

*5.2.4 Procedure*

Each participant gambled on a three-reeled electronic slot machine simulator in five conditions: Fast; Moderate; and Slow slot machine event frequencies (1.5s, 3s, and 4.5s event frequencies respectively); Moderate event frequency with a brief pause in play (fast spin of 1.5s plus 1.5s pause in play, totalling 3s event frequency); and Slow event frequency with brief pause in play (fast spin of 1.5s plus 3s pause in play, totalling 4.5s event frequency). The purpose of providing a brief pause in play following the spinning of the reels is in line with aim three of this study, to investigate if brief pauses in play allow a gambler to adaptively modulate their behaviour. It is hypothesised that providing a short pause following presentation of a gambling result will provide a refractory period to allow executive control systems to catch-up with actions that may be automatically stimulated by the provision of a new gambling event. Participants were provided with £20 to gamble with and were told that any money they had left at the end of the gambling session could be kept. The £20 was converted into 500 credits, and the credits were split equally among each of the five experimental conditions, meaning each participant had a starting credit total of 100 (£4) in each condition. The order of the gambling conditions was counterbalanced using a Latin Squares method (see Appendix C), and participants were given a five-minute break in between each gambling condition.

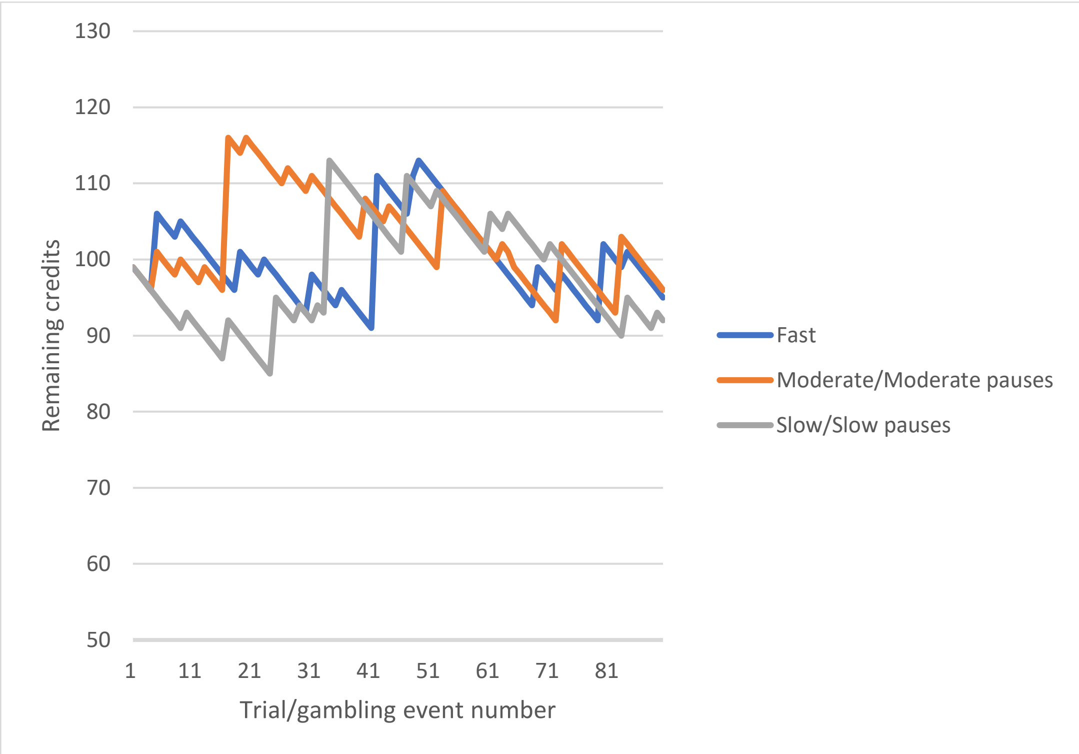


***Figure 5.2.*** Series of wins and losses for each of the slot machine speed of play conditions. The moderate speed with pauses machine and slow speed with pauses machine had the same outcome series as the moderate and slow speed machines respectively but varied in the visual symbols presented on the reels on non-win trials. Participants start with 100 credits in each condition.

Participants were given a tutorial in how to operate the slot machine and were informed of what each of the visual display features were, including the pay-line, credit balance, and win totals on winning spins (see Figure 5.3). A pay-out structure was also shown to participants during the tutorial, showing how much money could be won for specific matching symbols (see Figure 5.4). Participants were instructed to only operate the machine by pressing the spin button (space bar on standard computer keyboard) when the spin button on the visual display was green in colour, and instructed they must withhold from pressing the spin button when it was red in colour. The slot machine was programmed to spin automatically on no-go trials after a delay equivalent to one event frequency which was dependent on the speed of the slot machine. The first 30 trials of each slot machine condition were all go trials, allowing potential response prepotency to develop, and the remaining 60 trials consisted of a 4:1 ratio of go to no-go trials.

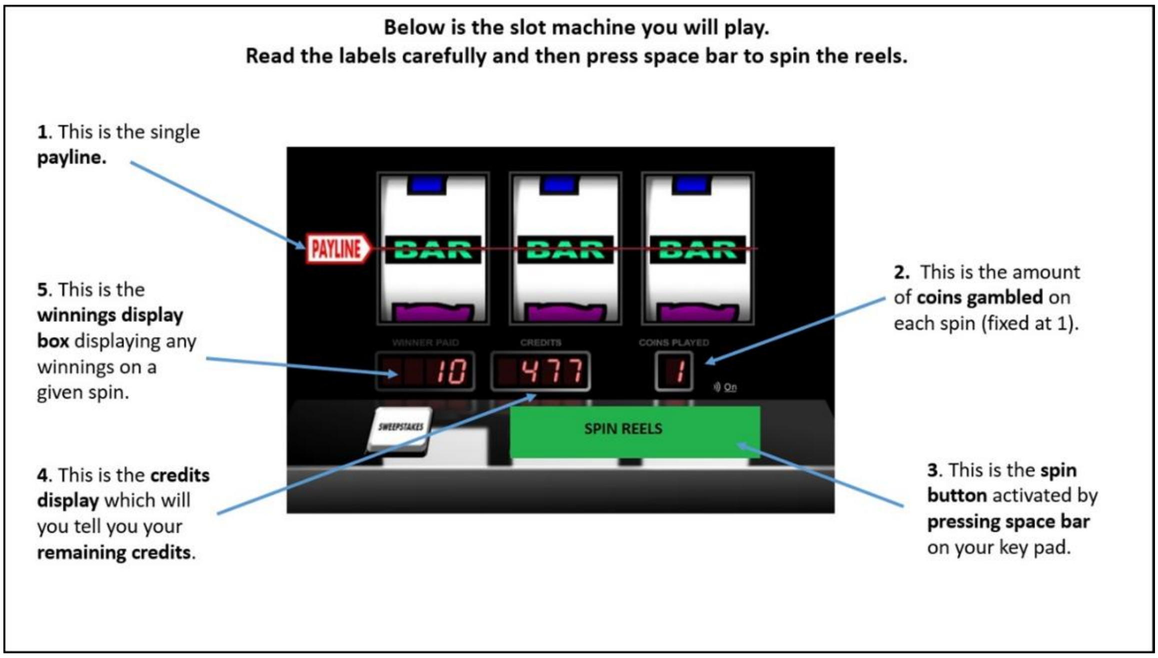


***Figure 5.3.*** Slot machine instructions presented to participants during the tutorial prior to the gambling simulation.


***Figure 5.4.*** Slot machine pay-out structure presented to participants during the tutorial prior to the gambling simulation.

Following each gambling condition, participants were instructed to complete the arousal and valence SAM, the single-item self-control questionnaire, and the four-item dissociative experience scale in that order. All scales were completed electronically immediately following the gambling simulation in each condition.

### *5.3 Ethics*

Before commencement of the study, the study was approved by the researcher's University Ethics Committee. The study protocol was designed in accordance with guidelines of the Declaration of Helsinki. Participants were fully briefed and instructed on how to complete all tasks prior to the beginning of the experiment and provided their informed consent to take part in the study. Participants were informed that all the data were confidential and anonymous.

### *5.4 Results*

#### *5.4.1 Response inhibition performance*

The value for the dependent variable response inhibition performance was derived by calculating the percentage for which gamblers were able to successfully withhold motor responses on no-go slot machine trials. Successfully withholding motor response on all 12 no-go trials will therefore return a response inhibition performance score of 100%.

Mean response inhibition performance in the fast speed condition (1.5s event frequency) was 65.8% (SD=18.54), 75.50% (SD=14.03) in the moderate speed condition (3s event frequency), and 86.67% (SD=16.84) in the slow speed condition (4.5s event frequency), indicating a trend towards increased impulsivity as speed of play increases. Mean response inhibition performance in the moderate speed condition with a brief pause in play was 80.50% (SD= 14.35), a 5% increase compared to the moderate speed condition with no pause in play. Performance in the slow speed condition with a brief pause in play was 74.50% (SD=16.01), a 12% reduction compared to the slow speed condition with no pause in play. All response inhibition performance means and standard deviations can be found in Table 5.1 and are presented in Figure 5.5 below.

A one-way repeated-measures ANOVA showed the differences in means was statistically significant, $F(4,245)=11.57$, $p<.001$, $\eta^2=.159$. Bonferroni pairwise comparisons indicated that performance in the fast condition was statistically significantly worse when compared to the moderate speed ($p<.001$, $d=.59$), moderate speed with pauses ($p<.001$, $d=.88$) and slow speed conditions ($p<.001$, $d=1.18$). Performance in the moderate speed condition was also significantly worse than performance in the slow speed condition ($p=.003$, $d=.72$).

The Bonferroni pairwise comparisons also showed a non-significant difference between response inhibition performance at moderate speeds of play when compared to performance at moderate speeds with a brief pause in play ($p=.99$, $d=.35$). Conversely, pair-wise comparisons showed a significant difference between performance at slow speeds of play compared to performance at slow speeds of play with brief pauses in play ($p<.001$, $d=.74$). However, results indicate that performance was impaired with the inclusion of the pauses at slow speeds of play.

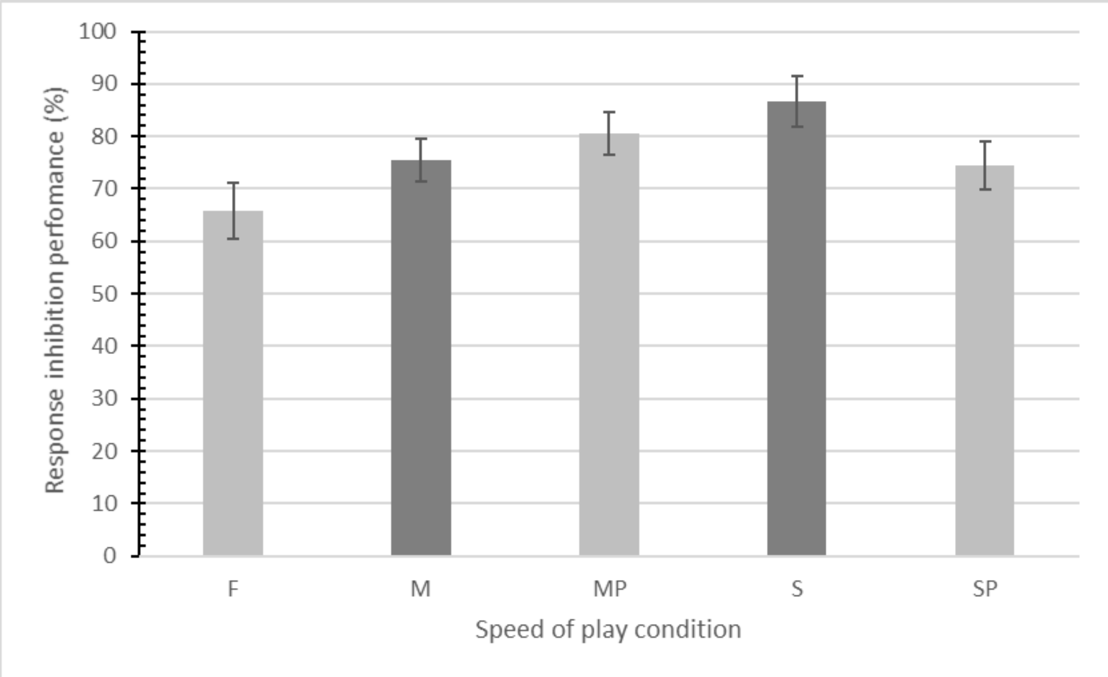


***Figure 5.5.*** Mean percentage of successfully inhibited motor responses in the fast (F), moderate (M), moderate with pauses (MP), slow (S), and slow with pauses (SP) speed of play conditions. Error bars represent 95% confidence intervals.

### *5.4.2 Overall reaction time*

Mean reaction time values were derived from measuring the average time between the start of the opportunity to gamble on a gambling trial and participants pressing the spin button on the slot machine simulator, measured in seconds. Mean reaction time for the fast speed of play condition was .61s (SD=.23), .72s (SD=.21) for the moderate speed condition, and .84s (SD=.18) for the slow speed condition, indicating a trend towards faster response times as speed of play increases. Mean reaction time for the moderate speed with brief pauses in play condition was .74s (SD=.19), indicating a marginal slowing of reaction time when compared to moderate speeds of play with no pause in play. Mean reaction time for the slow speed condition with brief pauses in play was .69s (SD=.19), indicating an approximate 17% decreases in reaction time when compared to slow speeds of play without pauses in play. All reaction times and standard deviations can be found in Table 5.1.

A one-way repeated-measures ANOVA showed the difference between mean reaction times across conditions was statistically significant, $F(4,196)=9.82$, $p<.001$, $\eta^2=.138$. Bonferroni pairwise comparisons showed that reaction time in the fast speed condition was significantly faster compared to the moderate speed ($p<.001$, $d=.58$) and slow speed condition ($p<.001$, $d=1.35$), and significantly faster in the moderate speed condition compared to the slow speed condition ($p=.001$, $d=.63$)

The Bonferroni pairwise comparisons also showed that the mean reaction times in the moderate speed condition did not differ to a statistically significant level when compared to the moderate speed with pauses in play condition (p=.99, *d*=.10). However, pairwise comparisons did reveal that mean reaction time in the slow speed condition was statistically significantly slower when compared to the slow speed with pauses in play condition (p=.02, *d*=.83), counterintuitively indicating faster reaction times where recorded as a result of providing pauses in play.

*5.4.3 Dissociation*

Overall dissociation scores for each participant were derived by summing the scores for each of the five-items on the dissociation scale. As ratings on each item could be made on a 1-5 scoring system, the minimum and maximum overall dissociation score was 5 and 25 respectively. Mean dissociation scores for the fast speed of play condition were 6.48 (SD=1.34), 7.04 (SD=1.52) for the moderate speed condition, and 9.76 (SD=2.92) for the slow speed condition, indicating a trend towards lower levels of dissociation as speed of play increases. Of note, dissociation scores overall across conditions were low, as even in the slow speed condition where dissociation was highest, mean scores here were only approximately equivalent to a rating of 'rarely' for all items. The mean dissociation score in the moderate speed with pauses in play condition was 7.14 (SD=1.85), a negligible increase when compared to moderate speeds without pauses in play. The mean dissociation score for the slow speed with pauses in play condition was 8.10 (SD= 2.55), a 17% decrease when compared to slow speeds without pauses in play. All dissociation scores and standard deviation can be found in Table 5.1.

A one-way repeated-measures ANOVA showed the differences in mean dissociation scores across conditions was statistically significant, $F(4,196)=18.32$, $p<.001$, $\eta^2=.23$. Bonferroni pairwise comparisons showed that dissociation levels in the fast speed condition were significantly lower when compared to the moderate ($p<.001$, $d=.39$) and slow speed condition ($p<.001$, $d=1.44$), and significantly lower in the moderate speed condition compared to the slow speed condition ($p<.001$, $d=1.17$).

Pairwise comparisons also showed that dissociation scores in the moderate speed with pauses in play condition did not differ to a statistically significant level when compared to moderate speeds without pauses in play ($p=.99$, $d=.06$). However, dissociation scores in the slow speed with pauses in play condition were lower to a statistically significant level when compared to slow speeds without pauses in play ($p=.001$, $d=.61$). These results indicate that brief pauses in play reduced dissociation levels, but only at slow game speeds.

*5.4.4 Arousal*

Mean arousal score, rated on a single-item scale ranging from 1-9, for the fast speed of play condition was 6.66 (SD=1.39), 5.56 (SD=1.33) for the moderate speed condition, and 3.64 (SD=1.05) for the slow speed condition, indicating a trend towards increased levels of arousal as speed of play increases. Mean arousal score for the moderate speed of play with pauses in play condition was 4.92 (SD=1.18), an approximate 12% decrease when compared to moderate speeds without pauses in play. Mean arousal score in the slow speed with pauses in play condition was 5.36 (1.76), a 47% increase when compared to slow speeds without pauses in play. All mean arousal scores and standard deviations can be found in Table 5.1.

A one-way repeated-measures ANOVA showed the differences in mean arousal scores across conditions reached statistical significance, F(4,196)=51.09, $p$<.001, $\eta^2$ =.35. Bonferroni pairwise comparisons showed that arousal scores in the fast speed condition were statistically significantly higher when compared to the moderate (p<.001, $d$=.81) and slow speed condition ($p$<.001, $d$=2.45), and significantly higher at moderate speeds compared to slow speeds ($p$<.001, $d$=1.60).

Pairwise comparisons also showed that mean arousal score was statistically significantly lower in the moderate speed with pauses in play condition compared to the moderate speed without pauses in play condition ($p$=.004, $d$=.51). However, conversely, arousal levels were statistically significantly higher in the slow speed with pauses in play condition compared to slow speed without pauses in play condition ($p$<.001, $d$=1.19). Taken together these findings suggest the impact of brief pauses in play on subjective arousal interact with speed of play, as the directional change in arousal as a result of pauses in play is dependent on game speed.

*5.4.5 Valence*

Mean valence score, rated on a single-item scale ranging from 1-9, for the fast speed of play condition was 5.66 (SD=1.19), 4.46 (SD=1.18) for the moderate speed condition, and 3.38 (SD=1.12) for the slow speed condition, indicating a trend towards increased positive valence as speed of play increases. Mean valence score for the moderate speed with pauses in play condition was 4.26 (SD=1.17), an approximate 4% decrease when compared to valence ratings for moderate speeds without pauses in play. Mean valence score for the slow speed with pauses in play condition was 2.76 (SD=1.08), an approximate 18% reduction when compared to slow speeds without pauses in play. All mean valence scores and standard deviations can be found in Table 5.1.

A one-way repeated-measure ANOVA showed the difference in mean valence scores reached statistical significance, F(4,196)=86.04, $p$<.001, $\eta^2$ =.43. Bonferroni pairwise comparisons showed that mean valence score in the fast speed condition was statistically significantly higher compared to the moderate speed ($p<.001$, $d=1.01$) and slow speed condition ($p<.001$, $d=1.97$), and significantly higher at moderate speeds compared to slow speeds ($p<.001$, $d=.94$).

Pairwise comparisons also showed that mean valence score in the moderate speed with pauses in play condition did not differ statistically significantly from mean valence score in the moderate speed without pauses in play condition ($p=.96$, $d=.17$). However, mean valence score was statistically significantly lower in the slow speed with pauses in play condition compared to the slow speed without pauses in play condition ($p<.001$, $d=.56$), indicating that pauses in play only significantly reduce valence ratings when applied at slow speeds of play.

*5.4.6 Perceived self-control*

During statistical assumptions testing, one extreme outlier was found in every speed of play condition for the perceived self-control variable. Upon closer inspection of these outliers, it was found that the same participant provided all of these data points and thus, their data for the self-control variable was removed from further analysis. Mean perceived self-control score, rated on a single-item scale ranging from 1-9, for the fast speed of play condition was 6.78 (SD=.89), 6.82 (SD=1.10) for the moderate speed condition, and 6.96 (SD=1.12) for the slow speed condition, indicating a negligible change in perceived self-control ratings as a result of speed of play. Mean self-control score for the moderate speed with pauses in play condition was 6.86 (SD=1.13), a negligible increase when compared to moderate speeds without pauses in play. Mean self-control score for the slow speed with pauses in play condition was 6.58 (SD=1.31), an approximate 5% decrease when compared to self-control ratings for the slow speed without pauses in play condition. All mean perceived self-control scores and standard deviations can be found in Table 5.1. A one-way repeated-measures ANOVA showed the difference in mean perceived self-control scores across conditions failed to reach statistical significance, $F(4,195)=2.23$, $p=.086$, $\eta^2=.01$.

**Table 5.1.** *Mean (SD) dependent variable scores and ANOVA p-values across speed of play conditions.*

| Speed condition | Dependent variable | | | | | |
|---|---|---|---|---|---|---|
| | Response Inhibition (%) | Reaction Time (s) | Dissociation total (5-25) | Arousal (1-9) | Valence (1-9) | Perceived self-control (1-9) |
| Fast | **65.80** *(18.54)* | **.61** *(.23)* | **6.48** *(1.34)* | **6.66** *(1.39)* | **5.66** *(1.19)* | **6.78** *(.89)* |
| Moderate | **75.50** *(14.03)* | **.72** *(.21)* | **7.04** *(1.52)* | **5.56** *(1.33)* | **4.46** *(1.18)* | **6.82** *(1.10)* |
| Moderate with pauses | **80.50** *(14.35)* | **.74** *(.19)* | **7.14** *(1.85)* | **4.92** *(1.18)* | **4.26** *(1.17)* | **6.86** *(1.13)* |
| Slow | **86.67** *(16.84)* | **.84** *(.18)* | **9.76** *(2.92)* | **3.64** *(1.05)* | **3.38** *(1.12)* | **6.96** *(1.12)* |
| Slow with pauses | **74.50** *(16.01)* | **.69** *(.19)* | **8.10** *(2.55)* | **5.36** (*1.76)* | **2.76** *(1.08)* | **6.58** *(1.31)* |
| ANOVA p-value | <.001 | <.001 | <.001 | <.001 | <.001 | =.086 |

### *5.4.7 Response modulation*

To assess if participants were able to modify their behaviour in order to facilitate response inhibition performance (proactive inhibition), participant reaction time was measured during the 'training' phase of each condition, that is, the first 30 trials in each condition in which only go trials are presented, and compared to participant mean reaction times from the onset of the first no-go trial to the end of each condition. A statistically significant slowing of reaction time is thus interpreted as adaptive behavioural modulation, as it represents proactive effort to avoid commission errors on the embedded go/no-go task.

Paired-sample *t*-tests showed evidence for this behavioural modulation at moderate speeds, slow speeds, and moderate speeds with pauses in play, but was not demonstrated at fast speeds or slow speeds with pauses in play. In the fast condition, mean reaction time for the first 30 trials was .58s (SD=.16) compared to a mean reaction time of .62s (SD=.20) from the onset of the first No Go trial, a slowing of reaction time that just failed to reach statistical significance, $t(49)=1.98$, $p=.054$, $d=.22$. In the moderate speed condition, mean reaction time for the first 30 trials was .65s (SD=.15) compared to .75s (SD=.24) from the onset of the first no-go trial, a slowing of reaction time that reached statistical significance, $t(49)=4.23$, $p<.001$, $d=.49$. In the moderate speed with pauses in play condition, mean reaction time for the first 30 trials was .66s (SD=.17) compared to .78s (SD=.23) from the onset of the first no-go trial, a slowing of reaction time that reached statistical significance, $t(49)=5.42$, $p<.001$, $d=.59$. In the slow speed condition, mean reaction time for the first 30 trials was .74s (SD=.19) compared to .89s (SD=.22) from the onset of the first No Go trial, a slowing of reaction time that reached statistical significance, $t(49)=6.03$, $p<.001$, $d=.73$. Finally, in the slow speed with pauses in play condition, mean reaction time for the first 30 trials was .66s (SD=.18) compared to .71s (SD=.18) from the onset of the first no-go trial, a slowing of reaction time that failed to reach statistical significance, $t(49)=1.89$, $p=.065$, $d=.28$. The evidence therefore suggests that at fast speeds of play, gamblers are impaired in their ability to modulate behaviour adaptively. Table 5.2 and Figure 5.6 summarises the response modulation findings.

The average slowing of reaction time upon the onset of no-go trials was .10s (SD=.13) in the moderate speed without pauses in play condition, and .12s (SD=.10) in the moderate speed with pauses condition. While these means suggest a greater proportion of behavioural modulation took place with the inclusion of brief pauses in play, a paired-sample t-test showed this difference in means failed to reach statistical significance, $t(49)=.236$, $p=.815$, $d=.17$, indicating the pauses in play had no additional advantage to response modulation at moderate speeds of play.

**Table 5.2.** *Mean (SD) participant response times to gambling stimuli for the first 30 trials compared to response times to gambling stimuli from the onset of the first no-go trial to the end of the condition.*

| Speed condition | Mean reaction times (RT) | | |
|---|---|---|---|
| | Mean RT for first 30 trials (s) | Mean RT from onset of first no-go trial (s) | t-test p-value |
| Fast | **.58** *(.16)* | **.62** *(.20)* | =.054 |
| Moderate | **.65** *(.15)* | **.75** *(.24)* | <.001 |
| Moderate with pauses | **.66** *(.17)* | **.78** *(.23)* | <.001 |
| Slow | **.74** *(.19)* | **.89** *(.22)* | <.001 |
| Slow with pauses | **.66** *(.18)* | **.71** *(.18)* | =.065 |

Note: Whilst adaptive response modulation was found in both the moderate speed and moderate speed with pauses conditions, additional analysis showed there was no statistically significant degree of response slowing between these two conditions, indicating no additional benefits stemming from the inclusion of pauses in play.

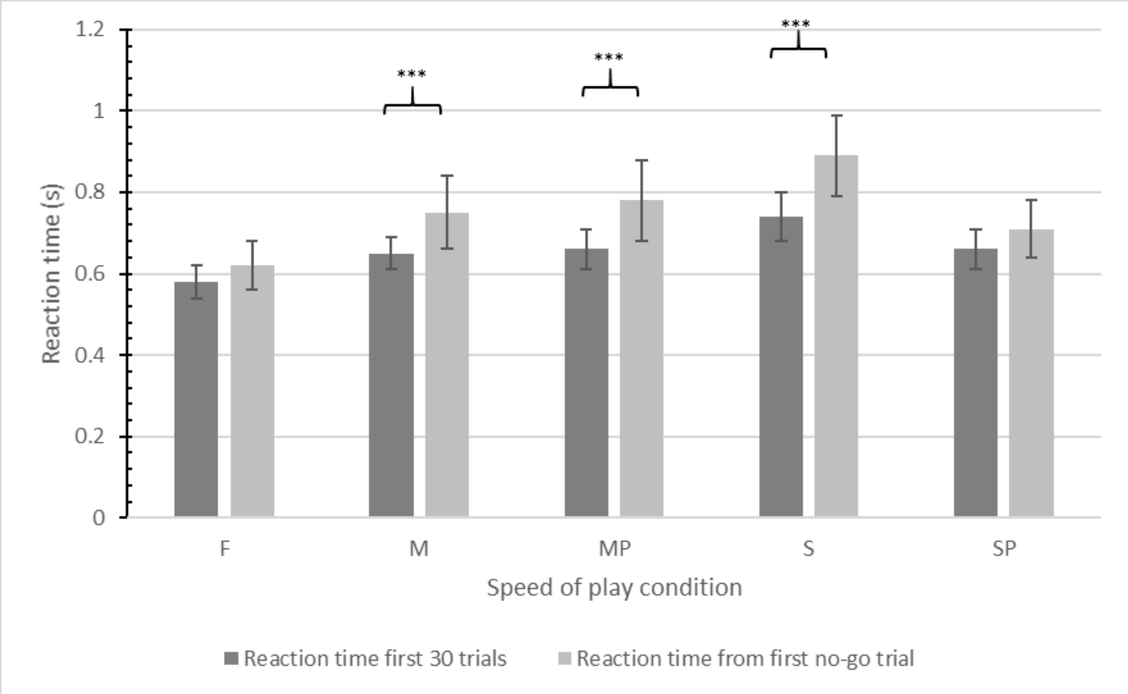


***Figure 5.6.*** Mean reaction time in seconds (s) for first 30 trials and from the onset of the first no-go trial. Error bars depict 95% confidence intervals. ***p<.001.

*5.4.8 Regression findings*

To investigate the psychological factors that predict impaired response inhibition performance, a series of multiple regression analysis were conducted. Multiple regression analysis was conducted on each speed of play condition separately, given both the theoretical rationale and empirical analysis conducted thus far, both of which provide a sound premise for an interaction effect between different speeds of play and the factors which impair response inhibition performance. This approach runs contrary to collapsing all data into a single condition to provide a single model of the factors that predict response inhibition performance, as this overlooks all interaction effects and ignores the differential psychological factors that different speeds of play impact. For all conditions, the variables arousal, dissociation, valence, and reaction time were entered into the regression model as predictor variables using the entry method, and response inhibition performance was the outcome variable.

In the fast speed of play condition, arousal and reaction time were variables predictive of response inhibition performance. The results of the regression indicated that arousal and reaction time accounted for 40.1% of the variance explained by the model ($R^2_{adjusted}$=.401, $F(1,49)$=19.48, $p$<.001). Arousal was a significant negative predictor of response inhibition performance in the fast speed condition (β= -.558, $p$<.001) and reaction time was a significant positive predictor (β=257, $p$=.023).

At a moderate speed of play, arousal and dissociation were both found to be predictors of response inhibition performance. The results of the regression indicated that the two predictors, arousal and dissociation, accounted for 39.5% of the variance explained by the model ($R^2_{adjuested}$=.395, $F(1,49)$ =16.99, $p$<.001). Arousal level was a significant negative predictor of response inhibition performance in the moderate speed condition (β= - .427, $p$<.001), as was levels of dissociation (β = -.348, $p$=.033).

At a moderate speed of play with the inclusion of brief pauses in play, arousal and reaction time were both found to be predictors of response inhibition performance. The results of the regression indicated that the two predictors, arousal and reaction time, accounted for 43.9% of the variance explained by the model ($R^2_{adjusted}$=.439, $F(1,49)$=20.15, $p$<.001). Arousal was found to be a significant negative predictor of response inhibition performance at moderate speeds with pauses in play (β= -.574, $p$<.001), whereas reaction time was found to be a significant positive predictor of response inhibition performance (β=.263, $p$=.02).

At a slow speed of play, level of dissociation was found to be a predictor of response inhibition performance. The results of the regression indicated that dissociation accounted for 39.7% of the variance explained by the model ($R^2_{adjusted}$=.397, $F(1,49)$=18.88, $p$<.001). Levels of dissociation was found to be a significant negative predictor of response inhibition performance at slow speeds of play (β=-.568, $p$<.001).

At a slow speed of play with the inclusion of brief pauses in play, arousal and dissociation were both found to be predictors of response inhibition performance. The results of the regression indicated that the two predictors, arousal and dissociation, accounted for 36.8% of the variance explained by the model ($R^2_{adjusted}$=.368, $F(1,49)$=15.26, $p$<.001). Arousal was found to be a significant negative predictor of response inhibition performance at slow speeds with pauses in play (β=-.509, $p$<.001), as was levels of dissociation (β=-.445, $p$<.001).

### *5.5 Discussion*

In support of H1, Experiment 1 found empirical evidence demonstrating that response inhibition performance in a sample of regular non-problem gamblers was statistically significantly impaired at faster gambling speeds of play. The percentage of successfully withheld motor responses during the slot machine gambling simulation fell to 65.80% at fast speeds of play, compared to 75.50% at moderate speeds, and 86.67% at slow speeds. Subjective levels of arousal were also significantly increased at fast speeds of play, supporting H2 and the notion that games with higher event frequencies are more arousing for gamblers. Furthermore, in partial support of H3, subjective levels of arousal were found to be a significant and negative predictor of response inhibition performance at fast speeds of play, as well as moderate speeds of play. However, at the slowest speed of play, arousal was no longer a significant predictor of response inhibition performance, where the level of dissociation was the dominant predictive factor. This provides insight into how the psychological factors that predict response inhibition performance during gambling interact with game speed and suggests two routes to impaired response inhibition within a gambling context, an arousal route and a dissociation route. Finally, there was no support for H4, because brief pauses in play did not facilitate response inhibition performance and there was no evidence for brief pauses in play enhancing response modulation through proactive motor control. To the contrary, perverse effects were found when including pauses in play at slow speeds. At slow speeds, the inclusion of brief pauses in play had a significant and negative impact on response inhibition performance, where on average, a 12% reduction in response inhibition performance was found when compared to slow speeds without pauses in play.

*5.5.1 Valence*

Valence ratings indicate that as the speed of play increased the enjoyment of the game also increased, consistent with the general findings from the speed of play review conducted in Chapter 2 (see also, Harris & Griffiths, 2017). Valence ratings also showed that brief pauses in play at a moderate speed of play did not detract from the enjoyment of the game when compared to moderate speeds without pauses, although this finding appears to be in vein, as pauses were not effective in facilitating response inhibition. However, the inclusion of pauses in play at slow speeds of play significantly reduced enjoyment of the game when compared to slow speeds without pauses. This, along with the finding that response inhibition was impaired and arousal was increased at slow speeds with pauses compared to slow speeds without pauses, may suggest a frustration effect and that participants may have become inpatient due to the increased time delay between completion of the reel spin and the next gambling event. This is consistent with previous research demonstrating a link between imposed breaks in play and gambling cravings, an effect that was mediated by subjective negative arousal (Blaszczynski et al., 2015). Although the imposed breaks in play in Blaszczynski et al.'s (2015) research equated to one several minutes long break, compared to several pauses of only a few seconds in the present experiment, it may be argued that placing a barrier between a gambler and gambling, in this case in the form of pauses in play, may give rise to an aversive state that is detrimental to self-control. Such a finding is consistent with the conceptual model of behavioural completion proposed by McConaghy (1980) and Tiffany (1990), that states imposing barriers on gamblers in an approach state will result in negative affective states and increased urges to gamble. These increased urges may give rise to approach behaviours and impulsive action in pursuit of gambling and may explain the reduced inhibition performance demonstrated at slow speeds with pauses in play compared to slow speeds without pauses.

### *5.5.2 Perceived self-control*

Perceived self-control ratings were consistently high across all conditions and did not differ to a statistically significant degree between conditions. These subjective self-control findings contradict the objective results obtained from the behavioural response inhibition task. The behavioural results show a clear reduction in response inhibition performance as speed of play increases, and yet the participants did not fluctuate in their perceived levels of self-control. Two explanations for this disparity in results are offered. First, it possible that the reduction in inhibitory control observed at fast speeds of play occurred sub-consciously due to high levels of engagement with the gambling simulation. An alternative explanation might be that what a gambler views as self-control does not constitute the ability to withhold motor responses and may consist of behavioural markers that are more superficial, such as time and money spent gambling, factors controlled for in this experiment. Both of these explanations point to a lack of awareness of the role of response inhibition in self-control, either because the effect of speed of play on motor control is happening sub-consciously, or due to the gambler's lack of awareness of the important role of response inhibition in self-control. Changing the nature of the question given to the participants designed to measure perceived self-control may be able to shed further light on this. For example, participants could be asked more simply to state how well they think they did on the response inhibition task, and then compare this to actual performance to test the conscious or subconscious theories proposed here.

The two arguments represent an important distinction with different implications for gambling harm minimisation approaches. If increased speeds of play result in sub-conscious response inhibition deficits, then it might be fruitful for harm minimisation approaches, such as pop-up responsible gambling messaging, to draw attention to indicators of reduced inhibition performance, including rapid response styles and failure to withhold motor responses. This could also take the form of motor feedback, whereby machines could provide an aversive audio tone if the gamble/spin buttons are being pre-emptively pressed before an appropriate event frequency duration. If the issue is a lack of appreciation by gamblers of the role of response inhibition in self-control, then effort might be best placed with educational approaches that highlight the link between poor response inhibition and disordered gambling.

### *5.5.3 Reaction time*

Unlike typical response inhibition tasks, participants in this experiment were not instructed to respond as fast and accurately as possible to allow participants to behave more naturally. Despite this, the time from the onset of a new gambling event to the participant executing a motor response to gamble was under one second in all conditions, suggesting slot machine gambling in general is associated with fast motor response speeds. Reaction time differed to a significant degree across speed of play conditions, with a trend towards faster reaction times as the speed of the game increased. One possible explanation for this finding is that behavioural synchronisation was occurring in response to the speed of the game. This phenomenon may be likened to examples outside of a gambling context where behaviour can be synchronised with environmental cues (Codrons, Bernardi, Vandoni, & Bernardi, 2014). A prominent example is that people are seen to walk faster in urban environments when exposed to higher tempo music (Franek, van Noorden, & Rezny, 2014). The structural gambling feature of speed therefore appears to have the ability to influence behaviour in similar way, which is problematic given than faster motor reaction times were predictive of poor response inhibition performance in the present experiment.

*5.5.4 Response modulation*

One adaptive and proactive strategy to avoid erroneous responses on no-go trials would be to modulate responses in favour of slower overall response speeds upon the onset of no-go trials. This would provide increased time to process go/no-go cues and increase the likelihood of correct responses being executed. Evidence for this adaptive response modulation was found in the moderate speed, moderate speed with pauses, and slow speed conditions, where overall participant reaction times increased (slowed) upon the onset of no-go trials. However, this was not demonstrated in the fast speed or slow speed with pauses conditions, where reaction times did not change between the training phases and remaining 60 trials containing no-go cues. This arguably represents reduced or impaired supervision by the executive system (see e.g., Verbruggen et al., 2012) in these gambling conditions. Of note, arousal was highest in these two conditions, which supports the link between arousal and response modulation found in previous studies that have also suggested that arousal has a detrimental impact on proactive motor control (Berkman, Kahn, & Merchant, 2014; Verbruggen & Houwer, 2007). This suggests a potential causal pathway in the relationship between gambling speed and lack of proactive motor control.

*5.5.5 Arousal, dissociation, and reaction time as predictors of response inhibition*

The finding that a gambler's level of arousal was a significant and negative predictor of response inhibition performance is consistent with previous research outside of gambling that demonstrates increases in arousal result in poorer inhibition performance (e.g., Nieuwenhuis & Kleijn, 2013).

Although reaction time within the fast speed condition was also significant predictor of response inhibition, arousal was the by far the dominant predictor of response inhibition performance at fast speeds of play. Subsequent analysis for mediation regression using the four steps approach proposed by Baron and Kenny (1986) showed that the effect of these two predictors were independent, because there was a lack of evidence to suggest that reaction time mediated the effect of arousal on response inhibition (see Appendix D). This is contrary to theoretical and empirical accounts stating that increased arousal leads to a state of readiness to respond, where increased arousal lowers respond thresholds and biases go and stop processes in favour of executing an action (see e.g., Logan & Cowan, 1984; Nieuwenhuis & Kleijn, 2013; Posner, 1978; Posner & Peterson, 1990).

Counterintuitively, poorer response inhibition performance is typically associated with *slower* reaction times in problem and pathological gambling groups, explained as a problem of response conflict resolution and disorganised stimulus-response schematics amongst these clinical groups (Kertzman et al., 2011; Odlaug et al., 2011; van Holst et al., 2010). This highlights that there may be qualitative differences between disordered gambling groups and healthy regular gamblers, particularly given the finding here that in fact *faster* reaction times were predictive of poorer inhibition performance. However, it is less clear whether these differences represent a progression in the symptomology of disordered gambling, or whether predispositional and/or comorbidity factors account for the differences seen in problem gamblers in response inhibition tasks. The evidence here suggests that for regular non-problem gamblers, faster gambling speeds of play lead to elevated levels of arousal which in turn leads to impulsive response styles detrimental to executive control, but this process appears independent of faster reaction times. Therefore, results here may be supportive of more recent theoretical explanations of the effect of arousal on response inhibition. Verbruggen and colleagues (2014) for example, propose that perceptual processing, which is susceptible to the effects of arousal, may represent a single underlying process that plays a key role in behavioural inhibition.

Whilst this view would predict inhibition performance can be enhanced by increased arousal if this is also met with task-relevant information being made salient, facilitating processing of essential information, it also conversely predicts that if increases in arousal are accompanied with distracting information, then arousal may impair inhibition performance. If the act of gambling is considered the primary task in this simulation, then the increased arousal may have led to increased processing of gambling stimuli at the expense of efficient processing of go and no-go cues, resulting in poorer inhibition performance. In this account, gamblers may be inefficiently processing no-go cues, as arousal increases their allocated attention towards gambling stimuli in the visual field.

As the speed of play decreased, the relative predictive strength of arousal in response inhibition performance decreased. At moderate speeds, whilst arousal remained a predictor of response inhibition performance, overall levels of dissociation also became a significant and negative predictor. At slow speeds, arousal was no longer a significant predictor, and yet the predictive strength of dissociation on response inhibition performance increased. This demonstrates an interaction effect between speed of play and the psychological variables predictive of response inhibition performance. However, an alternative explanation is that the dissociation predictive of response inhibition at slower speeds of play may not be a product of the speed of the game but a result of the increased time spent gambling during this condition. The number of gambling trials were controlled across all condition, but as event frequency was experimentally manipulated, this naturally led to changes in the time spent gambling across conditions. As event frequency was three times slower in the slow condition compared to the fast condition, the gambling session was approximately three times longer at slow speeds of play, providing more opportunity for dissociative experience to develop. To test this time-based rather than speed-based dissociation explanation, further experimental research would be required, controlling for gambling session duration whilst simultaneously manipulating speed of play.

At fast speeds, arousal may be maladaptive in adjusting the perceptual processing of go and no-go cues, whereas slower speeds give rise to increases in dissociative experience predictive of poorer response inhibition performance. As dissociative experiences within a gambling context have been described as a reduced state of awareness or a period of ‘zoning out’ (Allcock et al., 2006), it is argued that attentional mechanisms may again drive this effect found here. A reduced attentional awareness of no-go cues could account for the predictive value of dissociation in response inhibition performance found in moderate and slower game speeds. Perceptual processing may therefore be affected by separate processes. The arousal account found at fast speeds of play may explain reduced inhibition performance via enhanced processing of gambling stimuli and reduced attention towards no-go cues. Dissociation can account for this impaired perceptual processing explanation via an overall reduced level of awareness during the gambling simulation, which also includes impaired processing of go and no-go cues.

If adjusted perceptual processing represents an underlying causal mechanism between arousal/dissociation and response inhibition, then it may be useful to conceptualise these distinctive processes as representing a state of maladaptive ‘zoning in’ and ‘zoning out’. In this instance, increased arousal resulting from fast speeds of play predicts poorer response inhibition as attention is focused on gambling at the expense of other important environmental cues, such as the no-go cues in this simulation. Conversely, the increased dissociation experienced at slower speeds of play results in an overall reduced amount of conscious perceptual processing of stimuli in the visual field, including reduced ability to process the no-go cues and therefore withhold motor responses. However, this would suggest a dissociative relationship between arousal and levels of dissociation. Problematic for this position are theoretical accounts describing dissociation as an epiphenomenon of increased levels of arousal (Allcock et al., 2006). It may be the case that high arousal is a precursor for dissociative experience at the pathological level, such as those experienced in dissociative identity disorder (Ross, 1997) or pathological gambling (Diskin & Hodgins, 1999), but is not necessary for general and sub-clinical dissociative experiences to occur within a gambling context.

Follow-up research utilising eye-tracking techniques may represent a fruitful way to investigate the potential link between perceptual processing and response inhibition performance offered here. Although this is type of research is beyond the scope of the present thesis, it would be predicted that gambling stimuli would be attended to above and beyond go and no-go cues when gamblers are highly aroused, and that reduced attentional processing of no-go cues would be predictive of poorer response inhibition performance.

### *5.5.6 Caveats*

#### *5.5.6.1 Slot machine simulator*

The general limitations of the experimental approach to gambling research have already been discussed in Chapter 4. Whilst attempts were made to make the slot machine simulation in the current experiment as realistic as possible, such as the use of realistic stimuli and the use of real money with which to gamble, there were several structural and situational omissions when compared to slot machine gambling in a real-world setting. First, the slot machine here was simple in design, using a three-reel and single pay-line approach. The sophistication of slot machines is ever increasing, and it is not atypical to find slot machines in gambling venues in remote and online platforms to boast five-, and even seven-reel designs. In addition, the number of pay-lines on slot machines can go beyond 25-30 pay-lines, increasing the betting intensity of gamblers and providing more opportunity to both win and lose in shorter period of time. Whilst our pay-out structure purportedly allowed participants to win up to £10 on any one spin, this amount is small relative to the jackpot potential that can reach tens of thousands of pounds in real-world gambling settings. Finally, there are several in-game features lacking from the current slot machine simulation, most notably the use of 'nudge' features and bonus rounds. All of these features likely impact the experience of gambling and effect the psychological processes relevant to gambling. However, it is likely, that these features are not conducive to self-control and would only further compound illusions of control and give rise to impulsive behaviours. For example, Parke et al. (2015) found that the opportunity to gamble and win larger amounts of money resulted in more impulsive choices and higher tolerance for uncertainty in a reflection impulsivity task.

One of the drawbacks of the controlled experimental design was the fact that participants were required to complete all trials in all conditions. In line with ethical guidelines (British Psychology Society, 2004), participants were informed they could leave the overall study whenever they wanted and without reason, although they were asked to complete each gambling condition until the end, meaning that decisions to cease gambling was not a free choice *per se*. As a result, participants may have gambled for more or less time than they typically would in a real-world gambling setting, with likely implications for self-control. For example, if gamblers are restricted to a short period of time for their gambling session, then increased risk-taking and impulsive response styles may be a result of the temporal limitations imposed on their gambling. Conversely, if the experimental gambling session duration here was longer than typically experienced by gamblers, then fatigue effects may affect an individual's ability to exercise self-control and sustain concentration and self-awareness. The duration of the gambling conditions was approximately 3.5 minutes for the fast speed condition, 5.5 minutes for moderate speed conditions, and 7.5 minutes for the slow speed conditions. According to Salis et al. (2015), a typical gambling session duration is approximately eight minutes for machine gamblers. A typical amount of total time gambling in this experiment was approximately 30 minutes long, although this was accompanied by a break of five-minute between each condition. Requiring a gambler to gamble longer than they normally would could result in fatigue or boredom effects that have negative implications for self-control, although this limitation was likely offset by the forced breaks between conditions and the counterbalanced nature of trials.

One of the limitations already mentioned in the discussion was the lack of control over gambling session duration across gambling conditions. This was a direct result of the event frequency manipulations whilst simultaneously controlling for the number of trials in each condition. As a result, it is hard to determine if factors predictive of response inhibition performance, such as levels of dissociative experience, are a product of the speed of play or by the time spent gambling.

*5.5.6.2 Subjective arousal as a proxy for physiological arousal*

One of the assumptions made in the theoretical discussion presented here is the use of self-report measures of arousal as a proxy measure for physiological arousal. Cross-study comparisons typically demonstrate only a moderate to small levels of convergence between self-report and physiological emotional responses (Mauss & Robinson, 2009), although higher levels of convergence are typically found in research with within-participant designs (e.g., Mauss et al., 2005). It has also previously been argued that there is a temporal factor that effects the convergent validity of self-report with physiological measures. The fact that the SAM approach used here immediately follows the activity of interest likely adds to its convergent validity with other methodologies for measuring arousal. It has also been argued that the complex construct of emotional arousal cannot be captured in any one measure alone, and that it is multiply determined rather than characterised by a one-dimensional approach (Lang, 1988). The explanation and discussion of results, whilst grounded in theoretical evidence, is therefore naturally subjected to a degree of interpretation. Replication would be a first priority, although further research would benefit from multiple concurrent measures of arousal within the gambling simulation, directly measuring physiological arousal through heart rate variability and galvanic skin responses for example, as well as variations in the self-report approaches to test for their convergence.

### *5.5.7 Implications*

Experiment 1 provides evidence that as the event frequency in electronic slot machine gambling increases, a gambler's ability to exercise executive control is impaired. This was evidenced by a reduced capacity to withhold motor responses in an online test of response inhibition as speed of play increased during slot machine gambling. Arousal was a strong and negative predictor of response inhibition at fast speeds of play, although arousal's effect on response inhibition appeared to be independent of a motor priming effect, which may suggest arousal impairs motor inhibition by a maladaptive biasing of a gambler's perceptual processing in favour of gambling-related stimuli at the expense of environmental cues necessary for exercising self-control. Evidence suggests there is an interaction effect between the speed of slot machine gambling and the psychological factors that predict response inhibition performance. As speed of play is slowed, the relative predictive strength of arousal in inhibition is reduced, and levels of dissociative experience become the dominant and negative predictive of response inhibition. However, this speed-induced dissociation account must be taken with caution because the experimental design meant it was not possible to separate the effects of speed of play and duration of play in the slow speed condition. This means that increased dissociation may have resulted from a longer period of slot machine play at slow speeds, rather than as a direct result of the decreased speed of play. Nevertheless, both the arousal route and dissociation route to reduced motor inhibition are consistent with the notion that inefficient perceptual processing may represent an underlying mechanism that results in impaired response inhibition during gambling. At fast game speeds, if elevated arousal is resulting in enhanced processing of gambling-related stimuli, then this should leave fewer resources available for effortful self-control. Similarly, at slower game speeds, although associated with improved inhibition performance compared to fast speeds, if gamblers are experiencing greater levels of dissociation, environmental cues designed to aid self-control are less likely to be processed.

If this is the case, harm-minimisation approaches during gambling should aim at adjusting the salience of cues that may assist self-control. Whilst no-go cues are a feature specific to this gambling simulation, other cues exist in gambling environments that may help a gambler exercise greater levels of self-control. Such approaches may include making clocks and monetary spend displays more salient to ensure they are regularly processed and attended to by gamblers, with the intention of making them more self-aware of the amount of time and money they have spent gambling. In terms of motor impulsivity, the intermittent implementation of stop cues within slot machines may themselves offer a way of enhancing response inhibition. Although response inhibition was impaired as game speeds increased, an impaired perceptual processing when aroused account predicts that if the salience of stop cues were enhanced, then this should offset some of the negative effects of elevated arousal on response inhibition during gambling. Experiment 2 of the thesis will test this prediction utilising a range of new and existing harm-minimisation tools designed to facilitate self-control during gambling.

Without consideration for wider contextual issues, an obvious solution might be calls for legislative action to reduce the maximum speed of electronic slot machines, as slower speeds have been shown to be less detrimental to self-control with the present study. However, reducing the speed of play comes at the price of reducing gambling enjoyment, as evidenced here. As a result, in more liberal societies such as the UK, such policies are less likely to be publicly accepted and may potentially be viewed by gamblers as an overly paternalistic approach to harm reduction. In addition, there is potential for perverse and unintended consequences for gambling behaviour resulting from a cap on gambling machine speed. If speed is reduced, this could result in compensatory gambling behaviours, where gamblers play more gambling lines, bet larger amounts, and play for longer periods of time on slot machines to compensate for the reduced speed of play. Therefore, it is important that further academic research into these potential consequences is the prerequisite to any wide-scale changes in gambling policy.

### *5.5.8 Conclusion*

Motor response inhibition represents a single, and yet important aspect of self-control within a gambling context. Impulsivity by definition is the execution of action without foresight or planning (van den Bos, 2007), and therefore represents and undesirable response style within a gambling context where there is potential for gamblers to experience gambling-related harm. The more that gambling decisions are made through rationale and conscious choice, the more likely it is that gambling will remain an enjoyable and safe leisure pursuit. Conversely, the more frequent that actions are performed base on impulsive execution, the more likely that this will ultimately lead to behavioural markers of harm, including excessive time and money spent gambling and reduced ability to quit the game at appropriate times. Problematic for the gambling industry is that this research identifies that increased speed of play during slot machine gambling results in impairments in self-control during gambling in a sample of non-problem gamblers. This demonstrates that structural characteristics of gaming machines, in this case speed of play, can produce impulsive behaviours independent of predispositional vulnerability amongst gamblers.

# Chapter 6. A Critical Systematic Review of the Harm-Minimisation Tools Available for Electronic Gambling

### *6. Chapter overview*

Experiment 1 found evidence for an association between the structural characteristic of speed in gambling and impaired self-control in the form of motor response inhibition. It is the intention of future studies within this thesis to examine ways to combat this increased impulsivity found in high event frequency gambling, and therefore, gaining knowledge of the range of harm-minimisation tools available during gambling is pertinent. The purpose of the present chapter, which takes the form of a critical review, was to gather and synthesise the research exploring within-session gambling harm-minimisation tools and their efficacy in shaping behaviour and cognition.

### *6.1 Introduction*

High-intensity commercial gambling has evolved relatively recently in comparison to other legalised, hazardous, and consumptive behaviours, such as tobacco and alcohol use (Adams, Raeburn, & de Silva, 2008). Gambling products and their advertising are now almost unavoidable, and the promotion of gambling has arguably become a social norm (Parke, Harris, Parke, Rigbye, & Blaszczynski, 2014). The presence of gambling has become ubiquitous, inextricably linked with national and international sporting events on television, omnipresent in towns and cities in the form of licensed betting offices, casinos, bingo halls and amusement arcades, and remote gambling, including gambling via the internet, mobile phone and interactive television (Griffiths, King & Delfabbro, 2014).

Of particular importance to this thesis is the evolution of gambling products into sophisticated, electronic platforms that possess structural features that interact with the gambler to produce ego-dystonic and maladaptive effects (for example, see Breen & Zimmerman, 2002), which may broadly be described as 'gambling-related harm'. The strategic approach to tackling this harm is of great importance, as is the focus on efforts to reduce such harm. Adams, Raeburn, and de Silva (2008) argue that in a society demonstrating relatively stable consumption, it is justifiable that attention should be directed towards the treatment of those suffering with a gambling problem. However, such concentration of effort as Adams and colleagues (2008) go on to argue, is less urgent in a rapidly changing environment that is demonstrating escalation of risk. Instead, effort would be best directed towards attending to the situation itself.

This may be particularly relevant given the evolving view that the Theory of Total Consumption (Lederman, 1956) is valid for gambling behaviour (Lund, 2008). Using the field of alcohol as a theoretical marker, it has long been accepted that there is a positive association between mean alcohol consumption among a population and the relative proportion of heavy or problem drinkers in that society (Barbor et al. 2003). Such a relationship, originally proposed by Lederman (1956), is known as the total consumption model, or the single distribution theory. Emergent evidence suggests the total consumption model is valid in a wide variety of phenomena (Lund, 2008). This has included gambling behaviour, with several studies finding evidence of increased gambling participation as gambling accessibility increases (e.g., Room et al., 1999; Turner et al., 1999), with such evidence being taken as support for the application of the theory of total consumption to gambling.

One assumption of the theory is that when individuals along the entire consumption continuum increase their gambling, this will also include those gambling at a level below or just below the limit for heavy or excessive gambling (Lund, 2008). Consequently, increased gambling participation in this subgroup is enough to shift them towards the heavier gambling group. This is particularly important given the figures that demonstrate that in addition to a 0.5% prevalence estimate for problem gambling in the UK, an additional 4.2% of adults can be classed as ‘at-risk’ for developing a gambling problem (Wardle et al., 2014), equating to around 2.5 million people. From a total consumption perspective, increased gambling consumption has the potential to shift those at risk into the problem gambling category, as well as converting those who gamble recreationally, problem-free, to at-risk gamblers. Furthermore, for every problem gambler there are a number of family, friends and individuals in a community who are negatively impacted by problem gambling (Dickson-Swift, James, & Kippen, 2005) although the number of individuals affected is fewer for adolescent problem gamblers (Griffiths, 1995). This provides strong argument for problem gambling to be tackled from a public health perspective.

Biopsychosocial approaches to mental health have arguably evolved from (and indeed advanced) the medical model of disordered gambling, where these classic approaches hold a more narrow view, with intrapsychic and neurobiological vulnerability at the heart of the aetiology of disordered gambling. More modern views of the transition of controlled to disordered gambling include both situational (i.e., environmental) characteristics and structural characteristics. Relative to other forms of gambling, those playing electronic gaming machines appear to exhibit more rapid onset of gambling problems (Breen & Zimmerman, 2002) and experience higher prevalence of problem gambling compared to other forms of gambling (Weibe, Mun, & Kauffman, 2005).

The question remains as to how to tackle the promotion of responsible gambling (RG) and the prevention of problem gambling. This has led to the introduction of many RG and harm-minimisation initiatives. For example, one harm-minimisation approach has been to restrict the availability of gambling by reducing opening hours in licensed gambling premises (Wohl et al., 2010), as well as reduce the quantity of gambling products by restricting the number of electronic gambling machines (EGMs) in licensed betting offices in the UK to four (Association of British Bookmakers, 2015). Similarly, voluntary self-exclusion programmes allow individuals who feel they have a problem with gambling to identify themselves to the gambling venue and mutually agree upon a venue exclusion for a predetermined or indefinite period of time. It is important to note that such a decision to voluntarily self-exclude may also be viewed in a positive light and from a preventive approach, as voluntary self-exclusion is available to those who may not yet have developed a gambling problem but feel they may be at risk or simply feel like they do not want to gamble anymore.

The above examples represent the 'supply reduction' type of harm-minimisation. Other approaches include 'demand reduction', by adopting policies that make gambling less attractive, such as limiting or banning in-house smoking or the consumption of alcohol (Williams, Connolly, Wood, Currie, & Davis, 2004). Other demand reduction approaches may aim to educate customers about the true nature and odds of specific gambling games (e.g., Wohl et al., 2010), in the hope that this may enlighten gamblers that, statistically speaking, they are likely to lose money, or dispel cognitive myths relating to illusions of control or specific 'winning' gambling strategies, in the hope that this may reduce the desire to gamble.

The final type of harm-minimisation initiative – and the focus of the present chapter – is 'harm reduction', which operates more from a 'restrictivist' philosophical and moral standpoint in tackling problem gambling. As Collins et al. (2015) identify, a restrictivist view operates somewhere in the middle of the continuum between prohibitionists and libertarianism. Unlike prohibitionists, restrictivists disagree that gambling should be banned outright, and unlike libertarians, they identify that gambling is not like any other leisure or entertainment business (Collins et al., 2015). This view argues that while gambling should be allowed, restrictions should be put in place to ensure that gambling is done so as safely and responsibly as possible.

As gambling products become more technologically sophisticated, the same technological innovation can be used to facilitate the development of harm-minimisation tools to assist gamblers in maintaining self-control and make rational and controlled gambling-related decisions. Harm-minimisation tools aim to make the time spent gambling safer, without reducing the uptake of gambling *per se*. Such tools have taken on a variety of forms, and while harm-minimisation as a research field within psychology is on the rise in terms of volume and quality of empirical research, the evaluation of such tools remains in its infancy. The aim of the present chapter is to conduct a systematic literature review to synthesise and critically evaluate the empirical evidence available that tests the efficacy of current harm-minimisation tools. To the present author's knowledge, while some now dated reviews have been undertaken assessing the evidence for specific harm-minimisation tools, no systematic literature review exists that examines the collective evidence from across the harm-minimisation literature as a whole.

### *6.2 Method*

#### *6.2.1 Search strategy*

An in-depth literature review was carried out comprising three concurrent phases: (i) search of online electronic databases; (ii) use of professional contacts in the field of gambling to share personal collection of papers related to harm-minimisation in gambling; and (iii) 'snowballing' – a method in which reference lists from published papers are viewed and relevant papers pursued. Electronic databases included the use of the authors' *Library One Search* (an all-encompassing database search engine – including, but not limited to: Academic Search Elite; PsychArticles; PsychInfo; Science Direct; and Scopus) as a primary source, along with *Google Scholar* being used as a more general search engine. The search terms used were *'gambling', 'gaming', 'electronic gambling', and 'online gambling',* with more specific search terms comprising *'gambling harm-minimisation', 'responsible gambling', 'responsible gaming', 'pop-up messaging', 'responsible gambling messaging', 'pre-commitment', 'limit-setting', 'behavioural tracking',* and *'gambling safeguards'.*

#### *6.2.2 Inclusion criteria*

To be included as an output to be evaluated, the published paper had to have: (i) addressed harm-minimisation tools in a within-session (electronic/online) gambling context with the aim of facilitating controlled gambling (therefore, initiatives such as permanent voluntary self-exclusion schemes were not included); (ii) been written in English language; (iii) reported an empirical study; (iv) been published within the last 10 years (2005-2015); and (v) been published in a peer-reviewed journal.

#### *6.2.3 Harm-minimisation tool categorisation*

Once the retrieved papers had been initially filtered according to title and abstract content, a more in-depth assessment was conducted using the inclusion criteria as guidance. The remaining papers were then categorised according to the harm-minimisation tool in question. Categories of harm-minimisation tools comprised: (i) enforced breaks in play, (ii) pop-up messaging, (iii) limit-setting/pre-commitment, (iv) behavioural tracking tools, (v) visual clocks, (vi) note acceptor prohibition; and (vii) limiting stake size. These are categories that frequently appear in previous harm-minimisation literature. However, it should be noted that there are several overlaps between the types of tools and the elements involved. For example, pop-up messages also contain breaks in play, and the setting of monetary limits can sometimes involve receiving a pop-up message once limits have been reached. Consequently, each tool was categorised according to its primary purpose. For example, while pop-ups provide a break in play, the message content itself is the primary harm-minimisation objective, and is therefore categorised in the ‘pop-ups’ section, and approaches assessing limit-setting with pop-up reminders when limits are reached is therefore placed in the ‘limit-setting’ sections. A summary of research findings is provided in Table 6.1, and an overall evaluation of each tool will be given in the discussion section of this chapter.

**Table 6.1.** *Summary of included harm-minimisation studies.*

| Authors (Year) | Main Aims | Sample (n) (Design/Method) | HM Tool Assessed (Game Type Assessed) | Main Findings |
|---|---|---|---|---|
| **Breaks in Play** | | | | |
| **Blaszczynski, Cowley, Anthony, & Hinsley (2015)** | Assessed the effects of breaks in play of varying lengths in terms of their impact on cravings to continue gambling and subjective negative arousal. | 141 university students (78 female)<br><br>(Lab-based experimental study using simulated electronic blackjack game) | Breaks in play<br><br>(Electronic blackjack) | Self-reported craving higher in longer break condition. No effect of break on dissociation. Therefore, no evidence for the use of breaks in play as a way to combat dissociation was found. However, there was a significant and positive correlation between feelings of dissociation and cravings to continue play, supporting role of dissociation in continuation of gambling within a session. This effect was mediated by subjective negative arousal. |
| **Messaging** | | | | |
| **Monahghan & Blaszczysnki (2007)** | Comparison of recall for static versus dynamic message formats. | 92 undergraduate students (69 female)<br><br>(Lab-based experimental study) | Static messages and pop-up messages<br><br>(Electronic gaming machines) | 83% vs. 15.6% of participants were able to freely recall the message content for the dynamic and static messages respectively. Cued recall was also significantly greater for the dynamic messages (85.1% vs. 24.4%). |

**Table 6.1.** *Summary of included harm-minimisation studies.*

| | | | | |
|---|---|---|---|---|
| **Cloutier, Ladouceur & Sevigny (2006)** | Comparison of warning messages versus pauses in play in terms of their impact on erroneous cognitions and gambling-related behaviour. | 40 undergraduate students* (21 male)<br><br>*(participants who obtained the highest scores on illusion of control questionnaire from original sample of 768. 14 participants were low-risk gamblers, 5 were at-risk gamblers, and 1 was a probable pathological gambler)<br><br>(Experimental study in simulated bar setting) | Warning messages and breaks in play<br><br>(Video lottery terminals) | Correcting messages, compared to pauses in play, significantly reduced erroneous thinking, but no group level effects were found in terms of the message or pause influencing gambling-related behaviour. |
| **Floyd, Whelan & Meyers (2006)** | Evaluation of warning message's impact on gambling-related cognitions, gambling-related behaviour, as well as subjective experience during play. | 122 undergraduate students (70 female)<br><br>(Experimental study in lab-based casino simulation) | Warning messages<br><br>(Electronic roulette) | Those participants exposed to warning messages reported fewer irrational beliefs about gambling and had significantly more money remaining at the end of the session compared to participants in control condition, suggesting the messaging had some influence on subsequent gambling behaviour. Exposure to warning messages did not negatively impact on enjoyment of play. |

**Table 6.1.** *Summary of included harm-minimisation studies.*

| | | | | |
|---|---|---|---|---|
| **Monaghan & Blaszczynski (2010b)** | Evaluated the impact of self-appraisal messaging on self-reported gambling behaviour. Such messages were compared to informative style messaging and control message conditions. | Study 1, 127 regular EGM gamblersfrom university sample (male = 97)<br><br>(Lab-based, experimental study)<br><br>Study 2, 124 regular EGM players (male = 81)<br><br>(In-vivo experimental study) | Self-appraisal messages and warning messages<br><br>(Electronic gaming machines) | Both studies showed that pop-up messages were recalled more effectively than static messages immediately and at two-week follow-up. Pop-up messages reportedly had a significantly greater impact on within-session thoughts and behaviours. Messages encouraging self-appraisal resulted in significantly greater effect on self-reported thoughts and behaviours during both the experimental session and in subsequent EGM play. |
| **Harris & Parke (2016)** | Experimentally assessed the impact of self-appraisal messaging on actual gambling behaviour and the interaction effect between gambling outcome and messaging efficacy. | 30 gamblers (18 male) from university sample reporting gambling within the last 6 months<br><br>(Lab-based experimental study) | Self-appraisal messages<br><br>(Electronic coin-toss) | Computer-generated self-appraisal messaging significantly reduced the average speed of betting in the loss condition only, demonstrating an interaction effect between computer-generated messaging and gambling outcome. Messages had no impact on amount wagered. |
| **Stewart & Wohl (2013)** | Assessed the efficacy of monetary reminder pop-up messages in their ability to facilitate adherence to self-set monetary limits, and messaging's impact on dissociation and craving. | 59 university students (43 males; 17 recreational gamblers (no DSM–IV–TR symptoms), 26 sub-threshold pathological gamblers (1 to 4 DSM–IV–TR symptoms), and 16 pathological gamblers (5 or more DSM–IV–TR symptoms)) | Monetary limit pop-ups<br><br>(Virtual reality slot Machines) | Participants receiving monetary limit pop-up reminders were significantly more likely to adhere to monetary limits than participants who did not. Dissociation mediated the relationship between gambling symptomatology and |

**Table 6.1.** *Summary of included harm-minimisation studies.*

| | | | | |
|---|---|---|---|---|
| | | (Virtual reality environment experimental study) | | adherence to monetary limits, but only among those who did not receive a monetary limit pop-up reminder. Forced stop in play created by the pop-up message did not heighten craving to continue gambling. |
| **Auer, Malischnig and Griffiths (2014)** | Evaluated the impact of pop-up messages in a natural and ecologically valid setting in terms of messages ability to facilitate gambling session cessation. | 800,000 gambling sessions (400,000 prior to pop-up being introduced and 400,000 after pop-up message had been introduced - approx. 50,000 online slot machine gamblers)<br><br>(In-vivo, quasi-experimental) | Pop-up messages after predetermined number of plays<br><br>(Online Slot Machine) | Found a nine-fold increase in the number of gambling session cessations at the 1,000-spin mark when exposed to a pop-up message informing players of the number of plays. However, the percentage of total cessations following the pop-up message at 1000 spins was low (less than 1%). |
| **Celio & Lisman (2014)** | Assessed the impact of a stand-alone personalised normative feedback intervention on student gambling behaviour. | 136 undergraduate students (75 male) reporting gambling in last 30 days<br><br>(Randomised clinical trial design) | Personalised normative feedback<br><br>(Self-report gambling behaviour and Computer-based risk tasks) | After one week, those participants receiving PNF showed a marked decreased perception of other students' gambling, as well as demonstrated lower levels of risk-taking in two analogue measures of gambling. |
| **Auer & Griffiths (2015)** | Evaluated efficacy of personalised normative feedback using a real world sample in a real online gambling environment. Also compared normative feedback to more simplistic pop-up messages. | 1.6 million gambling sessions analysed (800,000 evaluating the simple pop-up message and 800,000 evaluating the enhanced pop-up message – approx. 70,000 online slot machine gamblers)<br><br>(In-vivo, quasi-experimental study) | Personalised Normative Feedback<br><br>(Online Slot Machine) | Positive increase in session cessation for the more sophisticated message containing normative feedback. Only a very small percentage of sessions reached 1,000 spins, meaning it is likely these pop-up messages were only given the most intense (within-session) gamblers. |

**Table 6.1.** *Summary of included harm-minimisation studies.*

| | | | | |
|---|---|---|---|---|
| **Limit-Setting**<br><br>**Broda et al. (2008)** | Examined the effects of enforced betting limits on gambling behaviour and analysed the behaviour of those gamblers who typically exceed limits in comparison to those who adhere to monetary limits. | 47,000 subscribed users of the online gambling company *bwin.*<br><br>(In-vivo, quasi-experimental study) | Limit-setting<br><br>(Sports gambling) | Only 0.3% of gamblers exceeded deposit limits at least once. Those gamblers who did were shown to have a higher than average number of daily bets and higher average bet sizes, compared to those who did not exceed limits. Indication that exceeding limits may be indicative of the most intense gambling sub-group. |
| **Wohl, Christie, Kimberly, & Anisman (2010)** | Assessed efficacy of animation-based educational video designed to facilitate adherence to pre-set limits in terms of reducing the exceeding of limits. | 242 non-problem gamblers (119 male)<br><br>(Self-report experimental study) | Animation-based education Vvdeo<br><br>(Various gambling activities) | Participants exposed to animation video reported a significant reduction in erroneous cognitions, an effect that was retained at 24-hour and 30-day follow-up. Exposure to the video also resulted in participants being more likely to strongly endorse 'low risk' gambling practices, including the use of limit-setting, but this effect was not retained at the 30-day follow up. |
| **Wohl, Gainsbury, Stewart,& Sztainert (2013)** | Examined if there was an interaction effect between the use of educational videos dispelling erroneous cognitions and promoting safe-play, including the use of limit, and pop-up messaging reminding participants when they had reached their pre-set limit. | 72 young adults (51 female) with recreational gambling experience<br><br>(Virtual reality environment experimental study) | Animation-based educational video and pop-up messages<br><br>(Electronic gaming machines) | Participants exposed to the educational animation video adhered to pre-set limits more than those in a control video condition. Those exposed to monetary limit pop-ups also showed greater adherence to pre-set limits. These two main effects were qualified by an interaction effect, with results showing that of the |

**Table 6.1.** *Summary of included harm-minimisation studies.*

| | | | | |
|---|---|---|---|---|
| | | | | participants who were not given a pop-up reminder, the ones who were exposed to the educational animation video stayed within their pre-set monetary limits more than those in a control condition. |
| **Auer & Griffiths (2013)** | Examined the impact of limit-setting on theoretical loss among high intensity gamblers, across a variety of gambling activities, in a real-world online setting. | Random sample of 100,000 players in online gambling environment<br><br>(In-vivo quasi-experimental study) | Time and Monetary Limits<br><br>(Online poker, online lottery, and online casino games) | Setting limits had significant and positive effect on theoretical loss for all sub-groups of gamblers. Casino gamblers showed the biggest significant change in theoretical loss following the setting of limits. |
| **Wohl, Parush, Kim, &Warren (2014)** | Designed new and enhanced monetary limit-setting tool using HCI and PSD principles, and compared this to older, more simple iterations of such tools in terms of their ability to facilitate limit adherence. | 56 current electronic gaming machine gamblers (37 female)<br><br>(Virtual reality environment, experimental study) | Monetary Limit-Setting<br><br>(Electronic gaming machines) | Those exposed to the HCI/PSD tool were significantly more likely to adhere to their pre-set limits compared to the standard monetary limit tool. |
| **Kim et al. (2014)** | Assessed the impact of prompts encouraging the setting of time-based limits on both the uptake of setting such limits, and the impact this had on session duration. | 43 non-problem/low risk gamblers recruited from university sample (26 female)<br><br>(Virtual reality environment experimental study) | Time limit-setting<br><br>(Electronic Gaming Machines) | Participants who were prompted to set a time limit did so with a 100% compliance rate compared to one out of 23 for those participants not prompted. Those prompted to set a limit prior to engaging in play gambled for significantly less time than those who were not prompted. |

**Table 6.1.** *Summary of included harm-minimisation studies.*

| | | | | |
|---|---|---|---|---|
| **Behavioural Tracking Tools** | | | | |
| **Auer & Griffiths (2015)** | Assessed the effectives of the behavioural feedback system *mentor*, in terms of its ability to influence the amount of time played and theoretical loss experienced by gamblers. | 16,231 online gamblers<br><br>(In-vivo, matched pairs, quasi-experimental design) | Behaviour Tracking and Personal Feedback<br><br>(Various online gambling activities) | Online gamblers receiving personalized feedback spent significantly less time and money gambling compared to controls that did not receive personalized feedback. |
| **Wood & Wohl (2015)** | Assessed the efficacy of the *PlayScan* behavioural tracking tool, which provided gamblers with behavioural feedback about their gambling, in terms of its impact on gambling behaviour. | 779 online gamblers (694 male)<br><br>(In-vivo, matched pairs, quasi-experimental design) | Behaviour Tracking and Personal Feedback<br><br>(Various online gambling activities) | At-risk players who used the feedback tool significantly reduced the amount of money deposited and wagered compared to players not utilising the tool, an effect that was obtained for both the week following enrolment and at 24-weeks later. Those gamblers who received behavioural feedback showed a significant reduction in deposited amounts compared to the control group, but this did not apply to at-risk or problematic gamblers. |
| **Note Acceptors (Prohibition/Lower money denomination)** | | | | |
| **Sharpe et al. (2005)** | Tested the effects of several modifications to gaming machines, including a restriction on note acceptors to a maximum of a $20 note. | 779 participants of varying problem gambling severity<br><br>(In-vivo quasi-experimental study) | Lower denomination note acceptor<br><br>(Electronic gaming machines) | Gaming machines with modified note acceptors had no impact on any aspect of gambling behaviour compared to control machines. |

**Table 6.1.** *Summary of included harm-minimisation studies.*

| | | | | |
|---|---|---|---|---|
| **Hansen & Rossow (2010)** | Explored the impact of prohibition of note acceptors on slot machine players in terms of its impact on gambling behaviour and problem gambling measures (SOGS-RA and Lie/Bet) in adolescent-aged gamblers. | Approx. 60,000 adolescent gamblers<br><br>(Questionnaire, quasi-experimental study) | Note Acceptor Prohibition<br><br>(Slot machines) | Following prohibition, slot machine gambling frequency was reduced by 20%, the proportion of 'frequent' slot machine gamblers was reduced by 26%, and overall gambling frequency was reduced by 10%. In addition, the proportion of problem gamblers was reduced by 20% |

### *6.3 Results*

#### *6.3.1 Enforced breaks in play*

Gamblers often enter into states of dissociation (Jacobs, 1986; Griffiths, Wood, Parke & Parke, 2005) which leads to a loss of control over time and money spent gambling. RG initiatives that force breaks in play and cause a machine to stop functioning temporarily, allowing dissociative states to be broken and the re-evaluation of one's gambling behaviour, thus seems to be a theoretically robust proposition. Indeed, the use of enforced breaks in play as an RG tool is derived from robust theoretical underpinnings.

Anderson and Brown (1984) hypothesised that arousal produced within a gambling session was able to narrow a gambler's attentional focus and facilitated a secondary reward of escaping psychologically distressing stimuli and wider distressing life situations. Jacobs (1986) extended this concept with his general theory of addiction, where it was proposed that those vulnerable to addictive patterns of behaviour or substance use were hypothesised to be either chronically hypo-aroused or hyper-aroused. Engagement in an addictive pattern of behaviour is therefore seen as a way of maintaining homeostatic balance of arousal through generated dissociative experiences.

The use of enforced breaks in play, in the absence of supporting mechanisms such as presentation of self-appraisal messages as a RG tool (e.g., Monaghan & Blaszczynski, 2010), may be challenged on theoretical grounds, which indicate that breaks in play may actually have an adverse effect on the gambler. For example, the Behaviour Completion Mechanism Model (McConaghy, 1980) posits that driven behaviours, which includes pathological gambling, build a neuronal model of behaviour which is facilitated by conditioning effects. Exposure to a conditioned stimulus or cue results in the activation of the neuronal model, and any interruption to the expression of the behaviour results in an aversive state, or a state of craving, which drives the individual to the completion of the behaviour (Blaszczynski, Cowley, Anthony, & Hinsley, 2015).

Recent research testing the efficacy of imposing breaks in play as an RG tool challenges the use of breaks in play as a standalone RG approach. Blaszczynski and colleagues (2015) tested the effects of breaks in play of varying lengths in terms of their impact on cravings to continue gambling and subjective negative arousal, and compared this to a control condition featuring no break in play. Their study comprised 141 university students (78 female) who played a simulated electronic blackjack game, and were randomly assigned to an eight-minute, three-minute, or no break condition. Results showed that self-reported craving, as assessed by the Gambling Craving Scale (Young & Wohl, 2009), was significantly higher in the longer break condition, compared to the shorter break and no break condition. Significantly higher craving was also reported in the shorter break condition compared to the no break condition. It was also predicted that forcing breaks in play should reduce levels of dissociation, which has been theoretically proposed as a mechanism promoting extended play. However, no relationship between break condition and feelings of dissociation, as assessed by the Dissociative Experience Scale (Jacobs, 1988) was found. Therefore, no evidence for the use of breaks in play as a way to combat dissociation was found. However, there was a significant and positive correlation between feelings of dissociation and cravings to continue play, which supports the theoretical position for the role of dissociation in continuation of gambling within a session. Furthermore, the effect of the break condition on craving was mediated by levels of subjective negative arousal.

Given these findings, caution must be taken when implementing breaks in play as a standalone RG strategy. Breaks with accompanying RG messages show a certain level of positive efficacy. However, breaks alone may have unintended effects. Such effects include the promotion of cravings and desire to continue to gamble, rather than breaking dissociative states often experienced by gamblers. Conversely, limited evidence exists to give indication as to the appropriate length of break required to produce positive effects, and as a result, the efficacy of breaks should not be disregarded based on one study alone. For example, the long break condition applied in Blaszczynski et al.'s (2015) research was only eight minutes long, and is open to interpretation as to whether or not this constitutes a 'long' break. For example, a much longer period of time may be required before maladaptive cravings dissipate and the positive effects of a break may begin to surface. However, recommendations as to what this length of time should be needs to be based on robust empirical evidence, but is likely to differ on an individual-by-individual basis. In addition, given differences in responses between university and real life gamblers (Gainsbury, Russell, & Blaszczynski, 2014), it remains to be determined if the findings have external validity in terms of how such effects are applicable to real gamblers in real world gambling environments.

#### *6.3.2 Pop-up messaging*

##### *6.3.2.1 Static versus dynamic delivery*

RG messages have evolved in recent times in terms of both their content and style of delivery. Originally, 'static' messages were used on the side of gambling terminals themselves, or access to RG messages required players to enter different menu screens on EGMs or online gambling websites (Harris & Parke, 2016). This is a markedly different approach to more modern 'dynamic messaging' delivery systems. Dynamic messages (i.e., 'pop-up') appear on screen and deliver RG-related content whilst interrupting play (Monaghan & Blaszczynski, 2007). Empirical research has demonstrated that when secondary information is delivered that interrupts a primary task, this has an orientating and focusing effect on attention that can positively impact performance on the primary task. Furthermore, this effect has been shown to last longer than the duration of presentation for the secondary information itself, indicating a sustained impact on cognitive performance (Bailey, Konstan, & Carlis, 2000).

This is arguably advantageous over a static messaging approach which requires a division of attention between the primary task of gambling and processing of secondary RG information in a separate location, which may either result in messages not being salient and thus not read, or if messages are read, the information is less likely to be processed and retained due to attentional demands, which is hypothesised to be a limited resource (Broadbent, 1958). Pop-up messaging in a variety of disciplines have demonstrated they have a greater impact in modifying thoughts and behaviour leading to greater task performance compared to their static counterparts (Bentrancourt & Bisseret, 1999).

The effect has also been demonstrated in a gambling context. Monahghan and Blaszczysnki (2007) demonstrated using a sample of undergraduate students that message content for dynamic messages was significantly more likely to be recalled compared to static messages. In the study, 83% vs. 15.6% of participants (N=92) were able to freely recall the message content for the dynamic and static messages respectively. Cued recall was also significantly greater for the dynamic messages (85.1% vs. 24.4%). Consequently, it was suggested that to maximise the effectiveness of RG messages, they should be delivered in a dynamic mode of display.

*6.3.2.2 Pop-up messaging content*

While evidence suggests pop-up messaging may be an effective way to communicate information during a gambling session, from an RG perspective, it is important to ascertain what type of information or message should be delivered. It is also important to investigate not only if this information is processed, but in addition, how effective the messages are in modifying thoughts and ultimately, behaviour. Monahgan and Blaszczynski (2010a) highlighted the frequent use of educational campaigns and warning messages in public health initiatives, where the information presented is typically in the form of an indication of potential risks of specific behaviours. The ultimate goal of such provisions is to moderate engagement with potentially hazardous activities and to minimise harm if individuals engage in such behaviours. It has been argued that presenting consumers with accurate information about specific products and behaviours reduces erroneous cognitions and biases, and leads to a facilitation of consumer informed choice (Monaghan & Blaszczynski, 2010b).

The provision of factual information has received some empirical support in a gambling context, where the behaviour of problem gamblers has been demonstrated to be moderated by correcting erroneous cognitions, misconceptions or probability, and likelihood of winning (Ladouceur, Sylvain, Boutin, & Doucet, 2003). Such evidence of informative messaging impacting upon behaviour is scarce in the gambling literature and indeed other health behaviour literature, including tobacco and alcohol consumption (Hammond et al., 2006). While providing gamblers with informative content may draw attention to the nature, odds, and risks involved in gambling, it has been argued that such information is relatively ineffective in modifying actual gambling behaviour (e.g., Hing, 2004), although there are now dated empirical accounts demonstrating informative messaging positively impacting upon gambling-related cognitions and behaviour (see Ladouceur & Sevigny, 2003; Steenberg et al., 2004; Benhsain. Taillefer, & Ladouceur, 2004).

More recently, Cloutier, Ladouceur and Sevigny (2006) demonstrated that correcting messages, compared to pauses in play, significantly reduced erroneous thinking among a sample of 40 undergraduate students who scored high on an illusion of control questionnaire. However, no group level effects were found in terms of the message or pause influencing gambling-related behaviour. Floyd, Whelan and Meyers (2006) advanced the pop-up messaging research by evaluating the warning message's impact on several measures of gambling-related cognitions as well as subjective experience during play. Results demonstrated that participants in the warning message group reported fewer irrational beliefs about gambling and had significantly more money remaining at the end of the session, suggesting the messaging had some influence on subsequent gambling behaviour. Importantly, while participants reported reading on average 81% of the messages, this did not appear to negatively impact the experience of play. Unfortunately, it cannot be ascertained whether the impact on cognitions and behaviour was facilitated by the messaging or breaks-in-play, as there was no break condition without the inclusion of a message, so the mechanisms of change remain largely unclear. In addition, while participants in the pop-up message condition had significantly more credits remaining at the end of the session, the level of risk or frequency of bets did not differ significantly across experimental groups, making it unclear as to how a perceivable increase in self-control was achieved. Furthermore, the frequency of pop-up message exposure appears particularly intrusive (despite participants not reporting a significant impact on experience of play) and unrealistic, with exposure to a message occurring every six spins.

Despite some positive results, it appears evidence for the impact of informative messaging on cognition and ultimately gambling behaviour, is largely inconsistent and limited. Drawing conclusions from the existing empirical literature, it may be argued that such informative messaging has a more consistent impact on correcting erroneous cognitions, but that this effect alone is not strong enough to exert influence over gambling behaviour. However, this does not negate the use of pop-up messaging as a harm-minimisation strategy as some effect appears to occur, albeit perhaps a weak effect. Instead, the message content itself may be manipulated to exert a greater effect in promoting RG behaviour. Therefore, the way in which information is presented, and in turn, perceived, may be critical for its influence over behaviour.

*6.3.2.3 The use of self-appraisal messaging*

Monaghan and Blaszczynski (2010a) argued that “interventions successful in improving participants’ statistical understanding of gambling do not result in any changes to gambling behaviour” (p.71). As a potentially effective alternative, they suggested that delivering messages that directly encourage a player to self-appraise the time and money spent gambling within a session, rather than simply describing probabilities, may cause them to evaluate their behaviour in a more personally relevant manner, resulting in more considered and informed decisions relating to their gambling.

Autonomy is regarded as fundamental psychological need for the maintenance of wellbeing and positive psychological functioning (Parke et al., 2014). In support of this notion, Deci and Ryan’s (1985, 2000) Self-Determination Theory argues that individuals have a fundamental need to engage in behaviour that is derived via their own value system and beliefs, rather than their behaviour being dictated from external influences. Consequently, more value is likely to be attributed to messaging that is not overly paternalistic, intrusive, and does not run contrary to an individual’s belief and value system. Pavey and Sparks (2010) argue that messages supporting an individual’s right to autonomy will be met with a less dismissive and defensive attitude.

The argument made by Monaghan and Blaszczynski (2010a) for the use of messaging that engages an individual in self-appraisal supports an autonomy-centred framework, as not only are the messages personally relevant, but also the actions taken following processing of the message will be derived through engagement with the individuals own thoughts, reflections, and motivations. This proposition for the use of self-appraisal messaging also has good face validity, particularly when considering the factors that contribute to problem gambling behaviour. Gamblers are often reported as experiencing dissociation from reality and absorption in the gambling task during gambling, which results in losing track of time and the experience of feelings of being outside of oneself (Monaghan, 2009). Gamblers also appear to be slower to respond to external stimuli and dissociate from previous thoughts and moods (Diskin & Hodgins, 1999). This overall lack of self-awareness can cause players to act in ways not previously intended, such as chasing losses and spending more money and time than they can afford (Harris & Parke, 2016). RG initiatives aimed at increasing self-awareness thus appear to be a useful approach in combating and preventing problem gambling behaviours.

Consequently, the use of self-appraisal pop-up messages as a harm-minimisation tool has received increased attention in recent years and has received some positive but limited empirical support. In a laboratory-based computer-simulated gambling experiment, Monaghan and Blaszczynski (20010b) had participants play an EGM with exposure to messages encouraging self-appraisal of time and monetary expenditure. A self-report experimental design showed that participants reported the self-appraisal messaging as having a significant influence on their thoughts and behaviour. In addition, participants also reported that the messages made them more aware of how long they had been gambling. Overall, the views of participants provided support for the application of such messages to real gaming machines in real gambling venues, as they felt that the messages would have similar impact in such environments.

Experiment two of the same study evaluated the impact of self-appraisal messaging on self-reported gambling behaviour. Such messages were compared to informative style messaging and control message conditions. The self-appraisal messages contained information designed to engage the participant in self-reflection, and were presented in the form of questions including:

"*Do you know how long you have been playing? Do you need to think about taking a break?"*

In comparison to informative and control messages, results showed that self-appraisal messaging had a significantly greater self-reported effect on participant's thoughts, behaviour, and awareness of the amount of time spent gambling. While results from the two above studies showed support for the efficacy of self-appraisal messaging in influencing thoughts and behaviour, the self-report research design prevents understanding how such messages actually influence behaviour, as the incongruences between thoughts, self-report intentions, and actual behaviour in high-risk activities are well known. For example, Nevitt and Lundak (2005) demonstrated that self-report accounts of drinking habits for alcohol-offenders significantly underreported both drinking severity and the problems caused by drinking.

Harris and Parke (2016) experimentally assessed the impact of self-appraisal messaging on actual gambling behaviour. Participant's pre- and post-pop-up exposure gambling speed of play and level of risk was assessed, and by combining the two variables, betting intensity (average speed of play [bets per minute] x average stake size = betting intensity) was also measured. In addition, this was the first study to assess the interaction effect between gambling outcome (wins/losses) and the impact of harm-minimisation tools on gambling behaviour. Thirty participants took part in a repeated-measures experiment and were exposed to a pop-up message after 16 wagering rounds on a computer-simulated coin-toss, in both a manipulated winning and losing outcome condition, separated by a minimum of 24 hours. The message simultaneously contained both instructive and self-appraisal content:

*"Play Responsibly*

*Pause and Think…*

*..Are you in Control of your Risk-Taking?"*

Results showed that there was an interaction effect between messaging efficacy and gambling outcome. In the losing outcome condition, the message significantly reduced participant speed of play as measured by bets-per-minute. However, no such effect was found in the winning outcome condition, and the pop-up message failed to reduce the average wager regardless of outcome condition. In fact, average stake size continued to increase following exposure to the message. However, several limitations exist, most notably the fact that participants gambled with tokens rather than their own money. Despite the fact there was a monetary prize for the participant with the most tokens at the end of the experiment, not gambling with one's own money is likely to have muted the effects of both the wins and losses, as well as the impact of the pop-up message in both outcome conditions. In addition, the computer-computer simulated and laboratory-based conditions did not have ecological validity and did not replicate many of the structural and situational factors associated with in-vivo electronic gambling. However, this is often the trade-off associated with experiments requiring high levels of experimental control.

In addition, the study by Harris and Parke (2016) was unable to identify which part of the message actually exerted a behavioural influence in terms of speed of gambling. It is not clear as to whether or not the instructive part of the message, the self-appraisal content, or indeed both parts of the message, had the impact. Of note, a recent study protocol outlining plans for a randomised control trial assessing RG tools, aims to independently assess and cross compare the effects of informative and self-appraisal style pop-up messages, which should shed light on this issue (Caillon, Grall-Bronnec, Hardouin, Venisse, & Challet-Bouju, 2015).

*6.3.2.4 Monetary and time-based pop-ups*

Engaging in addictive behaviours, including gambling, is associated with losing track of both time and space through a process of dissociation (Jacobs, 1988), particularly among problem gamblers (Diskin & Hodgins, 1999, 2001; Griffiths et al, 2006). Dissociation is one potential mechanism believed to explain why many gamblers, especially problem gamblers, exceed predetermined time monetary limits (Stewart & Wolh, 2012).

Similar to self-appraisal messaging, it has been argued that time and monetary pop-up reminders may combat such dissociative states as well as the failure to adhere to pre-set time and monetary limits. Investigating this, Stewart and Wohl (2013) conducted a randomised controlled experiment assessing the efficacy of monetary reminder pop-up messages in their ability to facilitate adherence to self-set monetary limits. A total of 59 university students with varying pre-screened levels of problem gambling severity participated in a virtual reality slot machine simulation. In support of the use of monetary pop-up reminders, results showed that those participants in the pop-up message condition were significantly more likely to stick to their pre-set limit (89.66%) compared to a control (no-pop-up) condition (43.33%). Results also showed that higher gambling symptomology and dissociation were associated with lower monetary limit adherence. The fact that there was no mediating effect of dissociation on limit adherence in the pop-up condition, but was found in the control condition, led the authors to suggest that the presence of the pop-up stopped participants experiencing dissociation.

Auer, Malischnig and Griffiths (2014) conducted the first ever study evaluating the impact of pop-up messages in a natural and ecologically valid setting. More specifically they examined whether a pop-up message presented after 1,000 consecutive plays of an online slot machine would help players cease their gambling. The pop-up message simply informed players: *"You have now played 1,000 slot games. Do you want to continue? (YES/NO)."* The 1,000-spin mark was chosen as this equated to approximately one hour of play, and empirical evidence suggests that this is a key point in play where pop-ups may be most effective (see Ladouceur & Sevigny, 2009). The authors' analysed 800,000 online slot machine gambling session, comprising of approximately 50,000 gamblers. Data sampled from 400,000 sessions prior to the introduction of a pop-up message showed that of the 4,220 games that consisted of 1,000 or more consecutive slot machine spins by the same players, only five sessions ended at 1,000 spins. A further 400,000 sessions were analysed after the introduction of the pop-up message. Of these 400,000 sessions, 4,205 contained at least 1,000 consecutive slot spins, which were then in turn exposed to the pop-up message. Forty-five of these sessions were terminated following pop-up exposure.

While the data set was too large for inferential statistics to be applied, results showed a nine-fold increase in the number of gambling session cessations at the 1,000-spin mark when exposed to a pop-up message reminding player of the length of their play. However, despite this increase, the percentage of total cessations following the pop-up at 1000 spins was still very low (less than 1%). It is important to note that of the 800,000 total sessions analysed, only a very small number (approximately 1% of all session), reached 1,000 consecutive spins by the same player, indicating that the study largely dealt with the most gambling-intense individuals. This finding has a number of potential implications. Firstly, it may be better to introduce pop-ups at an earlier stage of play to capture a larger sample of gamblers. Secondly, the results of the study indicate the relative ineffectiveness of such pop-up interventions for most (within-session) gambling-intense individuals.

*6.3.2.5 Normative feedback and enhanced messaging*

The use of normative feedback, delivered via the platform of a pop-up message, is a potential way to facilitate behavioural change, and is beginning to receive attention in the gambling literature. Personalised normative feedback (PNF) aims to correct an individual's perception about the normal levels of engagement in specific behaviours by others (see e.g. Moreira, Oskrochi, & Foxcroft, 2012). For example, it has been shown that young people tend to over-estimate peer group drinking levels (Moreira, Oskrochi, & Foxcroft, 2012), and PNF aims to correct this misperception by providing individuals with information concerning personal drinking levels and comparing this to societal or peer-group norms.

Normative feedback has been shown to have an influence on a variety of potentially hazardous behaviours, including smoking, where PNF increased smoking cessation (Van den Putte et al., 2009), increased condom use (Yzer, Siero, & Buunk, 2000), and reduced marijuana consumption (Yzer, Fishbein, & Cappella, 2007). The use of PNF also has clinical utility, where it has been shown to be important when incorporated into motivational interviewing (Miller & Rollnick, 1991).

The application of PNF in a gambling context has also received some empirical support, where it has been shown to exert both perceptual and behavioural influence. Celio and Lisman (2014) assessed the impact of a stand-alone PNF intervention on student gambling behaviour. Undergraduate students (N=136; 55% male) who reported gambling in the past 30 days were recruited to take part in a randomised clinical trial design. Participants were assigned to receive either PNF or an attention control task. In addition to self-report, Celio and Lisman's (2014) study used two computer-based risk tasks framed as "gambling opportunities" to assess cognitive and behavioural change at one week post intervention. Results showed that after one week, those participants receiving PNF showed a marked decreased perception of other students' gambling, as well as demonstrated lower levels of risk-taking in two analogue measures of gambling.

Auer and Griffiths (2015) extended the validity of the use of PNF as an RG tool by evaluating its efficacy using a real world sample in a real online gambling environment. Furthermore, the research design compared the efficacy of PNF pop-up messages (in combination with additional message content) to more simplistic forms of pop-up messages. The simplistic message (as in their previous pop-up message study) consisted of informing gamblers that they had played 1,000 consecutive slot machine games and asked them if they would like to continue gambling. The newer, enhanced message contained PNF and read:

*"We would like to inform you that you have just played 1,000 slot games. Only a few people play more than 1,000 slot games. The chances of winning does not increase with the duration of session. Taking a break often helps, and you can choose the duration of the break"* (see Auer & Griffiths, 2015, p.3).

A total of 1.6 million gambling sessions were analysed (800,000 evaluating the simple pop-up message and 800,000 evaluating the enhanced pop-up message). In the simple pop-up condition, 11,232 sessions lasted at least 1,000 spins and these players were exposed to the pop-up (1.4% of the total sessions). Of the 11,232 sessions, 75 were immediately terminated following pop-up exposure (0.67%). In the enhanced pop-up condition, 11,878 sessions lasted at least 1,000 spins (1.48% of the total sessions). Of the 11,878, 169 were immediately terminated following pop-up exposure (1.39%). The percentage of those stopping their gambling session at 1,000 spins was significantly higher for the enhanced PNF message compared to the simple message.

While this positive increase in session cessation for the more sophisticated message is promising from an RG perspective, several limitations are noted. Firstly, the enhanced message not only contained normative feedback, but also contained informative and self-appraisal content, so understanding which element or elements of the message had the most behavioural influence cannot be ascertained. Secondly (and as with their previous study), only a very small percentage of sessions reached 1,000 spins, meaning it is likely these pop-up messages were only given the most intense (within-session) gamblers. Finally, the normative part of the message was only a general statement, and therefore the effects of more specific normalised feedback were not assessed.

### *6.3.3 Limit-setting*

Gamblers frequently spend more time and money than initially intended (Monaghan & Blaszczynski, 2010a). Furthermore, exceeding financial time and monetary limits within a gambling session has been identified as a key risk behaviour for the development of problem gambling (Wohl, Christie, Matheson, & Anisman, 2009). Failure to stick to pre-set limits arguably reflects a loss of, or impairment in, self-control and self-regulation, which can be undermined by a variety of factors (Parke et al., 2014). Such factors include an inability to regulate emotion (Scannel et al., 2000), and the use of emotion in the decision-making process over the use of problem-focused strategy (Blaszczynski, McConaghy, & Frankova, 1990). Arousal has also been implemented as a key influence over behaviour, where arousal is seen to operate on an 'inverted-u-curve' (Yerkes & Dodson, 1908), where being over-aroused (as well as under-aroused) can impact the decision-making process and ultimately, behaviour.

Limit-setting as it will now be referred, is a harm-minimisation strategy that allows gamblers to set time and monetary limits prior to commencement of a gambling session. Identifying the potential mediators of a loss of self-control highlighted above, limit-setting is based on the principles that decisions concerning time and monetary limits (a) should be made in a state of non-emotional arousal, and (b) once made, must be adhered to for the remainder of the gambling session (Ladouceur, Blaszczynski, & Lalande, 2012).

Limit-setting represents an RG tool designed to prevent excessive expenditure in individuals prone to impaired self-control, as well as those who wish to use the feature as a positive, pre-emptive measure. The intention of limit-setting is to promote deliberate decisions regarding expenditure in advance of play, and, by imposing barriers, to ensure compliance with such decisions when emotionally aroused after losses (Ladouceur, Blaszczynski, & Lalande, 2012), or indeed, wins. Evidence for its use also comes from the natural recovery literature, where it has been shown that 40%-82% of individuals with a gambling disorder recover without professional help (see e.g. Abbot, Williams, & Volberg, 1999). One of the primary techniques adopted by such self-recovery populations was the use of self-imposed time and/or money limits (Blaszczynski & Nower, 2010).

Setting limits on gambling time and monetary expenditure may also be viewed as a form of public commitment, where past research indicates that publicly committing to a goal will increase the chances of that goal being reached (Mussell et al., 2000). Outside of gambling, such public commitment strategies have been successfully applied in other areas of health research such as weight loss programmes (see e.g. Nyer & Dellande, 2010).

Broda et al. (2008) examined the effects of enforced betting limits on gambling behaviour and analysed the behaviour of those gamblers who typically exceed limits in comparison to those who adhere to monetary limits. Two years of sports gambling behavioural data were analysed from 47,000 subscribed users of the online gambling company *bwin*. Only a very small proportion (0.3%) exceeded deposit limits at least once. Those gamblers who did were shown to have a higher than average number of daily bets and higher average bet sizes, compared to those who did not exceed limits, indicating that exceeding limits may be indicative of the most intense gambling sub-group. Furthermore, behaviour after exceeding limits showed that average bet sizes steeply increased, although the number of bets reduced. Results indicated that the setting of limits, accompanied by a reminder once limits have been reached, is enough to deter the vast majority of gamblers from exceeding those limits. However, the small majority of those who do exceed limits may represent the most heavily involved gamblers, and arguably, the most in need of help, suggesting the use of limit-setting may be best placed as a preventative RG tool, rather than an intervention for those who may already be exhibiting gambling problems.

Wohl, Christie, Kimberly, and Anisman (2010) applied the principles of the Health Belief Model (HBM; Janz, Champion, & Strecher, 2002) to an animation-based educational video designed to facilitate adherence to pre-set limits. The HBM predicts that healthy and adaptive behaviour will be adopted by individuals when an intervention has a targeted and specified impact on the knowledge, attitudes, and perceptions of target group members. This was applied in a gambling context, more specifically, during slot machine gambling, where the HBM suggests that risk behaviours will be reduced if players come to understand: the true odds of winning; that odds do not improve with persistence; that the consequences of exceeding financial limits can be serious and difficult to reverse; that staying within affordable limits eliminates the chances of developing gambling problems; and that low-risk practices can be used to stay within affordable limits (Wohl et al., 2009).

A total sample of 242 non-problem gamblers were recruited. Those exposed to an educational animation video applying the principles of the HBM, designed to dispel cognitive distortion, and promote the use of and adherence to time and monetary limits, reported a significant reduction in erroneous cognitions, an effect that was retained at 24-hour and 30-day follow-up. Exposure to the video also resulted in participants being more likely to strongly endorse 'low risk' gambling practices, including the use of limit-setting, but this effect was not retained at the 30-day follow up. In addition, the video promoted greater behavioural intention to use the 'low-risk' practices, but again, this effect was not retained at the 30-day follow-up. Finally, participants exposed to the video reported exceeded their self-set limits less often (8% vs. 25% for a control group), but again, the effect was not retained at 30-day follow-up.

Clearly, the self-report method applied is subject to inaccuracies, and behavioural intention does not always lead to behavioural execution, particularly in situations where demand characteristics may be working to provide positive outcomes. Alternatively, the effects of the animated video may be more subtle and not noticed by participants, meaning the failure to find a lasting effect at 30-day follow-up may simply be a failure for participants to experientially detect a change, and not necessarily portray a lack of change. What is required is empirical behavioural gambling data to measure pre-and post-intervention effects. It must also be noted that the effects of the video on cognitive distortions were long-lasting, which may equip individuals well in the long run as a protective factor against developing problems with gambling, but longitudinal evidence is required to test this proposition.

Using a virtual reality gambling environment, Wohl, Gainsbury, Stewart, and Sztainert (2013) examined if there was an interaction effect between the use of educational videos dispelling erroneous cognitions and promoting safe-play, including the use of limit-setting (see Wohl et al., 2009), and pop-up messaging reminding participants when they had reached their pre-set limit. Participants were 72 young adults (mean age=19.69 years, SD=1.82) with recreational gambling experience, and were predominantly female (70.8%). Participants played on an EGM in a virtual reality environment, gambling with a total of 80 credits equating to a monetary value of $20. Results showed that overall, those participants exposed to the educational animation video adhered to pre-set limits more than those in a control video condition (97% vs 77%). Those exposed to monetary limit pop-ups also showed greater adherence to pre-set limits (97% vs 77%). However, these two main effects were qualified by an interaction effect, with results showing that of the participants who were not given a pop-up reminder, the ones who were exposed to the educational animation video stayed within their pre-set monetary limits more than those in a control condition (94.1% vs. 61.1%). However, no difference was found in limit-adherence among the participants who all received monetary pop-up reminders, but either saw or did not see the education animation video. The authors concluded that from an RG perspective, there was no additive effect of exposure to both RG tools, and therefore, pop-up messages reminding gamblers when they have reached their pre-set limits would be the most effective and efficient RG tool.

It should also be noted that only the education video had a significant effect on reducing erroneous cognitions, and in the absence of pop-up messages, exposure to the video did have an effect on gambling behaviour in terms of limit adherence. This shows the potential for education animations as an RG tool, but that it may not be as effective as other measure such as pop-ups in terms of their efficacy in influencing gambling behaviour during play. There is potential for such strategies as educational animations, or education in general, to be applied where pop-ups may not be feasible, for example, in literature in and around gambling venues, or as part of a mathematics curriculum in schools. However, the effect on problem gamblers remains to be seen.

Auer and Griffiths (2013) examined the efficacy of limit-setting among high intensity gamblers, across a variety of gambling activities, in a real-world online setting. Data were initially collected from a representative random sample of 100,000 players, of which 5,000 had opted to use the voluntary time and/or monetary limits. The top 10% most intense gamblers, as derived via theoretical loss (house advantage multiplied by amount wagered; see Auer, Schneeberger & Griffiths, 2012), were taken from each of the sub-gambling type groups (i.e., poker, lottery, and casino games). Results showed that theoretical loss significantly decreased among the top 10% most gaming-intense lottery players in the 30-days following all kinds of voluntary limit-setting (time and money) compared to the total theoretical loss in the 30-days prior to the implementation of limits. The impact of the cash-in limits on theoretical loss was higher than playing duration limits. Similarly, limit-setting was also able to decrease the theoretical loss for the top 10% most intense casino gamblers. However, time limits had no significant impact on theoretical loss for this subgroup. It was also noted that casino gamblers showed the biggest significant change among the general gambling population, with 77% of the theoretical loss being spent in the 30-days following limit-setting compared to theoretical loss in the prior 30-days. Among the top 10% most intense poker players, the amount lost in the poker rake decreased in the 30-days following limit-setting, but this was only the case for those who set weekly spend limits and daily time limits. Overall, time limits had the greatest effect on rake loss for poker players, with those setting daily time limits losing 73% of the loss in the 30-days prior to the setting of limits.  As one would expect, the setting of daily time and session length limits had a highly significant effect on overall play duration. This is important given the fact that excessive time spent gambling, and not just excessive monetary spent, can have deleterious impacts on the lives of gamblers.

The behavioural tracking paradigm used in this study of course only gives information about gamblers on one particular gambling site and does not identify the overall profile and behaviour of a particular gambler. This is important as the most problematic gamblers have been shown to play multiple types of gambling platforms concurrently (McCormack, Shorter, & Griffiths, 2013), which may mean therefore, that reaching monetary or time limits on one site, on one platform, does not necessarily mean cessation of gambling until such limits are reset. It may simply mean that gamblers switch from one site to another once a self-set limit has been exhausted. Pairing (or grouping) of online gambling accounts may be a way around this issue, much like the facility afforded by gaming operators such as *PokerStars* and *Full Tilt*. Of course, this relies on cooperation among competing gambling operators to be a viable option, but it would allow the potential for 'central' limits to be set across all of an individual gambling accounts, rather than several isolate limits set at each of the sites where and gambler has an account.

The focus on the most intense gamblers is certainly of relevance given the fact that this sub-group is most likely to benefit from limit-setting. However, the results provided by Auer and Griffiths (2013) do not tell us how the majority of gamblers, falling more centrally in the distribution curve, interact with limit-setting. As limit-setting is often viewed as an RG tool with preventive utility (see Wohl, Parush, Kim, & Warren, 2014), such large scale, real-world, behavioural tracking techniques should also be applied to those gamblers below the threshold for problem gambling criteria.

Using the principles of Human Computer Interaction (HCI) and Persuasive System Design (PSD), Wohl, Parush, Kim, and Warren (2014) aimed to improve the efficacy of monetary limit-setting as an RG tool, by improving the way that gamblers interact with such features in electronic gambling. HCI principles suggest that for technology to be user-centred, potential users must be involved in the design, testing, and evaluation process. Consequently, Wohl, Parush, Kim, and Warren (2014) conducted a series of focus groups involving non-problem gamblers discussing their views one existing limit-setting tools, as well as discussing potential design improvements that may increase the tools RG utility.

While most participants stated such existing tools would help them stay within limits and they would use such features, one of the key points to come out of the focus groups was that the monetary reminder pop-ups should be used sparingly, or else, risk nullifying their effectiveness. Such views match theoretical accounts referred to as 'burn out', where over-exposure to a message may result in a less attention being paid and reducing the impact this has on behaviour (e.g., Bernstein, 1989). In terms of suggested improvements to current limit-setting designs, participants expressed a desire to be reminded of their spend relative to their pre-set limits, as opposed to messages being triggered by time intervals. While this seems a feasible suggestion, it must be noted that it is not always excessive monetary spend causing deleterious impacts on an individual's life, but also excessive time spent gambling. Also suggested was an option to track spend over time (such as a chart), as well as the incorporation of a delay between being able to continue to play once reaching their limit (see section on 'breaks in play' for theoretical discussion).

Using information gained from the focus groups, Wohl, Parush, Kim and Warren (2014) then designed new monetary limit-setting with pop-up message reminder, and compared this to older, more simple iterations of such a design. New monetary reminder pop-up message features included a traffic light visual display, informing participants of their spend relative to their limits (i.e., green light 'safe', amber 'close', red light 'limit reached'), this was to allow self-monitoring of behaviour, one of the principles of PSD. Once limits had been reached, a one-minute delay was enforced before players could opt to continue to play. Fifty-six participants (37 females) who reported currently being engaged with EGM gambling were recruited and took part in an EGM simulation in a virtual reality environment. They gambled with $20, which was converted into 80 credits, and any money left at the end of experiment was kept by the participant. Gambling outcome was controlled for by the experimenter to ensure all participants reached their limits.

Only seven participants (three from the HCI/PSD condition, and four from the standard monetary limit-setting condition) failed to reach their limits and were thus excluded from subsequent analysis. Results showed that those exposed to the HCI/PSD tool were significantly more likely to adhere to their pre-set limits compared to the standard monetary limit tool (62.2% vs. 2% respectively). Also of importance was the fact that two participants stopped prior to reaching their limits immediately after viewing their player statistics. Self-report data also indicated that participants perceived more engagement with the HCI/PSD tool. However, encouragingly, mean ratings for both the HCI/PSD and old design were above the mid-way point of the scale, showing perceived engagement in both conditions. Participant levels of dissociation was also assessed using Jacobs' (1988) four-item dissociation scale, but there was no significant difference between the two experimental conditions, with overall means for both groups scoring below the scales mid-way point, evidencing low levels of dissociation throughout the experiment.

Using an EGM simulator in a virtual reality environment, Kim et al. (2014) assessed the impact of prompts encouraging the setting of time-based limits on both the uptake of setting such limits, and the impact this had on session duration. A total of 43 non-problem/low risk Canadian university student gamblers were recruited and given $20 to gamble with in the experiment. Analysis showed that participants who were explicitly asked to set a time limit did so with a 100% compliance rate (20/20), compared to just one out of 23 for those participants not prompted to set limits. Those prompted to set a limit prior to engaging in play gambled for significantly less time than those who were not asked to set a limit (5 minutes vs. 9.48 minutes respectively). Of note, 11 out of 20 of participants in the limit-setting group gambled for less time than their self-set limit.

Several limitations exist, including then potential for demand characteristics in the experimental paradigm to drive the high percentage of participants setting limits In such a laboratory environment, many structural and situational characteristics of real gambling environments are lacking, all of which may draw attention away from the available RG tools. In addition, participants were only exposed to a single RG tool, and therefore, the study cannot report the relative additive (or deleterious) impact that multiple available tools can have in moderating gambling behaviour. However, the results do indicate that setting limits on gambling session duration may be effective as an RG tool by reducing the amount of time an individual spends gambling. The authors note that while some gambling activities may benefit from the use of monetary limits, some activities may benefit from time limits. This is perhaps particularly relevant for gambling platforms such as EGMs, where there may be a tendency to dissociate and lose track of time (see Diskin & Hodgins, 2001), or poker, where tournaments are typically long and cash games have no defined end as such.

### *6.3.4 Behavioural tracking tools*

Research indicates that providing gamblers with personalised feedback helps them to better understand their behaviour and change it if necessary (Auer & Griffiths, 2013). Digital technology affords the opportunity to track behavioural player data, which in turn, allows the opportunity to profile gamblers, assess behavioural change that may be indicative of a problem developing, and therefore, provide gamblers with personalised feedback to facilitate awareness of such behavioural change. Value is also found in behavioural tracking as it affords the creation of datasets that allow identification of behavioural markers that may be indicative of harm, which in turn, further allows the development of academic understanding related to problematic, and indeed, safe gambling practice. Auer and Griffiths (2013) argue that personalised messages can be applied using the principles of motivational interviewing, where behavioural tracking allows the delivery of personal, transparent, and motivational feedback. They argue that the target population for behavioural tracking tools should be those who are ‘at-risk’, or those who are developing a problem. The main focus of behavioural tracking tools may therefore be to provide motivation for change via the use of personalised feedback, and for this reason, personalised feedback via behavioural tracking is in line with the Stages of Change Model (SCM; Prochaska et al., 1994). The SCM has been applied to a broad range of behaviours, including weight loss and alcoholism, where the idea is that behaviour does not change in one step, rather, change occurs through a series of steps, starting from pre-contemplation, all the way through to maintenance of a behavioural change (for example, see Prochaska et al., 1994). Key steps in the SCM include acknowledging there is a problem (contemplation) and preparation/determination to change. Maintenance of any behavioural change is also a key component of the model, all of which may be facilitated by the presentation of personally relevant and objective behavioural data afforded by behavioural player tracking. Of course, in support of the efficacy of such RG tools, empirical evidence is needed.

Auer and Griffiths (2015) assessed the effectiveness of the behavioural feedback system *mentor*, in terms of its ability to influence the amount of time played and theoretical loss experienced by gamblers. Behavioural data were obtained from a European online gambling site, with a sample of 1,015 gamblers who had used the *mentor* system. A matched pairs design was used to compare behavioural change of gamblers who opted in to use the *mentor* behavioural feedback system, with behaviour of gamblers who did not use the mentor system (n=15,216), and were matched for age, gender, playing duration, and theoretical loss in the 14 days prior to uptake of the *mentor* system for the experimental group. The *mentor* system also applied the principles of HCI and PSD (see Wohl et. al., 2014), and provided players with visual feedback in the form of graph on the amount of time they had been gambling in comparison to normative behaviour of other gamblers in the database. Results indicated that of the 1,015 gamblers using the *mentor* system, 625 (62%) showed a smaller theoretical loss ratio and 60% showed a shorter playing duration ratio in comparison to theoretical loss and playing duration of matched control group ratio (12% and 10% above chance level respectively). The findings indicated that overall, gambling behaviour of those using a personalised behavioural feedback system decreased more than control group members.

While a difference in behaviour as a consequence of the personalised feedback system was found, the effects were small, which means a degree of caution is required before a full endorsement of behavioural feedback is made. In addition, a limitation of the study includes the fact that no information about the gambler's level of risk or problem gambling status was obtained. Consequently, it cannot be ascertained whether the tool was most effective for those players with problem gambling tendencies, or whether the tool was most effective in moderating the behaviour of those gamblers who already gambled responsibly. In addition, this study, as with many others, was unable to determine if the gamblers were concurrently using any other gambling sites or platforms during the evaluation period, as a way of avoiding potential negative feedback from the *mentor* system.

Wood and Wohl (2015) assessed the efficacy of the *PlayScan* behavioural tracking tool, which provided gamblers with behavioural feedback about their gambling, in terms of its impact on gambling behaviour. A sample of 779 gamblers (694 male) who opted in to use the *PlayScan* RG tool was obtained from the online gambling site *Svenska Spel*. Gambling behavioural data was compared for those who opted in to use the *PlayScan* system with matched controls who did not opt in. Behavioural feedback utilised an algorithmic system which provided players with a colour-coded risk rating according to their expressed behaviours, with green indicating no issues, yellow being at-risk, and red being problematic. Gambling expenditure data (deposit and wager amounts) were gathered for the week in which players enrolled to use *PlayScan*, as well as the subsequent week and 24 weeks later. These data were also gathered for the matched pairs control group.

Results showed that at-risk players (those given a yellow colour behavioural feedback indicator) who used the feedback tool significantly reduced the amount of money deposited and wagered compared to players not utilising the RG tool. Furthermore, this effect was obtained for both the week following enrolment and at 24-weeks later. Results overall indicated that those gamblers who received behavioural feedback showed a significant reduction in deposited amounts compared to the control group in the week after enrolment. However, those given 'red feedback' or 'yellow feedback' (i.e., those showing signs of problematic or risky play respectively) did not significantly reduce their deposit amounts in this period compared to a control group. Only the 'green' group showed a significant deposit reduction for this period, relative to the control group. However, deposit reductions were noticeable over time, with green and yellow feedback gamblers showing a significant deposit reduction from week of enrolment to week 24 compared to the control group. There was no such reduction over this period of time for red players.

In terms of wagering amounts, while red players reduced their wagering between enrolment and 24 weeks later, this amount did not differ compared to the control group. However, for the same period, yellow and green gamblers did significantly reduce their wagering amounts compared to a control group. This evidence suggests that behavioural feedback via behavioural tracking could have a positive impact in keeping controlled gamblers safe, as well as positively impacting at-risk players, while the effects on those gamblers already exhibiting problematic symptoms seems minimal. This supports the notion of behavioural feedback as an RG tool aimed at preventative measures, rather than an intervention for problem gamblers. However, as the authors noted, the extent to which the colour classifications actually relate to more standardised measures of problem gambling is unknown.

### *6.3.5 Visual clock display*

It has been argued that facilitating a gamblers awareness of the amount of time spent gambling may have a positive influence on behaviour, in terms of avoiding excessive play. In theoretical terms, Fraisse (1984) argues that individuals are frequently influenced by their situational conditions when making judgements about time. Therefore, a presumption can be made that presenting information about time spent gambling via a visually available on-screen clock may have a positive influence on gamblers by helping their awareness of time spent gambling and avoiding loss of track of time. Ultimately, this can help gamblers decide whether to continue play or not. While the use of clocks as an RG tool seems to have high face validity, Ladouceur and Sévigny (2009) postulate that their use may have potential unintended effects if gamblers are more focused on money spent as opposed to time spent. For example, they argue that clocks may have an iatrogenic impact on play, where at times, knowledge of time spent playing may result in gamblers feeling as though they have not gambled for long enough. However, empirical evidence assessing the impact of visual display clocks on gambling behaviour is scarce.

Ladouceur and Sévigny (2009) empirically examined the efficacy of clocks on gameplay (other features were investigated, but the focus here will be on visual clock display findings). A convenience sample of 38 adults from a relatively older adult population (mean age 52 years; 64% male) were recruited in bars containing video lottery terminals. The majority of the sample (n=24) were non-problem gamblers, with seven at-risk gamblers and seven probable problem gamblers, as assessed by the South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987). Following gameplay, the researchers asked gamblers a series of questions that included items relating to the use of clocks whilst gambling. Key findings from the study relating to the impact and use of clock in gameplay showed that the vast majority (89%) of gamblers noticed the presence of clocks during play, with approximately two-thirds of the sample reporting using the clocks at random intervals. Some participants stated that they never used the clock, with others reporting using it as much as 10 times during play, highlighting the heterogeneous uptake of clock use in this sample.

Interestingly, the majority reported that they did not consider time an important factor when they gambled (73%). However, ten participants did consider time as an important factor when gambling, and of these, seven reported they considered time as a means to ensure they were ‘on time for an event’, and three reported time consideration allowed them to ‘respect a gambling time limit’. Just over half of the sample (54%) stated that the use of a clock during play could be useful. However, 74% stated that such measures would not help them control their gambling activities. Fifteen participants agreed to meet the researcher for an interview 20 minutes following gambling on the video lottery terminals. Six participants (40%) were more than five minutes late, and of these participants, the average period of lateness was 30 minutes. In fact, only five participants used the clocks on the gambling terminals to help them be on time for the meeting.

Overall, the use of a clock as an RG tool was not perceived as being useful in controlling gambling behaviour despite its utility in preventing the underestimation of time spent gambling being recognised. However, one of the major limitations of this study is the self-report nature of the study, reliant on participant’s perceptions at the expense of empirical behavioural evidence for the efficacy of clocks as an RG tool. However, part of the study did test the uptake of clock use in terms of gamblers attending and being on time for a meeting. Only five of 15 gamblers used the clock on the gambling terminal for this purpose, and of those, two were still late. While the limited existing evidence suggests that gambler’s perceptions of the use of clocks shows they are not useful in influencing or controlling behaviour, it is clear that behavioural player tracking data are required before their use is dismissed as ineffective. Conversely, given the theoretical argument that on-screen clocks indeed produce unintended effects by promoting longer playing sessions if gamblers feel they have not gambled for long enough, further empirical evidence is needed before visual clock use can be classed as an effective RG strategy.

*6.3.6 Prohibition/size reduction of note acceptors*

One method that had been implemented in Norway as a way to reduce gambling expenditure and gambling-related harm is the prohibition of note acceptors on slot machine, which has been demonstrated to produce a 40% reduction in the turnover produced by slot machines (see Norwegian Gaming Authority, 2006; 2007). The prohibition or restriction of note acceptors appears to be a valid avenue of exploration in RG, particularly given evidence suggesting problem gamblers more frequently use high denomination bank notes when gambling compared to non-problem gamblers (Sharpe et al., 2005). Despite evidence from Australia that (i) suggests problem gamblers prefer to use note acceptors while gambling (Australian Productivity Commission, 1999), and (ii) there is a strong correlation between problem gambling and use of note acceptors (McMillen, Marshall, & Murphy, 2004), there is very little empirical evidence demonstrating the efficacy of prohibition/restriction of note acceptors in reducing problem gambling among EGM players.

Sharpe et al. (2005) tested the effects of several modifications to gaming machines, including a restriction on note acceptors to allow a maximum of a $20 note. The research was carried out in an ecologically valid environment, with 779 participants of varying problem gambling severity playing on the modified gaming machines in hotels and bars. Several proxy measures of gambling behaviour recorded, including time spent gambling, number of bets, net loss, and lines per wager. However, machines with restrictions on note acceptors failed to have any significant impact on any aspect of gambling behaviour compared to control machines, including the number of cigarettes smoked and the amount of alcohol consumed during the gambling session.

The authors highlighted several limitations of the research, including the fact that a large proportion of gamblers approached to take part in the study declined, bringing into question how representative the eventual sample was of the majority of gamblers. Other limitations include the potential part that demand characteristics played on participant gambling behaviour, due to the fact that participants were being observed by the experimenter to record gambling behaviour. In addition, there were an insufficient number of probable problem gamblers in the sample to compare whether the machine modifications had differential efficacy in modifying behaviour for problem gamblers in comparison to non-problem gamblers.

Hansen and Rossow (2010) explored the impact of prohibition of note acceptors on slot machine players in terms of its impact on gambling behaviour and problem gambling measures (SOGS-RA and Lie/Bet) in adolescent-aged gamblers. The samples comprised 20,703 students in 2004 (pre-intervention); 21,295 in 2005 (pre-intervention); and 20,695 in 2006 (post-intervention), and the response rates were 82.7% (2004), 86.7% (2005) and 85.7% (2006), respectively. Respondents were mostly 13–19 years old with an average age of 15 years and there was an approximate 50/50 gender split. Importantly for the efficacy of note acceptor prohibition as an RG measure, results showed no significant changes in gambling behaviour and problem gambling at time points one and two (pre-prohibition). However, significant differences were found at time point three following prohibition. Following prohibition, and controlling for potential confounding variables, slot machine gambling frequency was reduced by 20%, the proportion of ‘frequent’ slot machine gamblers was reduced by 26%, and overall gambling frequency was reduced by 10%. In addition, the proportion of problem gamblers was reduced by 20%. No significant gender differences were found.

Only one-third of adolescent gamblers reported noticing the removal of bank note acceptors, and two-thirds reported either stopping gambling or reduced gambling following the prohibition. Hansen and

Rossow (2010) reported that only a small fraction of participants attributed the changes in their gambling behaviour to the removal of bank note acceptors. Importantly, no compensatory behaviour in terms of transition to other forms of gambling was observed after the intervention, and decreases in gambling behaviour were also observed for both at-risk and problem gamblers.

A limitation of the research is that it does not offer explanatory value in terms of the mechanisms of change. One argument proposed by Hansen and Rossow (2010) stated that an inability to use notes slows down the speed of play, where speed of play has frequently been implemented as a problematic characteristic of electronic gambling (for example, see McCormack and Griffiths, 2013). In addition, it is possible that the need to transfer notes into coins may break up the rhythm of play, which may have the added effect of breaking dissociative states and raising levels of self-consciousness regarding gambling time and monetary expenditure. The time taken to transfer notes to coins, or the associated increased time it takes to load a machine with coins, may be sufficient time to allow any increased levels in stress and arousal to dissipate, allowing gambling decisions to be made rationally in a 'cold' (as opposed to 'hot') emotional state (for example, see Parke et al., 2014). An additional limitation is that the effects of prohibition of note acceptors was examined for one type of gambling game (i.e., slot machines), and it was beyond the scope of Hansen and Rossow's (2010) research to ascertain if the effects were mirrored in adult gambling populations.

### *6.4 Discussion*

It is now widely accepted that delivering RG information during play, to facilitate self-awareness, self-control, and dispel erroneous cognitions, should be delivered via the dynamic mode of display afforded by pop-up messaging. In terms of messaging content, despite some positive results, evidence shows an inconsistent effect of informative style message content on gambling behaviour. Informative content aimed at dispelling cognitive biases and erroneous cognitions related to gambling seem to be more effective. However, such an effect appears to inconsistently transfer to gambling-related behaviour. Such research also suffers from the limitation that it is often unclear as to whether it is the message content itself, or the break in play offered by the message that exerts what behavioural influence is demonstrated. In combination with recent evidence showing adverse impacts of breaks in play in isolation of RG messages on cravings and negative valence (Blaczczynski et al., 2015). This suggests that it is not the break in play afforded by pop-ups in the pop-up literature that facilitates behavioural change, although it cannot be established if the two in combination provide an additive effect.

As a consequence of the relative inconsistencies of informative messaging on gambling behaviour, other approaches, such as the use of self-appraisal messaging, normative feedback, and the use of time and monetary reminders have begun to be explored with often significant results but small effect sizes. These studies represent a diverse methodological approach, encompassing self-report, experimental laboratory work, and ecologically valid experimentation that offsets the weaknesses of each approach used in isolation. However, current research carried out in real world environments appears to have a focus on the most intense gamblers, and while significant results in the intended direction have been found, particularly in terms of messaging facilitating gambling cessation, the effects are small, and do not tell us anything about the influence of messaging on the majority of gamblers who gamble at moderate and safe levels. Counter to this argument is the fact that the most intense gamblers are likely to be the ones most in need of help to remain in control, and if messaging is able to help only small numbers of gamblers, then this should be regarded as positive (given that the mantra of many gaming operators is that “one problem gambler is one problem gambler too many”). However, RG tools should strive to assist more than a few gamblers, and pop-up messaging may be regarded as a preventative tool rather than an intervention for problem gambling. Consequently, longitudinal research may be of value to evaluate the relative effectiveness of messaging in term of helping the majority of gamblers, and those gambling recreationally, to stay in control.

While significant findings in the intended direction for pop-up messaging are emerging, it is suggested that research and industry should not be content with the results, and that research also needs to remain flexible and continue to explore the impact of other approaches to messaging content, both in isolation and in combination with other forms of messaging content. For example, the current authors suggest that the use of emotional imagery, emotion-laden content, and self-set messages offer a potentially successful alternative to current approaches. Implementation of such new approaches should continue to evolve from controlled laboratory-based investigations to real-world testing before widely implemented, as well as being tested on the diverse sub-groups of gamblers covering the entire spectrum of gambling behaviours, ranging from recreational through to pathological.

Combined, empirical data from both laboratory-based and real-world environments has shown positive results for the use of limit-setting as an RG tool. However, limit-setting research does not address the issues of gamblers being able to switch gambling platforms once limits have been reached. Other methodological limitations, such as the failure to account for concurrent gambling expenditure outside of the boundaries of the studies of focus, makes it hard to make any conclusive statement about the overall effectiveness of limit-setting as a harm-minimisation tool. Furthermore, often in EGM play, limits can be set, reached, and then overridden with the continuation of play when gamblers may be in elevated states of arousal and experiencing negative emotion, albeit following a brief pause in play.

Currently, in the UK, limit-setting is not mandatory, arguably due to a much more liberal attitude towards gambling and personal liberty. A mandatory limit-setting system, as applied in Norway, has the advantage of helping both recreational and problem gamblers adhere to pre-set limits and assists them in avoiding loss chasing, but this does not avoid the issue of gamblers potentially switching gambling platforms, although how often this occurs is yet to be established (Parke et al., 2014). A voluntary limit-setting system does boast some advantageous qualities over mandatory limit-setting, particularly given Self-Determination Theory (Deci & Ryan, 1985; 2000), in the sense that the free choice to self-set limits will more likely result in behavioural execution of limit adherence, as well as instil a more positive attitude towards the tool more generally, given the fact that decisions will be derived through one's own value system and motivations. This does not address the potential transition from a pre-session gambler, operating in a 'cold' emotional state, making rational decisions, to one who may be experiencing negative valance following losses, in a highly aroused state, making emotion-based choices, where reaching their pre-determined limit can be easily overridden following a pop-up reminder. Of course some sites, such as *PokerStars*, enforce a much longer delay period once pre-set deposit limits have been reached, allowing a much longer 'cooling-off' period. What may be required for EGMs or online gambling games is for sessions to be mandatorily terminated once limits have been reached, rather than asking gamblers if they would like to continue following a reminder and short delay. Although this would not address the potential for gamblers to switch terminals to the one in their immediate vicinity, or simply move venues, it may provide the delay required for the dissipation of highly aroused and emotional states.

Encouragingly, limit-setting research has started to incorporate psychological principles founded in wider areas of psychological research, and recent evidence shows promise for the use of HCI and PSD principles for example. HCI and PSD principles initially show a positive effect in facilitating limit adherence, although this initial evidence needs to be expanded to include real-world trialling to support its overall efficacy. However, real-world testing of limit-setting tools that do exist appear to focus on the most intense sub-groups of gamblers. While justifiable by the fact that intense gamblers will be the group most likely in need tools to help them gain control over their gambling behaviour, the vast majority of gamblers play at safe levels, yet the effects of limit-setting on this group remain unclear.

It is evident that research concerning the setting of time limits has received less attention. While the one study identified here shows a positive result by demonstrating reduced gambling session length for those gamblers setting time limits, endorsement cannot be made using findings from a single study. Indeed, there is potential for maladaptive behaviour to occur of setting time limits. For example, potential unintended effects may include inadvertently causing gamblers to gamble larger sums of money to compensate for the shorter session duration they set themselves. As a result of evidence, or lack thereof, of possible paradoxical, and unintended effects, full endorsement of the use of time limits cannot be made at the present time. A systematic and staged trial, encompassing a variety of gambling behaviour intensities, in which the effectiveness of limit-setting is monitored and evaluated over a sustained period of time appears to be the most advisable strategy moving forward before limit-setting receives full endorsement as a harm-minimisation tool.

In terms of actual behavioural evidence, results have shown that use of behavioural tracking tools that feedback to players the amount of time they have been gambling relative to normative data, show an overall reduced theoretical loss and gambling session duration. However, this effect is small with results from the *mentor* system showing its effect is only slightly (although significantly) above chance level.

The use of colour coded feedback systems, informing players of their level of risk according to expressed gambling behaviour, appear to have a positive influence on a majority of gamblers in various sub-groups categorised according to their level of risk. Overall reductions in deposit limits have been found as a result of behavioural tracking systems for those gamblers already demonstrating safe and RG behaviour – an effect that is sustained at a six-month interval. While initial effects of behavioural tracking are not found for those players demonstrating a greater level of risk immediately following enrolment to such systems, positive effects begin to emerge at a six-month interval period, expressed in terms of reduced wagering and depositing, potentially indicating that behavioural tracking systems offer long-term benefits in the absence of immediate gains for more risky players. Evaluation of behaviour over a more sustained period of time should shed further light on this suggestion.

Unfortunately, the effects of behavioural tracking from the existing studies here either do not show a positive impact on the most risky gamblers, or such information cannot be extracted due to the methodological approach failing to distinguish problem gambling status of the participants. While attempts have been made to categorise risk levels according to expressed online gambling behaviour using algorithmic software, there is currently no consensus on how much this actually relates to external and more widely used screening measures of problem gambling behaviour. While positive evidence exists for the use of behavioural tracking systems as an RG tool, a future key issue involves determining which specific features of behavioural tracking tools are the most effective in facilitating and enabling a positive behavioural change in gamblers. It also needs to be ascertained if specific features are more effective according to the level of risk of the gambler, rather than assuming a one-size fits all approach.

A consistent limitation in much of the limit-setting and behavioural tracking research is that while there was generally a positive effect of the tools on reducing gambling behaviour, current research design limitations make it impossible to ascertain whether or not gamblers simply swap machines or gambling sites once their personal limits have been reached, or if the same applies as a way of avoiding negative behavioural feedback on behavioural tracking systems. It is not known how often this occurs, and epidemiological surveys may be required to ascertain if this is a concern for harm-minimisation research. One way around this, although arguably unlikely in the foreseeable future, is to have a centralised 'hub' whereby a player may gamble on multiple gambling sites but their overall expenditure, stake sizing, frequency and duration of play, and limit-setting function, is governed by a central system where all accounts held by a player all correspond to a unique identifier code. Therefore, setting a limit on the central hub would mean that the personal limits applied as a maximum spend across all their gambling accounts. Other harm-minimisation approaches, such as the use of visual clocks and note acceptor prohibition have received less academic attention. Therefore, endorsement of such strategies cannot be made at present based on so few studies.

However, of such strategies, prohibition/restrictions on note acceptors shows promise. Hansen and Rossow (2010) demonstrated a reduction in gambling frequency and problem gambling in a large sample if adolescent-aged gamblers as a result of note acceptor prohibition. These results were only applicable to one sub-group of gamblers (i.e., adolescents), although the effects were shown across a range of problem gambling severity levels. In addition, these findings can only be applied to slot machine gambling, and it is unclear how this translates to other forms of gambling.

The use of visual clocks (Ladouceur & Sévigny, 2009) was not seen as important by participants in the study identified in the present review, although this view may arguably change as a result of the parameters of the game of choice for gamblers. For example, a poker game can last very several hours and is a game where skill is a factor, therefore, monitoring time for the purposes of taking a break and rest may be of particular importance to such a sub-group of gamblers. The effects (or lack thereof) of visual clocks may be overshadowed by the use of time limit-setting and notification of when this limit is reached by a pop-up message. This appears a better strategy than the use of a visual clock alone, as gamblers may pay less attention to peripheral information such as clocks whilst gambling, but interrupting play with time-based notification via a pop-up message may combat such an effect.

### *6.5 Conclusion*

It is important to bear in mind the heterogeneous structural and situational characteristics across electronic gambling and online platforms, and the games themselves. Consequently, endorsing an RG tool fully requires testing it across a diverse range of game types. For example, tools effective in breaking dissociation in games with smaller stakes but rapid gameplay speeds, may not necessarily transfer to success in slower speed higher stake games. For this to happen, it is important to empirically investigate the psychological mechanisms of change that transfer a gambler from a cognisant state of control to a loss of self-control, according to specific gambling parameters, if indeed these mechanisms differ according to game types and their associated structural characteristics.

Results appear to support the notion that harm-minimisation tools should be viewed as a responsible gambling prevention measure for those who already gamble safely, or are at risk of developing a problem, rather than an intervention for those already exhibiting problem gambling behaviour. That said, non-gamblers or non-problem gamblers make up the majority of participants in all the studies outlined (compared to the numbers of problem gamblers). However, some studies did show some RG tool efficacy for high-intensity gamblers, although how this can be extended to apply to actual diagnostic measurements of problem gambling scores remains unanswered at present. A danger would be to assume that new tools and approaches being developed would not work for problem gambling sub-groups. However, problem gamblers should still be involved in the testing of new approaches so that opportunities are not missed with regards to assisting this group regain control of their gambling behaviour.

Whilst the limitations of laboratory-based experimental work are recognised, this does not expel their relevance in the research field of gambling harm-minimisation. Indeed, while ecological validity is largely lacking in such studies, they offer a level of experimental control often not afforded by real world research, allowing the impact of specific game manipulations and tools to be tested for both their positive and negative influences on behaviour and cognition. This is an important stage in the research process, as RG tools should demonstrate positive efficacy before being widely implemented in real-world settings, which may prove costly both financially and for the gamblers themselves if tools are capable of producing unintended effects. However, the progression from laboratory research to real-world application should not be linear. Where a better conceptualisation should be one of an iterative or cyclic relationship, with laboratory work paving the way for real world application, where then in turn, issues, observations, and ideas based on this real world application are fed back into the laboratory to allow next generation improvements to RG tools to be made.

Research in this field should remain both creative and flexible to both deal with potential changing landscapes of gambling, as well as to continue to strive for advancement of current harm-minimisation tool approaches. This creativity should also extend not only to advancing current ideas, for example, changing the content and layout of pop-up messaging to bring about greater cognitive and behavioural impact, but also continue to use science and psychological theory to develop new approaches yet to be investigated.

# Chapter 7. The Case for Using Personally Relevant and Emotionally Stimulating Gambling Messages to Facilitate Responsible Gambling Behaviour

## *7. Chapter overview*

One of the findings from the review in Chapter 6 is that responsible gambling messaging has continued to evolve, both in terms of mode of delivery, as well as message content. However, an additional finding was that the effect of responsible gambling messages on behaviour is inconsistent and largely determined by the type of content delivered in such messages. Following the review, it was felt that the potential for responsible gambling messages as a harm-minimisation approach has not yet been reached. The present chapter therefore draws upon transdisciplinary evidence to make a conceptual argument for the use of personally relevant and emotional content in pop-up responsible gambling messages to positively influence behaviour, an approach that has not yet been widely explored within the gambling literature.

## *7.1 Responsible gambling messaging content*

Classically, responsible gambling messages were delivered in a 'static' format, where messages were placed (i) nearby and/or adjacent to electronic gambling terminals, (ii) in leaflets at the gambling venue, or (iii) online where internet gamblers can access a separate internet page containing responsible gambling-related content (Harris & Parke, 2016). Monaghan and Blaszczynski (2007) demonstrated that for messages to be better processed and their information retained, messages should be delivered in a dynamic mode of display in the form of a 'pop-up' message – messages that appear on-screen and interrupt play.

Later iterations of messages utilising this pop-up style of presentation have transitioned from containing informative style warning content, to content that is aimed at encouraging self-appraisal of gambling behaviour (e.g., Auer & Griffiths, 2015a). Self-appraisal encourages and facilitates autonomy, which is regarded as a fundamental psychological need for the maintenance of wellbeing and positive psychological functioning (Parke et al., 2014). In support of this notion, Deci and Ryan's (1985; 2000) Self-Determination Theory argues that individuals have a fundamental need to engage in behaviour that is derived via their own value system and beliefs, rather than their behaviour being dictated by external influences. Consequently, more value is likely to be attributed to messaging that is not overly paternalistic, intrusive, and/or does not run contrary to an individual's belief and value system.

Additionally, recent empirical research has examined the use of normative feedback as a way of promoting controlled gambling behaviour and gambling cessation, with some positive results demonstrated in samples containing high-intensity gamblers (Auer & Griffiths, 2015b). However, while recent reviews of the responsible gambling messaging literature (see e.g., Monaghan, 2008; Harris & Griffiths, 2017) highlight that while self-appraisal messaging works above and beyond informative (non-appraisal) style messaging, and that new approaches such as the use of normative feedback show promise, effect sizes and the number of gamblers being positively influenced by such messages remain small (Auer & Griffiths, 2015a; 2015b; Auer, Malischnig & Griffiths, 2014).

Consequently, researchers should not remain content with current approaches, and should push for new and innovative ways to positively impact upon a larger proportion of gamblers at all points along the gambling continuum from recreational and at-risk gambling through to problem and pathological gambling. The present chapter argues that the use of emotionally stimulating message content designed to facilitate responsible gambling has been overlooked, or at least not given the academic attention it may warrant, particularly given theoretical and empirical accounts highlighting the important role that emotion plays in the decision-making process, as well as empirical research evidence from other potentially hazardous consumptive behaviours (e.g., smoking nicotine, drinking alcohol).

### *7.2 Role of emotion in decision-making*

Many research studies have demonstrated that emotions constitute powerful and predictable influences over decision-making processes (for a recent review, see Lerner, Li, Valdesolo, & Kassam, 2015). The view of decision-making in academic literature has changed, from one negating the role of emotions, where the focus has classically been on understanding the cognitive processes involved (Lerner et al., 2015), to a view among many psychologists that emotions are in fact the dominant driver of the majority of important decisions in life (e.g., Ekman, 2007; Gilbert, 2006; Keltner & Lerner, 2010). Indeed, this is in line with the dominant functional or adaptation approach pioneered by Darwin, where emotion is seen as a reaction to significant events that prepares action readiness and different types of alternative, possibly conflicting, action tendencies (see Darwin, Ekman, & Prodger, 1998).

Indeed, decision-making and emotions may go hand-in-hand, a notion consistent with modern dual-system models of decision-making (for example, see Sohn et al., 2015). Such models postulate both an automatic, fast decision-making system (system one), as well as a more deliberate and slow decision-making system (system two; Kahneman, 2011). Factors that make system one's processes more dominant in decision-making include cognitive busyness, distraction, time pressure, and more intense mood-states, while system two's processes tend to be enhanced when the decision involves an important object, has heightened personal relevance, and when the decision-maker is held accountable by others (Kahneman, 2011).

The use of emotion in the decision-making process has often been viewed as the antithesis of controlled and rational decision-making, with arguably the majority view in Western cultures seeing emotion as having a negative impact in the decision-making process (Keltner & Lerner 2010). However, a minority of scholars, including Hume (1978), have put forward argument to the contrary, stating that reason itself should be slave to the emotions. In other words, reason should be there to modulate a positive subjective emotional state within humans, and subjective emotion itself should be the motivation and purpose of decisions. In line with this view, anger for example, provides the motivation to respond to injustice (Solomon, 1993). Important in a gambling context, anticipation of regret may provide motivation to avoid excessive risk-taking (Loomes & Sugden 1982) and loss-chasing behaviour.

However, recent fMRI evidence suggests that emotionally charged states *are* associated with increased impulsive decision-making. Sohn et al. (2015) for example, demonstrated that increased impulsive decision-making is related to highly emotionally aroused states at both ends of the valence scale, with decreased activation found in prefrontal-parietal brain regions believed to be responsible for human decision-making processes associated with the deliberate system, as is suggested by dual-system perspectives on cognition (Sohn et al., 2015). These findings indicate that people tend to make impulsive decisions during emotionally aroused states compared to states of low-arousal. This is because the deliberative system's ability to exercise regulatory control over impulsive behaviour becomes functional when individuals are not emotionally excited (Peters, Västfjäll, Gärling, & Slovic, 2006).

While it may therefore seem counterintuitive to utilise messages with heightened emotional content, it is argued that – in line with Kahneman's (2011) approach – if emotional messages are made personally relevant, then this should encourage greater activation of the more deliberate and controlled system two approach to decisions making, which may be more adaptive for the gambler. Such examples may include images of one's family as a reminder of the consequences of loss chasing, or to frame it in a positive light, the images may encourage positive play or gambling session cessation.

### *7.3 Attention capture by emotional stimuli*

Emotional stimuli are often shown to capture attention above and beyond neutral stimuli (Compton, 2003; Vuilleumier, 2005), a process that has been considered to be pre-attentive and resource independent (Ohman, Flykt, & Esteves, 2001; Ohman, Lundqvist, & Esteves, 2001). Several research paradigms, including visual search tasks, have demonstrated preferential processing for emotional stimuli, especially when these are threat-related (e.g., Huang, Baddeley, & Young, 2008). Emotionally stimulating words have consistently been shown to produce greater response interference compared to neutral words in Stroop tasks (Compton et al., 2003; Dresler, Mériau, Heekeren, & van der Meer), hypothesised to be due to the automatic allocation of attentional resources to emotionally-laden stimuli.

A review of the literature assessing the interface between emotion and attention suggests that emotion enhances attentional processing via a two-stage process, where initially, emotional significance is evaluated pre-attentively by a sub-cortical circuit involving the amygdala; and second, stimuli deemed emotionally significant are given priority in the competition for access to selective attention (Compton, 2003). Such evidence suggests that the use of emotionally stimulating messages in a gambling context may be effective as a harm-minimisation strategy on two counts. First, during a gambling session where large amounts of attentional resources are allocated to the task of gambling itself, often resulting in gamblers experiencing states of dissociation (Diskin & Hodgins, 1999), emotionally stimulating messages are more likely to capture the limited attention available from gamblers, as emotional content may require less attentional effort. Secondly, emotive messaging, especially those of personal significance, may be more likely to activate selective attention through well-rehearsed schemas or neural networks, and thus enable them to have greater influence in the decision-making process.

### *7.4 The role of positive and negative emotion in responsible drinking and anti-smoking campaigns*

While strong empirical evidence exists demonstrating the effectiveness of tobacco control media campaigns in encouraging smoking cessation (Sims et al., 2014), only more recently has attention been directed towards the impact of different emotional messages and how these can impact upon smoking behaviour measures, including smoking prevalence and cigarette consumption. Sims et al. (2014) conducted a population level observational study in the UK of smoking behaviour following both positive and negative emotive messages in televised advertisement campaigns. Positive emotive messages focused on the reasons for quitting and how to quit, whereas almost all of the negative emotive messages focussed on the health risk of smoking. Both positive and negative emotive messages delivered via televised advertising were associated with a reduction in smoking prevalence when compared to the effects of emotionally neutral messages, whereas only negative emotive ads were associated with a reduction in cigarette consumption among smokers, controlling for extraneous variables such as price of cigarettes.

However, the use of negative emotion-eliciting message campaigns amongst youth populations show that fear appeals are ineffective in youth alcohol, tobacco, and other drug (ATOD) prevention (Prevention First, 2008). Excessive use of fear in emotive messaging may cause an individual to ignore or not believe the message as they may feel negative consequences will happen regardless of what action they take (Prevention First, 2008). Even worse, fear may invoke the opposite behaviour intended by the message if the individual likes taking risks (e.g., Steele & Southwick, 1981; Zimmerman, 1997), which may be especially true among youth populations given the prematurity in brain regions associated with impulse control (Blakemore & Choudhury, 2006).

Prevention First (2008) have suggested that as a potentially more successful approach in combating youth ATOD use, low-fear messages from credible sources that are based on facts, tied to the present, and appeal to more positive emotions should be used instead. While both fear-based messages and fact-based drug education can increase knowledge and negative attitudes toward substance use, these approaches have not been shown to reduce or prevent substance use behaviour in youth populations.

Similarly, Agrawal and Duhachek (2010) demonstrated that the use of messages stimulating negative emotion directed at the self, had perverse effects on drinking intentions among a sample of students. In relation to 'irresponsible' drinking, Agrawal and Duhachek's (2010) studies show that when emotions eliciting uncomfortable perception of oneself are further stimulated in ways which threaten to heighten this discomfort, viewers of the emotional message tend to convince themselves that the message does not apply to them, in a process the authors described as 'defensive' processing. This results in leaving individuals more free to do what the message warned against than if it had never been received. In particular, shame-laden consumers exposed to messages which asserted that drinking might lead to additional shame-inducing situations, believed that their own drinking would not lead to those consequences, with similar findings for emotions of guilt. Conversely, messages that elicited no threat to the self but asked participants to think about the behaviour of others had the intended effects. One of the proposed mechanisms for this effect offered by Agrawal and Duhachek (2010) is that messages that overly stimulate negative emotion may cause viewers to shut down and not process the message as a form of self-protection. As an alternative, they suggested that following a warning, messages should end on a more positive note, relieving the negative emotion and defensiveness towards the message.

This is empirically supported in a Spanish study conducted by Carrera, Muñoz, and Caballero (2010) investigating the impact of emotionally stimulating messages on binge drinking intentions. They found that among a student sample, a mixed message containing both negative and positive emotional content generates lower post-message discomfort than an exclusively negative message. In addition, participants experiencing the mixed emotion message reported a lower probability of performing the risk behaviour (binge drinking) in the future. The mixed message also resulted in participants being more motivated to control the danger associated with binge drinking and showed a greater response efficacy in the mixed message condition compared to the negative only condition.

However, messages eliciting negative emotion have been shown to enhance responsible drinking efficacy. Hendriks, van den Putte, and de Bruijn (2014) investigated whether emotions induced by anti-alcohol messages influences conversational valence about alcohol and subsequent persuasion outcomes. The study found that fear was most induced by 'disgusting' messages, and in turn, fear induced a negative conversational valence that elicited healthier binge drinking attitudes, subjective norms, perceived behavioural control, intentions, and behaviour. Consequently, it was suggested that health campaign messages should aim to stimulate healthy conversational valence.

Duhachek, Agrawal, and Han (2012) highlight the fact that negative emotion is not a single construct and investigated how feelings of shame and guilt interact with the emotional framing of a message to persuade viewers to drink responsibly. They argued that guilt is an emotion associated with a problem-focus that emphasizes the regaining of benefits, and that shame is an emotion associated with an emotion-focus that emphasizes consequences to be avoided. Duhachek and colleagues (2012) hypothesised that when the coping strategy activated by the emotion matches the message frame, the resulting appeal is easier for consumers to process and therefore the message would be more persuasive.

In line with their predictions, results of their study showed that guilt appeals are more persuasive when combined with messages framing benefits to be gained by drinking responsibly, whereas shame appeals are more persuasive when combined with messages framing consequences to be avoided. They show that guilt/benefit framed messages and shame/consequence framed messages reduce intentions to binge drink, as well as reduce the willingness to view alcohol-related advertising. The authors claimed that these messages are effective because they facilitate the use of coping strategies associated with guilt and shame.

### *7.5 Positive framing of messages*

While some evidence exists for the use of negative valence messages in the prevention of hazardous behaviours, particularly when considering the multidimensional nature of negative emotion, research seems to highlight the need for positive framing of messages, particularly among younger adults. Particular emotional states also have the added influence of not only shaping content of thought but can also shape the depth of processing of information. Negative affect can reduce the accuracy of thin-slice judgements (a term used to mean taking quick decisions on the basis of limited information; Ambady & Gray, 2002). For example, those participants experiencing negative affect in a study by Ambady and Gray (2002) showed reduced accuracy in thin-slice judgments of teacher effectiveness, except when those participants experienced cognitive load, which suggests this decrease in accuracy was caused by more deliberative processing strategies.

This is of particular relevance in a gambling context, where pop-up messages are typically delivered to players when they have reached pre-set monetary (or time) limits (e.g., Stewart & Wohl, 2013). If gamblers are then informed by a pop-up message that they have spent their limit and asked if they would like to continue play, this decision may be impaired by the negative affective state caused by the monetary loss. Consequently, the use of emotionally stimulating messages should frame gambling cessation in a positive way. For example, rather than a focus on monetary loss, a message might focus on protection of money yet to be spent, for example, *"save the rest of your money for that family trip next month"*. This strategy is in line with 'reappraisal' approaches to emotional control, where reappraisal has consistently emerged as a superior strategy for dissipating an emotional response (Gross, 2002). As well as reducing self-reported negative feelings in response to negative events, reappraisal has been shown to reduce both physiological and neural responses to those events (e.g., Jamieson, Nock, & Mendes, 2012; Ochsner, Bunge, Gross, & Gabrieli, 2002), which overall may reduce the likelihood of a gambler impulsively choosing to continue play despite likely negative consequences.

### *7.6 Emotionally stimulating messages in a gambling context*

In support of the proposition made in the present chapter, one empirical study has touched upon the idea of using graphic messages to elicit an emotional response in a gambling context. Munoz and colleagues (2014) assessed the impact of graphic warning messages (in combination with text-based messages) versus text-only messages, in terms of their impact on gamblers' levels of processing of the message, cognitive appraisal, fear, and attitudes. The graphic warning message was a picture of an electronic gaming machine (EGM) being depicted as a monster eating a gambler, designed to invoke fear. The image also contained smaller embedded graphics within the EGM monster that depicted the negative (financial or family) outcomes that gamblers might experience due to excessive gambling (see Figure 7.1).

Their results indicated that the presence of a graphic enhanced both cognitive appraisal and fear, as well as having positive effects on the depth of information processing. In addition, graphic content, combined with text focused on family disruptions, was more effective in changing attitudes and complying with the warning compared with other combinations of the manipulated variables (i.e. graphic versus non-graphic, and family focus versus financial focus text).


***Figure 7.1.*** Graphic warning image used in Munoz, Chebat, and Borges (2014). Gambling terminal is depicted as a monster, with embedded graphics indicating what aspects of one's life may be adversely affected by excessive gambling.

Despite these preliminary findings, the present chapter argues that while the use of emotional content in a responsible gambling message context may be able to create an orientating attentional, and ultimately, a greater behavioural effect, this is likely to be more effective for stimuli that is seen as both personally relevant *as well as* emotionally stimulating. Evidence has shown that some gamblers carry specific items with them when they gamble (Griffiths & Bingham, 2005). While some may argue this is more of an irrational superstitious or ritualistic behaviour with no place in science, specific items (such as photos of their family) may be used as a tool to help one make sensible decisions by reminding them of what is at stake and the negative consequences of gambling. In addition, such photos may exert an enhancing cognitive effect, allowing players to perform better by providing a positive affective state, where positive affect in most circumstances enhances problem solving and decision-making, leading to cognitive processing that is not only flexible, innovative, and creative, but also thorough and efficient in a wide array of contexts (Isen, 2001).

Allowing gamblers to self-create and set their own messages before gambling, while in a state of non-emotional arousal, also means they can use cues that potentially have a calming influence. For example, a gambler may choose to use a message (or cue) that reminds them of a positive event, place, or 'thing', which may be able to assist a transition from a state of highly aroused 'hot' emotion, to 'cold' emotion, where gambling-related decisions are more likely to be carefully deliberated (see Ladouceur, Blaszczynski, & Lalande, 2012).

### *7.7 Summary and recommendations*

As noted above, empirical evidence from research examining prevention messaging on other potentially addictive behaviours demonstrates a potential asymmetric effect of fear-based messages relating to the age of the participants, where fear-based campaigns appear to be less effective for younger adults. In addition, a focus on family may be less effective for younger adults, or indeed gamblers with no dependants or those who are not in a relationship irrespective of age. This is an argument allowing gamblers to self-set the messages they receive, as they are best positioned to determine what would invoke an emotional response and motivate them to avoid excessive gambling, be it fear-based messages, or a more positively-valenced approach. Allowing gamblers to self-set the messages would require account-based play, more typical of online gambling sites, or jurisdictions where player cards are a mandatory requirement such as Norway and Sweden.

Emotional messages could be delivered via text and/or images. Empirical studies need to ascertain which mode of presentation is more effective, or indeed if there is an additive effect of having both. This may be less relevant for online modes of play, or jurisdictions with mandatory account-based play, as gamblers can set the mode of message most effective and preferred by them, which is likely to differ on an individual-by-individual basis.

While it is generally accepted that harm-minimisation tools are best used as a preventative measure to help non-problem or at-risk gamblers stay in control, as opposed to an intervention measure for problem gamblers, this should not be assumed. Indeed, the testing of emotionally stimulating messages should include gamblers across the entire playing continuum, ranging from part-time recreational gamblers through to pathological gamblers. In addition, current messaging approaches used as a harm-minimisation strategy should be tested in conjunction with the use of emotional messaging to test for potential additive benefits. It is proposed that self-appraisal messages, that demonstrate responsible gambling efficacy, should follow emotionally stimulating messages, as emotional messages are likely to create a greater orientating response which may then result in subsequent messages receiving greater attention, having a deeper level of processing, and ultimately, having a greater behavioural impact.

With any new approach to harm-minimisation, there are potential unintended consequences on behaviour, highlighting the need for new approaches to be first tested in controlled environments before being rolled out at population level. With the use of emotionally stimulating messaging, it is important to ensure that a focus on financial or familial consequences of excessive gambling does not have the unintended effect of promoting loss-chasing behaviour. For example, if gamblers view that they have passed a significant threshold of loss, quitting the game may not be an option for them as they may see any further loss as insignificant. Presenting financial or familial messages may only further compound this view.

# Chapter 8. Experiment 2. The Efficacy of New and Existing Harm-Minimisation Tools in Facilitating Response Inhibition During Gambling

## *8. Chapter overview*

Experiment 1 of the thesis identified that high speed gambling on an electronic slot machine simulator impaired participant response inhibition performance. The speed of play most detrimental to response inhibition was the simulation with a 1.5s event frequency. As a result, this speed of play will be taken forward to Experiment 2, with the intention of testing and identifying harm-minimisation approaches that can help facilitate self-control over motor responses during gambling at these high speeds.

The critical review of available gambling harm-minimisation tools conducted in Chapter 6 identified a range of within-session tools that have been tested for responsible gambling efficacy. One of the findings stemming from the review was that pop-up responsible gambling messages have received a lot of attention within academic research and that they are a widely used and accepted form of harm-minimisation. That said, the impact of such messages on the behaviour and cognition of gamblers is inconsistent and appears dependent on their mode of delivery, as well as content. A gap in the gambling literature yet to be explored in depth on this topic is how dynamic responsible gambling messages could serve as a platform to deliver emotive content and how this could be utilised to shape gambling behaviour. Chapter 7 therefore explored this idea in more in depth and provides discussion on the important influence of emotion on decision-making and behaviour. Experiment 2 aims to empirically test the concepts proposed in Chapter 7 by comparing pop-up messages with emotional content with non-emotive content, in terms of their ability to facilitate awareness and control over motor actions.

Experiment 1 identified that at fast speeds of play, subjective arousal and reaction time were predictors of response inhibition performance, with higher arousal and faster reaction times predicting poorer performance. These predictors appeared independent of each other, as there was no statistical evidence for reaction time mediating the effect of arousal on response inhibition. Therefore, the negative effects of arousal on response inhibition could not be explained by arousal priming motor response execution. An alternative explanation offered in Experiment 1 was that arousal was impacting latent variables in the form of perceptual processing, resulting in ineffective processing of no-go cues in the response inhibition task. Experiment 2 therefore aimed to test if approaches aimed at increasing a gambler's active attention during gambling would facilitate response inhibition performance. As well as the use of an emotive and non-emotive pop-up message to increase self-awareness of behaviour during the gambling simulation, two additional approaches designed to enhance attention allocation to motor outputs were tested. The first was a structural change to the slot machine itself, where rather than the same button press being required every time to spin the slot machine reels, the button changed dependent on visual cues presented during gambling. Because of such a structural change, gamblers would likely have to pay greater attention to, and discriminate between, motor outputs. A final approach to be tested was a non-structural change. A sub-group of gamblers were purportedly informed that failure to correctly withhold motor responses when instructed will result in a small financial penalty. This was designed to provide potential aversive outcomes for failing to withhold motor responses. It is argued therefore, that this will enhance the motivational salience of no-go cues and enhance the subjective value of withholding motor responses. Also of interest, is how such intrinsic motivational factors are impacted by the content of responsible gambling messages and structural changes. The following section summaries the aims and hypotheses for Experiment 2.

### *8.1 Research aims and hypotheses*

The first aim of Experiment 2 is to investigate if new harm-minimisation approaches are able to facilitate self-control during gambling at fast speeds of play. It is predicted that changing the structure of the game to increase attentional demands via an enforced discriminatory motor choice procedure will prevent prepotent response patterns developing and will improve response inhibition performance, relative to a non-intervention control condition (H1).

The second aim of Experiment 2 is to compare the relative efficacy of this structure change approach to existing harm-minimisation approaches in the form of pop-up messaging, in terms of their ability to facilitate response inhibition performance during gambling. Given that attentional demands are increased during gambling in the changed structure condition, it is predicted that new structure change approaches will facilitate motor response inhibition to a greater degree compared to pop-up messages (H2).

Different pop-up message content will be assessed for their efficacy in enhancing self-control during gambling in Experiment 2. Therefore, the third aim of Experiment 2 is to investigate if different types of message content differentially impact response inhibition performance during gambling. It is predicted that pop-up messages that display emotional content, such as familial and financial consequences of gambling, will lead to greater levels of self-control during gambling when compared to non-emotive, informative content (H3).

The fourth aim of Experiment 2 is to assess the impact of adjusting motivational salience towards no-go gambling trials on response inhibition performance. It is predicted that the presence of potential aversive outcomes for erroneous responses will facilitate response inhibition relative to the structure change and messaging interventions also being tested (H4).

## *8.2 Method*

### *8.2.1 Design*

A between-participants experiment was conducted to assess the impact of new and existing gambling harm minimisation tools on motor response inhibition performance. An electronic slot machine simulator was designed using a combination of the graphical user interface and coding function available on Psychopy (Peirce, 2007) experiment builder (see figure 5.1). The slot machine was a three-reeled design, with a single pay line, and had a 1.5s event frequency. The slot machine simulator had five conditions, each testing the efficacy of different harm-minimisation approaches in facilitating within session response inhibition: a no intervention control condition; an emotive pop-up message intervention; an informative pop-up message intervention; a structure change condition requiring participants to make discriminatory motor response to operate the machine; and a financial punishment condition, where participants were purportedly penalised for making erroneous motor responses. Each condition of the slot machine simulator had 90 trials (gambling events). The slot machine was programmed to give the illusion of randomness. However, the slot machine was pre-programmed to control for volume, frequency, and range of wins, as well as number of near misses (see Clark et al., 2009a). The slot machine used in Experiment 2 had a pay-back percentage of 94%, although participants were allowed to keep the full £10 starting stake at the end of the experiment as compensation for their time, although they were not informed of this until the debrief following the experiment.

As described in Experiment 1, a behavioural measure of response inhibition in the form of a go/no-go task was built into the slot machine simulator, and immediately following the gambling session, participants were given various electronic scales to complete to measure subjective arousal, dissociation, valence, perceived self-control, and motivation for self-control experienced during the preceding gambling session. All scales were presented and completed using the *Psychopy* experiment builder. Reaction time to gambling stimuli was also measured which is a standard function in the experimental software. Unlike Experiment 1, only a high speed of play slot machine with a 1.5s event frequency was used in the present experiment, as this speed was shown to be most problematic for exercising response inhibition in Experiment 1.

*8.2.2 Participants*

A sample of 60 (47 male) non-problem, regular gamblers were recruited from amusement arcades and sports clubs in the Lincolnshire, UK, region. These areas were targeted during the recruitment process as they were identified as areas likely to contain a high density of gamblers. All participants were classed as regular gamblers, defined for the purposes of this study as an individual who had gambled at least once per month over the past 12 months. Participant mean age was 30.28 years (SD=9.91), with ages ranging from 18-62. A short screening questionnaire was administered to both ensure participants reported regular participation in gambling, as well as to ensure participants had never suffered with a gambling problem, nor currently suffering with a gambling problem. An affirmative answer on either count of problem gambling resulted in participants being excluded from participation. Of note, five participants were excluded from participation following the screening questionnaire. Four of these participants reported either current or previous experience of problematic gambling behaviour, and one of these participants did not meet the criteria for regular gambling.

*8.2.3 Materials*

*8.2.3.1 Trait impulsivity*

Prior to participation in the gambling simulation, participants completed the Barratt Impulsivity Scale version 11 (BIS-11; Patton, Stanford, & Barratt, 1995 see Appendix B), a questionnaire designed to assess the personality/behavioural construct of impulsiveness. The BIS-11 is a 30-item questionnaire capable of providing an overall impulsivity score, as well as measures scores on sub-components of impulsivity, including attentional, motor, and non-planning impulsivity. Eight of the 30 items focus on attentional impulsivity, and 11 items are used to assess both motor and non-planning impulsivity respectively. All items are rated using a 1-4 scale, with higher scores indicative of greater levels of trait impulsivity.

*8.2.3.2 Behavioural response inhibition task*

The electronic slot machine simulator consisted of 90 trials (gambling events) in each condition. With the exception of the structure change condition, the machine was activated by pressing the 'spin button' which was the spacebar on a standard keyboard. The spin button on the slot machine simulator visual display varied in colour from green to red, with green trials indicating participants could spin the machine and continue gambling, but red indicating that they need to withhold their motor responses. Response inhibition was therefore measured with an 'online' behavioural go/no go task, as the task was embedded into the gambling simulator. The first 30 trials of each condition were all green ‘go’ responses, often referred to as a ‘training phase’ in classic response inhibition tasks (for a review, see Simmonds et al., 2008). The purpose of the first 30 trials all being go-trials was to allow any prepotent patterns of motor responses to develop during the slot machine gambling. The remaining 60 trials in each condition consisted of a random 4:1 ratio of green ‘go’ to red ‘no-go’ trials.

*8.2.3.3 Dissociation*

Dissociative experience was assessed using a modified version of Jacobs’ (1988) four-item dissociation scale. As with Experiment 1, the original scale was modified in two ways for the current research. First, the original four items were modified to ask participants to reflect on the gambling session they had just participated in, as opposed to gambling experience in general. For example, the question ‘When gambling, how often do you feel like you have been in a trance?’, was modified to read ‘Thinking back to the gambling session you have just completed, how often did you feel like you were in a trance?’. The second modification of the scale was the addition of a fifth item, asking participants about their perception of time during the gambling session, an item incorporated into previous experimental gambling research (see e.g., Gupta & Derevensky, 1988; Blaszczynski et al., 2015). All five items were self-report on a five-point Likert-scale, anchored at 1, ‘never’, and five, ‘all the time’. The midpoint of the scale, 3, indicated ‘occasionally’.

*8.2.3.4 Subjective arousal and valence*

As with Experiment 1, participant subjective levels of arousal and valence during each experimental condition were assessed using the Self-Assessment Manikin approach (SAM; Lang, 1980b), which is a non-verbal pictorial assessment technique that directly measures the pleasure and arousal associated with a person's affective reaction to a wide variety of stimuli (for a full discussion, see Chapter 4). Full body versions of the SAMs were used for both the valence and arousal scale (portrait-only versions are available for the valence scale), and both scales were presented in their nine-point scale versions (see valence and arousal SAMs in Figure 4.1 Chapter 4).

*8.2.3.5 Perceived self-control*

Participants’ perceived level of self-control was assessed using a single-item nine-point Likert scale. Perceived self-control was assessed to ascertain to what extent participants felt they were exercising self-control during the various gambling conditions. Participants were asked, ‘To what extent do you feel you were in control of your actions during the last gambling session?’ Responses were anchored at 1, ‘no self-control’, and 9,’maximum self-control’. The midpoint of the scale, 5, was labelled ‘moderate levels of self-control’.

*8.2.3.6 Motivation*

To assess the influence of the harm-minimisation interventions on participant motivation to exercise self-control, following the gambling simulation, participants were asked, 'To what extent did you feel motivated to stay in control of your actions?' Responses could be made on a nine-point Likert scale which was anchored at 1,'no motivation', and 9, 'extremely motivated'. The midpoint of the scale, 5, was labelled 'moderately motivated'.

*8.2.4 Procedure*

Each participant was randomly assigned to gamble on a three-reeled electronic slot machine simulator in one of five conditions: a no-intervention control condition; emotive pop-up message intervention; informative pop-up message intervention; structure change intervention; and a financial 'punishment' condition. Participants were provided with £10 to gamble with, which was converted into 100 credits with each spin of the slot machine costing one credit (10p). Participants were informed that any credits they had left at the end of the gambling session would be converted back into money for them to keep.

Participants were given a tutorial on how to operate the slot machine and were informed of what each of the visual display features were, including the pay-line, credit balance, and win totals on winning spins (see Figure 5.2 in Experiment 1, Chapter 5). A pay-out structure was also shown to participants during the tutorial, showing how much money could be won for specific matching symbols. Participants were instructed to only spin the reels on the slot machine when the spin button on the visual display was green in colour, and instructed they must withhold from pressing the spin button when it was red in colour. The slot machine was programmed to spin automatically on 'no go' trials after a delay equivalent to 1.5s. The first 30 trials of each slot machine condition were all 'go' trials, and the remaining 60 trials consisted of a 4:1 ratio of go to no-go trials. Following the gambling simulation, participants were asked to complete the arousal SAM, valence SAM, 5-item measure of dissociation, single-item measure of perceived self-control, and single-item measure of motivation, in that order. All scales were completed electronically immediately following the gambling simulation in each condition.

*8.2.4.1 Structure change*

In all conditions, with the exception of the structure change condition, the slot machine was operated by pressing the space bar on a standard keyboard when the spin button was green in colour on the visual display. However, in the structure change condition, the operation of the slot machine consisted of pressing *either* the left arrow key *or* the right arrow key, depending on the image of the black directional arrow displayed within the green spin button on the visual display (see Figure 8.1).

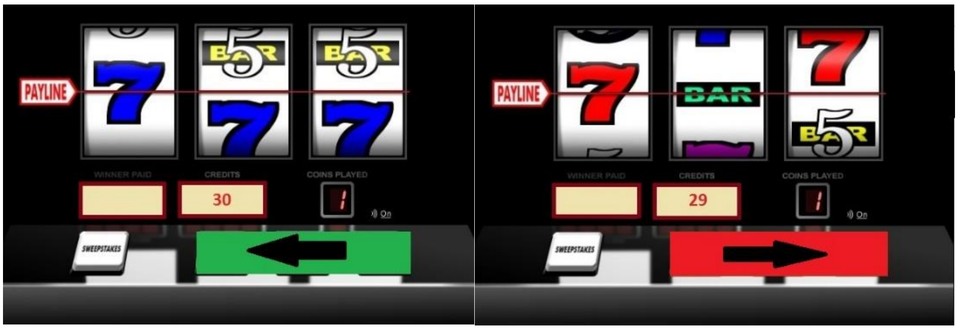


***Figure 8.1.*** Screen shots from slot machine used in the structure change condition. Reels were operated by pressing the corresponding arrow on the keyboard relative to the direction of the arrow in the visual display. Trials where the spin button turned red (see right-hand image) required participants to withhold motor responses. In all other conditions, the reels were operated by pressing space bar on a standard keyboard.

### *8.2.4.2 Pop-up messages*

In both pop-up message intervention conditions, a pop-up message appeared on screen for 30 seconds after the 30th trial. The message could not be skipped, and gambling could only continue once the message had been on screen for 30 seconds. Depending on the condition, the message either displayed general information about potential dangers relating to gambling, or displayed emotional content related to potential familial and financial consequences stemming from a loss of self-control (see Figure 8.2).


***Figure 8.2.*** Pop-up responsible gambling messages used in Experiment 2. Pictured left is the emotive message designed to force gamblers to reflect on the familial and financial consequences of losing control during gambling. Pictured right is the non-emotive informative message, providing information explaining that a loss

of control can occur sub-consciously. Both messages appeared on screen following the 30th gambling event (trial) in their respective conditions. They remained on screen for 30 seconds and could not be skipped.

*8.2.4.3 Punishment*

In the punishment condition, participants were informed that erroneously pressing the spin button during a no-go trial (i.e., when the spin button turned red) would result in 10% of their final winnings being deducted for each erroneous response. Participants were not actually financially punished for erroneous responses but were only informed of this during the experimental debrief, which was a necessary deception for the potential aversive consequences to appear real.

## ***8.3 Ethics***

Before commencement of the study, the study was approved by the researcher's University Ethics Committee. The study protocol was designed in accordance with guidelines of the Declaration of Helsinki. Participants were fully briefed and instructed on how to complete all tasks prior to the beginning of the experiment and provided their informed consent to take part in the study. Participants were informed that all the data were confidential and anonymous.

## ***8.4 Results***

*8.4.1 Age effects*

Although there was some variability in participant mean ages across conditions (see Table 8.1), a between-participants ANOVA showed that this difference failed to reach statistical significance (F[4,59]=1.62, *p*=.182, $\eta^2$ =.105

*8.4.2 Trait impulsivity*

Participant mean BIS-11 scores were calculated and compared across experimental conditions. As well as overall BIS-11 scores, means were calculated and compared across groups for all second-order factors identified on the BIS-11, namely, Attentional, Motor, and Non-planning impulsivity. Attentional impulsivity means were derived from scores on eight items, Motor and Non-planning impulsivity means are both derived from scores on 11 items. All items were rated on a 1-4 scale, indicating the range of scores possible for Attentional impulsivity = 8-32; Motor and Non-planning impulsivity =11-44, and Overall impulsivity scores =30-120, with higher scores indicating higher levels of impulsivity.

Results from the between-participants ANOVA demonstrated that the difference in overall mean impulsivity scores for participants in the control condition (58.42, SD=6.89), emotive messaging condition (59.00, SD=6.59), informative message condition (59.75, SD=8.97), structure change condition (59.67, SD=5.60), and punishment condition (59.17, SD=5.72), did not reach statistical significance, F(4,59)=.075, *p*=.89, $\eta^2$ =.005.

The ANOVA also demonstrated that difference in means across conditions on the second-order factors Attentional impulsivity (F[4,59]=.716, *p*=.59, $\eta^2$ =.049), Motor impulsivity (F[4,59]=.155, *p*=.96, $\eta^2$ =.011), and Non-planning impulsivity (F[4,59]=.045, *p*=.99, $\eta^2$ =.003), all failed to reach statistical significance (see Table 8.1 for all means and standard deviations). Taken together, these results indicate that the random allocation of participants to experimental groups did not result in higher trait impulsivity levels across groups, maximising the likelihood that any differences in response inhibition performance are due to the experimental effects rather than any underlying impulsive tendencies.

**Table 8.1.** *Participant mean (SD) age and baseline impulsivity scores across experimental conditions. Impulsivity was assessed using the BIS-11 and scores were broken down into overall BIS-11 scores as well as the three second-order factors listed here.*

| Condition | Participant variable | | | | |
|---|---|---|---|---|---|
| | BIS-11 non-planning | BIS-11 motor | BIS-11 Attention | BIS-11 overall | Age |
| Control | **21.25** *(3.31)* | **21.08** *(3.26)* | **16.08** *(2.27)* | **58.42** *(6.89)* | **29.17** *(9.38)* |
| Structure change | **21.58** *(3.18)* | **21.17** *(2.95)* | **16.91** *(1.98)* | **59.67** *(5.60)* | **35.25** *(11.48)* |
| Emotive message | **21.25** *(2.83)* | **20.58** *(2.81)* | **17.17** *(2.69)* | **59.00** *(6.59)* | **31.67** *(7.49)* |
| Informative message | **21.08** *(3.77)* | **21.08** *(3.63)* | **17.58** *(2.97)* | **59.75** *(8.97)* | **25.50** *(6.35)* |
| Punishment | **21.41** *(2.27)* | **21.58** *(2.91)* | **16.17** *(3.16)* | **59.17** *(5.72)* | **29.83** *(12.45)* |

Note: Overall participant BIS-11 scores, all second-order BIS-11 factors, and participant mean ages were statistically non-significant across experimental conditions.

### *8.4.3 Response inhibition performance*

Results from the between-participants ANOVA showed a statistically significant difference (F[4,59]=9.92, *p*<.001, $\eta^2$ =.42) between mean response inhibition scores across the control condition (68.75%, SD=16.71), emotive message condition (66.67%, SD=13.29), informative message condition

(65.28%, SD=15.42), structure change condition (84.72%, SD=9.29), and punishment condition (91.67%, SD=9.40).

Bonferroni pairwise comparison showed that only response inhibition performance in the structure change condition (*p*=.044, *d*=1.18) and punishment condition (*p*=.001, *d*=1.69) differed statistically significantly from the control condition, where performance was facilitated by both interventions. Furthermore, performance levels were statistically significantly higher in the structure change condition compared to both the emotive message (*p*=.014, *d*=1.57) and informative message conditions (*p*=.007, *d*=1.53). Performance levels were also statistically significantly higher in the punishment condition compared to both the emotive message (*p*<.001, *d*=2.17) and informative message conditions (*p*<.001, *d*=2.07). A non-statistically significant difference in performance was found between the structure change and punishment conditions, and no difference in performance was found between the two variations of messaging interventions. Table 8.2 and Figure 8.3 below summarise the response inhibition findings from Experiment 2.

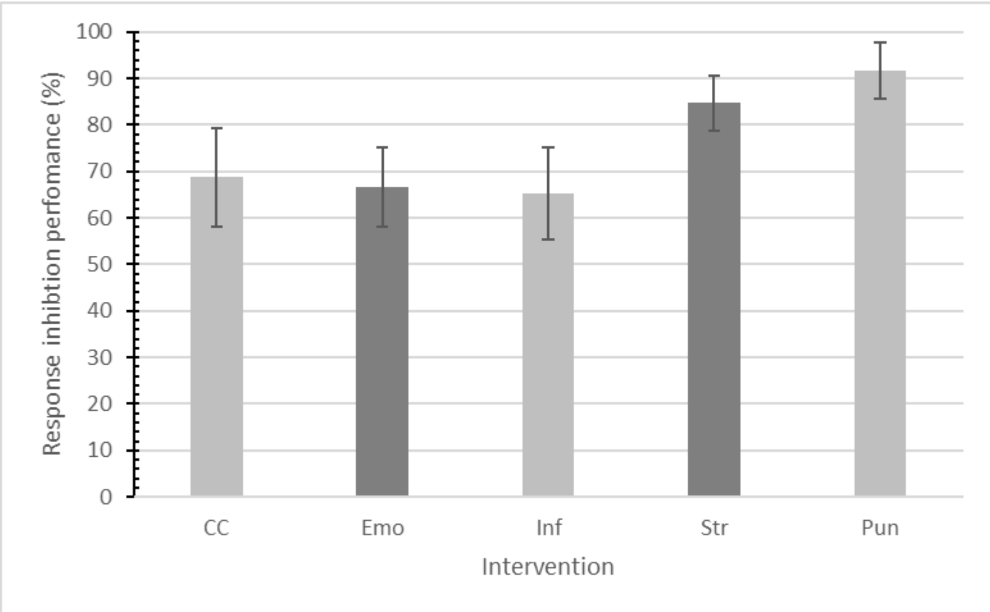


***Figure 8.3.*** Mean response inhibition performance in the control (CC), emotive message (Emo), informative message (Inf), structure change (Str), and punishment (Pun) intervention conditions. Error bars depict 95% confidence intervals.

### *8.4.4 Reaction time*

Results from the between-participants ANOVA showed a statistically significant difference (F[4,59]=13.60, *p*<.001, $\eta^2$ =.50) between mean reaction time across the control condition (.62s, SD=.19), emotive message condition (.60s, SD=.21), informative message condition (.68s, SD=.22), structure change condition (1.01s, SD=.25), and the punishment condition (1.14s, SD=.28). Bonferroni pairwise comparison showed that only mean reaction time in the structure change condition ($p$=.001, $d$=1.76) and punishment condition ($p$<.001, $d$=2.17) differed statistically significantly from the control condition, where reaction time was increased (slowed) in both conditions. Furthermore, reaction times were statistically significantly higher in the structure change condition compared to both the emotive message ($p$=.001, $d$=1.78) and informative message conditions ($p$=.011, $d$=1.40). Mean reaction times were also statistically significantly higher in the punishment condition compared to both the emotive message ($p$<.001, $d$=2.18) and informative message conditions ($p$<.001, $d$=1.83). A non-statistically significant difference in reaction time was found between the structure change and punishment conditions, and no difference in reaction time was found between the two variations of pop-up messaging interventions.

*8.4.5 Arousal*

A between-participants ANOVA showed a non-statistically significant difference in mean arousal ratings across conditions (F[4,59]=2.04, $p$=.101, $\eta^2$ =.129). Broadly speaking, reported arousal levels in all conditions were moderately high, with all mean arousal scores being above the midpoint of the scale (see table 8.2 for means and standard deviations). Collapsing all the groups into a single data set showed that the overall grand mean arousal score was 6.40 (SD=1.15), which is a closely comparable rating when compared to the mean arousal rating of 6.60 in the fast condition found in Experiment 1, confirming the arousing nature of games with high event-frequencies.

*8.4.6 Dissociation*

A between-participants ANOVA showed a non-statistically significant difference in mean dissociation scores across conditions (F[4,59]=.265, $p$=.899, $\eta^2$ =.02). Dissociation scores overall were extremely low, with a grand mean dissociation score of 6.98 (SD=1.99) where possible scores could range between 5 and 25 (see Table 8.2 for means and standard deviations). Furthermore, the most common rating on the five-point scale was a '1' ('never'), indicating potential floor effects, but also confirms results from Experiment 1 that demonstrated dissociation levels at fast speeds of play during gambling are very low.

*8.4.7 Valence*

A between-participants ANOVA showed a statistically significant difference (F[4,59]=2.77, $p$=.036, $\eta^2$ =.17) between mean valence ratings across the control condition (5.58, SD=1.31), emotive message condition (5.33, SD=1.33), informative message condition (4.33, SD=1.07), structure change condition (5.42, SD=1.00), and punishment condition (4.50, SD=1.31). Overall, mean valence levels were around the midpoint of the nine-point scale, with the highest mean valence levels being reported in the control condition and lowest in the informative message condition. However, Bonferroni pairwise comparisons demonstrated that the difference in means between groups fell below the threshold for statistical significance when adjustment for multiple comparisons was made.

*8.4.8 Perceived self-control*

A between-participants ANOVA showed a statistically significant difference ($F[4,59]=7.76$, $p<.001$, $\eta^2=.36$) between mean perceived self-control ratings across the control condition (6.42, SD=1.08), emotive message condition (5.58, SD=.90), informative message condition (5.83, SD=1.03), structure change condition (7.17, SD=1.11), and punishment condition (7.50, SD=1.00). Bonferroni pairwise comparison showed that there was no statistically significant difference in mean perceived self-control in all experimental conditions when compared to the control condition. Self-control ratings were statistically significantly higher in the structure change condition when compared to the emotive message ($p=.004$, $d=1.57$) and informative message condition ($p=.024$, $d=1.25$). Mean ratings were also statistically significantly higher in the punishment condition when compared to the emotive message ($p<.001$, $d=2.02$) and informative message condition ($p=.002$, $d=1.65$). There was a non-significant difference between the structure change and punishment condition self-control ratings, and a non-significant difference between the emotive and informative message conditions.

Similar to the findings in Experiment 1, self-control ratings overall were relatively high, with all condition demonstrating a mean rating above the midpoint of the scale, with an overall grand mean of 6.5 (SD=1.24) on the nine-point scale. The results show that both the structure change and punishment intervention raised participant levels of perceived self-control relative to both types of pop-up message interventions, but did not increase this perception beyond levels demonstrated in the control condition.

*8.4.9 Motivation*

A between-participants ANOVA showed that participant self-report motivation to exercise self-control differed to statistical significant degree across conditions ($F[4,59]=4.98$, $p=.002$, $\eta^2=.266$). In the control condition, mean motivation score was 5.17 (SD=1.53), 6.75 (SD=1.42) in the emotive message condition, 5.67 (SD=1.49) in the informative message condition, 5.67 (SD=.78) in the structure change condition, and 7.17 (SD=1.11) in the punishment condition. Bonferroni pairwise comparisons showed that relative to the no-intervention control group, only motivation levels in the emotive message ($p=.042$, $d=1.07$) and punishment condition ($p=.004$, $d=1.50$) differed to a statistically significant degree, where motivation levels were higher relative to the control group. All other pairwise comparisons failed to reach statistical significance. Table 8.2 below summaries all means and standard deviations across experimental conditions for all dependent variables.

**Table 8.2.** *Mean (SD) dependent variable scores and ANOVA p-values across conditions.*

| Condition | Dependent variable | | | | | | |
|---|---|---|---|---|---|---|---|
| | Response inhibition (%) | Reaction time (s) | Dissociation total (5-25) | Arousal (1-9) | Valence (1-9) | Perceived self-control (1-9) | Motivation (1-9) |
| Control | **68.75** *(16.71)* | **.62** *(.19)* | **7.17** *(2.17)* | **6.50** *(1.31)* | **5.58** (1.31) | **6.42** *(1.08)* | **5.17** *(1.53)* |
| Emotive message | **66.67** *(13.29)* | .**60** *(.21)* | **7.42** *(2.20)* | **6.25** *(1.14)* | **5.33** (1.33) | **5.58** *(.90)* | **6.75** *(1.42)* |
| Informative message | **65.28** *(15.42)* | **.68** *(.22)* | **6.83** *(2.25)* | **6.58** *(1.16)* | **4.33** (1.07) | **5.83** *(1.03)* | **5.67** *(1.49)* |
| Structure change | **84.72** *(9.29)* | **1.01** *(.25)* | **6.67** *(1.61)* | **5.75** *(.97)* | **5.42** (1.00) | **7.17** *(1.11)* | **5.67** *(.78)* |
| Punishment | **91.67** *(9.40)* | **1.14** *(.28)* | **6.83** *(1.90)* | **7.00** *(.95)* | **4.50** (1.31) | **7.50** *(1.00)* | **7.17** *(1.11)* |
| ANOVA p-value | <.001 | <.001 | =.899 | =.101 | =.036 | <.001 | =.002 |

### *8.5 Discussion*

In support of H1, Experiment 2 found evidence that response inhibition performance was statistically significantly improved for participants gambling on a slot machine with an adapted structure, when compared to a control condition. Requiring participants to simply discriminate between a left button press and a right button press in order to activate the slot machine resulted in 85% of correctly inhibited motor responses, compared to 69% in a non-intervention control condition. Furthermore, and in support of H2, the structure change intervention improved response inhibition performance to a statistically significant degree when compared to both types of pop-up message interventions. There was no evidence in support of H3; response inhibition performance remained consistent irrespective of the type of message that was presented in the pop-up messages, meaning emotional content had no greater impact on response inhibition than general informative content. Both pop-up message conditions also failed to facilitate motor response inhibition when compared to the control condition. Finally, there was only partial support for H4. Adjusting the motivational salience of no-go cues in the punishment condition resulted in a statistically significantly greater number of correctly inhibited motor responses when compared to a control condition and both forms of pop-up message intervention. However, although response inhibition performance in the punishment condition (91%) was higher than in the structure change condition (85%), this difference failed to reach statistical significance. This pattern of results indicates that existing harm-minimisation approaches, namely pop-up message interventions, were not successful in facilitating the motor aspect of behavioural inhibition in this slot machine simulation. New approaches requiring gamblers to actively attend to gambling cues, or that enhance their motivation to exercise greater levels of self-control, appear to be more successful in facilitating response inhibition.

### *8.5.1 Valence*

Valence ratings failed to reach statistical significance when the critical p-value was adjusted for multiple comparisons, suggesting that the interventions did not significantly affect the enjoyment of the gambling experience. However, this statistical interpretation should be taken with caution because the ANOVA showed there was a statistical significance in valence ratings between conditions. A closer examination of mean valence scores across conditions demonstrates that whilst valence was positive in the control condition, structure change condition and emotional message condition, mean valence fell below the midpoint of the scale in the punishment and informative message condition, indicating an overall small degree of negative affect in these conditions. Encouraging for harm-minimisation approaches to gambling was the fact that affect in the structure change condition remained positive and comparable to the control condition with no intervention, meaning the approach did not detract from the enjoyment of the gambling experience.

### *8.5.2 Reaction time*

Participant reaction times were significantly slower in the structure change and punishment conditions when compared to all other conditions, demonstrating the important role of response speed on response inhibition performance in this gambling simulation. This finding is consistent with multiple research accounts demonstrating speed-accuracy trade-off effects, where in general, faster responses on a variety of cognitive tasks leads to more inaccurate and erroneous responses (MacKay, 1982; Rinkenauer et al., 2004; van Veen, Krug, & Carter, 2008). Reasons for this slowing of response times relative to a control condition in these conditions are likely distinct. The structure change condition required a greater level of attention allocation to the go cues, as operating the slot machine required a discriminatory choice to be made between pressing the left arrow button or right arrow button in order to spin the reels. Reaction times were therefore likely increased as a result of this change in structure which required greater attention to go-cues (and as a bi-product, greater attention is also given to no-go cues), as well as a small degree of deliberation being required before response execution. Gambling on slot machines usually requires only a simple button press in order to initiate a gambling event. Because of this simple structure, it is more likely that responses can be conditioned via a simple stimulus-response mapping, where the lighting up of the spin button triggers a conditioned response to press the spin button and initiate a gambling event. These simple structural approaches, such as that seen in the control condition within this experiment, have greater potential for prepotent responses to develop at the expense of more conscious and planned motor actions. Breaking this simplicity by forcing the gambler to engage in response selection had a positive impact on their ability to exercise response inhibition. Here, the greater levels of attention required in the structure change and punishment conditions likely restrain prepotent responses and allow evaluation of other response candidates.

However, in the punishment condition there was no physical change to the slot machine parameters, meaning that the increase in reaction time in this condition stems from intrinsic motivation to avoid aversive consequences for failure to withhold motor responses. This is supported by the fact that motivation levels to exercise self-control was highest in the punishment condition compared to all other conditions, and was one of only two conditions (the other being the emotive message condition) where motivation was significantly higher relative to a control condition. The purported financial consequence of failed inhibition attempts appeared to have resulted in participants exercising a greater degree of motor cautiousness, stemming from an increase in attention towards, and processing of, go and no-go cues, leading to longer reaction times upon the onset of gambling events. Therefore, the longer reactions times, which have been shown to predict more successful motor inhibition in Experiment 1, likely result from the increased attentional demands of gambling in the structure change and punishment conditions. This demonstrates that increasing attentional salience of cues relevant to motor cautiousness and self-control may represent successful gambling harm-minimisation approaches.

### *8.5.3 Arousal*

Statistical analysis showed that arousal failed to change to a statistically significant degree across experimental conditions. As a result, the efficacy of the structure change and punishment conditions in improving response inhibition performance cannot be attributed to the interventions adjusting gambler’s subjective arousal levels. Changing the relative salience of no-go cues was able to facilitate self-control in the form of response inhibition even when subjective arousal levels were moderately high.

Experiment 1 argued that increased arousal may be adjusting the perceptual processing of gambling-related stimuli at the expense of efficient processing of no-go cues. However, if latent variables in the form of attention allocation are driving the relationship between the successful interventions and improved response inhibition performance found here in Experiment 2, given the lack of change in arousal across conditions, this means that effective processing of no-go cues can be enhanced independent of subjective changes in arousal. As a result, harm-minimisation approaches do not necessarily need to detract from the arousing experience of gambling, as here it has been demonstrated that response inhibition can be facilitated by enhancing the salience of cues designed to facilitate motor caution.

*8.5.4 Pop-up messages*

Pop-up messages in gambling are tools aimed towards increasing self-reflection and self-monitoring which research has shown can successfully impact behaviour in the desired direction (Gilberts et al., 2001; Hardeman et al.,2002). Here it was investigated if pop-up messages, which also provide a break in play, were successful in facilitating response inhibition performance during gambling. The messages investigated here presented either general information about self-control, or emotional content highlighting the financial and familial consequences of a loss of self-control during gambling. Both types of message were unsuccessful in facilitating response inhibition relative to a control condition, and neither message was more successful than the other, suggesting that emotionally valenced messages are no more efficacious in facilitating the motor aspect of self-control than non-emotional informative content. The pop-up messages tested here appeared unable to facilitate the desired level of attention towards no-go cues. Of the two types of messages, only the emotive message was able to significantly enhance motivation for self-control, relative to a control condition. However, the elevated motivation to exercise self-control found among participants in the emotive message condition was not sufficient to improve response inhibition performance.

This finding appears contradictory to the results obtained in the punishment condition, where motivation for self-control was also high and was accompanied by enhanced response inhibition performance. Whilst both the emotive message and punishment conditions highlighted aversive outcomes for a lack of self-control, the nature of the aversive outcomes were not necessarily equal and differ on temporal factors. For example, the familial and financial consensus portrayed in the emotive message condition likely reflect the consequences of long-term loss of control. On the other hand, the purported financial penalties in the punishment condition had a potentially immediate financial impact on the participant. As a result, though both conditions enhanced motivation for self-control, motivation itself appears insufficient for gamblers to exercise self-control unless potential outcomes are closer in temporal proximity.

Overall, these findings are problematic given the wide use of pop-up messages as a harm-minimisation tool in gambling and the important role motor inhibition plays in self-control during gambling. However, there is a range of research demonstrating that pop-up messages have been successful in correcting irrational beliefs (Floyd et al., 2006; Cloutier et al., 2006) as well as encouraging gambling cessation (Auer & Griffiths, 2015). It is difficult to compare pop-up message research given the variety of formats and contents of the messages across studies, as well as the dependent variables of interest. For example, this is the first study to the present author's knowledge that has experimentally examined the efficacy of pop-up messages in facilitating motor response inhibition and is among the first to experimentally examine the use of emotional content in messages as a harm-minimisation approach (see also, Munoz et al., 2014).

The disparity of results relating to pop-up messages as a harm-minimisation tool might suggest that specific tools impact upon different psychological processes within a gambling context. Here, regardless of content, pop-ups were unable to facilitate motor inhibition, although elsewhere they have been shown to combat erroneous thoughts and illusions of control during gambling (e.g. Floyd et al., 2006). This distinction is tantamount to the difference between thought and action. It may be the case therefore, that pop-ups are better suited to influencing thought and choice, but are less successful in influencing action in the form of motor inhibition. Experiment 3 of the thesis will examine the efficacy of harm-minimisation approaches across a variety of cognitive domains relevant for self-control during gambling, including motor inhibition, delay discounting, and reflection impulsivity. Approaches that have shown to be successful here, such as changing the structure of the game to increase attentional demands, may not automatically be successful in influencing wider aspects of cognition required for self-control during gambling. Equally, approaches such as pop-ups that were unsuccessful in influencing impulsive action may be successful in combating the choice component of impulsivity.

*8.5.5 Caveats*

The general limitations of the experimental approach to gambling research have already been discussed in detail in Chapter 4. In addition, the limitations of the use of self-report measures of emotional responses, as well as the limitations of the slot machine simulator designed for these thesis studies, have already been discussed in Experiment 1 in Chapter 5. Therefore, only the caveats unique to the present experiment will be discussed here.

*8.5.5.1 Pop-up messages*

Whilst different iterations of pop-up message were tested for their efficacy in facilitating response inhibition during gambling in this experimental simulation, pop-up messages have been used to display a variety of information with successful outcomes. For example, pop-ups have also been used successfully to remind gamblers of the amount of time and money they have spent gambling (Monaghan & Blaszczynski, 2007; 2010a; 2010b). They are also becoming more sophisticated and being combined with other harm-minimisation approaches, such a behavioural tracking tools, to provide gamblers with normative behavioural feedback which has been shown to increase gambling cessation (Auer & Griffiths, 2015). Motor response inhibition represents an important aspect of executive control necessary for self-control during gambling (Hoffman, Schmeichel, & Baddeley, 2012), although it is not the only factor pertinent to controlled gambling. Other psychological factors including cognitive biases, problem solving skills, and reflection impulsivity are all factors that likely determine the likelihood of an individual experiencing gambling-related harm. As a result, although pop-up messages in this experiment were unable to support response inhibition, their efficacy may lay in supporting wider psychological domains important for self-control during gambling.

*8.5.5.2 Speed of play*

Experiment 1 of the thesis identified that inhibition performance was significantly impaired during slot machine gambling with fast speeds of play. As a result, Experiment 2 focused on slot machine gambling with the highest event frequency. However, it was demonstrated in Experiment 1 that the psychological factors that predict response inhibition performance vary as a result of the speed/duration of play. Although slower speeds of play were associated with improved response inhibition performance, levels of dissociative experience were a negative predictor of response inhibition at slower speeds. As a result, harm-minimisation approaches shown to be unsuccessful in facilitating response inhibition at fast speeds in the present experiment, namely pop-up message interventions, may be better suited to gambling at slower speeds of play and/or longer gambling durations. Due to the intense absorption and often time disorientation experienced by gamblers engaging in electronic forms of gambling (Monaghan, 2009), tools such as pop-up messages that are designed to temporary draw focus away from gambling have high face validity. Both Experiment 1 and the present experiment found that levels of dissociative experience were extremely low when gambling at fast speeds of play, but Experiment 1 highlighted that as game speed slows and the associated time spent gambling increases, dissociative tendencies also increase. Therefore, harm-minimisation approaches such as pop-up messages are likely better suited during slower gameplay and/or longer gambling session durations to break these associated dissociative states.

*8.5.5.3 Participants*

Although baseline levels of impulsivity were controlled across groups according to BIS-11 scores (which includes measures of secondary factors including motor impulsivity), participants were not matched on response inhibition according to performance on impulsivity task performance outside of a gambling context. In addition, data pertaining to potential clinical problems were not obtained from participants. For example, ADHD, other impulse and compulsive control disorders, as well as other addictions represent underlying issues that could impact group level differences for motor and choice impulsivity measures found in this study, particularly given the relatively small number of participants (n=12) in each of the five conditions.

*8.5.6 Implications and conclusion*

This experimental gambling simulation demonstrated that the presence of potential aversive financial consequences for failed motor inhibition was sufficient for participants to exercise motor cautiousness, leading to improved response inhibition during gambling. However, the feasibility and ethical viability of implementing such approaches in a real-world gambling environment is questionable. Although financial consequences for failed inhibition has sown to be beneficial for self-control here, it is an approach unlikely to be accepted by gambling patrons and regulators as a harm-minimisation tool. Implementing simple structural changes to the operation of a slot machine had a comparable positive impact on self-control, and arguably represents a more feasible and less controversial harm-minimisation approach during electronic gambling.

Structural changes that force increased attention towards motor responses and induce responses that are more cautious offer a fruitful avenue of exploration to help shape gambling behaviour in favour of greater levels of self-control. Aversive consequences for poor self-control need not take the form of financial punishment. Such consequences could include enforced breaks in play, or 'freeze-outs'. These may temporarily prevent gambling participation and also act as a cooling off period for gamblers pre-empting spin/gamble buttons before an appropriate event-duration, with the intended outcome being a reduction in rapid response styles that may lead to erroneous and impulsive responses and decisions.

Furthermore, previous research has also demonstrated that inducing motor cautiousness during gambling tasks leads to a reduction in monetary risk-taking (Verbruggen, Adams, & Chambers, 2012). Adjusting the structure of the slot machine or imposing aversive consequences for failed motor inhibition may therefore impact upon wider cognitive processes as well as motor inhibition performance. Verburggen and colleagues (2012) make the theoretical argument that executive control processes within motor domains share mechanisms with monetary decision-making and gambling. This proposition is also supported by recent neuroscience studies that have shown that frontal brain regions involved in response inhibition and action monitoring might also be involved in monetary decision-making in gambling tasks (Clark, 2010; Knoch et al., 2006).

Although motor inhibition represents an important aspect of executive control, other processes such as decision-making deficiencies are implemented as risk-factors for problem gambling (for review see Clark, 2010). Experiment 1 of the thesis has demonstrated that the speed of gambling can impact response inhibition capacity in heathy regular gamblers, with fast speeds of play resulting in reduced ability to withhold motor responses when required. The present experiment has demonstrated that response inhibition in healthy regular gamblers can be facilitated when gambling at fast speeds of play by imposing aversive consequences for failed inhibition or increasing the attentional demands of slot machine gambling by adjusting the structure of the spin button. Tackling decision-making deficits is arguably a more complex task, especially given the fact that maladaptive cognitive biases and gambling-related decision styles are often robust and resistant to change (Toneatto & Ladoceur, 2003). If there is a link between impulsive action and impulsive choice domains, as aforementioned research discussed here suggests, then it may be possible to influence gambling-related decision by controlling motor response styles. The present experiment demonstrated that simple slot machine structure changes can lead to more favourable response styles conducive to response inhibition. Experiment 3 of the thesis investigates whether this approach to inducing greater levels of response inhibition has a transfer effect to wider executive control domains pertinent to self-control during gambling.

# Chapter 9. Impulsivity Transfer Effects

### *9. Chapter overview*

The present chapter serves as the introductory chapter for Experiment 3. The main aim of Experiment 3 is to assess if inducing motor cautiousness during gambling has cautiousness transfer effects to wider executive cognitive domains, including delay discounting and information sampling. The present chapter therefore discusses transdisciplinary research findings from both human and animal studies that explores the nature of the relationship between impulsive choice and impulsive action.

### *9.1 Introduction*

Several research studies have noted that the construct of impulsivity should be considered multifaceted, comprising sub-domains representing distinct processes (for a review see: Arce & Santisteban, 2006). A number of scholars (e.g., Evenden, 1999; Bechara, Damasio, & Damasio 2000; and Bechara, 2002) make the distinction between motor impulsivity and cognitive/choice impulsivity. Motor impulsivity is considered the antithesis of motor response inhibition, typically assessed using the Go/No-go task, as seen in the first two experiments of this thesis, although it can also be assessed with the Continuous Performance Test (e.g., Holmes et al., 2002) and the Stop Signal Task (e.g., Avila et al., 2004). Motor impulsivity is usually associated with disruption to the dorsolateral prefrontal cortex (Bechara, Damasio, & Damasio, 2000). For example, individuals with frontal cortex lesions are more likely to display risky and more impulsive behaviour when it is contextually inappropriate (Duncan, 1986; Shallice, 1982). Brain stimulation studies utilising techniques such as transcranial magnetic stimulation (TMS) show that similar patterns of behaviour are found in healthy individuals when these brain regions are stimulated (e.g., Chambers et al., 2006; Verbruggen, Aron, Stevens, & Chambers, 2010).

Cognitive impulsivity is considered the inability to weigh the consequences of immediate and future events, with higher levels of cognitive impulsivity being associated with an inability to delay gratification (Arce & Santisteban, 2006). Cognitive impulsivity is typically assessed with approaches including the Iowa Gambling Task (Bechera et al., 1994), as well as experimental delay discounting tasks (Matta, Gonçalves, & Bizarro, 2012), including the Monetary Choice Questionnaire (Kirby, Petry, & Bickel, 1999). Although still associated with prefrontal cortex regions in the brain, lesion studies suggest that the ventromedial region of the prefrontal cortex is the main area involved in cognitive impulsivity (Bechara, 2002).

More recent research into human impulsivity has resulted in an increased understanding of the neurobiological mechanisms involved in impulsivity, leading to the view that impulsivity is not a unitary construct. However, whilst psychopathological research has identified distinctions between impulsive choice and action in disorders including ADHD (Solanto et al., 2001) and substance abuse (Broos et al., 2012a; Diergaarde et al., 2008), there is also evidence suggesting a considerable overlap between neurotransmitter systems and brain regions involved in impulsive choice and impulsive action (Chambers, Garavan, & Bellgrove, 2009; Peters & Buchel, 2011). This brings into debate the degree to which these two constructs are distinct. The aims of Experiment 3 are therefore to assess the nature of this relationship between impulsive choice and action within a gambling context, with a view to assessing the impact of gambling harm-minimisation tools in reducing levels of impulsivity displayed by gamblers within a gambling session.

*9.1.1 Evidence for distinction between impulsive choice and impulsive action*

Broos et al. (2012b) examined the relationship between impulsive choice and impulsive action amongst 101 healthy university student participants. They compared within-participant delay discounting (impulsive choice) with performance on a modified continuous performance task (immediate and delayed memory task) and a stop signal task (impulsive action). Performance on these behavioural tasks was also compared with self-report impulsivity using the BIS-11 (Patton, Stanford, & Barratt, 1995). Results showed that the immediate and delayed memory task performance correlated positively with each other, but there was no correlation between performance on these tasks assessing impulsive action with delay discounting rates in the delayed discounting task assessing impulsive choice. Additionally, there was only a weak correlation between the delayed memory task and Stop Signal Task performance. Furthermore, BIS-11 scores failed to correlate significantly with any of the behavioural measures of impulsivity.

In the same study, Broos and colleagues (2012) also conducted a similar investigation with rats, using analogous measures of impulsive choice and action, yielding a similar pattern of results as those with human participants. Their results from human participants suggest impulsive choice and impulsive action are largely unrelated in healthy adults. Furthermore, there may even be some level of dissociation to be made within behavioural measures of impulsive action given the weak (if any) correlation between the Stop Signal Task and delayed and immediate memory task performance, respectively.

Furthermore, Evenden (1999) reports a series of drug trials using rats that provide support for the notion that different aspects of impulsivity are dissociable from one another and consist of different biological bases. Evenden (1999) identified that different drugs had distinct effects on three measures of impulsivity – an unreliable visual discrimination task, a paced fixed consecutive number task, and a variable delay of reinforcement task. For example, ethanol increased impulsivity within rats on the variable delay of reinforcement task, but had no effect on performance assessed using the other impulsivity measures. Amphetamine increased impulsivity on both the Paced Fixed Consecutive Number Task and Variable Delay of Reinforcement Task, but had no effect on performance in the Unreliable Visual Discrimination Task. Imipramine, a tricyclic antidepressant, reduced impulsive tendencies on both the visual discrimination task and paced fixed consecutive number task, but had no effect on performance on the variable delay of reinforcement task. However, several limitations exist with such evidence, most notably the fact that these experiments were conducted on non-human participants, limiting the application of this evidence to the understanding of human models of impulsivity.

Although studies with non-human mammals are often used to make predictions about human psychobiological structures and responses to drugs, they often fall short in terms of predictive value (Shanks, Greek, & Greek, 2009). Additionally, only one procedure was used to assess each impulsivity factor, meaning the drug-induced effects on impulsivity can only be applied to the specific procedure in question. This is particularly problematic given evidence suggesting there is a degree of dissociation amongst procedures purportedly measuring the same sub-component of impulsivity (e.g., Broos et al., 2012b), leading to the possibility that the drugs affect novelties associated with the procedure of tasks and not the underlying impulsivity construct *per se*.

### *9.1.2 Evidence for overlap between impulsive choice and impulsive action*

Contemporary neuroscience research offers an alternative account of the relationship between impulsive action and impulsive choice. For example, Knoch et al. (2006) used TMS to demonstrate that when the dorsolateral prefrontal cortex is disrupted from normal functioning – an area associated with the suppression of impulsive motor actions (Bogacz et al., 2010) – it leads to increased risk-taking within a gambling context. Such results have led to arguments that controlling impulses across a variety of domains including suppression of thoughts, decisions, and actions, relies on overlapping inhibitory control networks. However, direct evidence is rare because the empirical findings are typically correlational in nature (Verbruggen, Adams, & Chambers, 2012).

Studies have directly compared the neural components active in a range of tasks assessing self-control and the suppression of impulsive choice and action (for a review, see: Cohen & Lieberman, 2010). Such studies typically compare motor response inhibition performance with other forms of self-control, utilising measures such as the Flanker Task, which requires the suppression of distracting information (Bunge et al., 2002; Wager et al., 2005), and the Wisconsin Card Sorting Test, which assesses setshifting and perseverance (Konishi et al., 1999). Combined neuroimaging techniques typically show that the right inferior frontal cortex and/or right anterior insula are active during inhibition trials within such tasks, regions that are associated with response inhibition in experiments utilizing Go/No-go and Stop Signal paradigms (Bunge et al., 2002; Wager et al., 2005). Such studies indicate that various forms of self-control – a construct viewed as the antithesis of impulsivity (Bickel et al., 2012) – share underlying neural components.

Muraven and Baumesiter (2000) conducted studies assessing the relatability of different forms of self-control, a construct viewed as the antithesis of impulsivity (Bickel et al., 2012). Here, participants were asked to complete tasks involving various aspects of self-control, including the suppression of impulsive motor actions in a Stop Signal Task, as well as tasks assessing suppression of thoughts, emotions, and temptation. Participants who were asked to perform a second impulse control task generally performed worse on that task than participants who were initially asked to complete an effort-matched task not requiring self-control. These results are explained using a shared resources account of self-control, suggesting that self-control is not only a unified process, but that various aspects of self-control are derived from a limited resource that is prone to fatigue effects.

*9.1.3 Impulsivity transfer effects within a gambling context*

Within a gambling context, Verbruggen, Adams, and Chambers (2012) demonstrated that participants encouraged to exercise response inhibition and monitor their motor actions demonstrated a preference for less risky gambling choices in a novel gambling task. Requiring participants to exercise a degree of motor cautiousness in the presence of potential stop signals resulted in participants making gambling-related decisions that were less risky. In addition, participants spent more time making decisions as indicated by longer choice latencies. This line of research was later extended by Stevens and colleagues (2015) who examined whether the relationship between motor cautiousness and monetary decisions was driven by changes in arousal and/or perceptual processing style. Results showed that inducing motor cautiousness with the presence of stop signals resulted in participants selecting smaller and less risky betting choices, but that the relationship was not mediated by the stop signals adjusting the perceptual processing pattern assessed using eye tracker technology, nor was the effect mediated by the stop signals adjusting participant's arousal levels, as assessed using skin conductance responses. One explanation for these transfer phenomena offered by Stevens et al. (2015) is that the presence of stop signals adjusted the hedonic and motivational value of subsequent gambling-related stimuli, and is consistent with Dickinson and Dearing's (1979) suggestion of an antagonistic appetite and aversive centre within the brain. One key limitation of these findings is that they were based on a novel gambling procedure that does not replicate a typical gambling product structure. In addition, the procedure used to assess the choice component of impulsivity, whilst having real-world application, is not a recognised and standardised test of impulsive choice, making the findings difficult to compare with wider research assessing the relationship between different aspects of impulsivity.

The potential for impulsivity transfer effects within a gambling context provides the opportunity for harm-minimisation approaches that are designed to facilitate motor response inhibition (as seen in the second experiment of the thesis) to also influence a gambler's wider decision-making capacity within a gambling session. Although research has provided competing views regarding the relationship between subcomponents of impulsivity, neurobiological evidence suggests that there are both distinct and shared mechanisms involved within different aspects of impulsivity (Chambers, Garavan, & Bellgrove, 2009). Consequently, the context of the studies (in terms of task demands) may account for the lack of consistency between different aspects of impulsivity. For example, it could be argued that participation in the impulsivity tests administered by Broos and colleagues (2012) was passive, in the sense that the tasks lacked real-world context, and that performance on one or more tasks had no consequences. Transfer effects have been found within a gambling context (e.g., Verbruggen, Adams, and Chambers, 2012; Stevens et al., 2015), where performance on risk-taking tasks was related to monetary choice relevant to the gambling context of the study.

### *9.1.4 Relevance to Experiment 3*

It may be more difficult to directly adjust a gambler's decision-making style during a gambling session than to induce motor cautiousness because it was demonstrated in Experiment 2 of the thesis that the latter can be achieved by making simple structural changes to slot machine gambling that force gamblers to actively discriminate between responses. If an association or link exists between impulsive action and impulsivity choice, then it may be possible to positively influence the choice component of impulsivity by inducing a more cautious motor response style. From a gambling harm-minimisation perspective, it is important that any proposed approach be tested for unintentional perverse effects. For example, evidence suggests that different aspects of self-control rely on a shared pool of resources (Muraven & Baumesiter, 2000), meaning that the application of motor control during gambling could negatively affect performance on choice impulsivity tasks via fatigue effects.

# Chapter 10. Experiment 3. Gambling, Motor Cautiousness, and Choice Impulsivity: An Experimental Study

***10. Research aims and hypotheses***

The first aim of Experiment 3 was to experimentally assess if inducing motor cautiousness during a slot machine gambling simulation would result in a cautiousness transfer effect to performance on choice impulsivity tasks. The majority of aforementioned evidence from neuroscience and behavioural studies demonstrates significant overlaps between impulsive action and impulsive choice, both within and outside of a gambling context. This led to the hypothesis that inducing motor cautiousness during slot machine gambling will result in less impulsive performances on subsequent choice impulsivity tasks (H1).

If inducing a less impulsive and more controlled motor response style within a gambling context has an impact on choice impulsivity, it should also intuitively follow that inducing a rapid and highly impulsive motor response style could also influence decision-making style on choice impulsivity tasks. The second research aim of the experiment was therefore to examine the impact of inducing a rapid motor response style during slot machine gambling on subsequent performance on impulsive choice tasks. It was hypothesised that inducing a more rapid motor response style during a slot machine gambling simulation would result in greater levels of impulsivity being demonstrated in subsequent impulsive choice tasks (H2).

The third aim of the experiment was to assess the efficacy of new and existing harm-minimisation tools in facilitating more cautious decision-making during a gambling session. It was hypothesised that harm-minimisation tools successful in reducing impulsive actions would lead to reduced levels of impulsive choice (H3).

**10.1 Method**

*10.1.1 Design*

A between-participants experiment was conducted to assess the impact of new and existing gambling harm minimisation tools on impulsive action and impulsive choice. An electronic slot machine simulator was designed using a combination of the graphical user interface and coding function available on the *Psychopy* experiment builder (Peirce, 2007; see Figure 5.1 in Chapter 5). Behavioural measures of response inhibition were built into the slot machine simulator, and following each session of gambling, participants were given various online psychometric scales to complete to assess subjective arousal, dissociation, valence, and perceived self-control. All scales were presented and completed using the *Psychopy* experiment builder. Reaction time was also measured, which is a standard function in the experimental software. Choice impulsivity tasks were then conducted via the same computer platform, in the form of a 27-item Monetary Choice Questionnaire (MCQ; Kirby, Petry, & Bickel, 1999) and Information Sampling Task (IST; Clark et al., 2006; Parke et al., 2015).

*10.1.2 Participants*

A sample of 70 (53 males) non-problem, regular gamblers were recruited from amusement arcades and sports clubs in the Lincolnshire areas of the UK. These areas were targeted during the recruitment process as they were identified as areas likely to contain a high density of gamblers. All participants were classed as regular gamblers, defined for the purposes of the present study as an individual who had gambled at least once per month in the past 12 months. Participant mean age was 31.14 years (*SD*=10.90), with ages ranging from 18-60 years. A short screening questionnaire was administered to ensure that participants: (i) reported regular participation in gambling, and (ii) had never suffered with a gambling problem or were currently suffering with a gambling problem. An affirmative answer on either count of problem gambling resulted in participants being excluded from participation. Consequently, five participants were excluded from participation following the screening questionnaire, as they were found to have previously experienced problem gambling.

*10.1.3 Materials*

*10.1.3.1 Trait impulsivity*

Prior to participation in the gambling simulation, participants completed the Barratt Impulsivity Scale version 11 (BIS-11; Patton, Stanford, & Barratt, 1995 see Appendix B), a questionnaire designed to assess the personality/behavioral construct of impulsiveness. The BIS-11 is a 30-item questionnaire capable of providing an overall impulsivity score, as well as measures scores on sub-components of impulsivity, including attentional, motor, and non-planning impulsivity. Eight of the 30 items focus on attentional impulsivity, and 11 items are used to assess both motor and non-planning impulsivity respectively. All items are rated using a 1-4 scale, with higher scores indicative of greater levels of trait impulsivity.

*10.1.3.2 Behavioural response inhibition task*

The electronic slot machine simulator consisted of 90 trials (gambling events) in each condition. With the exception of the structure change condition, the machine was activated by pressing the ‘spin button’ which was the spacebar on a standard keyboard. The slot machine used in Experiment 3 had a high event frequency of 1.5s. The spin button on the slot machine simulator visual display varied in colour from green to red, with green trials indicating participants could spin the machine and continue gambling, but red indicating that they need to withhold their motor responses. Response inhibition was therefore measured with an 'online' behavioural go/no go task, as the task was embedded into the gambling simulator. The first 30 trials of each condition were all green 'go' responses, often referred to as a 'training phase' in classic response inhibition tasks (for a review, see Simmonds et al., 2008). The purpose of the first 30 trials all being go-trials was to allow any prepotent patterns of motor responses to develop during the slot machine gambling. The remaining 60 trials in each condition consisted of a random 4:1 ratio of green 'go' to red 'no-go' trials.

*10.1.3.3 Dissociation*

Dissociative experience was assessed using a modified version of Jacobs' (1988) four-item dissociation scale. As with Experiments 1 and 2, the original scale was modified in two ways for the current research. First, the original four items were modified to ask participants to reflect on the gambling session they had just participated in, as opposed to gambling experience in general. For example, the question 'when gambling, how often do you feel like you have been in a trance?' was modified to read 'thinking back to the gambling session you have just completed, how often did you feel like you were in a trance?' The second modification of the scale was the addition of a fifth item, asking participants about their perception of time during the gambling session, an item incorporated into previous experimental gambling research (see e.g., Gupta & Derevensky, 1988; Blaszczynski et al., 2015). All five items were self-report on a five-point Likert-scale, anchored at 1, 'never', and five, 'all the time'. Midpoint of the scale, 3, indicated 'occasionally'.

*10.1.3.4 Subjective arousal and valence*

Participant subjective levels of arousal and valence during each experimental condition were assessed using the Self-Assessment Manikin approach (SAM; Lang, 1980b), which is a non-verbal pictorial assessment technique that directly measures the pleasure and arousal associated with a person's affective reaction to a wide variety of stimuli (for a full discussion, see Chapter 4). Full body versions of the SAMs were used for both the valence and arousal scale (portrait-only versions are available for the valence scale), and both scales were presented in their nine-point scale versions (see valence and arousal SAMs in Figure 4.1 Chapter 4).

*10.1.3.5 Choice impulsivity measures*

*10.1.3.5.1 Delay discounting*

The 27-Item Monetary Choice Questionnaire (MCQ; Kirby et al., 1999) is a delay discounting task where participants have to choose between a smaller immediate hypothetical monetary reward, or a larger but temporally delayed reward. The questionnaire varies in both the amount of hypothetical money on offer, as well as the hypothetical temporal delay between the immediate and delayed reward. Each question was presented individually on a computer screen. The left-hand side of the screen always read '*Would you prefer £x today'* and the right-hand screen always read '*or £x in x days',* where the delayed reward was always higher in value. Participants made their choices by pressing the corresponding number next to the two options, '1' for the immediate reward and '0' for the delayed reward. These numbers were spatially related to the options on screen. This was also done to minimise erroneous key presses because they appeared on opposite ends of the number scale on the keyboard. An overall preference for immediate reward over larger but delayed rewards has been reliably shown to indicate higher levels of choice impulsivity (Anokhin, Golosheykin, & Mulligan, 2015).

*10.1.3.5.2 Reflection impulsivity*

The Information Sampling Task (IST) is a measure of reflection impulsivity. The IST in the present experiment was a modified version of the IST developed by Clark et al. (2006). The original IST was a grid of 5 x 5 covered boxes that contained one of two unseen colours, and participants were required to sequentially select a box to reveal the colour underneath the cover. Participants were required to identify which of the two colours would be in the majority when all boxes were uncovered.

In the present study, the IST was modified to be more representative of a familiar probability task and was based upon the classic 'Urn Problem' (see Parke et al., (2015) for use of this task in a gambling context). The urn contained 19 unseen balls, and each ball was coloured black or red. Participants were required to determine whether red or black balls within the urn were in the majority. Participants were able to gather information by selecting to remove a ball from the urn to reveal its colour. Points were awarded in the IST for correct predictions regarding which colour was in the majority. For each IST trial, participants began with 95 points, and had five points removed for each ball taken from the urn. For example, if a participant removed three balls from the urn, and correctly predicted that red was in the majority they would win 80 points for that IST trial (see Figure 10.1 for example). However, if participants made an incorrect prediction, then they would be fined 100 points for that trial. Participants were informed that all of the points that they accumulated over the IST trials would be totalled, and the top five participants who accumulated the most points would receive a £50 shopping voucher as a prize.

During the experiment, participants were not provided with feedback regarding whether their predictions in each IST trial were correct. This is also a modification on classic ISTs, because feedback on correct/incorrect responses is normally provided following each trial. Because the present study wanted to control for valence as a covariate, it was decided that no feedback would be given following each trial to prevent emotional carry-over contamination effects (i.e., to prevent the results from one trial changing the emotional state of the participant in later trials which may have the undesirable effect of facilitating or impeding performance). As a result of this control, any differences in performance across conditions can be more confidently attributed to the experimental manipulations.

Reflection impulsivity was assessed by observing three component variables: Mean Information Sampled, Mean Response Latency and Mean Probability of Making Correct Decisions (P-correct). Mean Information Sampled referred to the mean average number of balls removed from the urn for each IST trial, and the Mean Response Latency refers to the mean amount of time taken to make a decision to remove another ball or to make a prediction of which colour was in the majority. Mean Probability of Making Correct Decisions (P-correct) referred the probability of the participants' colour predictions being accurate, based on the available information at the time the decision was made (Clark et al., 2006; Parke et al., 2015).


***Figure 10.1.*** Images taken from an IST trial. In the first image (far left) the participant has so far removed two balls from the urn, which were both black, thus gaining more information about the likely starting content of the urn, but losing 10 (2 x 5) point from their maximum potential gain for correct decisions. The participant then continues to remove balls from the urn (middle and far right), gaining more information about its original content, but losing 5 points per ball sampled, sacrificing the potential points gain in order to make a more accurate decision. The participant is free to guess whether the urn originally contained more red or black balls at any time by pressing 'R' or 'B' on a standard keyboard. Balls are removed by pressing 'SPACE BAR'.

*10.1.4 Procedure*

Each participant was randomly assigned to gamble on a three-reeled EGM simulator in one of five conditions: no intervention (control condition); emotive pop-up message intervention; informative pop-up message intervention; structure change intervention; and a double-response condition. Participants were provided with £9 to gamble with which was converted into 90 credits and each spin of the machine cost 1 credit (10p per spin). Participants were told that any money they had left at the end of the experiment could be kept. The event frequency of the slot machine simulator was 1.5s, because this speed has been shown to be the most problematic for exercising response inhibition in Experiment 1. Each slot machine condition was programmed to give the illusion of randomness. However, the slot machines were pre-programmed to control for volume, frequency, and range of wins, as well as number of near misses (Clark et al., 2009). The slot machine pay-back percentage was 94%, although participants were allowed to keep the full £9 as a compensation for their time, but they were not informed of this until the end of the experiment.

Participants were given a tutorial on how to operate the EGM simulator, and were informed of what each of the visual display features were, including the pay-line, credit balance, and win totals on winning spins (see Figure 5.2 in Chapter 5). A pay-out structure was also shown to participants during the tutorial, showing how much money would be won for specific matching symbols. Participants were instructed to only operate the machine by pressing the spin button (space bar on standard computer keyboard) when the spin button on the visual display was green in colour, and instructed they must withhold from pressing the spin button when it was red in colour. The slot machine was programmed to spin automatically on 'no-go' trials after a delay equivalent to one event frequency (1.5s). The first 30 trials of each slot machine condition were all 'go' trials, and the remaining 60 trials consisted of a 4:1 ratio of 'go' to 'no-go' trials.

With the exception of the structure change condition and double-response condition, the slot machine simulator was operated by pressing the space bar on a standard keyboard when the spin button was green in colour on the visual display. However, in the structure change condition, the operation of the slot machine simulator consisted of pressing *either* the left arrow key *or* the right arrow key, depending on the image of the black directional arrow displayed within the green spin button on the visual display. During the double-response condition, participants were instructed to press the spin button (i.e., space bar) twice in rapid succession to operate the machine, inducing a rapid response style.

In both pop-up message intervention conditions, a pop-up message appeared on screen for 30 seconds after the 30$^{th}$ trial. The message could not be skipped, and gambling could only continue once the message had been on screen for 30 seconds. Depending upon the condition, the message either displayed general information about potential dangers relating to gambling, or displayed emotional content related to potential familial and financial consequences related to reckless gambling (see Figure 8.2 in Chapter 8). Following each gambling condition, participants were asked to complete the arousal SAM, valence SAM, Dissociative Experience Scale, and single-item measure of perceived self-control, in that order. All scales were completed online immediately following the gambling simulation in each condition.

The choice impulsivity tasks followed the completion of the various scales, separated by a message that remained on screen for five seconds informing participants that the cognitive choice tasks were about to start. All five IST trials were presented first, each with a different combination of pre-programmed to-be-removed red and black balls, and finally, participants completed the 27-item MCQ, delivered electronically on-screen.

### *10.2 Ethics*

Before commencement of the study, the study was approved by the researcher's University Ethics Committee. The study protocol was designed in accordance with guidelines of the Declaration of Helsinki. Participants were fully briefed and instructed on how to complete all tasks prior to the beginning of the experiment and provided their informed consent to take part in the study. Participants were informed that all the data were confidential and anonymous.

### *10.3 Results*

#### *10.3.1 BIS-11 and age controls*

Mean participant trait impulsivity scores were assessed using the BIS-11 (Patton et al., 1995). A between-participants ANOVA showed that participant overall BIS-11 scores ($F[4,69]=.149$, $p=.963$), as well as the second order factors motor impulsivity ($F[4,69]=.801$, $p=.529$), attentional impulsivity ($F[4,69]=.924$, $p=.455$), and non-planning impulsivity ($F[4,69]=.141$, $p=.966$), did not differ between groups to a statistically significant degree. In addition, a between-participants ANOVA showed that participant mean ages did not differ to a statistically significant degree between experimental groups ($F[4,69]=.348$, $p=.844$). Therefore, differences in the dependent variables assessed at the group level throughout the experiment can be more confidently attributed to the experimental manipulations, as opposed to participant pre-existing levels of trait impulsivity and/or age-effects. All means and standard deviations for the BIS-11 and age values are shown in Table 10.1.

**Table 10.1.** *Participant mean (SD) age and BIS-11 scores across experimental conditions.*

| Condition | Participant variable | | | | |
|---|---|---|---|---|---|
| | BIS-11 non-planning | BIS-11 motor | BIS-11 Attention | BIS-11 overall | Age |
| Control | **21.57** *(3.34)* | **21.28** *(3.20)* | **16.79** *(2.15)* | **59.64** *(7.02)* | **33.79** *(13.25)* |
| Structure change | **21.35** *(3.00)* | **21.21** *(2.78)* | **16.86** *(1.83)* | **59.43** *(5.32)* | **30.71** *(9.83)* |
| Emotive message | **20.92** *(2.84)* | **20.21** *(2.78)* | **16.78** *(2.08)* | **57.93** *(6.39)* | **29.07** *(11.62)* |
| Informative message | **21.14** *(3.59)* | **20.50** *(3.65)* | **17.21** *(2.72)* | **58.86** *(8.65)* | **30.43** *(10.40)* |
| Double-response | **21.64** *(21.64)* | **22.07** *(2.73)* | **15.57** *(3.13)* | **59.29** *(4.77)* | **31.71** *(10.13)* |

Note: Overall participant BIS-11 scores, all second-order BIS-11 factors, and participant mean ages were statistically non-significant across experimental conditions.

### *10.3.2 Arousal*

A one-way between-participants ANOVA showed a non-statistically significant effect of intervention on mean participant reported levels of arousal (F[4,69]=.867, *p*=.489, $\eta^2$ =.05). Results also showed that mean arousal ratings in all conditions, which were conducted at fast gambling speeds, were moderately high. Mean arousal ratings in all conditions were above six on the nine-point scale, with a grand mean of 6.39 (*SD*=.98), confirming the subjectively arousing experiencing of the gambling simulation conducted at a high event frequency (see Table 10.2).

### *10.3.3 Dissociation*

A one-way between-participants ANOVA showed that mean levels of dissociation experienced by the participants did not vary to a statistically significant level between groups (F[4,69]=.336, *p*=.852, $\eta^2$ =.02). Overall, dissociation levels in all conditions whilst gambling at fast speeds of play were very low, with grand mean dissociation levels (7.00, *SD*=1.53) falling close to the bottom end of the possible range of scores (5-25). All dissociation means and standard deviations are summarised in Table 10.2.

### *10.3.4 Valence*

A one-way between-participants ANOVA showed that difference in mean valence ratings between conditions did not vary to a statistically significant degree (F[4,69]=.257, *p*=.904, $\eta^2$ =.02). In all conditions, mean valence ratings were above the midpoint of the nine-point scale (grand mean=5.79, *SD*=1.07), indicating that on average, participants found the gambling experience overall moderately pleasurable, and that none of the harm minimisations interventions had deleterious effects on the emotional experience during the gambling simulation. All valence means and standard deviations are summarised in Table 10.2.

*10.3.5 Reaction time*

A one-way between-participants ANOVA showed that the difference in mean reaction times between conditions was statistically significant ($F[4,69]=13.09$, $p<.001$, $\eta^2 = .45$). The fastest mean reaction time was found in the double-response condition (.56s, *SD*=.09). Bonferroni pairwise comparisons showed that this mean reaction time was statistically significantly faster when compared to the control condition (.72s, *SD*=.12; *p*=.01, *d*=1.51), emotive message condition (.71s, *SD*=.13; *p*=.022, *d*=1.34), informative message condition (.70s, *SD*=.13; *p*=.031, *d=1.25*), and structure change condition (.90s, *SD*=.14; *p*<.001, *d=2.89*). The slowest mean reaction time was found in the structure change condition, which was statistically significantly slower than the control condition (*p*=.004, *d*=1.38), emotive message condition (*p*=.002, *d*=1.41), informative message condition (*p*=.001, *d*=1.48), and the double-response condition (*p*<.001, *d*=2.89). There was no statistically significant difference between mean reaction time in the emotive message and control conditions, the informative message and control conditions, nor between the emotive and informative message conditions. Therefore, results indicate that only the structure change condition was successful in slowing participant mean reaction times when compared to a control group, whereas inducing a rapid response style with the double-response condition sped up participant mean reaction time.

*10.3.6 Response inhibition performance*

A one-way between-participants ANOVA showed that the difference in mean response inhibition performance between conditions was statistically significant ($F[4,69]=8.71$, $p<.001$, $\eta^2 = .35$). Performance was highest in the structure change condition (83.93%, *SD*=10.57). Bonferroni pairwise comparisons showed that this mean response inhibition performance in the structure change condition was statistically significantly higher when compared to the control condition (66.67%, *SD*=12.23; *p*=.004, *d*=1.51), emotive message condition (69.05%, *SD*=11.05; *p*=.02, *d*=1.38), informative message condition (67.86%, *SD*=14.57, *p*=.009, *d*=1.26), and double-response condition (57.14%, *SD*=12.17, *p*<.001, *d*=2.35). Whilst performance was lowest in the double-response condition, pairwise comparisons failed to show this mean performance was statistically significantly worse than the control, emotive message, or the informative message conditions. All other pairwise comparisons showed non-statistically significant results. Taken together, only the structure change condition facilitated response inhibition performance relative to a control condition, and worked significantly better when compared to the emotive and informative message interventions. Inducing a rapid response style via the double-response condition resulted in the worst response inhibition performance overall, but this failed to reach statistical significance.

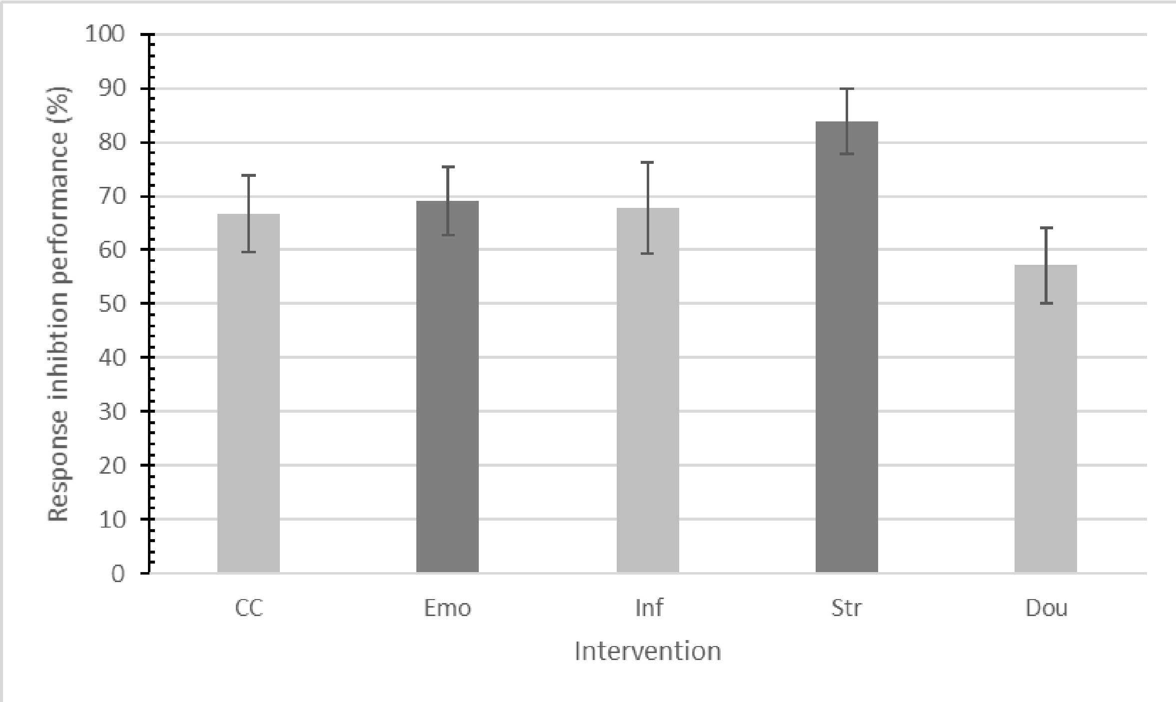


***Figure 10.2.*** Mean response inhibition performance in the control (CC), emotive message (Emo), informative message (Inf), structure change (Str), and double response (Dou) intervention conditions. Error bars depict 95% confidence intervals.

**Table 10.2.** *Mean (SD) of arousal, valence, dissociation, reaction time, and response inhibition scores across experimental conditions.*

| Condition | Dependent variable | | | | |
|---|---|---|---|---|---|
| | Arousal (1-9) | Valence (1-9) | Dissociation (5-25) | Reaction time (s) | Response inhibition (%) |
| Control | **6.29** *(1.33)* | **5.57** *(1.16)* | **7.29** *(1.77)* | **.72** *(.12)* | **66.67** *(12.23)* |
| Structure change | **6.43** *(.51)* | **5.50** *(1.09)* | **6.71** *(1.38)* | **.90** *(.14)* | **83.93** *(10.57)* |
| Emotive message | **6.14** *(.95)* | **5.42** *(1.02)* | **7.21** *(1.72)* | **.71** *(.13)* | **69.05** *(11.05)* |
| Informative message | **6.29** *(1.07)* | **5.71** *(1.20)* | **6.86** *(1.41)* | **.70** *(.13)* | **67.86** *(14.57)* |
| Double-response | **6.79** *(.89)* | **5.79** *(.97)* | **6.93** *(1.49)* | **.56** *(.09)* | **57.14** *(12.17)* |
| ANOVA p-vale | =.489 | =.904 | =.852 | <.001 | <.001 |

*10.3.7 Information sampling task*

*10.3.7.1 P-correct*

The main variable of interest regarding reflection impulsivity, as assessed by the Information Sampling Task, was the probability of a participant being correct at the time of making a decision, which is referred to as *p-correct.* Under some circumstances, the number of balls sampled from the urn provides a limited index of the information available. For example, if the participant removes 10 balls from the urn, the distribution of the balls could be five red and five black (*p*-red =.5, *p*-black =.5) or 10 red and 5 black (*p*-red= 1.0, *p*-black= 0). The *p*-correct equation quantifies the extent of information revealed on a trial-by-trial basis, although this variable is invariably correlated with the amount of information sampled (Clark et al., 2006). *P*-correct was calculated using the following formula (see also Clark et al., 2006; Parke et al., 2015):

$$\text{P(Correct)}=\frac{\sum_{\mathrm{k-A}}^{\mathrm{z}}\binom{\mathrm{z}}{\mathrm{k}}}{2^{\mathrm{z}}}$$

Where z=19 - number of balls removed from the urn, and A=10 - number of balls removed of the selected colour. In the original IST design, comprising a 5x5 grid of yellow and blue to-be-opened boxes, whilst the formula remained the same, the values of z and A were therefore 25 and 13 respectively. If a decision was made that yellow boxes were in the majority after sampling 10 boxes with an eight yellow and two blue distribution, then z=25-10=15, A=13-8=5, and *p*-correct= [15!/(5!x10!)+15!/(6!x9!)+…+15!/(15!x0!)]/$2^{15}$=.94 (see Clark et al., 2006).

A one-way between-participants ANOVA showed a statistically significant difference between mean *p*-correct scores across conditions (F[4,69]=7.41, *p*<.001, $\eta^2$ =.31). Bonferroni pairwise comparisons showed that participants in the emotive message condition (.8449, *SD*=.0371; *p*=.024, *d*=.61) and structure change condition (.8593), *SD*=.0267; *p*=.008, *d*=1.22), had statistically significantly higher *p*-correct values when compared to the control group (.8240 *SD*=.0311). However, there was no statistically significant difference between mean *p*-correct scores in the emotive message and structure change conditions. The *p*-correct values for the informative message (.8188, *SD*=.0291) and double-response (.8072, *SD*= .0421) conditions did not differ significantly when compared to a control group. Performance was significantly worse in the double-response condition when compared to the emotive message (*p*=.003, *d*=.95) and structure change (*p*=.001, *d*=1.47) conditions. Performance was also significantly worse in the informative message condition when compared to the structure change condition (*p*=.02, *d*=1.45), but the difference in mean *p*-correct values between the informative message and emotive message conditions just failed to reach statistical significance at the $p<.05$ level ($p=.054$, $d=.78$). Results therefore indicate that the use of a structure change intervention and emotive message intervention are able to facilitate probabilistic decision-making during gambling, when compared to a control group. The use of a structure change intervention also facilitated performance above that of an informative message intervention, and while the trend in the data suggest emotive messaging also facilitated performance above that of an informative message intervention, the *p*-value just failed to reach statistical significance. Figure 10.3 and Table 10.3 below summarises the mean p-correct performance across experimental conditions.

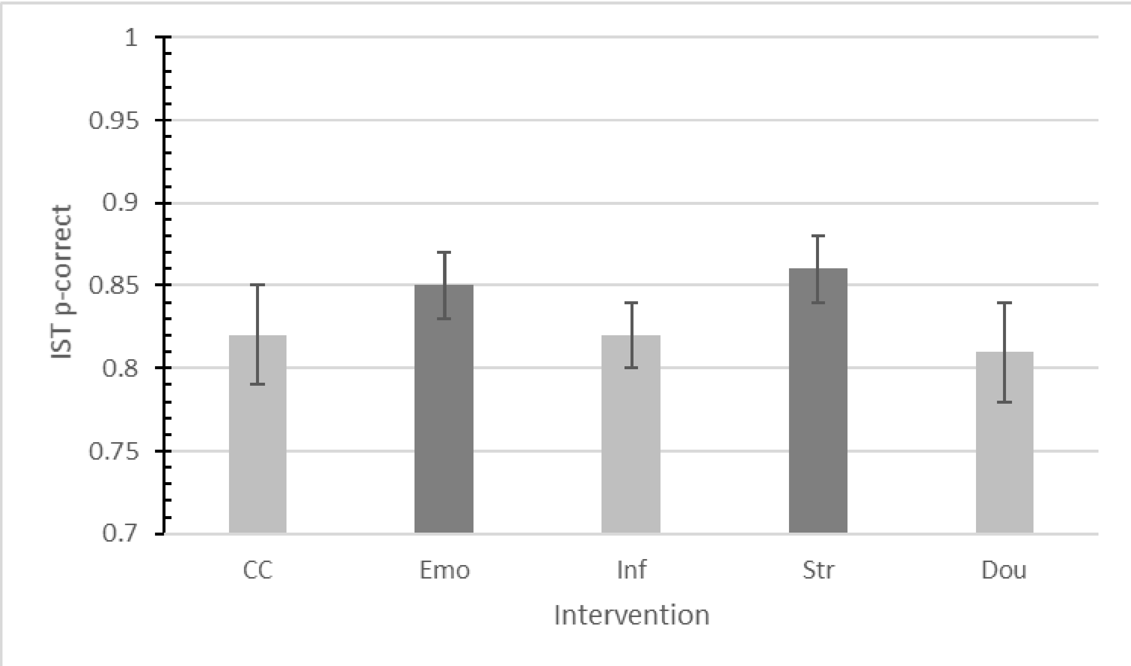


**Figure 10.3.** Mean Information Sampling Task (IST) probability-correct (p-correct) scores across the control (CC), emotive message (Emo), informative (Inf), structure change (Str), and double-response (Dou) conditions. Error bars depict 95% confidence intervals. P-correct refers to the probability of the participants guess being correct regarding which coloured ball was in the majority within the urn.

*10.3.7.2 Response latency*

The mean time it took participants to arrive at a decision in the Information Sampling Task was compared across conditions using a one-way between-participants ANOVA. Results showed that the difference in means was statistically significant ($F[4,69]=7.37$, $p<.001$, $\eta^2 =.31$). Bonferroni pairwise comparisons showed that only the mean time taken in the structure change (9.19s, $SD=2.78$; $p=.027$, $d= 1.20$) and emotive message conditions (9.76s, $SD=3.22$; $p=.005$, $d=1.30$) differed from the control condition (5.93s, $SD=2.65$) to a statistically significant level, where participants took significantly more time to make a decision. Significantly less time was taken to make a decision in the double-response condition (5.19s, *SD*=2.28) compared to the emotive message condition ($p$<.001, $d$=1.64) and the structure change condition ($p$=.003, $d$= 1.57). All other pairwise comparisons failed to reach statistical significance at the $p$<.05 level.

*10.3.7.3 Information sampled*

Mean information sampled refers to the mean number of balls removed (i.e., sampled) from the urn during the Information Sampling Task, before a decision on predicted majority colour was made. Results from the one-way between-participants ANOVA showed a significant difference between the mean amount of information sampled across conditions (F[4,69]=7.40, $p$<.001, $\eta^2$ =.31). Bonferroni pairwise comparisons showed that when compared to a control group (3.51, *SD*=1.21), only the mean amount of information sampled in the structure change condition (5.14, *SD*=1.28) differed to a statistically significant level ($p$=.012, $d$=1.31), where participants on average sampled more information before making their decision. Significantly more information was sampled in the structure change condition when compared to the informative message (3.51, *SD*=1.32; $p$=.012, $d$=1.25) and double-response conditions (2.96, *SD*=1.22; $p$<.001, $d$=1.74). More information was sampled in the emotive message condition (4.76, *SD*=1.33) compared to the double-response condition ($p$=.004, $d$=1.41). All other pairwise comparisons showed a non-statistically significant result at the $p$<.05 level. All mean scores and standard deviations relating to the IST can be found in Table 10.3.

*10.3.8 27-item monetary choice questionnaire*

*10.3.8.1 K-value*

Data for one participant assigned to the double-response condition was excluded from analysis due to an overall response consistency of 59% on the MCQ, indicative of potential random response choices. This figure of 59% is adequately lower than the 75% response consistency suggested by Kaplan et al. (2014) for meaningful analysis, and therefore the data were removed, leaving 69 participants for this section of data analysis. Of note, three other participants, all in separate conditions, had an overall response consistency score of 70.37%. While this falls marginally below the recommended 75% for inclusion, given the relatively modest number of participants in each group and the fact that these participants only fell marginally below the recommended threshold of consistency for one subcategory of delay period (i.e., large, medium, or short delay period), their data were retained for analysis.

The $k$-value is an estimate of discounting rate demonstrated by the participant, and the possible $k$-values, as assessed by the 27-item MCQ, range from .00016 and .25, where a larger value represents a steeper discounting rate indicative of greater levels of choice impulsivity. A one-way between-participants ANOVA showed that the difference in overall mean *k*-values across conditions reached statistical significance (F[4,68]=7.302, $p<.001$, $\eta^2$ =.31). Bonferroni pairwise comparisons showed that relative to the control condition (.137, *SD*=.085), only the emotive message condition (.027, *SD*=.041; *p*=.003, *d*=1.65) and structure change condition (.052, *SD*=.086; *p*=.043, *d*=.99) had *k*-values that differed to a statistically significant degree, where *k*-values were significantly lower indicating greater tolerance for reward delay. The highest overall *k*-value was found in the double-response condition (.155, *SD*=.081), which was statistically significantly higher than both the emotive message (*p*<.001, *b*=1.99) and structure change conditions (*p*=.007, *b*=1.23), as well as the informative message condition (.068, *SD*=.076; *p*=.039, *b*=1.11), but was not statistically significantly higher when compared to the control condition. All other pairwise comparisons of means failed to reach statistical significance. Figure 10.4 below summarises the mean k-values and Table 10.3 below summarises performances on the choice impulsivity tasks across the experimental conditions.

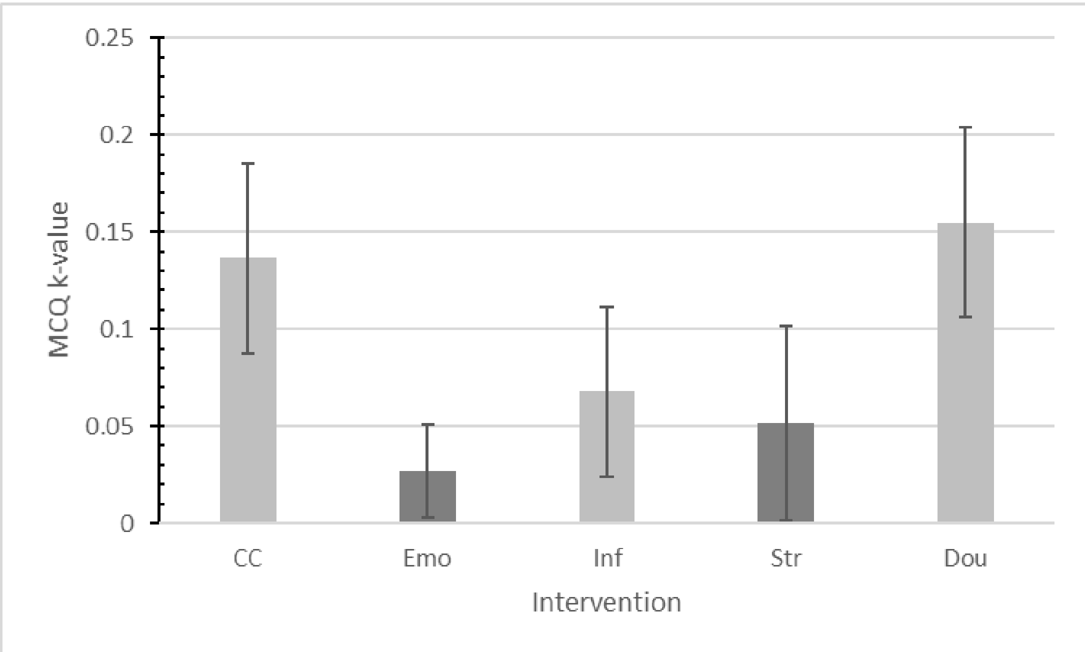


***Figure 10.4.*** Mean k-values in the Monetary Choice Questionnaire (MCQ) across the control (CC), emotive message (Emo), informative message (Inf), structure change (Str), and double response (Dou) intervention conditions. Error bars depict 95% confidence intervals. A lower k-value is indicative of greater tolerance for delayed rewards and is regarded as representing less impulsive choices.

**Table 10.3.** *Mean (SD) of IST and MCQ values across experimental conditions.*

| Condition | Dependent variable | | | |
|---|---|---|---|---|
| | IST response latency (s) | IST balls sampled(1-19) | IST probability-correct | MCQ *k*-value (0.00016 - 0.25) |
| Control | **5.93** *(2.65)* | **3.51** *(1.21)* | **.82** *(.03)* | **.14** (.09) |
| Structure change | **9.19** *(2.78)* | **5.14** *(1.28)* | **.86** *(.03)* | **.05** (.09) |
| Emotive message | **9.76** *(3.22)* | **4.76** *(1.33)* | **.85** *(.04)* | **.03** (.04) |
| Informative message | **6.84** *(2.83)* | **3.51** *(1.32)* | **.82** *(.03)* | **.07** (.08) |
| Double-response | **5.19** *(2.28)* | **2.96** *(1.22)* | **.81** *(.04)* | **.15** (.08) |
| ANOVA p-value | <.001 | <.001 | <.001 | <.001 |

### *10.4 Discussion*

In support of the empirical findings from the second experiment, only the structure change condition resulted in improved response inhibition performance relative to a non-intervention control condition. In support of H1, participants in the structure change condition on average also demonstrated the highest *p*-correct values on the Information Sampling Task, where they also sampled more information before making a decision and demonstrated more deliberation over their decision, as demonstrated by longer choice latencies. Participants in the structure change condition also had a statistically significantly lower *k*-value on the MCQ when compared to the control condition, indicating a greater tolerance for larger delayed reward. The data therefore suggest that inducing motor cautiousness during EGM gambling has beneficial transfer effects that also reduce impulsive choice tendencies.

The fastest reaction times during gambling were found in the double-response condition, where reaction times were statistically significantly shorter when compared to all other conditions including the control condition. The worst performance on the motor response inhibition task, IST (in terms of lowest mean *p*-correct value), as well as highest *k*-value on the MCQ, was also found in the double-response condition, indicating that inducing rapid and impulsive motor responses is associated with impaired cognitive choice. However, differences in the percentage of successfully inhibited motor responses, *p*-correct scores, and *k*-values between the double-response and control condition just failed to reach statistical significance, meaning full support for H2 was not obtained.

Notably, IST *p*-correct scores were also statistically significantly higher in the emotive message condition compared to the control condition, as well as *k*-values on the MCQ in the emotive message condition being statistically significantly lower when compared to the control condition. Given the fact that the emotive message intervention failed to facilitate motor response inhibition means that increased motor cautiousness, whilst beneficial for cognitive choice in this gambling simulation, is not an essential factor in improving information sampling and delay discounting performance during gambling. Therefore, only partial support for H3 was obtained. This is because whilst structure change approaches that reduced impulsive action also reduced impulsive choice, the emotive message condition failed to reduce impulsive action and yet was able to reduce impulsive choice. Importantly, these group level differences in motor and cognitive performances cannot be attributed to baseline levels of trait impulsivity given the lack of statistically significant differences in participant BIS-11 scores between experimental groups.

The findings of the present study support existing evidence from neuroscience (Knoch et al., 2006), neuroimaging (Bunge et al., 2002; Wager et al., 2005), and behavioural approaches (Muraven & Baumesiter, 2000; Verbruggen et al., 2012) that demonstrate significant overlaps between impulsive action and impulsive choice. Although the relationship between these constructs has received less attention in gambling, existing work exploring this relationship within a gambling context found that forcing gamblers to exercise greater caution over motor responses resulted in a preference for smaller and lower risk wagers in a novel gambling task (Verbruggen et al., 2012). The present study extends these findings to a more realistic gambling activity and demonstrates that inducing motor cautiousness within slot machine gambling reduces impulsive choice tendencies. To the authors' knowledge, this is also the first empirical study to directly assess the efficacy of gambling harm minimisation tools in inducing motor cautiousness, and the impact this has on reflection impulsivity and delay discounting.

### *10.4.1 Evidence for direct and indirect influence on impulsive choice*

The findings of the present study suggest that a gambler's level of impulsive choice during gambling can be positively influenced via multiple processes. There is evidence for an 'indirect' route, in which decision-making is shaped via a motor cautiousness transfer effect. There is also evidence that decision-making during gambling is influenced via a more 'direct' route, whereby the presentation of messages containing responsible gambling information cause a gambler to reflect more carefully upon their decisions. The efficacy of responsible gambling messages in this direct process appears dependent upon the type of information delivered via the pop-up message, because levels of impulsive choice were significantly reduced only when emotive content was presented to the participant.

*10.4.1.1 Indirect cautiousness transfer account*

Arousal is a non-cognitive factor that has been shown to be influenced by the presence of cues requiring the withholding of motor responses (see e.g. Jennings et al., 1992; van Boxtel et al., 2001). However, like the study carried about by Stevens et al. (2015), there was no evidence in this gambling simulation to suggest that the association between motor cautiousness and cognitive choice in the structure change condition was due to subjective changes in arousal given the non-significant change in arousal across all experimental conditions. Subjective arousal ratings in the present study thus appear to corroborate findings from biological assessment of arousal that also shows no relationship between arousal and impulsivity transfer effects (e.g. Stevens et al., 2015). There was also a lack of evidence to suggest that the association between increased motor cautiousness and cognitive choice was a result of the structure change condition reducing the level of dissociation experienced by participants, nor was there evidence to suggest the association was related to changes in emotional valence.

Several studies suggest an association between withholding/cancelling motor responses in Go/No-Go and Stop Signal paradigms with subsequent approach behaviours (Houben & Jansen, 2011; Lawrence et al., 2014; Veling; Aarts, & Stroebe, 2013). Being forced to exercise caution over motor responses in the structure change condition may have stimulated aversive centres in the brain, which are postulated by Dickinson and Dearing (1979) to act antagonistically with appetitive or approach centres. Dickinson and Dearing argue that the perceived affective dimension of a stimulus determines subsequent approach or avoidance behaviour. Consistent with this notion, but outside of a gambling context, Dickinson and Balleine (2002) report an experiment in which inducing aversive defensive eye-blinks supressed appetite jaw movements in rabbits. Furthermore, with human participants, Jones et al. (2011) demonstrated that cautiousness in a motor inhibition task using neutral stimuli resulted in reduced alcohol consumption in a later alcohol taste test and was argued to be the result of the presence of stop signals stimulating the aversive/avoidance system within the brain.

Therefore, exercising motor control appears to have carryover effects to impulsive choice tasks, where participants are primed towards a more cautious decision-making style, where risk is valued as less desirable. This translated in the present study as a willingness for participants in the structure change condition to make decisions on the IST based on more information (i.e., more balls removed from the urn and thus less uncertainty in decision-making) and taking more time to arrive at a decision as to the majority ball colour, as well as being more tolerant of reinforcement delays in the MCQ.

*10.4.1.2 Direct cautiousness transfer account*

Participants exposed to the emotive message intervention had *p*-correct scores in the IST and *k*-values in the MCQ comparable to participants in the structure change condition. Given the fact that response inhibition performance for participants in the emotive message condition showed no improvement relative to a control condition, this rules out a motor cautiousness transfer effect being responsible for the improved performance on the cognitive choice tasks in this condition. Pop-up messages have been argued to encourage responsible gambling behaviour by increasing a gambler's self-awareness over their behaviour and engage gamblers in self-appraisal of that behaviour (Monaghan, 2008). This appeared to be effective post-gambling on subsequent cognitive choice tasks but had no impact on response inhibition during the gambling simulation in the present study and is consistent with results from the second experiment.

One potential explanation for this is that pop-ups become effective during periods of time that allow for deliberation and reflection to occur. The rapid speed of play of slot machine gambling may override the effect of the pop-up message resulting in a lack of improved response inhibition during the slot machine gambling. It was only following the end of the gambling simulation that the effects of pop-up message exposure were evident. Arguably, the subsequent cognitive choice tasks were an example of a situation which encouraged deliberation, and this was therefore a situation in which the cognitive effects of the pop-up message exposure had opportunity to influence decision-making. Only the message containing emotive content (i.e., a warning of the potential familial and financial consequences of a loss of control during gambling) was effective as a harm-minimisation approach. Non-emotive message content appeared to fail to influence decisions, emphasising the notion that the type of content displayed in pop-up messages is vital for their effectiveness as a harm-minimisation tool.

*10.4.1.3 Argument for shared mechanism of change*

The positive impact of the emotive pop-up message on decision-making has been referred to here as a 'direct' cautiousness transfer effect. The impact of the emotive pop-up message intervention on cognitive choice appears independent of a motor cautiousness effect, and can be regarded as a direct impact on decision-making. However, the impact of the structure change condition on decision-making has been referred to as an 'indirect' transfer effect because changes in structure appear to impact motor response processes that subsequently and indirectly transfer to wider aspects of decision-making involved in the cognitive choice tasks. It may be the case that there is a shared mechanism underlying both the direct and indirect pathways postulated here. Both the need to exercise greater caution over motor responses in the structure change condition, and the presentation of negative consequences associated with loss of control via the emotive pop-up message condition possibly reduce the hedonistic and motivational value of subsequent risk in favour of a more cautious and risk-averse approach. This potential explanation is consistent with Dickinson and Dearing's (1979) proposal of an antagonistic appetitive and aversive system within the brain.

*10.4.2 Caveats*

One of the limitations of the present study is that the results can only be assumed to apply to healthy, non-problem gamblers. For example, problem gamblers have been shown to fail to properly activate inhibitory control networks within the brain and poor inhibition of prepotent responses has been associated with reduced capacity to remain abstinent following outpatient treatment for pathological gambling (Brevers et al., 2012). As a result, the effectiveness of implicating structural changes to gambling products to promote cautious motor responses remains unclear for problem gambling groups, which represents an important area of future research. One assumption made by the screening questions to check for current or previous periods of problem gambling is that participants had an absence of problem gambling symptomology. However, problem gambling severity lies along a continuum, and therefore those participants that may be considered as low or even moderate risk problem gamblers may have gone undetected by the simple screening procedure if the participant did not consider milder issues as problematic.

Furthermore, those with gambling-related issues may not have been aware that they had a problem. Use of a scale sensitive to these sub-categories of problem gambling severity, such as the Problem Gambling Severity Index (PGSI), could shed light on how these sub-groups are influenced by the harm-minimisation approaches investigated in the present study. However, it is not the intention of the present study for these successful harm-minimisation approaches to help cure problem gambling in isolation. Instead, the intention is to help the much larger majority of gamblers who gamble without problems to remain in control during gambling and minimise the potential for harm caused by specific structural characteristics of gambling products (see Harris & Griffiths, 2017). However, this does not rule out the potential for future research to investigate how approaches encouraging motor cautiousness could have potential clinical utility alongside other treatment approaches for problem gamblers.

Although the participants were screened for problem gambling behaviour, there were a range of potential behavioural and clinical factors not screened that may drive the group level differences in impulsivity found in the between-participant design. Although baseline levels of impulsivity were controlled across groups according to BIS-11 scores (which includes measures of secondary factors including motor impulsivity), participants were not matched on response inhibition according to performance on impulsivity task performance outside of a gambling context. In addition, data pertaining to potential clinical problems were not obtained from participants. For example, ADHD, other impulse and compulsive control disorders, as well as other addictions represent underlying issues that could impact group level differences for motor and choice impulsivity measures found in this study, particularly given the relatively small number of participants (n=14) in each of the five conditions.

Although to the authors' knowledge the present study is the first to assess impulsivity transfer effects using widely used cognitive measures within a gambling simulation, it is not clear-cut as to how decisions in the cognitive choice tasks translate to real-world gambling-related decisions. It would be difficult to argue against the notion that making probabilistic decisions based on more information and increased deliberation time have advantages within a wide range of disciplines, including gambling. In addition, preferences for larger delayed rewards over immediate but smaller reward is advantageous from a utility perspective. What is required is follow-up research assessing how these positive decision-making features relate to within- and between-gambling session factors, including loss-chasing behaviour, monetary spend during gambling, time spent gambling, and gambling frequency.

### *10.4.3 Conclusion*

This experimental investigation using regular non-problem gamblers demonstrated that structural modifications to slot machine gambling can impact executive control domains, including motor response inhibition and delay discounting, as well as information sampling. These effects were found to be independent of trait impulsivity. There was also evidence that inducing motor cautiousness by forcing gamblers to discriminate between motor responses had positive indirect transfer effects to wider aspects of cognitive choice, suggesting impulsive choice and impulsive action have related underlying processes. The use of emotive content in pop-up messages directly facilitated decision-making in cognitive choice tasks, although this effect was independent of a motor cautiousness transfer account. Furthermore, these direct and indirect effects appeared independent of subjective changes in arousal, dissociation, and valence. Inducing motor cautiousness during gambling appears to have global benefits for self-control and has the potential to assist non-problem gamblers avoid behaviours that may lead to risky gambling practises. Consequently, future research should assess how inducing motor cautiousness transfers to specific gambling factors such as time and monetary spend, and loss chasing behaviours, as well as the impact of inducing motor cautiousness during slot machine gambling on gamblers with varying degrees of problem gambling severity.

# Chapter 11. Summary of Findings and Conclusions

### *11. Summary of thesis aims and original contribution to knowledge*

Gambling is an activity that can be undertaken as a legitimate leisure pursuit but is also an activity that can be taken to excess and result in a wide range of psychological, monetary, and social issues (Orford, 2001). To ensure gambling remains safe and fun for those who choose to participate, it is important that all gambling-related decisions are informed and are executed in a controlled and conscious manner. Technology continues to develop in all aspects of society, including the gambling industry, and affords an increase in the sophistication of gambling products. Of concern to this thesis is how this increased sophistication of electronic gambling products affords rapid and continuous play (Breen & Zimmerman, 2002), with the potential to minimise the role of controlled decision-making processes in favour of more rapid and automatic responses during gambling.

This thesis aimed to assess the impact of structural characteristics of electronic gambling on executive control processes. More specifically, the thesis focused on how event frequency (speed of play) in electronic slot machine gambling affects behavioural inhibition. It also aimed to examine the efficacy of new and existing harm-minimisation tools for within-session gambling, in terms of their ability to facilitate self-control in the form of response inhibition performance. Finally, the thesis aimed to assess the potential for impulsivity transfer effects between motor and choice impulsivity domains during gambling, by examining the wider cognitive effects of inducing motor cautiousness within a gambling session.

Whilst an association between high event frequency gambling and maladaptive gambling behaviour already exists (for a review, see Harris & Griffiths, 2018), the original contribution to knowledge within this thesis is in attempting to explain some of the potential causal mechanisms between speed of play and a loss of control *during* gambling. The thesis demonstrates a clear and repeated link between increased speeds of play during gambling and reduced response inhibition performance, considered to be the hallmark of executive control (Diamond, 2016). Furthermore, to the present author's knowledge, the impact of emotional content in pop-up responsible gambling messages has not been tested for its impact on response inhibition, reflection impulsivity, and delay discounting processes. In addition, this is the first series of studies to assess the impact of a forced discriminatory motor choice procedure on executive control processes within a gambling context. Finally, to the author's knowledge, this thesis represents the first empirical assessment of the impact of inducing motor cautiousness on choice impulsivity processes during slot machine gambling.

### *11.1 Discussion of key findings*

Chapter 2 comprised a critical review of the impact of speed of play in gambling on psychological and behavioural factors. Multiple empirical and qualitative studies were identified addressing this research question, and the review provided an overall consensus that as the speed of gambling games increase, as does the overall subjective excitement and enjoyment of the activity. This trend applied to non-problem gamblers as well as gamblers across the full spectrum of problem gambling intensity, with some studies (e.g., Linnet et al., 2010) even suggesting that faster speeds of play are particularly appealing to problem gamblers. The fact that the nature of electronic gambling boasts the highest capabilities in terms of speed of play, likely explains one of the reasons for the popularity of this form of gambling and could account at least in part for the association between electronic gambling and problem gamblers. Qualitative accounts from gamblers and problem gamblers suggest that some of the reasons increased speeds of play are appealing is due to the instant gratification fast games provide, and the absence of long delays between gambling events. Further findings stemming from the review included problem gamblers reporting greater desire to continue gambling at faster speeds of play, as well as this population reporting a greater tension reduction when playing faster games compared to slower forms of gambling.

Studies examining the behavioural effects of increased speeds of play have also reported that problem gamblers have more difficulty stopping gambling in general when compared to non-problem gamblers (Linnet et al., 2010), with this difference between-groups being exacerbated as the speed of gambling is increased. Problem gamblers are also more likely to demonstrate an escalation in wager amounts when playing games with high speeds of play compared to slower games (Metzoni et al., 2012). Finally, the review also identified that gamblers tend to place more bets in a given period when the speed of play is increased (Choliz, 2010; Metzoni et al., 2012). This latter finding is perhaps unsurprising given the fact that high event frequency games allow more bets to be placed for the same period of time compared to lower event frequency games whilst controlling for other structural gambling variables (Griffiths & Auer, 2013).

The overall trend identified in the review was that faster speeds of play in gambling have a more deleterious impact on the psychological and behavioural variables discussed here. However, the evidence was not unanimous, with a few studies (e.g., Mentzoni et al., 2012; Sharpe et al., 2005) reporting that speed of play had no significant impact on variables including the amount of time and money spent gambling, number of bets placed, desire to continue gambling, and illusions of control. These differences in results are likely due to several factors, including the disparity in research methodologies, lack of consensus on what constitutes high and low speeds of play, as well as the differences in dependent variables of interest between the studies.

Chapter 3 of the thesis was included to acquaint the reader with relevant theoretical and empirical accounts regarding executive control processes, with a focus on these processes within a gambling context. Automatic behaviours can be considered to be rapid in execution, require minimal effort to perform, and are typically triggered by environmental cues (Stevens et al., 2015). Such automatic and relatively effortless processes have clear adaptive evolutionary benefits. However, gambling arguably represents an activity where the routine activation of stimulus-driven behaviour is undesirable. Gambling is therefore an activity where high-levels of cognitive control over behaviour is desirable to prevent stimulus-driven prepotent actions dominating behavioural output.

Response inhibition is considered a quintessential feature of executive control, a feature that allows us to overcome strongly conditioned and habituated responses to allow self-guided behaviour towards chosen goals and to keep us safe from potential harm (Macleod, 2007). Impairment in this domain is typical within the problem gambling population, where it is often demonstrated that problem and pathological gamblers fail to withhold behavioural responses when instructed to do so, resulting in the execution of undesired and maladaptive actions (for a review, see van Holst et al., 2010). One of the motivating factors for the empirical chapters within this thesis is the fact that considerably less attention in the literature has been allocated to the way that gambling structural characteristics affect such executive control processes. Researching such questions on healthy, non-problem gambling samples allows us to examine these processes without the confounding effects of psychopathology. Such investigations are pertinent from a harm-minimisation perspective given emergent evidence highlighted in Chapter 3 that suggests executive control domains, including response inhibition performance, are susceptible to contextual factors. These contextual factors interact with proximal and distant brain mechanisms that bring about changes in response inhibition performance. Chapter 3 identified that factors including physiological arousal, motivation, and the event frequency of stimuli presentation can impact on an individual's ability to exercise motor control, factors that are of high relevance within a gambling context.

Chapter 4 provided a critique of, and justification for the experimental methodology used within this thesis. Whilst some of the limitations of laboratory-based gambling research include reduced ecological validity and a reduction in perceived risk for the participants, high levels of experimental control were required in order to control for various extraneous gambling variables, such as gambling outcome, as well as allowing for the speed component of the game to be manipulated efficiently. Although the use of a simple slot machine simulation resulted in various slot machine features such as bonus rounds and nudges to be absent, it did allow for programming flexibility and thus, allowed response inhibition to be measure during the activity of interest.

The first empirical study of the thesis, Experiment 1, was presented in Chapter 5. The main aim of Experiment 1 was to assess the impact of the speed of play in slot machine gambling on response inhibition performance in healthy, regular gamblers. Results indicated that as the speed of play was increased, response inhibition performance decreased. Gamblers were less able to withhold motor responses when instructed to do so when the event frequency of the slot machine was increased, suggesting faster game speeds in electronic gambling is detrimental to executive control and give rise to impulsive motor actions.

A second aim of Experiment 1 was to investigate the psychological factors that predict the relationship between speed of play and response inhibition performance. An unexpected finding was that the relative predictor strength of variables, including levels of arousal and dissociation, changed as a result of the speed of the game, demonstrating an interaction effect. At the fastest speed of play with a 1.5 second event frequency, level of subjective arousal was the dominant and negative predictor of response inhibition performance. As a gambler's subjective levels of arousal increased, this was associated with poorer inhibition performance at fast speeds of play. Participant mean reaction time was also a significant predictor of response inhibition, where faster reaction times were associated with poorer response inhibition performance. The effects of these two predictors of response inhibition appeared to be independent, as there was no evidence that reaction time mediated the effect of arousal on response inhibition, as would be predicted by theoretical and empirical accounts stating that increased arousal leads to a state of readiness to respond, where increased arousal lowers response thresholds and biases go and stop processes in favour of executing an action (Logan & Cowan, 1984; Nieuwenhuis & Kleijn, 2013; Posner, 1978; Posner & Peterson, 1990). This resulted in consideration of alternative explanations for the relationship between subjective arousal and response inhibition performance. It was suggested that arousal may be impacting latent variables in the form of perceptual processing which is susceptible to the effects of arousal (Pessoa, 2009) and may represent a single underlying process that plays a key role in behavioural inhibition. Failure to adequately identify and process no-go cues in Experiment 1 is an example of how an arousal-influenced perceptual account can explain the reduction in response inhibition performance during the gambling simulation.

At moderate speeds, whilst arousal remained a predictor of response inhibition performance, overall levels of dissociation also became a significant and negative predictor. At slow speeds, arousal was no longer a significant predictor, and yet the predictive strength of levels of dissociation on response inhibition performance increased. This demonstrates an interaction effect between speed of play and the psychological variables predictive of response inhibition performance. However, an alternative explanation offered is that the dissociation predictive of response inhibition at slower speeds of play may not be a product of the speed of the game *per se,* more a result of the increased time spent gambling as the speed of the game decreased. This increased time spent gambling as the speed of the game was reduced was a result of the number of gambling trials remaining the same across all experimental conditions, but an increase in the time between gambling events.

The critical systematic review of gambling harm-minimisation tools conducted in Chapter 6 identified the range of such tools available within session for electronic gambling, and their relative efficacy in facilitating a gambler's self-control. The tools identified included imposed breaks-in-play, time and monetary limit setting approaches, behavioural feedback, and responsible gambling messaging. The review identified that delivering responsible gambling information via visual messages is a widely used and accepted form of harm-minimisation. However, the efficacy of such messages, in terms of their ability to facilitate cognitive and behavioural factors during gambling, is dependent on their mode of display as well as type of content presented. For example, research has demonstrated that when responsible gambling information is presented to the gambler in a dynamic mode of display (e.g., via pop-up messages), the messages are better recalled and have greater impact on behaviour during gambling when compared to messages delivered in a static format, although these findings have only been found in laboratory-based experiments with small sample sizes (Monaghan & Blaszczynski, 2007; 2010b).

Furthermore, the review highlighted research showing that messages have a greater impact on behaviour when the content encourages self-appraisal of behaviour, when compared to messages that deliver informative content (Monaghan & Blaszczynski, 2010a). However, results presented in the review in Chapter 6 show that whilst behaviour assessed via self-report approaches improves as result of exposure to dynamic responsible gambling messages, objective measures of behaviour taken during gambling show a more inconsistent finding. Furthermore, much of the recent work investigating the impact of dynamic messages on gambling behaviour focuses on how these messages impact the most intense gamblers. This therefore, may limit our understanding of how such messages impact the vast majority of non-problem gamblers, providing some of the motivation for testing variations of pop-up messages as a harm-minimisation tool amongst healthy regular gamblers in Experiment 2 and 3 within this thesis.

In the Chapter 6 review discussion, it was suggested that due to the findings that the effectiveness of pop-up messages in influencing self-control and other aspects of behaviour is dependent on the content delivered in the messages, researchers should continue to explore potential iterations of pop-up messages. This was followed up in Chapter 7, with a conceptual discussion of the role that emotion has in the decision-making process, and how the use of emotional content in dynamic responsible gambling messages could be explored as a harm-minimisation approach.

Based on empirical findings from other health-related research fields and cognitive research more generally, the conceptual discussion in Chapter 7 proposed the use of emotional content in pop-up responsible gambling messages to help shape gambling-related behaviours (see also, Harris et al., 2016). This argument is based on findings suggesting information that is personally relevant or contains emotive content is more likely to draw attention (Compton, 2003; Vuilleumier, 2005), more likely to be deeply processed at a semantic level (Munoz et al., 2014), and therefore, more likely to influence thoughts and subsequent behaviour during gambling. At face value, based on such factors, the use of emotional content in dynamic responsible gambling messages shows promise. However, there are potential negative unintended consequences of invoking emotional responses during gambling. For example, it may be desirable that gamblers consider the potential emotional impact of excessive gambling during a gambling session, but not desirable should they behave in a heightened state of emotion at the expense of more controlled and rational decision-making processes. Therefore, such an approach requires controlled empirical testing prior to any wide-scale policy implementation.

Experiment 2 in Chapter 8 experimentally tested these messages designed to invoke an emotional response and were compared to more classic approaches to pop-up messages with non-emotive content, as well as new harm-minimisation approaches designed to improve self-control in the form of response inhibition during gambling. The two types of pop-up messages tested for their ability to facilitate motor response inhibition during a high event frequency slot machine simulation were emotional content messages and informative messages. The emotional messages referred to the potential financial and familial impact that a lack of self-control during gambling can have, whilst the informative message simply highlighted to the participant that a loss of control can occur without being aware of it and to carefully consider the bets they make.

As well as the use of emotional content in pop-up messages, the original approach to harm-minimisation tested in Experiment 2 was the implementation of a forced discriminatory motor choice procedure in order to operate the slot machine. This involved participants having to press different buttons (left or right arrow key) associated with varying visual cues (left or right arrows) in order to spin the slot machine reels. It was theorised that such an approach would induce greater levels of attention and therefore, more control of motor responses compared to traditional slot machine structures where the spin/gamble button remains the same, with the latter more likely to allow prepotent response styles to develop. It was argued that changing the structure of the of game to one requiring a forced discriminatory motor choice would prevent more automatic prepotent response styles developing, in favour of more deliberate motor outputs.

A final harm-minimisation approach compared in Experiment 2 was a purported financial 'punishment' condition, whereby participants were informed that failing to withhold prepotent responses when appropriate would result in a small financial penalty. It was theorised that such an approach could motivate participants to engage in gambling in a heightened state of attention and self-awareness and therefore exercise greater self-control over motor outputs to avoid erroneous responses. In this light, the potential mechanisms that could result in greater levels of motor control are similar to those in the forced motor choice condition, but without the physical changes to the slot machine simulation structure itself.

Results from the between-participant experiment indicated that when gambling on a high event frequency slot machine simulator, only the forced motor choice procedure and 'punishment' conditions were able to facilitate response inhibition performance when compared to a no-intervention control condition. Pop-up messages, regardless of their content, had no impact on the participant's ability to withhold motor responses when instructed. Levels of subjective arousal in all conditions as assessed using the SAM scale were moderately high but did not differ to a statistically significant degree across conditions. However, significant differences in reaction times across conditions were found, with significantly slower reactions times found in the punishment and structure change conditions when compared to the control condition and both pop-up message conditions. Consistent with an array of literature within cognitive psychology demonstrating speed/accuracy trade-offs (e.g., MacKay, 1982; Bootsma et al., 1994), participants in the structure change and punishment conditions demonstrated slower reaction times but more accurate responses.

The longer reactions times, which have been shown to predict more successful motor inhibition (Logan & Cowan, 1984), likely result from the increased attentional demands of gambling in the structure change and punishment conditions. This demonstrates that increasing attentional salience of cues relevant to motor cautiousness and self-control may represent successful gambling harm-minimisation approaches. However, the approaches in the structure change and punishment conditions are not equivalent. In the structure change condition, the structural parameters and cognitive demands of the game were changed, which required greater levels of attention to operate the slot machine. In the punishment condition, there were no structural changes to the game, meaning the increased reaction time and attention given to gambling cues was likely intrinsically motivated, a notion supported by the finding that self-report motivation to exercise self-control was highest in this punishment condition.

Chapter 9, which served as the introductory chapter to the third and final experiment within the thesis, discussed the construct of impulsivity and how it is now regarded as multifaceted and can be sub-categorised into both motor and cognitive sub-domains. Whilst not conclusive, there is an array of empirical evidence to suggest that different sub-domains of impulsivity are interrelated, where these constructs rely on shared anatomical structures and pathways (see e.g., Chambers et al., 2009; Peters & Buchel, 2011). Fast speeds of play during slot machine gambling had already been demonstrated within this thesis to increase impulsivity in the motor domain, evidenced by poorer response inhibition performance at faster game speeds. The issue still to be addressed in the final empirical chapter of the thesis was whether this speed component in gambling impacts wider aspects of impulsivity. If motor and choice impulsivity are indeed interrelated, then it should follow that a change in one might lead to a change in the other, which affords potential benefits for self-control from a gambling harm-minimisation perspective.

Indeed, this issue was addressed from a positive perspective in Experiment 3 in Chapter 10, where it was investigated that inducing a more cautious motor response style during slot machine gambling can lead to positive carry-over effects in measures of impulsive choice. In a between-participants design experiment, it was demonstrated that when regular non-problem gamblers were forced to pay more attention and take more time over their motor responses, induced by a forced motor choice procedure whilst gambling, this significantly reduced impulsive choice tendencies compared to a no-intervention control condition. Positive outcomes for impulsive choice included the fact that participants showed a greater preference for larger delayed hypothetical monetary rewards over smaller immediate rewards in a delay discounting task, as well as making more accurate decisions, sampling more information, and taking more time over their decisions in an information sampling task.

Of note, these positive choice impulsivity effects were also found when participants were exposed to an emotive pop-up message intervention. However, the emotive message had no impact on motor response inhibition (supporting similar findings in Experiment 2), suggesting the positive impact the message had on impulsive choice elements was independent of a motor cautiousness transfer account. Importantly, the same pattern of results was not found for the non-emotive message intervention condition. The informative message was unsuccessful in facilitating motor response inhibition, but also unsuccessful in providing benefits for impulsive choice domains. This suggests that the content of responsible gambling messages is important for their responsible gambling efficacy, and that emotional content appears a more successful approach warranting further exploration.

The evidence here suggests that the various responsible gambling tools tested in Experiment 3 impacted decision-making by two separate routes; a 'direct route', and an 'indirect route'. In the indirect route, positive cognitive choice effects appear influenced by a transfer of cautiousness stemming from the forced motor choice procedure. This procedure resulted in more cautious motor responses in an online test of response inhibition, evidenced by more accurate motor responses and longer reaction times during gambling. Being forced to exercise caution over motor responses in the structure change condition may have stimulated aversive centres in the brain, which are postulated by Dickinson and Dearing (1979) to act antagonistically with appetitive or approach centres. As a result, subsequent stimuli are more likely to be treated with caution, draw greater levels of attention, and increase the likelihood that choices will be deliberated and considered for longer, evidenced here in Experiment 3 by an increase in choice latency and an increase in the amount of information sampled in an information sampling task. Conversely, the emotive pop-up message intervention failed to have any impact on motor response inhibition performance, and yet had positive effects on impulsive choice, ruling out a motor cautious transfer effect in this experimental condition. It has been argued within this thesis that pop-up messages become effective during periods of time that allow for deliberation and reflection to occur.

The rapid speed of play of slot machine gambling may override the effect of the pop-up message resulting in a lack of improved response inhibition during the slot machine gambling. It was only following the end of the gambling simulation that the effects of pop-up message exposure were evident. Arguably, the subsequent cognitive choice tasks were an example of a situation which encouraged deliberation, and this was therefore a situation in which the cognitive effects of the pop-up message exposure had opportunity to influence decision-making. Within the discussion of Chapter 10, it was proposed that there may be a shared mechanism underlying both the direct and indirect pathways suggested here. Both the need to exercise greater caution over motor responses in the structure change condition, and the presentation of negative consequences associated with loss of control via the emotive pop-up message condition possibly reduce the hedonistic and motivational value of subsequent risk in favour of a more cautious and risk-averse approach. Whilst this does not account for the fact that there was no increase in cautiousness over motor responses in the emotive pop-up message condition, it does suggest that when given the opportunity to consider choices, the relative hedonistic and motivational value of risk is reduced following exposure to responsible gambling messages containing emotive content. This explanation is consistent with Dickinson and Dearing's (1979) proposal of an antagonistic appetitive and aversive system within the brain.

## *11.2 Methodological limitations*

### *11.2.1 General limitations*

The empirical chapters within this thesis utilised the experimental method, the relative strengths and limitations of which within gambling research were discussed in detail in Chapter 4. Generally speaking, common limitations of laboratory-based gambling research include limited real-world validity, failure to capture 'intention to gamble' effects, muted risk/reward effects, and an expectancy of manipulation, as well as demand characteristic effects.

In terms of real-world validity, when one imagines a typical gambling environment, it is one with a vast array of arousing visual and audio stimulation acting as gambling cues and reinforces gambling behaviour via classical and operant conditioning (Blaszczynski & Nower, 2002). This appears to be a marked contrast to a psychological laboratory setting where such reinforcers are typically absent. Becoming more common is the use of the internet and smartphones as platforms for gambling (Griffiths, et al., 2009), meaning that the physical location of gambling may more likely represent those encountered in everyday lives and do not require one to enter a physical gambling environment *per se*. However, online gambling comes with its own problems for gambling behaviour, where one can gamble with increased anonymity and reduced inhibitions compared with gambling in a more social and physical environment. Laboratory-based gambling studies such as those reported within this thesis, fail to fully replicate the sensory stimulating environment of physical gambling venues, nor the anonymous and uninhibited nature of remote gambling.

From a practical standpoint, there is typically a delay of several days between recruiting gambling participants and them actually taking part in a gambling simulation study. Having a predetermined day and specific time to gamble appears somewhat artificial because individuals will usually engage in gambling based on desires and urges to gamble. The affordance of modern remote gambling technology, as well as the abundance of access to high street gambling venues, reduces the temporal delay between getting the urge to gamble and engaging in gambling. Committing to gambling at a specified time and location in the future regardless of desire or intention to gamble likely has cofounding effects on gambling behaviour, where it is arguably likely that less impulsive behaviour will be displayed when compared to gambling in an approach state (Langewisch & Frisch, 1998). Gambling in a laboratory-based environment may therefore lead to muted behavioural effects compared to the behaviour displayed by gamblers gambling based on urges and impulse.

Psychological gambling research is often critiqued for failing to replicate the risk involved in gambling. Ethical restrictions and safeguards usually result in gambling research utilising non-monetary units such as credits or ‘points’. Even if careful ethical consideration allows this restriction to be bypassed, gambling research at a stretch will involve modest amounts of ‘house’ money provided to the participant by the experimenter, with a view that they can keep what they win or have not lost. In this thesis, the participants in each experiment were given either £20, £10, or £9 with which to gamble (depending on the experimental study) where a fixed limit could be wagered on each spin of the slot machine and the highest reward available on any spin was £10. Allowing participants to gamble with real money during gambling experiments was an attempt to maximise the ecological validity of the procedure, though it may still be argued that based on the fact ‘house’ money is being used, the gambling is risk-free for the participant. The level of risk perceived by the participant is likely subjective based on how the monetary stake provided is viewed. Some participants may indeed see their wagers as risk-free, likely reducing the caution taken over their gambling behaviour during the study, whilst others may in fact view the money provided as something real and tangible that can be lost, resulting in greater caution and perceived risk. Effort was made in the present studies to instil a greater sense of ownership in the participant over the initial monetary stake they were provided with. These studies used a carefully constructed participant briefing, where language was used to emphasise to the participants ‘this is now your money to gamble with’. If such approaches are successful in instilling ownership over the monetary stake, then it can be argued that the participants do perceive the monetary risk in the gambling simulations, although validation studies to confirm the efficacy of this procedure are required.

There is a degree of participant expectation in psychological research that their behaviour will be closely scrutinised and that manipulation is taking place. This may result in participants behaving over-cautiously or in an unnatural way, particularly problematic for the current series of experiments given that impulsivity was a key construct of interest. Several procedural measures were put in place to ensure that participants felt they were taking part in slot machine gambling session as opposed to a psychological research experiment, thus maximising the likelihood that more naturalistic behaviour was exercised. Such measures included the fact that the participant briefing emphasised they were about to take part in slot machine gambling, as well as deception as to the key dependent variables of interest, i.e., participants were not told that behavioural response inhibition was being assessed in all experiments, and were simply told to try to withhold motor responses when the spin button was red. Instead, participants were told that the researcher was interested in them feeding back on their experiences of the game. This mild but ethical deception, likely reduced participant self-consciousness over behavioural and cognitive variables of interest, and more likely resulted in naturalistic participant behaviour.

*11.2.2 Limitations of the stimuli set*

The slot machine designed and used for the purpose of this series of experiments had several positive factors contributing to the realism and enjoyment of the game. For example, real money was used to gamble with, monetary prizes were available for matching symbols on each spin, the symbols on the slot machine reels were common and identifiable with other gambling products, and the simulation was accompanied with appealing visual and sound effects. However, there are several limitations with this slot machine simulation compared with in-vivo slot machine products, discussed in detail in Chapter 5. This slot machine simulation was relatively simple in design compared to more sophisticated machines found in live gambling venues and online. For example, this slot machine simulator was a three-reel design with a single pay-line, whereas some slot machines now boast five-reel designs and pay-lines that can go in excess of 10 or even 20 in more extreme examples (although the number of pay-lines in play is usually subject to the choice of the gambler). The maximum amount of money that could be purportedly won on any one spin in this simulation was £10, whereas jackpots can be in excess of hundreds or even thousands of pounds on some slot machine gambling products. There were also several in-game features missing from this simpler slot machine simulation, including 'nudges' and 'holds' which allows a gambler to freeze and manipulate specific reels on a slot machine, as well as the fact there was an absence of 'bonus rounds'. All of these features likely impact the subjective experience of gambling and affect the psychological processes relevant to gambling. For example, gambling with smaller monetary stakes with less opportunity to win large prizes likely mutes the risk of loss and excitement of potential reward. However, of note, other experimental gambling studies have demonstrated that gambling at larger monetary stake sizes has a negative impact on aspects of choice impulsivity (Parke et al., 2015). It is also possible that features such as nudges and holds only add to the illusion of control experienced by the gambler and may be responsible for some of the erroneous cognitions found amongst gambling participants (for example, see Ladouceur & Walker, 1998).

Due to the carefully controlled experimental design, participants were required to complete all trials in all conditions. In line with ethical guidelines (British Psychology Society, 2004), participants were informed they could leave the overall study whenever they wanted and without reason, although they were asked to complete each gambling condition until the end, meaning that decisions to cease gambling was not a free choice *per se*. As a result, participants may have gambled for more or less time than they typically would in a real-world gambling setting, with likely implications for self-control. For example, if a gambler is restricted to a short period of time for his/her gambling session, then increased risk-taking and impulsive response styles may be a result of the temporal limitations imposed on their gambling. Conversely, if the experimental gambling session duration here was longer than typically experienced by gamblers, then fatigue effects may affect an individual's ability to exercise self-control and sustain concentration and self-awareness.

*11.2.3 Measurement limitations*

Self-report measures were used to gather information regarding the participant's subjective levels of arousal, dissociation, motivation, and perceived self-control. Although common criticisms of using self-report to capture emotional states include their lack objectivity and construct validity (for a review, see Robinson & Clore, 2002), it must be noted that the use of self-report psychometric instruments are a commonly used approach within psychological research, and that their general level of convergence with more objective emotional response measures are higher when the self-report information is gathered within close temporal proximity to the emotional event (Maus & Robinson, 2009), principles which were followed in the present series of experiments. Furthermore, Mauss and Robinson (2009) concluded that there is a lack of a 'gold standard' assessment of emotional responses, and that experiential, physiological, and behavioural measures are all relevant to understanding emotion responses and cannot be assumed to be interchangeable. Whilst more objective measures of arousal were considered, the use of external measurement instrumentation would likely have hindered attempts to frame the experiments as a 'gambling experience' to participants, in favour of a more clinical battery of assessment. It was deemed more valuable to try to promote naturalistic behaviour within a more relaxed environment, where the use of self-report measures of emotional responses still provides meaningful quantitative level data without interfering with the former objective, or at least to a lesser extent.

The go/no-go paradigm is one of the most widely used objective measures of response inhibition in psychological research. Within this series of experiments, the go/no-go task was embedded into a slot machine simulation which allowed response inhibition to be measured during the activity in question (i.e., gambling). As a result, the variation of the go/no-go task used in these experiments can be considered an 'online' measurement. This is one of the factors that separate the go/no-go procedure used here with other studies, where it is not atypical for participants to be exposed to an experimental manipulation first, and then for response inhibition to be measured using the go/no-go task later but close in temporal proximity to the end of the experimental exposure. Emotional responses from gambling can fluctuate and dissipate rapidly following gambling cessation (Meyer et al., 2000), meaning that a traditional go/no-go procedure could result in several influential emotional factors that influence response inhibition performance failing to be captured.

Another significant procedural modification of this go/no-go task is that it is common for participants to be instructed to respond as rapidly and accurately as possible on go/no-go tasks (for a review, see

Simmonds et al., 2008). One of the principal aims of the thesis was to examine the impact of speed of play of gambling on psychological and behavioural factors in gamblers, which includes an examination of how the speed of the game impacts response times and behavioural inhibition. Therefore, instructing participants to respond rapidly would likely induce more commission errors on the embedded go/no-go task, as well as unnaturally increasing the rate at which the gambler feels compelled to gamble on the simulator. Because of this procedural modification, participant response times and response inhibition performance across conditions can be more confidently attributed to the experimental manipulations. Not instructing gamblers to respond rapidly kept the experiment more naturalistic and representative of real-world gambling and kept the purported emphasis of the purpose of the gambling simulator as a 'gambling experience', rather than a cognitive test battery.

A final limitation of the go/no-go task used in this series of experiments was the lack of the use of a gaze fixation point before each gambling trial in the vicinity of upcoming go and no-go cues. Whilst this has the benefit of allowing for a naturalistic gaze and fixation pattern during the gambling simulation, one of the drawbacks of this is that it makes it less clear whether commission errors on the task were a result of poor inhibitory motor control, or a failure to identify and therefore, respond appropriately to go and no-go cues. To help resolve this issue, follow-up investigations could utilise eye-tracking technology to assess the gaze patterns of participants and identify if commission errors on this online response inhibition task are correlated with a failure to fixate on no-go cues when they are present.

It should be noted that individuals can shift their focus of attention without an eye movement (Wright & Ward, 2008). All experimental stimuli were presented within a relatively small visual display (12''x 7''), the section of the screen that presented the coloured go and no-go cues was relatively large and in close proximity to the gambling-related stimuli within the slot machine simulation (see Figure 5.1 in Chapter 5), and the fact that this was a coloured go/no-go paradigm, meant go and no-go cues were brightly coloured and were highly contrasted relative to the dark boarders of the screen. Given these factors, it is deemed highly unlikely that these visual go and no-go cues would be missed regardless of participant on-screen fixation location.

### *11.3 Implications and future research*

The discussion of the first experimental study in this thesis argued that it may not be possible to fully capture the complex construct of emotional arousal in a single measurement approach. As Lang (1988) argues, the construct of arousal is best conceptualised as multiply determined rather than characterised by a one-dimensional approach. The theoretical explanation for the role of arousal as a predictor in response inhibition performance during gambling would benefit from multiple concurrent measures of arousal within the gambling simulation. More objective tests utilising measurement methods including heart rate variability and galvanic skin responses for example, could provide confirmatory biological evidence for the proposed significant role that arousal plays in motor impulsivity during gambling, as well as shed light on the level of convergence between these objective tests and the self-report methods used here.

Experiment 1 also demonstrated that participants were able to exercise a greater level of self-control in the form of motor response inhibition when the slot machine event frequency was reduced. Considering this finding in isolation could result in the reasonable conclusion that the maximum event frequency of slot machines need to be reduced. Future research would benefit from assessing how these structural changes to gambling products impact gambling behaviour in terms of the pattern, frequency, and size of wager amounts. For the purposes of high levels of extraneous control, participants were limited to a single sized wager that could not be adjusted, as well as restricted to gambling with a single slot machine pay-line. It might be the case that if a gambler was restricted to gambling at a particular speed, they may have displayed compensatory behaviour in the form of higher-risk bets, larger wager amounts, and more pay-lines when gambling on these slower products. Contrary to this, other empirical gambling studies highlighted in Chapter 2 of the thesis (e.g., Mentzoni et al., 2012), show that higher wager amounts are found when gambling at faster speeds of play.

Also, as evidenced in Experiment 1 shows, slowing down game speed comes at the cost of significant decreased enjoyment whilst gambling, which could lead to a migration of gambling behaviour towards games with higher stakes. Higher stakes gambling, which has been shown to elicit a greater emotional response (for example, see Parke et al., 2015; Wuflert et al., 2008), may act in a compensatory way for the reduced arousal and enjoyment experienced when gambling on slower event frequency slot machines, and yet potentially pose a higher monetary risk to gamblers, and the knock-on effect this can have on health, interpersonal, and vocational factors. A slower game speed whilst controlling for all other factors, such as the amount of slot machine spins and amount of money wagered on each spin cycle, also results in a longer gambling session, as evidenced in experiment one. These longer sessions at slower speeds result in higher levels of self-report dissociative experiences which predict poorer response inhibition performance.

Some gamblers report one of the reasons for engaging in slot machine gambling is to dissociate as a way of reducing tension and stress (Ste-Marie, Gupta, & Derevensky, 2002). In this psychological state characterised as ‘zoning out’ or disengagement (Allcock et al., 2006) and gambling on ‘autopilot’ (Griffiths, 1994), then this likely results in a reduction in the amount of conscious behavioural execution, in favour of more automatic stimulus driven responses, arguably undesirably given the risk involved in gambling when self-control is diminished. As a result of these potential negative unintended consequences to slowing maximum game speeds, research would benefit from assessing the longer-term behavioural implications of such policy changes, and an assessment of such should take place in a more naturalistic setting. Arguably, this could be run using a pilot sample of gamblers prior to any large-scale policy changes.

An alternative to slowing slot machine game speed that has received empirical support here, is the provision of structural changes that prevent response prepotency and automatic response tendencies developing. Experiment 2 demonstrated that making simple structural changes to the spin button on slot machines, where increased attentional engagement and discrimination of motor responses is required to operate the machine, has beneficial effects for self-control. Not only did such structural changes improve response inhibition performance, but experiment three showed they also had beneficiary carry-over effects to wider aspects of cognitive functioning. Such carry-over effects included the fact that participants who gambled on the structurally altered slot machine also later showed a greater preference for larger delayed rewards over smaller immediate rewards in a monetary delay discounting task. Participants exposed to the structurally altered slot machine also sampled more information, spent more time making decisions, and overall, made more accurate decisions in a subsequent information sampling task. Taken together, those participants induced to exercise greater levels of motor control also showed reduced impulsive choice tendencies, arguably demonstrating a transfer of cautiousness effect. One of the potential appeals of this approach from a gaming industry perspective is that whilst the simple structural changes here had benefits for impulsive action and impulsive choice, the measures did not detract from the arousing and emotional experience of gambling. Furthermore, facilitating response inhibition with a gambling session may provide gamblers with the tools required to maintain higher levels of within session self-control, and the ability to inhibit motor behaviour could have a beneficial impact on a gambler’s ability to quit the game before excessive time and monetary losses are experienced.

To the present author’s knowledge, this is the first series of studies that has assessed the impact of structural changes to slot machines on response inhibition, and therefore, the discriminatory motor choice procedure used here to induce motor cautiousness is perhaps just one of several ways this effect during gambling can be obtained. For example, touch-screen technology utilised in digital forms of gambling could be utilised where the position of the spin/gamble button on-screen could be altered between gambling events. In a similar way to the experimental manipulation here, this would likely reduce a gambler’s ability to gamble in a more passive conscious state, in favour of more active engagement and consciousness over motor actions. Of course, such measures should be tested for their efficacy before any wide-scale implementation, and such concepts could be feasibly investigated with follow-up experimental investigations.

Further implications to be taken from the experiments within this thesis is that it appears current approaches to responsible gambling messages, in terms of content efficacy on responsible gambling behaviour, could be improved. Here, to the present author's knowledge, this is the first time that the use of emotive content in pop-up messages during slot machine gambling has been used. Whilst pop-up messages in the gambling simulations in Experiments 2 and 3 failed to facilitate response inhibition performance irrespective of the content displayed in the messages, emotional content had a greater impact on performance on choice impulsivity tasks compared to non-emotive content in Experiment 3. The use of emotional content in responsible gambling messages thus appears a fruitful avenue of exploration. However, the emotional content displayed in the emotive messages here was non-specific to the gambler, though could easily have triggered thoughts that were indeed more specific and personal to the individual viewing the messages. It is likely the case that what motivates someone to exercise greater levels of self-control in a gambling context would be subjective. For example, the thought of familial relationship breakdown for one person could be a more powerful motivator, for others, it might be the thought of not being able to afford an upcoming holiday if they gamble excessively. Account-based play that is typically found in online gambling and is available when gambling in live venues, affords the opportunity for gamblers to set their own responsible gambling message content when gambling on electronic products. With this approach, gamblers will not only be subjected to generic emotive content, but content that is both emotive and personally relevant to them. This combines the decision-making benefits of emotional content in messages found here with research findings that suggest that when messages are personally relevant and derived through one's own value system, they are likely to have a greater impact on thoughts and behaviour (Harris et al., 2016).

### *11.4 Final remarks*

This thesis employed experimental research methodology to investigate the impact of speed of play of slot machine gambling on executive control processes. Experiment 1 showed that machines that possess higher gambling event frequencies were detrimental to the response inhibition performance of regular, non-problem gamblers, resulting in a failure to withhold motor responses when required. The game with the highest event frequency also resulted in higher levels of subjective arousal and faster reactions times, with both variables independently and negatively predicting response inhibition performance. Experiment 2 demonstrated that when gambling on high event frequency slot machines, response inhibition performance can be facilitated by making structural changes to the machine that require gamblers to actively attend to, and discriminate between, motor responses. Pop-up messages containing responsible gambling information that was either emotive or non-emotive both failed to facilitate motor response inhibition. Experiment 3 demonstrated that inducing motor cautiousness has positive carry-over effects for wider areas of cognition, demonstrated by greater tolerance for delayed rewards, longer response latencies, and more accurate decisions in a battery of impulsive choice tasks. The same effect on impulsive choice task performance was also found when participants were previously exposed to an emotive pop-up message. The emotive messages' effects were independent of a transfer of motor cautiousness account, demonstrating that impulsivity on impulsive choice tasks can be reduced via this more direct route, as well as by inducing motor cautiousness with simple structural changes to slot machines.

Taken together, the results provide experimental evidence for a cause and effect relationship between increased speed of play during gambling and impairment in motor response inhibition. These deleterious effects can be limited, without impacting the enjoyment of gambling, by making structural changes to slot machines that encourage controlled motor responses in favour of more simplistic structures that afford development of response prepotency and automaticity. Furthermore, implementing such changes to slot machines appear to have wider benefits for gambling-related decisions, and therefore, the benefits are not limited to motor inhibition domains. Finally, the use of emotion-laden content in in pop-up responsible gambling messages appear to be more efficacious in reducing impulsive choice than non-emotive responsible gambling messages, therefore, warranting further investigation into this approach as a harm-minimisation measure on gaming machines.

It is important to emphasise that these measures are not intended as a 'silver bullet' for problem gambling and are instead intended as a proactive approach to prevent the vast majority of gamblers who gamble without problems to maintain high levels of self-control within a gambling session. However, that is not to say that problem gamblers would not benefit from such approaches. For example, impairments in executive control, and in particular motor control, have been associated with several impulse-control disorders including pathological gambling (Chambers et al., 2009; Verbruggen & Logan, 2008). Motor disinhibition has been shown to predict relapse in problem gamblers (Goudriaan et al., 2008), therefore emphasising the clinical significance of inhibitory control. Future research could therefore benefit from assessing the clinical utility of incorporating motor control training into treatment for problem gambling, which based on findings within this thesis, could also have benefits for wider cognitive domains beyond motor control.

This thesis has demonstrated that higher event frequency gambling is detrimental for inhibitory control. However, this can be counteracted by making simple structural changes to slot machines that facilitate motor inhibition, which has also been demonstrated to reduce levels of impulsive choice. Replication of the results within this thesis is a priority, as well as an assessment of the efficacy of these harm-minimisation approaches in more naturalist gambling settings prior to any wide-scale gambling policy implementations.

## References

Abbott, M., Williams, M. M., & Volberg, R. A. (1999). *Seven years on: A follow-up study of frequent and problem gamblers living in the community.* Wellington, New Zealand: Department of Internal Affairs.

Adams, P. J., Raeburn, J., & de Silva, K. (2009). A question of balance: prioritizing public health responses to harm from gambling. *Addiction*, *104*, 688–691.

Agrawal, N., & Duhachek, A. (2010). Emotional compatibility and the effectiveness of anti-drinking messages: A defensive processing perspective on shame and guilt. *Journal of Marketing Research, 47*(2), 263–273.

Ahn, W. Y., Rass, O., Fridberg, D. J., Bishara, A. J., Forsyth, J. K., Breier, A., ... & O'donnell, B. F. (2011). Temporal discounting of rewards in patients with bipolar disorder and schizophrenia. *Journal of Abnormal Psychology*, *120*(4), 911-921.

Alderson, R. M., Rapport, M. D., & Kofler, M. J. (2007). Attention-deficit/hyperactivity disorder and behavioral inhibition: A meta-analytic review of the stop-signal paradigm. *Journal of Abnormal Child Psychology, 35*(5), 745-758.

Allcock, C., Delfabbro, P., Garcia, A., Griffiths, M. D., Jacobs, D., McCorriston, T., … & Wanner, B. (2006). *Current Issues Related to Dissociation.* Melbourne: Australian Gaming Council.

Ambady, N., & Gray, H. M. (2002). On being sad and mistaken: Mood effects on the accuracy of thin-slice judgments. *Journal of Personality and Social Psychology, 83*, 947-961.

American Psychiatric Association. (1980). *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed.). Washington, DC: Author.

American Psychiatric Association. (1987). *Diagnostic and Statistical Manual of Mental Disorders* (3rd ed., revised). Washington, DC: Author.

American Psychiatric Association. (1994). *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.). Washington, DC: Author.

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). Washington, DC: Author.

Anderson, G., & Brown, R. I. F. (1984). Real and laboratory gambling, sensation-seeking and arousal. *British Journal of Psychology, 75,* 401–410.

Anderson, C. A., Lindsay, J. J., & Bushman, B. J. (1999). Research in the psychological laboratory: Truth or triviality? *Current Directions in Psychological Science*, *8*(1), 3-9.

Anglin, M. D., & Hser, Y. I. (1990). Treatment of drug abuse. *Crime and justice*, *13*, 393-460.

Anokhin, A. P., Golosheykin, S., & Mulligan, R. C. (2015). Long-term test–retest reliability of delayed reward discounting in adolescents. *Behavioural Processes, 111*, 55-59.

Arce, E., & Santisteban, C. (2006). Impulsivity: A review. *Psicothema, 18*(2), 213-220.

Aron, A. R. (2011). From reactive to proactive and selective control: developing a richer model for stopping inappropriate responses. *Biological Psychiatry*, *69*(12), 55-68.

Aron, A. R., Robbins, T. W., & Poldrack. R. A. (2014). Inhibition and the right inferior frontal cortex: One decade on. *Trends in Cognitive Sciences, 18*, 177–185.

Aron, A. R., & Verbruggen, F. (2008). Stop the presses: dissociating a selective from a global mechanism for stopping. *Psychological Science*, *19*(11), 1146-1153.

Association of British Bookmakers (2015). *What is a FOBT (Fixed Odd Betting Terminal) and why do betting shops have them when they didn't have them before?* Retrieved October 25, 2015, from http://abb.uk.com/what-are-fobts-and-why-do-betting-shops-have-them-when-they-didnt-have-them-before/.

Aston-Jones, G., & Cohen, J. D. (2005). An integrative theory of locus coeruleus-norepinephrine function: adaptive gain and optimal performance. *Annual Review of Neuroscience, 28*, 403-450.

Auer, M., & Griffiths, M. D. (2013). Behavioral tracking tools, regulation, and corporate social responsibility in online gambling. *Gambling Law Review and Economics, 17*(8), 579-583.

Auer, M., & Griffiths, M. D. (2013). Voluntary limit setting and player choice in the most in-tense online gamblers: An empirical study of gambling behaviour. *Journal of Gambling Studies, 29,* 647-660,

Auer, M., & Griffiths, M. D. (2015). Testing normative and self-appraisal feedback in an online slot-machine pop-up in a real-world setting*. Frontiers in Psychology, 6*, 339.

Auer, M. M., & Griffiths, M. D. (2015). The use of personalized behavioral feedback for online gamblers: An empirical study. *Frontiers in Psychology, 6*, 1406.

Auer, M. & Griffiths, M. D. (2016). Personalized behavioral feedback for online gamblers: A real world empirical study*. Frontiers in Psychology*, *7,* 1875.

Auer, M., Malischnig, D., & Griffiths, M. D. (2014). Is 'pop-up' messaging in online slot machine gambling effective as a responsible gambling strategy? An empirical research note. *Journal of Gambling Issues, 29*, 1–10.

Auer, M., Schneeberger, A. & Griffiths, M. D. (2012). Theoretical loss and gambling intensity: A simulation study. *Gaming Law Review and Economics, 16*, 269-273.

Augustinova, M., & Ferrand, L. (2014). Automaticity of word reading: Evidence from the semantic Stroop paradigm. *Current Directions in Psychological Science*, *23*(5), 343-348.

Australian Productivity Commission (APC) (1999). *Australia's Gambling Industries. Report No. 10.* Canberra: Ausinfo.

Ávila, C., Cuenca, I., Félix, V., Parcet, M. A., & Miranda, A. (2004). Measuring impulsivity in school-aged boys and examining its relationship with ADHD and ODD ratings. *Journal of Abnormal Child Psychology, 32,* 295-304.

Babor, T., Caetano, R., Casswell, S., Edwards, G., Giesbrecht, N., Graham, K., … Rossow, I. (2003). Alcohol: *No ordinary commodity. Research and public policy*. New York: Oxford University Press.

Baddeley, A. (1996). Exploring the central executive. *The Quarterly Journal of Experimental Psychology*, *49*(1), 5-28.

Bailey, B.P., Konstan, J.A., & Carlis, J.V. (2001). The effects of interruptions on task performance, annoyance, and anxiety in the user interface. *Proceedings of IFIP TC.13 International Conference on Human–Computer Interaction* (pp. 593–601). Amsterdam: IOS Press.

Bari, A., Kellermann, T. S., & Studer, B. (2016). Impulsiveness and inhibitory mechanisms. In Abshe, J. R., & Clotier, J. (Eds), *Neuroimaging Personality, Social Cognition, and Character* (pp. 113-136). Amsterdam: Academic Press.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182.

Batstra L., & Frances, A. (2012). Diagnostic inflation: Causes and a suggested cure. *Journal of Nervous. Mental Disorders, 200,* 474–479.

Bechara, A. (2002). The neurology of social cognition. *Brain, 125*, 673-1675.

Bechara A. (2003). Risky business: emotion, decision-making, and addiction. *Journal of Gambling Studies, 19,* 23-51.

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex, 10*, 295-307.

Bechara, A., Noel, X., & Crone, E. A. (2006). Loss of Willpower: Abnormal Neural Mechanisms of Impulse Control and Decision Making in Addiction. In R. W. Wiers & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction* (pp. 215-232). Thousand Oaks, CA, US: Sage Publications, Inc.

Becheur, I., Dib, H., Merunka, D., & Valette-Florence, P. (2007). Emotions of fear, guilt or shame in anti-alcohol messages: Measuring direct effects on persuasion and the moderating role of sensation seeking. In Borghini, S., McGrath, M. A., & Otnes, C. Duluth (Eds.), *E - European Advances in Consumer Research, 8* (pp. 99-106). MN: Association for Consumer Research.

Benhsain, K., Taillefer, A., & Ladouceur, R. (2004). Awareness of independence of events and erroneous perceptions while gambling. *Addictive Behaviors, 29*, 299-304.

Berkman, E. T., Kahn, L. E., & Merchant, J. S. (2014). Training-induced changes in inhibitory control network activity. *Journal of Neuroscience, 34*(1), 149-157.

Bernstein, R. (1989). Exposure and affect: Overview and meta-analysis of research. *Psychological Bulletin, 106*, 265-289.

Bernstein, E. M., & Putnam, F. W. (1986). Development, reliability, and validity of a dissociation scale. *Journal of Nervous and Mental Disease*, *174*(12), 727-735.

Berwid, O. G., Curko Kera, E. A., Marks, D. J., Santra, A., Bender, H. A., & Halperin, J. M. (2005). Sustained attention and response inhibition in young children at risk for Attention Deficit/Hyperactivity Disorder. *Journal of Child Psychology and Psychiatry*, *46*(11), 1219-1229.

Betrancourt, M. & Bisseret, A. (1999) Integrating textual and pictorial information via pop-up windows: An experimental study. *Behaviour and Information Technology, 17*, 263-273.

Bickel, W. K., Jarmolowicz, D. P., Mueller, E. T., Gatchalian, K. M., & McClure, S. M. (2012). Are executive function and impulsivity antipodes? A conceptual reconstruction with special reference to addiction. *Psychopharmacology, 221*(3), 361–387.

Billieux, J., Lagrange, G., Van der Linden, M., Lançon, C., Adida, M., & Jeanningros, R. (2012). Investigation of impulsivity in a sample of treatment-seeking pathological gamblers: A multidimensional perspective. *Psychiatry Research*, *198*(2), 291-296.

Birren, J. E., & Fisher, L. M. (1995). Aging and speed of behavior: Possible consequences for psychological functioning. *Annual Review of Psychology*, *46*(1), 329-353.

Blakemore, S. J., & Choudhury, S. (2006). Development of the adolescent brain: Implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry, 47*(3), 296-312.

Blaszczynski, A. (1988). *Clinical studies in pathological gambling*. PhD Thesis, University of New South Wales, Sydney, Australia.

Blaszczynski, A., Cowley, E., Anthony, C., & Hinsley, K. (2015). Breaks in play: Do they achieve intended aims? *Journal of Gambling Studies,* 32(2), 789-800.

Blaszczynski, A., & Nower, L. (2002). A pathways model of problem and pathological gambling. *Addiction, 97*(5), 487–499.

Blaszczynski, A. & Nower, L. (2010). Instrumental tool or drug: Relationship between attitudes to money and problem gambling. *Addiction Theory and Research, 18*(6), 681-691.

Blaszczynski, A., McConaghy, N., & Frankova, A. (1990). Boredom-proneness in pathological gambling. *Psychological Reports, 67*, 35-42.

Blaszczynski, A., Sharpe, L., Walker, M., Shannon, K., & Coughlan, M.J. (2005). Structural characteristics of electronic gaming machines and satisfaction of play among recreational and problem gamblers. *International Gambling Studies, 5*, 187-198.

Bogacz, R., Wagenmakers, E. J., Forstmann, B. U., & Nieuwenhuis, S. (2010). The neural basis of the speed-accuracy tradeoff. *Trends in Neurosciences, 33*, 10-16.

Bootsma, R. J., Marteniuk, R. G., MacKenzie, C. L., & Zaal, F. T. (1994). The speed-accuracy trade-off in manual prehension: Effects of movement amplitude, object size and object width on kinematic characteristics. *Experimental Brain Research, 98*(3), 535-541.

Bradley, J. V. (1958). Complete counterbalancing of immediate sequential effects in a Latin square design. *Journal of the American Statistical Association, 53*(282), 525-528.

Bradly, M. M. (1994). Emotional memory: A dimensional analysis. In S. van Goozen, N. E. van de Poll, & J. A. Sergeant (Eds.), *The emotions: Essays on emotion theory* (pp. 97-134). Hillsdale, NJ: Erlbaum.

Bradly, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behaviour, Therapy, and Experimental Psychiatry, 25*(1), 49-59.

Braver, T. S., Barch, D. M., Gray, J. R., Molfese, D. L., & Snyder, A. (2001). Anterior cingulate cortex and response conflict: effects of frequency, inhibition and errors. *Cerebral cortex, 11*(9), 825-836.

Breen, H., & Zimmerman, M. (2002). Rapid onset of pathological gambling in machine gamblers. *Journal of Gambling Studies, 18*, 31-43.

Brevers, D., Cleeremans, A., Verbruggen, F., Bechara, A., Kornreich, C., Verbanck, P., & Noel, X. (2012). Impulsive action but not impulsive choice determines problem gambling severity. *PLoS ONE, 7*(11), e50647.

Brevers, D., He, Q., Keller, B., Noël, X., & Bechara, A. (2017). Neural correlates of proactive and reactive motor response inhibition of gambling stimuli in frequent gamblers. *Scientific Reports*, *7*(1), 7394.

British Psychological Society. (2004). *Code of Conduct, Ethical Principles and Guidelines. BPS Publication.* Retrieved November 17, 2016, from:http://www.bps.org.uk/document-download-area/document-download$.cfm?file_uuid=6D0645CC-7E96-C67F-D75E2648E5580115&ext=pdf.

Broadbent, D. E. (1958). *Perception and communication*. London: Pergamon Press.

Broda, A., LaPlante, D. A., Nelson, S. E., LaBrie, R. A., Bosworth, L. B., & Shaffer, H. J. (2008). Virtual harm reduction efforts for internet gambling: Effects of deposit limits on actual internet sports gambling behaviour. *Harm Reduction Journal, 5*(27).

Broos, N., Diergaarde, L., Schoffelmeer, A. N., Pattij, T., & De Vries, T. J. (2012a). Trait impulsive choice predicts resistance to extinction and propensity to relapse to cocaine seeking: A bidirectional investigation. *Neuropsychopharmacology, 37*(6), 1377-1386.

Broos, N., Schmaal, L., Wiskerke, J., Kostelijk, L., Lam, T., Stoop, N., ... Goudriaan, A. E. (2012b). The relationship between impulsive choice and impulsive action: A cross-species translational study. *PLoS ONE 7*(5), e36781.

Bunge, S. A., Dudukovic, N. M., Thomason, M. E., Vaidya, C. J., & Gabrieli, J. D. (2002). Immature frontal lobe contributions to cognitive control in children: Evidence from fMRI. *Neuron, 33*(2), 301-311.

Caillon, J., Grall-Bronnec, M., Hardouin, J. B., Venisse1, J. L., & Challet-Bouju, G., (2015). Online gambling's moderators: how effective? Study protocol for a randomized controlled trial. *BMC Public Health, 15*, 519.

Calado, F., & Griffiths, M. D. (2016). Problem gambling worldwide: An update and systematic review of empirical research (2000-2015). *Journal of Behavioural Addictions, 5*(4), 592-613.

Callejas, A., Lupia`ñez, J., Funes, M. J., & Tudela, P. (2005). Modulations among the alerting, orienting and executive control networks. *Experimental Brain Research, 167*, 27-37.

Cardena, E. (1994). The domain of dissociation. In S. J. Lynn & J. W. Rhue (Eds.), *Dissociation: Clinical and theoretical perspectives* (pp. 15-31). New York, NY, US: Guilford Press.

Carrera, P., Muñoz, D., & Caballero, A. (2010). Mixed emotional appeals in emotional and danger control processes. *Health Communication, 25*(8), 726-736.

Celio, M. A., and Lisman, S.A. (2014). Examining the efficacy of a personalized normative feedback intervention to reduce college student gambling. *Journal of American College Health, 62,* 154–164.

Chambers, C. D., Bellgrove, M. A., Stokes, M. G., Henderson, T. R., Garavan, H., Robertson, I. H., ... Mattingley, J. B. (2006). Executive "brake failure" following deactivation of human frontal lobe. *Journal of Cognitive Neuroscience, 18*, 444-455.

Chambers, C. D., Garavan, H., & Bellgrove, M. A. (2009) Insights into the neural basis of response inhibition from cognitive and clinical neuroscience. *Neuroscience and Biobehavioral Reviews, 33*, 631-646.

Chan, R. C., Shum, D., Toulopoulou, T., & Chen, E. Y. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives of Clinical Neuropsychology*, *23*(2), 201-216.

Charlton, S. R., & Fantino, E. (2008). Commodity specific rates of temporal discounting: Does metabolic function underlie differences in rates of discounting? *Behavioural Processes*, 77(3), 334-342.

Chen, X. J., & Kwak, Y. (2017). What makes you go faster? The effect of reward on speeded action under risk. *Frontiers in Psychology*, *8*, 1057.

Cherek, D. R., & Lane, S. D. (1999). Laboratory and psychometric measurements of impulsivity among violent and nonviolent female parolees. *Biological Psychiatry, 46*(2), 273-280.

Chóliz, M. (2010). Experimental analysis of the game in pathological gamblers: Effect of the immediacy of the reward in slot machines. *Journal of Gambling Studies, 26*, 249-256.

Clark, L. (2010). Decision-making during gambling: an integration of cognitive and psychobiological approaches. *Philosophical Transactions of the Royal Society of London: Biological Sciences*, *365*(1538), 319-330.

Clark, L., Lawrence, A. J., Astley-Jones, F., & Gray, N. (2009a). Gambling near-misses enhance motivation to gamble and recruit win-related brain circuitry. *Neuron, 61*(3), 481-490.

Clark, L., Robbins, T. W., Ersche, K. D., & Sahakian, B. J. (2006). Reflection impulsivity in current and former substance users. *Biological Psychiatry, 60*(5), 515-522.

Clark, L., Roiser, J. P., Robbins, T. W., & Sahakian, B. J. (2009b). Disrupted reflection impulsivity in cannabis users but not current or former ecstasy users. *Journal of Psychopharmacology, 23*(1), 14-22.

Cloutier, M., Ladouceur, R., & Sevigny, S. (2006). Responsible gambling tools: Pop-up messages and pauses on video lottery terminals. *Journal of Psychology, 140*(5), 434-438.

Codrons, E., Bernardi, N. F., Vandoni, M., & Bernardi, L. (2014). Spontaneous group synchronization of movements and respiratory rhythms. *PLoS ONE, 9*(9): e107538.

Collins, P, Blaszczynski, A., Ladouceur, R., Shaffer, H. J., Fong, D., & Venisse, J. L. (2015). Responsible gambling: Conceptual considerations. *Gaming Law Review and Economics, 19*(8), 594-599.

Compton R. J. (2003). The interface between emotion and attention: A review of evidence from psychology and neuroscience. *Behavioural and Cognitive Neuroscience Reviews, 2*(2), 115-129.

Compton, R. J., Banich, M. T., Mohanty, A., Milham, M. P., Herrington, J.,Miller, …Heller, W. (2003). Paying attention to emotion: An fMRI investigation of cognitive and emotional Stroop tasks. *Cognitive, Affective, and Behavioral Neuroscience, 3*(2), 81–96.

Cook, E. W., Melamed, B. G., Cuthbert, B. N., McNeil, D. W., & Lang, P. J. (1988). Emotional imagery and the differential diagnosis of anxiety. *Journal of Consulting and Clinical Psychology, 56*(5), 734-740.

Corr, P. J. & Thompson, S. J. (2014). Pause for thought: Response perseveration and personality in gambling. *Journal of Gambling Studies, 30*, 889-900.

Coull, J. T., Nobre, A. C., & Frith, C. D. (2001). The noradrenergic α2 agonist clonidine modulates behavioural and neuroanatomical correlates of human attentional orienting and alerting. *Cerebral Cortex*, *11*(1), 73-84.

Currie, S. R. & Casey, D. M. (2007). Quantification and dimensionalisation of gambling behaviour. In G.J. Smith, D.C. Hodgins, & R.J. Williams (Eds), *Research and Measurement Issues in Gambling Studies*. (pp.664) New York: Elsevier Inc.

Dalley, J. W., Everitt, B. J., & Robbins, T. W. (2011). Impulsivity, compulsivity, and top-down cognitive control. *Neuron*, *69*(4), 680-694.

Dalley J. W., Fryer T. D., Brichard L., Robinson E. S., Theobald D. E.,…& Laane K. (2007). Nucleus accumbens D2/3 receptors predict trait impulsivity and cocaine reinforcement. *Science, 315*, 1267-1270.

Damasio, A.R. (2000). *The feeling of what happens: Body and emotion in the making of consciousness*. London: Heinemann.

Darwin, C., Ekman, P., & Prodger, P. (1998). *The expression of the emotions in man and animals*, (3rd ed.). London: Harper Collins.

Davey, G. (2008). *Psychopathology: Research, assessment and treatment in clinical psychology*. Leicester: BPS Blackwell.

de Arcos, F. A., Verdejo-García, A., Peralta-Ramírez, M. I., Sánchez-Barrera, M., & Pérez-García, M. (2005). Experience of emotions in substance abusers exposed to images containing neutral, positive, and negative affective stimuli. *Drug and Alcohol Dependence, 78*(2), 159-167.

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Deci, E. L., & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behaviour. *Psychological Inquiry, 11*, 227- 268.

Delfabbro, P., Falzon, K., & Ingram, T. (2005). The effects of parameter variations in electronic gambling simulations: Results of laboratory-based pilot investigation. *Gambling Research, 17*(1), 7-25.

Dell, P. F. (2001). Why the diagnostic criteria for dissociative identity disorder should be changed. *Journal of Trauma & Dissociation*, *2*(1), 7-37.

Derevensky, J., Merrick, J., & Shek, D. T. L. (2011). *Youth gambling: The hidden addiction*. Berlin, Germany: Hubert and Co.

Derryberry, D., & Rothbart, M. K. (1988). Arousal, affect, and attention as components of temperament. *Journal of Personality and Social Psychology, 55*(6), 958.

Diamond, A. (2016). Why improving and assessing executive functions early in life is critical. In P. McCardle, L. Freund, J. A. Griffin (Eds), *Executive function in preschool-age children: Integrating measurement, neurodevelopment, and translational research*. (pp.11-43). American Psychological Association.

Dickinson, A., & Balleine, B. (2002). The role of learning in the operation of motivational systems. In H. Pashler & R. Gallistel (Eds.), *Steven's handbook of experimental psychology: Learning, motivation, and emotion* (pp. 497-533). Chichester: Wiley.

Dickinson, A., & Dearing, M. F. (1979). Appetitive-aversive interactions and inhibitory processes. In: Dickinson A, Boakes RA, editors. *Mechanisms of learning and motivation* (pp. 203-231). Hillsdale, NJ: Erlbaum.

Dickman, S. J., & Meyer, D. E. (1988). Impulsivity and speed-accuracy tradeoffs in information processing. *Journal of Personality and Social Psychology*, *54*(2), 274-290.

Dickson-Swift, V. A., James, E. L., & Kippen, S. (2005). The experience of living with a problem gambler: Spouses and partners speaking out. *Journal of Gambling Issues, 13*, 1-22.

Diergaarde, L., Pattij, T., Poortvliet, I., Hogenboom, F., De Vries W., Schoffelmeer, A. N., & De Vries T. J. (2008). Impulsive choice and impulsive action predict vulnerability to distinct stages of nicotine seeking in rats. *Biological Psychiatry, 63*, 301-308.

Diskin, K., & Hodgins, D. (1999). Narrowing of attention and dissociation in pathological video lottery gamblers. *Journal of Gambling Studies, 15*, 17-28.

Diskin, K. M., & Hodgins, D. C. (2001). Narrowed focus and dissociative experiences in a community sample of experienced video lottery gamblers. *Canadian Journal of Behavioural Science, 33*, 58–64.

Dombrovski, A. Y., Szanto, K., Siegle, G. J., Wallace, M. L., Forman, S. D., Sahakian, B., ... & Clark, L. (2011). Lethal forethought: delayed reward discounting differentiates high-and low-lethality suicide attempts in old age. *Biological Psychiatry, 70*(2), 138-144.

Donders, F. C. (1969). On the speed of mental processes. *Acta Psychologica*, *30*, 412-431.

Dong, G., & Potenza, M. N. (2014). A cognitive-behavioral model of Internet gaming disorder: theoretical underpinnings and clinical implications. *Journal of Psychiatric Research*, *58*, 7-11.

Dow Schüll, N. (2012). *Addiction by design: Machine gambling in Las Vegas*. Princeton, NJ: Princeton University Press.

Dresler, T., Mériau, K., Heekeren, H. R., & van der Meer, E. (2009). Emotional Stroop task: Effect of word arousal and subject anxiety on emotional interference. *Psychological Research PRPF, 73*(3), 364-371.

Droungas, A., Ehrman, R. N., Childress, A. R. & O'Brien, C. P. (1995). Effect of smoking cues and cigarette availability on craving and smoking behaviour. *Addictive Behaviors, 20*, 657-673.

Duckworth, A. L., & Kern, M. L. (2011). A meta-analysis of the convergent validity of self-control measures. *Journal of Research in Personality*, *45*(3), 259-268.

Duhachek, A., Agrawal, N., & Han, D. (2012). Guilt versus shame: Coping, fluency, and framing in the effectiveness of responsible drinking messages. *Journal of Marketing Research, 49*(6), 928-941.

Duncan, J. (1986). Disorganisation of behaviour after frontal lobe damage. *Cognitive Neuropsychology, 3,* 271-290.

Eagle, D. M., Baunez, C., Hutcheson, D. M., Lehmann, O., Shah, A. P., & Robbins, T. W. (2007). Stop-signal reaction-time task performance: role of prefrontal cortex and subthalamic nucleus. *Cerebral Cortex*, *18*(1), 178-188.

Ekman, P. (2007). *Emotions revealed: Recognizing faces and feelings to improve communication and emotional life.* New York: Holt.

Ericcson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 3*, 215-251.

Evenden, J. L. (1999). Varieties of impulsivity. *Psychopharmacology, 146*, 348-361.

Fan, J., Gu, X., Guise, K. G., Liu, X., Fossella, J., Wang, H., & Posner, M. I. (2009). Testing the behavioral interaction and integration of attentional networks. *Brain and Cognition, 70*, 209-220.

Fang, X., & Mowen, J. C. (2009). Examining the trait and functional motive antecedents of four gambling activities: Slot machines, skilled card games, sports betting, and promotional games. *Journal of Consumer Marketing, 26*, 121-131.

Ferris, J., & Wynne, H. J. (2001). *The Canadian Problem Gambling Index Final Report*. Ottawa, ON: Canadian Centre on Substance Abuse.

Fineberg, N. A., Chamberlain, S. R., Goudriaan, A. E., Stein, D. J., Vanderschuren, L. J., Gillan, C. M., ... & Denys, D. (2014). New developments in human neurocognition: Clinical, genetic, and brain imaging correlates of impulsivity and compulsivity. *CNS Spectrums, 19*(1), 69-89.

Fischer, R., Plessow, F., & Ruge, H. (2013). Priming of visual cortex by temporal attention? The effects of temporal predictability on stimulus (-specific) processing in early visual cortical areas. *Neuroimage, 66*, 261–269.

Floyd, K., Whelan, J. P., & Meyers, A. W. (2006). Use of warning messages to modify gambling beliefs and behavior in a laboratory investigation. *Psychology of Addictive Behaviors, 20*, 69-74.

Foxall, G. R., & Sigurdsson, V. (2012). When loss rewards: The near-miss effect in slot machine gambling. *Analysis of Gambling Behavior*, *6*(1), 5-22.

Fraisse, P. (1984). Perception and estimation of time. *Annual Review of Psychology, 35*, 1-36.

Franek, M., van Noorden, L., & Rezny, L. (2014). Tempo and walking speed with music in the urban context. *Frontiers in Psychology, 5*, 1361.

Frank, M. J., Seeberger, L. C., & O'reilly, R. C. (2004). By carrot or by stick: cognitive reinforcement learning in parkinsonism. *Science*, *306*(5703), 1940-1943.

Frankel, F. H. (1996). Dissociation: The clinical realities. *American Journal of Psychiatry, 153*(7), 64-70.

Fu, W., & Yu, C. K-C. (2015). Predicting disordered gambling with illusory control, gaming preferences, and internet gaming addiction among Chinese youth. *International Journal of Mental Health and Addiction, 13*, 391-401.

Fuentes, D., Tavares, H., Artes, R., & Gorenstein, C. (2006). Self-reported and neuropsychological measures of impulsivity in pathological gambling. *Journal of the International Neuropsychological Society*, *12*(6), 907-912.

Gaher, R. M., Hahn, A. M., Shishido, H., Simons, J. S. & Gaster, S. (2015). Associations between sensitivity to punishment, sensitivity to reward and gambling. *Addictive Behaviors, 42*, 180–184.

Gainsbury, S., Russell, A., & Blaszczynski, A. (2014). Are psychology university student gamblers representative of general student and adult gamblers? A comparative analysis. *Journal of Gambling Studies, 30*, 11-25.

Gilbert, D. T. (2006). Stumbling on Happiness. New York: Knopf.

Gilberts, G., Agran, M., Hughes, C., and Wehmeyer, M. (2001). The effects of peer-reviewed self-monitoring strategies on the participation of students with severe disabilities in general education classrooms. *Journal of the Association for Persons with Severe Handicaps,* 26, 25-36.

Gondan, M., Gotze, C., & Greenlee, M. W. (2010). Redundancy gains in simple responses and go/no-go tasks. *Attention, Perception, & Psychophysics*, *72*(6), 1692-1709.

Gonzalez-Ibanez, A., Jimenez, S., & Aymami, M. N. (1999). Evaluation of the cognitive–behavioural treatment of pathological poker machine gamblers. *Anuario de Psicologia, 30*, 111-125.

Gotestam, K. G., & Johansson, A. (2003). Characteristics of gambling and problematic gambling in the Norwegian context: A DSM-IV-based telephone interview study. *Addictive Behaviors*, *28*(1), 189-197.

Goudriaan, A. E., Oosterlaan, J., de Beurs, E. & van den Brink, W. (2004). Pathological gambling: A comprehensive review of biobehavioral findings. *Neuroscience and Biobehavioral Reviews, 28*, 123-141.

Goudriaan, A. E., Oosterlaan, J., de Beurs, E., & van den Brink, W. (2005). Decision making in pathological gambling: A comparison between pathological gamblers, alcohol dependents, persons with Tourette syndrome, and normal controls. *Cognitive Brain Research*, *23*(1), 137-151.

Goudriaan, A. E., Oosterlaan, J. A. A. P., de Beurs, E. D. W. I., & van den Brink, W. (2006). Neurocognitive functions in pathological gambling: A comparison with alcohol dependence, Tourette syndrome and normal controls. *Addiction*, *101*(4), 534-547.

Goudriaan, A. E., Oosterlaan, J. A. A. P., de Beurs, E. D. W. I., & van den Brink, W. (2008). The role of self-reported impulsivity and reward sensitivity versus neurocognitive measures of disinhibition and decision-making in the prediction of relapse in pathological gamblers. *Psychological Medicine, 38*(1), 41-50.

Grant, J. E., Potenza, M. N., Weinstein, A., & Gorelick, D. A. (2010). *Introduction to behavioral addictions*. *American Journal of Drug and Alcohol Abuse, 36*, 233-241.

Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behavioral Research Therapy, 8,* 249-266.

Gray, J. A. (1981). A critique of Eysenck's theory of personality. In H. J. Eysenck (Ed.), *A model for personality* (pp. 246-276). Berlin: Springer-Verlag.

Gray, J. A. (1991). Neural systems, emotion, and personality. In J. Madden, IV (Ed.), *Neurobiology of learning, emotion, and affect* (pp. 273-306). New York: Raven Press.

Green, L., & Myerson, J. (1996). Exponential versus hyperbolic discounting of delayed outcomes: Risk and waiting time. *American Zoologist, 36*(4), 496-505.

Greenbaum, P. E., Turner, C., Cook, E. W., & Melamed, B. G. (1990). Dentists' voice control: Effects on children's disruptive and affective behavior. *Health Psychology*, *9*(5), 546.

Griffiths, M. D. (1991). The observational study of adolescent gambling in UK amusement arcades. *Journal of Community & Applied Social Psychology*, *1*(4), 309-320.

Griffiths, M. D. (1993). Fruit machine gambling: The importance of structural characteristics. *Journal of Gambling Studies, 9*, 101-120.

Griffiths M. D. (1994). The role of cognitive bias and skill in fruit machine gambling. *British Journal of Psychology, 85*, 351-369.

Griffiths, M. D. (1995). *Adolescent gambling.* London: Routledge.

Griffiths, M. D. (1999). The observational study of adolescent gambling in UK amusement arcades. *Journal of Community & Applied Social Psychology, 1*, 309-320.

Griffiths, M. D. (2002). *Gambling and Gaming Addictions in Adolescence*. Oxford: BPS Blackwell.

Griffiths, M. D. & Smeaton, M. (2002). Withdrawal in pathological gamblers: A small qualitative study. *Social Psychology Review, 4*, 4-13.

Griffiths, M. D. (2005). A 'components' model of addiction within a biopsychosocial framework. *Journal of Substance use*, *10*(4), 191-197.

Griffiths, M. D. (2008). *Impact of high-stake, high-prize, gaming machines on problem gambling: Overview of research findings.* Birmingham: Gambling Commission.

Griffiths, M. D. (2014). *Problem gambling in Great Britain: A brief review.* London: Association of British Bookmakers.

Griffiths, M. D., & Auer, M. (2013). The irrelevancy of game-type in the acquisition, development, and maintenance of problem gambling. *Frontiers in Psychology, 3*, 621.

Griffiths, M. D. & Bingham, C. (2005). A study of superstitious beliefs among bingo players. *Journal of Gambling Issues, 13*. Retrieved March 20, 2016, from: http://jgi.camh.net/doi/full/10.4309/jgi.2005.13.7.

Griffiths, M. D., King, D. L. & Delfabbro, P. H. (2014). The technological convergence of gambling and gaming practices. In Richard, D.C.S., Blaszczynski, A. & Nower, L. (Eds.). *The Wiley-Blackwell handbook of disordered gambling* (pp. 327-346). Chichester: Wiley.

Griffiths, M. D., Wardle, H., Orford, J., Sproston, K., & Erens, B. (2009). Sociodemographic correlates of internet gambling: Findings from the 2007 British Gambling Prevalence Survey. *CyberPsychology & Behavior*, *12*(2), 199-202.

Griffiths, M. D., Wood, R.T.A., Parke, J. & Parke, A. (2006). Dissociative states in problem gambling. In C. Allcock (Ed.). *Current Issues Related to Dissociation* (pp.27-37). Melbourne: Australian Gaming Council.

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*, 281-291.

Gullo, M. J., Loxton, N. J., & Dawe, S. (2014). Impulsivity: four ways five factors are not basic to addiction. *Addictive Behaviors, 39*, 1547-1556.

Gupta, R., & Derevensky, J. (1998). Adolescent gambling behavior: A prevalence study and examination of the correlates associated with excessive gambling. *Journal of Gambling Studies, 14*, 319-345.

Hamilton, K. R., Mitchell, M. R., Wing, V. C., Balodis, I. M., Bickel, W. K., Fillmore, M., ... & Mathias, C. W. (2015). Choice impulsivity: Definitions, measurement issues, and clinical implications. *Personality Disorders: Theory, Research, and Treatment, 6*(2), 182-198.

Hammond, D., Fong, G. T., McNeill, A., Borland, R., & Cummings, K. M. (2006). Effectiveness of cigarette warning labels in informing smokers about the risks of smoking: Findings from the International Tobacco Control (ITC) Four Country Survey. *Tobacco Control, 15*, 19-25.

Hansen, M., & Rossow, I. (2010). Limited cash flow on slot machines: Effects of prohibition of note acceptors on adolescent gambling behaviour. *International Journal of Mental Health Addiction, 8*, 70-81.

Hardeman, W., Johnston, M., Johnston, D., Bonetti, D., Wareham, N., and Kinmoth, A. (2002). Applications of theory of planned behaviour in behaviour change interventions: A systematic review. *Psychological Health, 17*, 123-158.

Harris, A. & Griffiths, M. D. (2016, May). *Facilitating Executive Control during Within-Session Gambling: The Relationship between Gambling Event-Frequency, Motor Impulsivity, and Impulsive Choice*. Nottingham Trent University Postgraduate Research Conference, Nottingham, UK.

Harris, A. & Griffiths, M.D. (2017). A critical review of the harm-minimisation tools available for electronic gambling. *Journal of Gambling Studies, 33*, 187–221.

Harris, A., & Griffiths, M. D. (2018). The impact of speed of play in gambling on psychological and behavioural factors: A critical review. *Journal of Gambling Studies*, *34*, 393-412.

Harris, A., & Parke, A. (2015). Empirical evidence for the differential impact of gambling outcome on behaviour in electronic gambling: Implications for harm-minimisation strategies. *Responsible Gambling Review, 1*(2), 10-19.

Harris, A., & Parke, A. (2016). The interaction of gambling outcome and gambling harm-minimisation strategies for electronic gambling: The efficacy of computer generated self-appraisal messaging. *International Journal or Mental Health and Addiction, 14*(4), 597-617.

Harris, A., Parke, A., & Griffiths, M. D. (2018). The case for using personally relevant and emotionally stimulating gambling messages as a gambling harm minimisation tool. *International Journal of Mental Health and Addiction*, *16,* 266-275.

Harrison, Y., & Horne, J. A. (2000). The impact of sleep deprivation on decision making: A review. *Journal of Experimental Psychology: Applied*, *6*(3), 236.

Hassin, R. R., Aarts, H., Eitam, B., Custers, R., & Kleiman, T. (2009). Nonconscious goal pursuit and the effortful control of behavior. In E. Morsella, J. A. Bargh, & P. M. Gollwitzer (Eds.), *Social cognition and social neuroscience. Oxford handbook of human action* (pp. 549-566). New York, US: Oxford University Press.

Heiskanen, M. (2017). Is it all about money? A qualitative analysis of problem gamblers' conceptualisations of money. *Nordic Studies on Alcohol and Drugs, 34*(5), 362-374.

Hendriks, H., & van den Putte, B., & de Bruijn, G. J. (2014). Changing the conversation: The influence of emotions on conversational valence and alcohol consumption. *Prevention Science, 15*, 684–693.

Henges, A. L., & Marczinski, C. A. (2012). Impulsivity and alcohol consumption in young social drinkers. *Addictive Behaviors, 37*(2), 217-220.

Herpertz, S. C., Kunert, H. J., Schwenger, U. B., & Sass, H. (1999). Affective responsiveness in borderline personality disorder: A psychophysiological approach. *American Journal of Psychiatry*, *156*(10), 1550-1556.

Hing, N. (2004). The efficacy of responsible gambling measures in NSW clubs: The gamblers' perspective. *Gambling Research, 16*(1), 32-46.

Hodes, R. L., Cook III, E. W., & Lang, P. J. (1985). Individual differences in autonomic response: conditioned association or conditioned fear? *Psychophysiology*, *22*(5), 545-560.

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences*, *16*(3), 174-180.

Holmes, J., Hever, T., Hewitt, L., Ball, C., Taylor, E., Rubia, K. & Thapar, A. (2002). A pilot twin study of psychological measures of attention deficit hyperactivity disorder. *Behavioral Genetics, 32*, 389-395.

Houben, K., & Jansen, A. (2011). Training inhibitory control: A recipe for resisting sweet temptations. *Appetite, 56*, 345-349.

Howells, F. M., Stein, D. J., & Russell, V. A. (2012). Synergistic tonic and phasic activity of the locus coeruleus norepinephrine (LC-NE) arousal system is required for optimal attentional performance. *Metabolic Brain Disease*, *27*(3), 267-274.

Huang, Y. M., Baddeley, A., & Young, A. W. (2008). Attentional capture by emotional stimuli is modulated by semantic processing. *Journal of Experimental Psychology: Human Perception and Performance, 34*(2), 328-339.

Hume, D. (1978). *A treatise of human nature*. Oxford: Clarendon.

Isen, A. M. (2001). An influence of positive affect on decision making in complex situations: Theoretical issues with practical implications. *Journal of Consumer Psychology, 11*(2), 75-85.

Jacobs, D.F. (1986). A general theory of addictions: A new theoretical model. *Journal of Gambling Behavior, 2,* 15-31.

Jacobs, D. (1988). Evidence for a common dissociative-like reaction among addicts. *Journal of Gambling Behavior, 4*, 27-37.

Jamieson, J. P., Nock, M. K., & Mendes, W. B. (2012). Mind over matter: Reappraising arousal improves cardiovascular and cognitive responses to stress. *Journal of Experimental Psychology: General, 141*, 417-422.

Janz, N. K., Champion, V. L., & Strecher, V. J. (2002). The Health Belief Model. In K.Glanz, B.K. Rimer, & F.M. Lewis (Eds*.), Health behavior and health education: Theory, research, and practice, 3rd Edition* (pp.45-66). San Francisco, CA: Jossey-Bass.

Jasinska, A. J., Stein, E. A., Kaiser, J., Naumer, M. J. & Yalachkov, Y. (2014). Factors modulating neural reactivity to drug cues in addiction: A survey of human neuroimaging studies. *Neuroscience Biobehavioural Review, 38*, 1–16.

Jennings, J. R., van der Molen, M. W., Brock, K., & Somsen, R. J. (1992). On the synchrony of stopping motor responses and delaying heartbeats. *Journal of Experimental Psychology: Human Perception and Performance, 18*, 422-436.

Johnson, M. W., & Bruner, N. R. (2012). The Sexual Discounting Task: HIV risk behavior and the discounting of delayed sexual rewards in cocaine dependence. *Drug and Alcohol Dependence*, *123*(1-3), 15-21.

Jones, A., Guerrieri, R., Fernie, G., Cole, J., Goudie, A., & Field, M. (2011). The effects of priming restrained versus disinhibited behaviour on alcohol-seeking in social drinkers. *Drug and Alcohol Dependence, 113,* 55–61.

Kagan, J. (1966). Reflection-impulsivity: The generality and dynamics of conceptual tempo. *Journal of Abnormal Psychology, 71*(1), 17-24.

Kagan, J., Rosman, B. L., Day, D., Albert, J., & Phillips, W. (1964). Information processing in the child: Significance of analytic and reflective attitudes. *Psychological Monographs: General and Applied, 78*(1), 1-37.

Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality. *American Psychologist, 58*, 697-720

Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giroux.

Kaplan, B. A., Lemley, S. M., Reed, D. D., & Jarmolowicz, D. P. (2014*). 21- and 27-Item Monetary Choice Questionnaire Automated Scorer (spreadsheet application).* Retrieved March 28, 2018 from: http://hdl.handle.net/1808/15424.

Keltner, D., & Lerner, J. S. (2010). Emotion. In Gilbert, D. T., Fiske, S. T., & Lindzey, G. (Eds.), *The handbook of social psychology* (pp. 317-352). New York: Wiley.

Kertzman, S., Lidogoster, H., Aizer, A., Kotler, M., & Dannon, P. N. (2011). Risk-taking decisions in pathological gamblers is not a result of their impaired inhibition ability. *Psychiatry Research*, *188*(1), 71-77.

Kertzman, S., Lowengrub, K., Aizer, A., Vainder, M., Kotler, M., & Dannon, P. N. (2008). Go–no-go performance in pathological gamblers. *Psychiatry Research, 161*(1), 1-10.

Kim, S. H., Wohl, M. J. A., Stewart, M. J., Sztainert, T., & Gainsbury, S. M. (2014). Limit your time, gamble responsibly: Setting a time limit (via pop-up message) on an electronic gaming machine reduces time on device. *International Gambling Studies*, *14*(2), 266-278.

Kirby, K. N. (2009). One-year temporal stability of delay-discount rates. *Psychonomic Bulletin & Review*, *16*(3), 457-462.

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology: General, 128*(1), 78-87.

Knoch, D., Gianotti, L. R. R., Pascual-Leone, A., Treyer, V., Regard, M., Hohmann, M., & Brugger, P. (2006). Disruption of right prefrontal cortex by low-frequency repetitive transcranial magnetic stimulation induces risk-taking behavior. *Journal of Neuroscience, 26*, 6469-6472.

Kollins, S. H. (2003). Delay discounting is associated with substance use in college students. *Addictive Behaviors*, *28*(6), 1167-1173.

Konishi, S., Nakajima, K., Uchida, I., Kikyo, H., Kameyama, M., & Miyashita, Y. (1999). Common inhibitory mechanism in human inferior prefrontal cortex revealed by event related functional MRI. *Brain, 122*(5), 981-991.

Kuley, N. B., & Jacobs, D. F. (1988). The relationship between dissociative-like experiences and sensation seeking among social and problem gamblers. *Journal of Gambling Studies, 4*(3), 197-207.

Ladouceur, R., Blaszczynski, A., & Lalande, D. R. (2012). Pre-commitment in gambling: A review of the empirical evidence. *International Gambling Studies, 12*(2), 215-230.

Ladouceur, R., & Sevigny, S. (2003). Interactive messages on video lottery terminals and persistence in gambling. *Gambling Research, 15*, 45-50.

Ladouceur, R. & Sevigny, S. (2006). The impact of video lottery game speed on gamblers. *Journal of Gambling Issues, 17,* 297-320.

Ladouceur, R., & Sevigny, S. (2009). Electronic gaming machines: Influence of a clock, a cash display, and a pre-commitment on gambling time. *Journal of Gambling Issues, 23*, 31–41.

Ladouceur, R., Sevigny, S., Blaszczynski, A., O'Conor, K., & Lavoie, M. (2003). Video lottery: Winning expectancies and arousal. *Addiction, 98,* 733-738.

Ladouceur, R., & Walker, M. (1998). The cognitive approach to understanding and treating pathological gambling. In *Comprehensive clinical psychology*, Edited by: Bellack, A. S., & Hersen, M. (pp. 588–601). New York: Pergamon.

Laibson, D. (1997). Golden eggs and hyperbolic discounting. *The Quarterly Journal of Economics*, *112*(2), 443-478.

Lang, P. J (1980a). Behavioral treatment and bio-behavioral assessment: Computer applications. In J. B. Sidowski, J. H. Johnson, & T. A. Williams (Eds.), *Technology in mental health care delivery systems* (pp. 119-137). Norwood, NJ: Ablex.

Lang, P. J. (1980b). *Self-assessment Manikin*. Gainesville, FL: The Center for Research in Psychophysiology, University of Florida.

Lang, P. J. (1988). What are the data of emotion? In *Cognitive perspectives on emotion and motivation* (pp. 173-191). Dordrecht: Springer

Lang, P. J., Greenwald, M. K., Bradley, M. M. & Hamm, A. O. (1993). Looking at pictures: Evaluative, facial, visceral, and behavioral responses. *Psychophysiology, 30*(3), 261-273.

Langewisch, M. W., & Frisch, G. R. (1998). Gambling behavior and pathology in relation to impulsivity, sensation seeking, and risky behavior in male college students. *Journal of Gambling Studies, 14*(3), 245-262.

Langford, Z. D., Schevernels, H., & Boehler, C. N. (2016). Motivational context for response inhibition influences proactive involvement of attention. *Scientific Reports*, *6*, 35122.

Lawrence, A. J., Luty, J., Bogdan, N. A., Sahakian, B. J., & Clark, L. (2009). Impulsivity and response inhibition in alcohol dependence and problem gambling. *Psychopharmacology, 207*(1), 163-172.

Lawrence, N. S., Verbruggen, F., Morrison, S., Adams, R. C., & Chambers, C. D. (2014). Stopping to food can reduce intake: Effects of stimulus-specificity and individual differences in dietary restraint. *Appetite, 85*, 91-103.

Lawyer, S. R., Schoepflin, F., Green, R., & Jenks, C. (2011). Discounting of hypothetical and potentially real outcomes in nicotine-dependent and nondependent samples. *Experimental and Clinical Psychopharmacology, 19*(4), 263-274.

Lederman, S. (1956). *Alcool, alcoolisme, alcolisation (alcohol, alcoholism, alcoholisation), Vol 1.* Institut National d'etudes Demographiques, Travaux et Documents, Cahier no 29, Presses Universitaires de France, Paris.

Leeman, R. F., & Potenza, M. N. (2012). Similarities and differences between pathological gambling and substance use disorders: a focus on impulsivity and compulsivity. *Psychopharmacology*, *219*(2), 469-490.

Leino, T., Torsheim, T., Pallesen, S., Blaszczynski, A., Sagoe, D., & Molde, H. (2016). An empirical real-world study of losses disguised as wins in electronic gaming machines. *International Gambling Studies, 16*(3), 470-480.

LeMarquand, D. G., Pihl, R. O., Young, S. N., Tremblay, R. E., Séguin, J. R., Palmour, R. M., & Benkelfat, C. (1998). Tryptophan depletion, executive functions, and disinhibition in aggressive, adolescent males. *Neuropsychopharmacology*, *19*(4), 333-341.

Leotti, L. A., & Wager, T. D. (2010). Motivational influences on response inhibition measures. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(2), 430-447.

Lerner, J. S., Li, Y., Valdesolo, P., & Kassam K. S. (2015). Emotion and decision making. *Annual Review of Psychology*, *66*, 799-823.

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.

Linnet, J., Thomsen, K. R., Møller, A., & Callesen, M. B. (2010). Event frequency, excitement and desire to gamble, among pathological gamblers. *International Gambling Studies, 10*(2), 177-188.

Loba, P., Stewart, S. H., Klein, R. M., & Blackburn, J. R. (2002). Manipulations of the features of standard video lottery terminal (VLT) games: Effects in pathological and non-pathological gamblers. *Journal of Gambling Studies, 17*(4), 297-320.

Logan, G. D., & Cowan, W. B. (1984). On the ability to inhibit thought and action: A theory of an act of control. *Psychological Review*, *91*(3), 295-327.

Lund, I. (2006). Gambling and problem gambling in Norway: What part does the gambling machine play? *Addiction Research & Theory*, *14*(5), 475-491.

Lund, I. (2008). The population mean and the proportion of frequent gamblers: Is the Theory of Total Consumption valid for gambling? *Journal of Gambling Studies*, *24,* 247-256.

MacKay, D. G. (1982). The problems of flexibility, fluency, and speed–accuracy trade-off in skilled behavior. *Psychological Review*, *89*(5), 483-506.

MacLeod, C. M. (2007). The concept of inhibition in cognition. In D. S. Gorfein & C. M. MacLeod (Eds.), *Inhibition in cognition* (pp. 3-23). Washington, DC, US: American Psychological Association.

MacLeod, C. M., Dodd, M. D., Sheard, E. D., Wilson, D. E., & Bibi, U. (2003). In opposition to inhibition. *Psychology of Learning and Motivation*, *43*, 163-215.

MacLeod, J. W., Lawrence, M. A., McConnell, M. M., Eskes, G. A., Klein, R. M., & Shore, D. I. (2010). Appraising the ANT: Psychometric and theoretical considerations of the attention network test. *Neuropsychology, 24,* 637–-651.

Mahmood, O. M., Goldenberg, D., Thayer, R., Migliorini, R., Simmons, A. N., & Tapert, S. F. (2013). Adolescents' fMRI activation to a response inhibition task predicts future substance use. *Addictive Behaviours, 38*, 1435-1441.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion*, *5*(2), 175-190.

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition and Emotion, 23*(2), 209-237.

McConaghy, N. (1980). Behavioral completion mechanisms rather than primary drive maintain behavioural patterns. *Activitas Nervosa Superior (Praha), 22*, 138-151.

McCormack, A. & Griffiths, M. D. (2013). A scoping study of the structural and situational characteristics of internet gambling. *International Journal of Cyber Behavior, Psychology and Learning, 3*(1), 29-49.

McCormack, A., Shorter, G. W., & Griffiths, M. D. (2013). Characteristics and predictors of problem gambling on the internet. *International Journal of Mental Health and Addiction, 11*(6), 634-657.

Mclellan, A. T., Lewis, D. C., O'Brien, C. P., & Kleber, H.D. (2000). Drug dependence, a chronic medical illness: implications for treatment, insurance, and outcome evaluation. *JAMA*, *284*(13), 1689- 1695.

Implications for Treatment, Insurance, and Outcomes Evaluation

McMillen, J., Marshall, L., & Murphy, L. (2004). *The use of ATMs in ACT gaming venues: An empirical study*. Canberra: ANU Centre for Gambling Research.

McNeil, D. W., & Brunetti, D. G. (1992). Pain and fear: a bioinformational perspective on responsivity to imagery. *Behaviour Research and Therapy*, *30*(5), 513-520.

Mehrabian, A., & Russell, J. A. (1974). The basic emotional impact of environments. *Perceptual and Motor Skills, 38*(1), 283-301.

Menon, V., Adleman, N. E., White, C. D., Glover, G. H., & Reiss, A. L. (2001). Error-related brain activation during a Go/NoGo response inhibition task. *Human Brain Mapping*, *12*(3), 131-143.

Mentzoni, R. A., Laberg, J. C., Brunborg, G. S., Molde, H., & Pallesen, S. (2012). Tempo in electronic gambling machines affects behaviour among at risk gamblers. *Journal of Behavioural Addictions, 1*, 135-139.

Merckelbach, H., Muris, P., & Rassin, E. (1999). Fantasy proneness and cognitive failures as correlates of dissociative experiences. *Personality and Individual Differences*, *26*(5), 961-967.

Messer, S. B. (1976). Reflection-impulsivity: A review. *Psychological Bulletin, 83*(6), 1026-1052.

Meyer, G., Hauffa, B. P., Schedlowski, M., Pawlak, C., Stadler, M. A., & Exton, M. S. (2000). Casino gambling increases heart rate and salivary cortisol in regular gamblers. *Biological Psychiatry, 48*(9), 948-953.

Meyer, G., Hayer, T. & Griffiths, M.D. (2009). *Problem Gambling in Europe: Challenges, Prevention, and Interventions.* New York: Springer

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function*. Annual Review of Neuroscience, 24,* 167-202.

Miller, W. R., & Rollnick, S. (1991). *Motivational interviewing: Preparing people to change addictive behavior*. New York: Guilford Press.

Monaghan, S. (2008). Review of pop-up messages on electronic gaming machines as a proposed responsible gambling strategy. *International Journal of Mental Health and Addiction, 6*(2), 214-222.

Monaghan, S. (2009). Responsible gambling strategies for internet gambling: The theoretical and empirical base of using pop-up messages to encourage self-awareness. *Computers in Human Behaviour, 25,* 202-207.

Monaghan, S., & Blaszczynski, A. (2007). Recall of electronic gaming machine signs: A static versus a dynamic mode of presentation*. Journal of Gambling Issues, 20*, 253-268.

Monaghan, S., & Blaszczynski, A. (2010a). Electronic gaming machine warning messages: Information versus self-evaluation. *Journal of Psychology, 144* (1), 83-96.

Monaghan, S., & Blaszczynski, A. (2010b). Impact of mode of display and message content of responsible gambling signs for electronic gaming machines on regular gamblers. *Journal of Gambling Studies, 26,* 67-88.

Moreira, M. T., Oskrochi, R., & Foxcroft, D. R. (2012). Personalised normative feedback for preventing alcohol misuse in university students: Solomon three- group randomised controlled trial. *PLoS ONE, 7*(9), e44120.

Munoz, Y., Chebat, J. C., & Suissa, J. A. (2014). Using fear appeals in warning labels to promote responsible gambling among VLT players: The key role of depth of information processing. *Journal of Gambling Studies, 6,* 593–609.

Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*(2), 247-259.

Mussell, M. P., Mitchell, J. E., Crosby, R. D., Fulkerson, J. A., Hoberman, H. M., & Romano, J. L. (2000). Commitment to treatment goals in prediction of group cognitive-behavioral therapy treatment outcome for women with bulimia nervosa. *Journal of Consulting and Clinical Psychology, 68*, 432-437.

Nambu, A., Tokuno, H., & Takada, M. (2002). Functional significance of the cortico–subthalamo–pallidal ‘hyperdirect’ pathway. *Neuroscience Research*, *43*(2), 111-117.

National Research Council. (1999). *Pathological gambling: A critical review.* Washington, D.C.: National Academy Press.

Nevitt, J.R. & Lundak, J. (2005) Accuracy of self-reports of alcohol offenders in a rural Midwestern county. *Psychological Reports, 96,* 511-514.

Newman, J. P., Patterson, C. M., & Kosson, D. S. (1987). Response perseveration in psychopaths. *Journal of Abnormal Psychology, 96*, 145-148.

Newman, J. P., & Schmitt, W. A. (1998). Passive avoidance in psychopathic offenders: A replication and extension. *Journal of Abnormal Psychology*, *107*(3), 527-532.

Nieuwenhuis, S., & de Kleijn, R. (2013). The impact of alertness on cognitive control. *Journal of Experimental Psychology: Human Perception and Performance, 39*, 1797–1801.

Nigg, J. T. (2001). Is ADHD a disinhibitory disorder? *Psychological Bulletin*, *127*(5), 571-598.

Nigg, J. T., Wong, M. M., Martel, M. M., Jester, J. M., Puttler, L. I., Glass, J. M., ... & Zucker, R. A. (2006). Poor response inhibition as a predictor of problem drinking and illicit drug use in adolescents at risk for alcoholism and other substance use disorders. *Journal of the American Academy of Child & Adolescent Psychiatry*, *45*(4), 468-475.

Norman, D. A., & Shallice, T. (1986). Attention to Action. In R. J. Davidson, G. E. Schwartz, & D. Shapiro, (Eds.), *Consciousness and self-regulation* (pp. 1-18). New York: Springer.

Norwegian Gaming Authority (2006). *Annual Report*. Førde, Norway. Retrieved December 13, 2015 from: http://www.lottstift.no/eway/default.aspx?pid=236&trg= visliste_5998&MainPaige_5482 = 5609:0:8,1573&visliste_5998 = 6122:0:8,1575.

Norwegian Gaming Authority (2007). *Annual report*. Førde, Norway. Retrieved December 13, 2015 from: http://www.lottstift.no/eway/default.aspx?pid = 236&trg = visliste_5998&MainPaige_5482 = 5609:0:8,1573&visliste_5998 = 6122:0:8,1575.

Nyer, P. U., & Dellande, S. (2010). Public commitment as a motivator for weight loss. *Psychology and Marketing, 27*(1), 1–12.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. E. (2002). Rethinking feelings: An fMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience, 14*, 1215-1229.

Odlaug, B. L., Chamberlain, S. R., Kim, S. W., Schreiber, L. R. N., & Grant, J. E. (2011). A neurocognitive comparison of cognitive flexibility and response inhibition in gamblers with varying degrees of clinical severity. *Psychological Medicine*, *41*(10), 2111-2119.

Odum, A. L. (2011). Delay discounting: I'm a k, you're a k. *Journal of the Experimental Analysis of Behavior, 96*(3), 427-439.

Ohman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130*, 466-478.

Oosterlaan, J., Logan, G. D., & Sergeant, J. A. (1998). Response inhibition in AD/HD, CD, comorbid AD/HD+ CD, anxious, and control children: A meta-analysis of studies with the stop task. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *39*(3), 411-425.

Orford, J. (2001). *Excessive appetites: A psychological view of addictions* (2nd ed.). New York: John Wiley & Sons Ltd.

Papachristou, H., Nederkoorn, C., Corstjens, J. & Jansen, A. (21012). The role of impulsivity and perceived availability on cue-elicited craving for alcohol in social drinkers. *Psychopharmacology, 224*, 145-153.

Parke, A. J., Harris, A., Parke, J., & Goddard, P. (2015). Understanding within-session loss-chasing: An experimental investigation of the impact of stake size on cognitive control. *Journal of Gambling Studies, 32*(2), 721-735.

Parke, A. J., Harris, A., Parke, J. Rigbye, J., & Blaszczynski, A. (2014a). Facilitating player control in gambling. *Journal of Gambling Business and Economics, 8*(3), 36-51.

Parke, A. J., Harris, A., Parke, J. Rigbye, J., & Blaszczynski, A. (2014b). Responsible marketing and advertising in gambling: A critical review. *Journal of Gambling Business and Economics, 8*(3), 21-35.

Parke, J. & Griffiths, M.D. (2006). The psychology of the fruit machine: The role of structural characteristics (revisited). *International Journal of Mental Health and Addiction, 4*, 151-179.

Parke, J. & Griffiths, M. D. (2007). The role of structural characteristics in gambling. In G. Smith, D. Hodgins & R. Williams (Eds.), *Research and measurement issues in gambling studies* (pp. 211-243). New York: Elsevier.

Patrick, C. J., Bradley, M. M., & Lang, P. J. (1993). Emotion in the criminal psychopath: startle reflex modulation. *Journal of Abnormal Psychology*, *102*(1), 82.

Patros, C. H., Alderson, R. M., Kasper, L. J., Tarle, S. J., Lea, S. E., & Hudec, K. L. (2016). Choice-impulsivity in children and adolescents with attention-deficit/hyperactivity disorder (ADHD): A meta-analytic review. *Clinical Psychology Review, 43*, 162-174.

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology, 51,* 768-764.

Pavey, L.J. & Sparks, P. (2010). Autonomy and reactions to health-risk information. *Psychology and Health, 25*(7), 855-872.

Peirce, J. W. (2007). *PsychoPy – Psychophysics software in Python*. *Journal of Neuroscience Methods, 162*(1-2), 8-13.

Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in cognitive sciences, 13*(4), 160-166.

Peters, E., Västfjäll, D., Gärling, T., & Slovic, P. (2006). Affect and decision making: A "hot" topic. *Journal of Behaviour and Decision Making, 19*, 79–85.

Peters, J., & Buchel, C. (2011). The neural mechanisms of inter-temporal decision-making: Understanding variability. *Trends in Cognitive Science, 15*, 227-239.

Pickering, A. D., & Gray, J. A. (1999). The neuroscience of personality. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and Research (2nd ed.)* (pp. 277-299). New York: Guilford Press.

Porges, S. W. (2001). The polyvagal theory: Phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology, 42*(2), 123-146.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*(1), 25-42.

Potenza, M. N. (2006). Should addictive disorders include nonsubstance-related conditions? *Addiction, 101*, 142– 51.

Prevention First (2008). *Ineffectiveness of Fear Appeals in Youth Alcohol, Tobacco and Other Drug (ATOD) Prevention.* Springfield, IL: Prevention First.

Prochaska, J. O., Velicer, W. F., Rossi, J. S., Goldstein, M. G., Marcus, B. H., Rakowski, W., … Susan, R. (1994). Stages of change and decisional balance for 12 problem behaviors. *Health Psychology, 13*(1), 39-46.

Ratcliff, R., & Tuerlinckx, F. (2002). Estimating parameters of the diffusion model: Approaches to dealing with contaminant reaction times and parameter variability. *Psychonomic Bulletin & Review, 9*(3), 438-481.

Rauschenberger, S. L., & Lynn, S. J. (1995). Fantasy proneness, DSM-II—R Axis 1 psychopathology, and dissociation. *Journal of Abnormal Psychology, 104* (2), 373-380.

Redick, T. S., & Engle, R. W. (2006). Working memory capacity and attention network test performance. *Applied Cognitive Psychology, 20*, 713-721.

Reise, S. P., Moore, T. M., Sabb, F. W., Brown, A. K., & London, E. D. (2013). The Barratt Impulsiveness Scale–11: Reassessment of its structure in a community sample. *Psychological Assessment*, *25*(2), 631-642.

Rennert, L., Denis, C., Peer, K., Lynch, K. G., Gelernter, J., & Kranzle, H. R. (2014). DSM-5 gambling disorder: Prevalence and characteristics in a substance use disorder sample. *Experimental Clinical Psychopharmacology, 22*(1), 50-56.

Rentrop, M., Backenstrass, M., Jaentsch, B., Kaiser, S., Roth, A., Unger, J., ... & Renneberg, B. (2008). Response inhibition in borderline personality disorder: performance in a Go/Nogo task. *Psychopathology, 41*(1), 50-57.

Reynolds, B. (2006). A review of delay-discounting research with humans: Relations to drug use and gambling. *Behavioural Pharmacology*, *17*(8), 651-667.

Reynolds, B., & Schiffbauer, R. (2004). Measuring state changes in human delay discounting: An experiential discounting task. *Behavioural Processes, 67*(3), 343-356.

Rinkenauer, G., Osman, A., Ulrich, R., Müller-Gethmann, H., & Mattes, S. (2004). On the locus of speed-accuracy trade-off in reaction time: inferences from the lateralized readiness potential. *Journal of Experimental Psychology: General*, *133*(2), 261.

Robinson, M. D., & Clore, G. L. (2002). Belief and feeling: Evidence for an accessibility model of emotional self-report. *Psychological Bulletin*, *128*(6), 934.

Rodriguez-Jimenez, R., Avila, C., Jimenez-Arriero, M. A., Ponce, G., Monasor, R., Jimenez, M. E. E. A., ... & Palomo, T. (2006). Impulsivity and sustained attention in pathological gamblers: Influence of childhood ADHD history. *Journal of Gambling Studies*, *22*(4), 451-461.

Room, R., Turner, N. E., & Ialomiteanu, A. (1999). Community effects of the opening of the Niagara Casino. *Addiction*, *94*, 1449-1466.

Rosenthal, R. (1992). Pathological gambling. *Psychiatric Annals, 22*, 72-78.

Rosenthal, R. & Lesieur, H. (1992). Self-reported withdrawal symptoms and pathological gambling. *American Journal of Addictions, 1*, 150-154.

Ross, C. A. (1997). *Dissociative identity disorder: Diagnosis, Clinical features, and treatment of multiple Personality*. Chichester: John Wiley & Sons Inc.

Salis, S., Wardle, H., Morris, S., & Excell, D. (2015). *ABB code for responsible gambling and player protection: Evaluation of early impact among machine gamblers*. London: Responsible Gambling Trust.

Samson, A., & Voyer, B. (2012). Two minds, three ways: Dual system and process models in consumer psychology. *Academy of Marketing Science Review, 2*, 48–71.

Samson, A., & Voyer, B. (2014). Emergency purchasing situations: Implications for consumer decision-making. *Journal of Economic Psychology, 44*, 21-33.

Scanell, E. D., Quirk, M. M., Smith, K., Maddern, R., & Dickerson, M. (2000). Females' coping styles and control over poker machine gambling. *Journal of Gambling Studies, 16*(4), 417-432.

Schulz, K. P., Fan, J., Magidina, O., Marks, D. J., Hahn, B., & Halperin, J. M. (2007). Does the emotional go/no-go task really measure behavioral inhibition? Convergence with measures on a non-emotional analog. *Archives of Clinical Neuropsychology*, *22*(2), 151-160.

Seabury, C. & Wardle, H. (2014). *Gambling behaviour in England and Scotland*. Birmingham: Gambling Commission.

Shaffer, H. J., & Korn, D. A. (2002). Gambling and related mental disorders: A public health analysis. *Annual Review of Public Health, 23*, 171-212.

Shaffer, H. J., LaPlante, D. A., LaBrie, R. A., Kidman, R. C., Donato, A. N., & Stanton, M. V. (2004). Toward a syndrome model of addiction: Multiple expressions, common etiology. *Harvard Review of Psychiatry*, *12*(6), 367-374.

Shallice, T. (1982). Specific impairments of planning. Philosophical Transactions of the Royal Society of London, Series B. *Biological Sciences, 298*, 199-209.

Shanks, N., Greek, R., & Greek, J. (2009). Are animal models predictive for humans? *Philosophy, Ethics, and Humanities in Medicine, 4*(2). Retrieved September 2, 2018, from: http://doi.org/10.1186/1747-5341-4-2.

Sharpe, L., Walker, M., Coughlan, M-J., Enersen, K., & Blaszczynski, A. (2005). Structural changes to electronic gaming machines as effective harm minimization strategies for non-problem and problem gamblers. *Journal of Gambling Studies, 27*(4), 503–520.

Simmonds, D. J., Pekar, J. J., & Mostofsky, S. H. (2008). Meta-analysis of Go/No-go tasks demonstrating that fMRI activation associated with response inhibition is task-dependent. *Neuropsychologia*, *46*(1), 224-232.

Sims, M., Langley, T., Lewis, S., Richardson, S., Szatkowski, L., McNeill, A., & Gilmore A. B., (2014). Effectiveness of tobacco control television advertising in changing tobacco use in England: A population-based cross-sectional study. *Addiction, 109*, 986-94.

Sohn, J. H., Kim, H. E., Sohn, S., Seok, J. W., Choi, D., & Watanuki, S. (2015). Effect of emotional arousal on inter-temporal decision-making: An fMRI study. *Journal of Physiological Anthropology, 34*(1):8. DOI: 10.1186/s40101-015-0047-5.

Solanto, M. V., Abikoff, H., Sonuga-Barke, E., Schachar, R., Logan, G. D. … Turkel, E. (2001) The ecological validity of delay aversion and response inhibition as measures of impulsivity in AD/HD: A supplement to the NIMH multimodal treatment study of AD/HD. *Journal of Abnormal Child Psychology, 29*, 215-228.

Solomon, R. C. (1993). *The passions: Emotions and the meaning of life*. Indianapolis, IN: Hackett.

Sproston, K., Erens, B., & Orford, J. (2000). *British gambling prevalence survey 1999*. London: National Centre for Social Research.

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E., & Patton, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences*, *47*(5), 385-395.

Steele, C. M., & Southwick, L. (1981). Effects of fear and causal attribution about alcoholism on drinking and related attitudes among heavy and moderate social drinkers. *Cognitive Therapy and Research, 5*, 339-350.

Steenberg, T. A., Wheelan, J. P., Meyers, A. W., May, R. K., & Floyd, K. (2004). Impact of warning and brief intervention messages on knowledge of gambling risk, irrational beliefs and behaviour. *International Gambling Studies, 4*, 3-16.

Steel, Z. & Blaszczynski, A. (1996) The factorial structure of pathological gambling. *Journal of Gambling Studies, 12,* 3-20.

Ste-marie, C., Gupta, R., & Derevensky, J. L. (2002). Anxiety and social stress related to adolescent gambling behaviour. *International Gambling Studies, 2*(1), 123-141.

Stevens, T., Brevers, D., Chambers, C. D., Lavric, A., McLaren, I. P. L., Mertens, M., … Verbruggen, F. (2015). How does response inhibition influence decision-making when gambling? *Journal of Experimental Psychology: Applied, 21*(1), 15-36.

Stewart, M. J., & Wohl, M. J. A. (2013). Pop-up messages, dissociation, and craving: How monetary limit reminders facilitate adherence in a session of slot machine gambling. *Psychology of Addictive Behaviors*, *27*(1), 268-73.

Stinchfield, R. (2003). Reliability, validity, and classification accuracy of a measure of DSM-IV diagnostic criteria for pathological gambling. *American Journal of Psychiatry, 160*,180–182.

Stinchfield, R., Govoni, R., & Frisch, G. R. (2005). DSM-IV diagnostic criteria for pathological gambling: reliability, validity, and classification accuracy. *American Journal of Addiction, 14*, 73–82.

Strong, D. R., & Kahler, C. W. (2007). Evaluation of the continuum of gambling problems using the DSM-IV. *Addiction, 102*(5), 713-721.

Stroop, J.R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 28,* 643-662.

Sundali, J., & Croson, R. (2006). Biases in casino betting: The hot hand and the gambler's fallacy. *Judgment and Decision Making*, *1*, 1-12.

Suler, J. (2004). The online disinhibition effect. *CyberPsychology and Behavior, 7*, 321–326.

Thompson, S. J., & Corr, P. J. (2013). A feedback-response pause normalises response perseveration deficits in pathological gamblers. *International Journal of Mental Health and Addiction, 11*, 601-610.

Thompson, M., Hollings, P., & Griffiths, M. D. (2009). *Qualitative study into machine gamblers.* Birmingham: Gambling Commission.

Tiffany, S. T. (1990). A cognitive model of drug urges and drug-use behavior: Role of automatic and nonautomatic processes. *Psychological Review, 97*(2), 147-168.

Toneatto, T., & Ladoceur, R. (2003). Treatment of pathological gambling: A critical review of the literature. *Psychology of Addictive Behaviors*, *17*(4), 284-292.

Trommershauser, J., Maloney, L. T., & Landy, M. S. (2003). Statistical decision theory and the selection of rapid, goal-directed movements. *JOSA A*, *20*(7), 1419-1433.

Turner, N. E., & Horbay, R. (2004). How do slot machines and other electronic gambling machines actually work? *Journal of Gambling Issues, 11*, 10-50.

Turner, N. E., Ialomiteanu, A., & Room, R. (1999). Chequered expectations: Predictors of approval of opening a casino in the Niagara community. *Journal of Gambling Studies*, *15*, 45-70.

van Boxtel, G. J., van der Molen, M. W., Jennings, J. R., & Brunia, C. H. (2001). A psychophysiological analysis of inhibitory motor control in the stop-signal paradigm. *Biological Psychology, 58*, 229-262.

van den Putte, B., Yzer, M., Willemsen, M., & de Bruijn, G. J. (2009). The effects of smoking self-identity and quitting self-identity on attempts to quit smoking. *Health Psychology, 28*, 535–544.

van den Wildenberg, W. P., van der Molen, M. W., & Logan, G. D. (2002). Reduced response readiness delays stop signal inhibition. *Acta Psychologica*, *111*(2), 155-169.

van der Schoot, M., Licht, R., Horsley, T. M., & Sergeant, J. A. (2005). Effects of stop signal modality, stop signal intensity and tracking method on inhibitory performance as determined by use of the stop signal paradigm. *Scandinavian Journal of Psychology, 46*(4), 331-341.

van Holst, R. J., van den Brink, W., Veltman, D. J., & Goudriaan, A. E. (2010). Why gamblers fail to win: A review of cognitive and neuroimaging findings in pathological gambling. *Neuroscience and Biobehavioral Reviews*, *34*(1), 87-107.

Van Veen, V., Krug, M. K., & Carter, C. S. (2008). The neural and computational basis of controlled speed-accuracy tradeoff during task performance. *Journal of Cognitive Neuroscience*, *20*(11), 1952-1965.

Veling, H., Aarts, H., & Stroebe, W. (2013). Stop signals decrease choices for palatable foods through decreased food evaluation. *Frontiers in Psychology, 4*, 875.

Verbruggen, F., Adams, R., & Chambers, C. D. (2012). Proactive motor control reduces monetary risk taking in gambling. *Psychological Science, 23*, 805-815.

Verbruggen, F., Aron, A. R., Stevens, M. A., & Chambers, C. D. (2010). Theta burst stimulation dissociates attention and action updating in human inferior frontal cortex. *Proceedings of the National Academy of Sciences of the United States of America, 107,* 13966-13971.

Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and Emotion*, *21*(2), 391-403.

Verbruggen, F., Liefooghe, B., & Vandierendonck, A. (2004). The interaction between stop signal inhibition and distractor interference in the flanker and Stroop task. *Acta Psychologica*, *116*(1), 21-37.

Verbruggen, F., & Logan, G. D. (2008). Response inhibition in the stop-signal paradigm. *Trends in Cognitive Sciences*, *12*(11), 418-424.

Verbruggen, F., McLaren, I. P., & Chambers, C. D. (2014). Banishing the control homunculi in studies of action control and behavior change. *Perspectives on Psychological Science*, *9*(5), 497-524.

Verdejo-Garcia A., Lawrence A. J., & Clark L. (2008). Impulsivity as a vulnerability marker for substance-use disorders: Review of findings from high-risk research, problem gamblers and genetic association studies. *Neuroscience Biobehavioural Review, 32*, 777-810.

Vuilleumier, P. (2005). How brains beware: Neural mechanisms of emotional attention. *Trends in Cognitive Sciences, 9,* 585-594.

Wager, T. D., Sylvester, C. Y., Lacey, S. C., Nee, D. E., Franklin, M., & Jonides, J. (2005). Common and unique components of response inhibition revealed by fMRI. *Neuroimage, 27*(2), 323-340.

Waller, N., Putnam, F. W., & Carlson, E. B. (1996). Types of dissociation and dissociative types: A taxometric analysis of dissociative experiences. *Psychological Methods*, *1*(3), 300-321.

Wardle, H., Sproston, K., Erens, B., Orford, J., Griffiths, M., Constantine, R., et al. (2007). *British gambling prevalence survey 2007*. London: The Stationery Office.

Wardle, H., Moody, A., Spence, S., Orford, J., Griffiths, M., Volberg, R., et al. (2011). *British gambling prevalence survey 2010*. London: The Stationery Office.

Wardle, H. Seabury, C., Ahemed, C., Payne, C., Byron, C., Corbett, J., & Sutton, R. (2014). *Gambling Behaviour in England and Scotland: Findings from the Health Survey for England 2012 and Scotland Health Survey 2012.* Birmingham: Gambling Commission.

Wascher, E., Hoffman, S., Sanger, J., Grosjean, M. (2009). Visuo-spatial processing and the N1 component of the ERP. *Psychophysiology, 46*, 1270-1277.

Weafer, J., Baggott, M. J., & de Wit, H. (2013). Test–retest reliability of behavioral measures of impulsive choice, impulsive action, and inattention. *Experimental and Clinical Psychopharmacology*, *21*(6), 475-481.

Weinbach, N., & Henik, A. (2012). The relationship between alertness and executive control. *Journal of Experimental Psychology: Human Perception and Performance, 38*, 1530-1540.

Weinbach, N., & Henik, A. (2014). Alerting enhances attentional bias for saliency: Evidence from a global/local processing task. *Cognition, 133*, 414-419.

Weinbach, N., Kalanthroff, E., Avnit, A., & Henik, A. (2015). Can arousal modulate response inhibition? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(6), 1873-1877.

Welte, J. W., Barnes, G. M., Tidwell, M.C. O., & Hoffman, J. H. (2009). The association of form of gambling with problem gambling among American youth. *Psychology of Addictive Behaviors, 23*, 105-112.

Wiebe, J., Mun, P., & Kauffman, N. M. A. (2005). *Gambling and Problem gambling in Ontario 2005*. Ontario: Responsible Gambling Council.

Wildman, R. (1997). *Gambling: An Attempt at an Integration*. Edmonton: Wynne Resources Inc.

Williams, R. J., Connolly, D., Wood, R., Currie, S., & Davis, R. M. (2004). Program findings that inform curriculum development for the prevention of problem gambling. *Gambling Research, 16*, 47–69.

Williams, R. J., Volberg, R. A., & Stevens, R. M. G. (2012). *The population prevalence of problem gambling: methodological influences, standardized rates, jurisdictional differences, and worldwide trends.* Ontario, Canada: Ontario Problem Gambling Research Centre and the Ontario Ministry of Health and Long Term Care.

Witte, E. A., & Marrocco, R. T. (1997). Alteration of brain noradrenergic activity in rhesus monkeys affects the alerting component of covert orienting. *Psychopharmacology, 132*(4), 315-323.

Wohl, M. J. A., Christie, K. L., Matheson, K., & Anisman, H. (2010). Animation-based education as a gambling prevention tool: Correcting erroneous cognitions and reducing the frequency of exceeding limits among slots players. *Journal of Gambling Studies, 24, 4*69-486.

Wohl, M. J., Gainsbury, S., Stewart, M. J., & Sztainert, T. (2013). Facilitating responsible gambling: The relative effectiveness of education-based animation and monetary limit setting pop-up messages among electronic gaming machine players. *Journal of Gambling Studies*, *29*(4), 703-717.

Wohl, M. J., Parush, A., Kim, H. S., & Warren, K. (2014). Building it better: Applying human-computer interaction and persuasive design principles to a monetary limit tool improves responsible gambling. *Computers in Human Behaviour,* 37, 124-132.

Wood, R. T. A., & Wohl, M. J. A. (2015). Assessing the effectiveness of a responsible gambling behavioural feedback tool for reducing the gambling expenditure of at-risk players. *International Gambling Studies*, *15*(2), 1-16.

Wright, R. D., & Ward, L. M. (2008). *Orienting of attention*. New York: Oxford University Press.

Wulfert, E., Franco, C., Williams, K., Roland, B., & Maxson, J. H. (2008). The role of money in the excitement of gambling. *Psychology of Addictive Behaviors*, *22*(3), 380-390.

Yerkes, R. M., & Dodson, J.D. (1908). The relation of strength of stimulus to rapidity of habit information. *Journal of Comparative Neurology of Psychology, 18*, 459-482.

Young, M. M., & Wohl, M. J. A. (2009). The gambling craving scale: Psychometric validation and behavioural outcomes. *Psychology of Addictive Behaviors, 23*(3), 512-522.

Yzer, M. C., Siero, F.W., & Buunk, B. P. (2000). Can public campaigns effectively change psychological determinants of safer sex? An evaluation of three Dutch safer sex campaigns. *Health Education Research*, *15*, 339-352.

Zamorano, F., Billeke, P., Hurtado, J. M., López, V., Carrasco, X., Ossandón, T., & Aboitiz, F. (2014). Temporal constraints of behavioral inhibition: Relevance of inter-stimulus interval in a Go-Nogo task. *PLoS ONE, 9*(1), e87232.

Zimmerman, R. (1997). *Social Marketing Strategies for Campus Prevention of Alcohol and Other Drug Problems.* Newton, MA: Higher Education Center for Alcohol and Other Drug Prevention.

## Appendix A

### 27 Item Monetary-Choice Questionnaire (Kirby et al., 1999)

Instructions:

For each of the next 27 choices, please indicate which reward you would prefer: the smaller reward today, or the larger reward in the specified number of days.

1. Would you prefer $54 today, or $55 in 117 days?
2. Would you prefer $55 today, or $75 in 61 days?
3. Would you prefer $19 today, or $25 in 53 days?
4. Would you prefer $31 today, or $85 in 7 days?
5. Would you prefer $14 today, or $25 in 19 days?
6. Would you prefer $47 today, or $50 in 160 days?
7. Would you prefer $15 today, or $35 in 13 days?
8. Would you prefer $25 today, or $60 in 14 days?
9. Would you prefer $78 today, or $80 in 162 days?
10. Would you prefer $40 today, or $55 in 62 days?
11. Would you prefer $11 today, or $30 in 7 days?
12. Would you prefer $67 today, or $75 in 119 days?
13. Would you prefer $34 today, or $35 in 186 days?
14. Would you prefer $27 today, or $50 in 21 days?
15. Would you prefer $69 today, or $85 in 91 days?
16. Would you prefer $49 today, or $60 in 89 days?
17. Would you prefer $80 today, or $85 in 157 days?
18. Would you prefer $24 today, or $35 in 29 days?
19. Would you prefer $33 today, or $80 in 14 days?
20. Would you prefer $28 today, or $30 in 179 days?
21. Would you prefer $34 today, or $50 in 30 days?
22. Would you prefer $25 today, or $30 in 80 days?
23. Would you prefer $41 today, or $75 in 20 days?

24. Would you prefer $54 today, or $60 in 111 days?

25. Would you prefer $54 today, or $80 in 30 days?

26. Would you prefer $22 today, or $25 in 136 days?

27. Would you prefer $20 today, or $55 in 7 days?

Note: The questionnaire used in Experiment 3 of the thesis was adapted to display the hypothetical monetary units in pounds sterling instead of dollars. In addition, the questionnaire was completed electronically with each item being presented one at a time.

## Appendix B

# The Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995)

**Table A.1.** *Barratt Impulsiveness Scale-11 factor structure and scoring.*

| 2nd Order Factors | 1st Order Factors | # of items | Items contributing to each subscale |
|---|---|---|---|
| Attentional | Attention | 5 | 5, 9*, 11, 20*, 28 |
| | Cognitive Instability | 3 | 6, 24, 26 |
| Motor | Motor | 7 | 2, 3, 4, 17, 19, 22, 25 |
| | Perseverance | 4 | 16, 21, 23, 30* |
| Nonplanning | Self-Control | 6 | 1*, 7*, 8*, 12*, 13*, 14 |
| | Cognitive Complexity | 5 | 10*, 15*, 18, 27, 29* |

Note: * highlights reversed scored items

DIRECTIONS: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and circle the appropriate number on the right of each statement. Do not spend too much time on any statement. Answer quickly and honestly.

| Rarely/Never | Occasionally | Often | Almost Always/Always |
|---|---|---|---|
| **1** | **2** | **3** | **4** |

| | | | | |
|---|---|---|---|---|
| 1 I plan tasks carefully. | 1 | 2 | 3 | 4 |
| 2 I do things without thinking. | 1 | 2 | 3 | 4 |
| 3 I make-up my mind quickly. | 1 | 2 | 3 | 4 |
| 4 I am happy-go-lucky. | 1 | 2 | 3 | 4 |
| 5 I don’t “pay attention.” | 1 | 2 | 3 | 4 |
| 6 I have “racing” thoughts. | 1 | 2 | 3 | 4 |
| 7 I plan trips well ahead of time. | 1 | 2 | 3 | 4 |
| 8 I am self-controlled. | 1 | 2 | 3 | 4 |
| 9 I concentrate easily. | 1 | 2 | 3 | 4 |
| 10 I save regularly. | 1 | 2 | 3 | 4 |
| 11 I “squirm” at plays or lectures. | 1 | 2 | 3 | 4 |
| 12 I am a careful thinker. | 1 | 2 | 3 | 4 |
| 13 I plan for job security. | 1 | 2 | 3 | 4 |
| 14 I say things without thinking. | 1 | 2 | 3 | 4 |
| 15 I like to think about complex problems. | 1 | 2 | 3 | 4 |
| 16 I change jobs. | 1 | 2 | 3 | 4 |
| 17 I act “on impulse.” | 1 | 2 | 3 | 4 |
| 18 I get easily bored when solving thought problems. | 1 | 2 | 3 | 4 |
| 19 I act on the spur of the moment. | 1 | 2 | 3 | 4 |
| 20 I am a steady thinker. | 1 | 2 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| 21 I change residences. | 1 | 2 | 3 | 4 |
| 22 I buy things on impulse. | 1 | 2 | 3 | 4 |
| 23 I can only think about one thing at a time. | 1 | 2 | 3 | 4 |
| 24 I change hobbies. | 1 | 2 | 3 | 4 |
| 25 I spend or charge more than I earn. | 1 | 2 | 3 | 4 |
| 26 I often have extraneous thoughts when thinking. | 1 | 2 | 3 | 4 |
| 27 I am more interested in the present than the future. | 1 | 2 | 3 | 4 |
| 28 I am restless at the theatre or lectures. | 1 | 2 | 3 | 4 |
| 29 I like puzzles. | 1 | 2 | 3 | 4 |
| 30 I am future oriented. | 1 | 2 | 3 | 4 |

## Appendix C

### Latin Squares Counterbalanced Measures Designs

Incomplete counterbalanced measures designs are a compromise, designed to balance the strengths of counterbalancing with financial and practical reality. One such incomplete counterbalanced measures design is the Latin Square method, which attempts to offset some of the complexities and keep the experiment to a reasonable size.

With Latin Squares, a five-condition research program would look like the following:

| | Position 1 | Position 2 | Position 3 | Position 4 | Position 5 |
|---|---|---|---|---|---|
| Order 1 | A | B | C | D | E |
| Order 2 | B | C | D | E | A |
| Order 3 | C | D | E | A | B |
| Order 4 | D | E | A | B | C |
| Order 5 | E | A | B | C | D |

The Latin Squares method still suffers from the same weakness as the standard repeated measures design in that carryover effects are a problem. In the Latin Square, A always precedes B in all but one order, and this means that anything in condition A that potentially affects B will affect all but one of the orders. Also, in the above design A always follows E in all but one order, and these interrelations can impact the validity of the experiment.

To combat this in Experiment 1 of the thesis, which had an odd number of conditions (5), two Latin Squares were used to avoid carryover effects. The first is created in exactly the same way as the above and the second is a mirror image. Below, the numbers represent one of the five speed of play conditions in Experiment 1:

| | | | | | |
|---|---|---|---|---|---|
| Order 1 | 1 | 2 | 5 | 3 | 4 |
| Order 2 | 2 | 3 | 1 | 4 | 5 |
| Order 3 | 3 | 4 | 2 | 5 | 1 |
| Order 4 | 4 | 5 | 3 | 1 | 2 |
| Order 5 | 5 | 1 | 4 | 2 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| Order 6 | 4 | 3 | 5 | 2 | 1 |
| Order 7 | 5 | 4 | 1 | 3 | 2 |
| Order 8 | 1 | 5 | 2 | 4 | 3 |
| Order 9 | 2 | 1 | 3 | 5 | 4 |
| Order 10 | 3 | 2 | 4 | 1 | 5 |

With this design, every single condition follows another two times, and therefore allows more meaningful analysis of the data. This balanced Latin Square is a commonly used instrument to perform large repeated measured designs and is an excellent compromise between maintaining validity and practicality.

## Appendix D

# Post-Hoc Mediation Regression Findings Experiment 1

***The Baron and Kenny (1986) method***

Baron and Kenny (1986) propose four steps in establishing mediation:

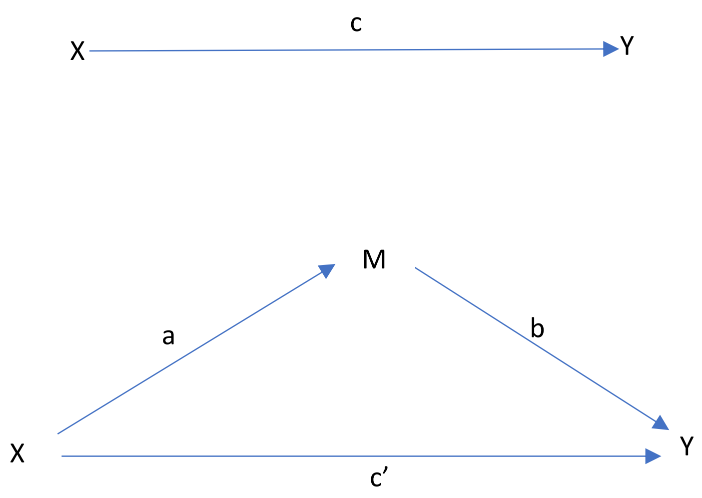


***Figure A-1.*** Model representing pathways in a mediation regression

Step 1: Show that the causal variable (X) is correlated with the outcome (Y). Use Y as the criterion variable in a regression equation and X as a predictor (estimate and test path c in the above figure). This step establishes that there is an effect that may be mediated.

Step 2: Show that the causal variable (X) is correlated with the mediator (M). Use M as the criterion variable in the regression equation and X as a predictor (estimate and test path a). This step essentially involves treating the mediator as if it were an outcome variable.

Step 3: Show that the mediator affects the outcome variable. Use Y as the criterion variable in a regression equation and X and M as predictors (estimate and test path b). It is not sufficient just to correlate the mediator with the outcome because the mediator and the outcome may be correlated because they are both caused by the causal variable X. Therefore, the causal variable must be controlled in establishing the effect of the mediator on the outcome.

Step 4: To establish that M completely mediates the X-Y relationship, the effect of X on Y controlling for M (path c') should be zero. The effects in both Steps 3 and 4 are estimated in the same equation.

If all four of these steps are met, then the data are consistent with the hypothesis that variable M completely mediates the X-Y relationship, and if the first three steps are met but the Step 4 is not, then partial mediation is indicated. However, meeting these steps does not conclusively establish that mediation has occurred because there are other (perhaps less plausible) models that may be consistent with the data.

***Experiment 1 mediation findings***

Mediation regression analysis was conducted to assess if the impact of arousal on response inhibition performance was mediated by faster reaction times in the fast speed of play gambling condition. Theoretical accounts and empirical evidence suggests that increased arousal leads to a state of readiness to respond, where increased arousal lowers respond thresholds and biases go and stop processes in favour of executing an action (see e.g., Logan & Cowan, 1984; Nieuwenhuis & Kleijn, 2013; Posner, 1978; Posner & Peterson, 1990), therefore resulting in reduced reaction time (faster responses) to environmental stimuli.

A simple linear regression analysis demonstrated that arousal was a significant and negative predictor of response inhibition performance ($F(1,49)=14.48$, $p<.001$ with an $R^2_{adjusted}$ value of .365). However, step 2 of the analysis for mediation regression showed that arousal was not predictive of reaction time ($F(1,49)=3.50$, $p=.067$ with an $R^2_{adjusted}$ value of .049). Therefore, all the criteria to proceed with mediation analysis according to the Barron and Kenny (1986) method are not met and the effects of both arousal and reaction times as predictors of response inhibition performance appear independent.

## Appendix E

# Assumptions Testing

Experiment 1

Normality testing

**Table A.2.** *Fast speed condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| RTmean | .079 | .337 | -1.096 | .662 |
| Arousal | -.533 | .337 | -.982 | .662 |
| Diss | 1.137 | .337 | 1.628 | .662 |
| RI | .305 | .337 | -1.031 | .662 |
| Valence | -.588 | .337 | -.706 | .662 |
| Self-control | .053 | .340 | .491 | .668 |

**Table A.3.** *Medium speed condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| RTmean | .382 | .337 | .089 | .662 |
| Arousal | -.325 | .337 | -1.209 | .662 |
| Diss | .506 | .337 | -.105 | .662 |
| RI | -.258 | .337 | -.417 | .662 |
| Valence | -.287 | .337 | -.414 | .662 |
| Self-control | -.042 | .340 | .828 | .662 |

**Table A.4**. *Medium speed with pauses condition skewness and kurtosis values.*

| Variable | Skewness | | Kurtosis | |
|---|---|---|---|---|
| | Statistic | Std. Error | Statistic | Std. Error |
| RTmean | .044 | .337 | -.848 | .662 |
| Arousal | .004 | .337 | -.950 | .662 |
| Diss | .912 | .337 | .285 | .662 |
| RI | -.870 | .337 | 1.644 | .662 |
| Valence | .018 | .337 | -1.086 | .662 |
| Self-control | .082 | .340 | .058 | .668 |

**Table A.5.** *Slow speed condition skewness and kurtosis values.*

| Variable | Skewness | | Kurtosis | |
|---|---|---|---|---|
| | Statistic | Std. Error | Statistic | Std. Error |
| RTmean | -.495 | .337 | -.032 | .662 |
| Arousal | .673 | .337 | .705 | .662 |
| Diss | .028 | .337 | -1.162 | .662 |
| RI | -1.286 | .337 | .978 | .662 |
| Valence | .088 | .337 | -.326 | .662 |
| Self-control | .266 | .340 | .100 | .668 |

**Table A.6.** *Slow speed with pauses condition skewness and kurtosis values.*

| Variable | Skewness | | Kurtosis | |
|---|---|---|---|---|
| | Statistic | Std. Error | Statistic | Std. Error |
| RTmean | .361 | .337 | -.093 | .662 |
| Arousal | -.203 | .337 | -.891 | .662 |
| Diss | .777 | .337 | -.632 | .662 |
| RI | 1.009 | .337 | 1.260 | .662 |
| Valence | .200 | .337 | -.486 | .662 |
| Self-control | -.273 | .340 | -.012 | .668 |

## Homogeneity of variances

**Table A.7.** *Experiment 1 homogeneity of variance values.*

| Variable | Mauchley's Statistic | Significance value |
|---|---|---|
| RTmean | .425 | .790 |
| Arousal | 2.255 | .063 |
| Dissociation | 1.823 | .120 |
| Response Inhibition | 1.687 | .154 |
| Valence | .409 | .802 |
| Self-control | 2.297 | .057 |

## Regression multicollinearity

**Table A.8.** *Fast speed of play multicollinearity diagnostics for regression model.*

| Predictor variable | Tolerance | VIF |
|---|---|---|
| Arousal | .674 | 1.484 |
| Dissociation | .966 | 1.035 |
| Valence | .671 | 1.491 |
| Reaction time | .886 | 1.129 |

**Table A.9.** *Medium speed of play multicollinearity diagnostics for regression model.*

| Predictor variable | Tolerance | VIF |
|---|---|---|
| Arousal | .674 | 1.484 |
| Dissociation | .966 | 1.035 |
| Valence | .671 | 1.491 |
| Reaction time | .886 | 1.129 |

**Table A.10.** *Medium speed with pauses multicollinearity diagnostics for regression model.*

| Predictor variable | Tolerance | VIF |
|---|---|---|
| Arousal | .955 | 1.047 |
| Dissociation | .998 | 1.002 |
| Valence | .994 | 1.006 |
| Reaction time | .949 | 1.054 |

**Table A.11.** *Slow speed multicollinearity diagnostics for regression model.*

| Predictor variable | Tolerance | VIF |
|---|---|---|
| Arousal | .955 | 1.047 |
| Dissociation | .998 | 1.002 |
| Valence | .994 | 1.006 |
| Reaction time | .949 | 1.054 |

**Table A.12.** *Slow speed with pauses multicollinearity diagnostics for regression model.*

| Predictor variable | Tolerance | VIF |
|---|---|---|
| Arousal | .955 | 1.047 |
| Dissociation | .998 | 1.002 |
| Valence | .994 | 1.006 |
| Reaction time | .949 | 1.054 |

## Experiment 2

### Normality testing

**Table A.13.** *Control condition skewness and kurtosis values.*

| Variable | Skewness Statistic | Skewness Std. Error | Kurtosis Statistic | Kurtosis Std. Error |
|---|---|---|---|---|
| RT | .614 | .637 | -.648 | 1.232 |
| Response inhibition | -.086 | .637 | -1.124 | 1.232 |
| Arousal | .000 | .637 | .654 | 1.232 |
| Valence | -.217 | .637 | .733 | 1.232 |
| Dissociation | 2.130 | .637 | 1.992 | 1.232 |
| Self-control | 1.028 | .637 | 2.047 | 1.232 |
| BIS overall | -.396 | .637 | -.210 | 1.232 |
| BIS attention | -.846 | .637 | -.072 | 1.232 |
| BIS motor | -.693 | .637 | -.695 | 1.232 |
| BIS non-planning | .080 | .637 | -.725 | 1.232 |

**Table A.14.** *Emotive message condition skewness and kurtosis values.*

| Variable | Skewness Statistic | Skewness Std. Error | Kurtosis Statistic | Kurtosis Std. Error |
|---|---|---|---|---|
| RT | .508 | .637 | -.470 | 1.232 |
| Response inhibition | -.002 | .637 | -1.602 | 1.232 |
| Arousal | -.583 | .637 | -.138 | 1.232 |
| Valence | -.416 | .637 | -.449 | 1.232 |
| Dissociation | 1.361 | .637 | 1.199 | 1.232 |
| Self-control | .152 | .637 | -.427 | 1.232 |
| BIS overall | -.535 | .637 | -.671 | 1.232 |
| BIS attention | .325 | .637 | -.993 | 1.232 |

| | | | | |
|---|---|---|---|---|
| BIS motor | .602 | .637 | -.1.433 | 1.232 |
| BIS non-planning | -.736 | .637 | -.554 | 1.232 |

**Table A.15**. *Informative message condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| RT | .434 | .637 | -1.394 | 1.232 |
| Response inhibition | .911 | .637 | 1.382 | 1.232 |
| Arousal | -1.070 | .637 | 1.047 | 1.232 |
| Valence | .255 | .637 | -.996 | 1.232 |
| Dissociation | 1.084 | .637 | 1.080 | 1.232 |
| Self-control | .388 | .637 | 1.099 | 1.232 |
| BIS overall | -.884 | .637 | 1.746 | 1.232 |
| BIS attention | .013 | .637 | .235 | 1.232 |
| BIS motor | -.436 | .637 | -.254 | 1.232 |
| BIS non-planning | -1.001 | .637 | .318 | 1.232 |

**Table A.16.** *Structure change condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| RT | -1.601 | .637 | 1.991 | 1.232 |
| Response inhibition | -.384 | .637 | -.057 | 1.232 |
| Arousal | -.136 | .637 | -.770 | 1.232 |
| Valence | .274 | .637 | -.654 | 1.232 |
| Dissociation | .962 | .637 | .148 | 1.232 |
| Self-control | -.385 | .637 | -.055 | 1.232 |

| | | | | |
|---|---|---|---|---|
| BIS overall | -.553 | .637 | -.567 | 1.232 |
| BIS attention | .902 | .637 | .713 | 1.232 |
| BIS motor | -.374 | .637 | -.870 | 1.232 |
| BIS non-planning | -.646 | .637 | -.175 | 1.232 |

**Table A.17.** *Financial punishment condition skewness and kurtosis values.*

| | **Skewness** | | **Kurtosis** | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| RT | .428 | .637 | -1.153 | 1.232 |
| Response inhibition | -.912 | .637 | -.337 | 1.232 |
| Arousal | -.755 | .637 | .161 | 1.232 |
| Valence | 1.730 | .637 | -2.022 | 1.232 |
| Dissociation | .954 | .637 | .490 | 1.232 |
| Self-control | -.001 | .637 | -.764 | 1.232 |
| BIS overall | -.223 | .637 | -.322 | 1.232 |
| BIS attention | .399 | .637 | -1.004 | 1.232 |
| BIS motor | .018 | .637 | -.790 | 1.232 |
| BIS non-planning | -.009 | .637 | 1.129 | 1.232 |

## Homogeneity of variances

**Table A.18.** *Experiment 2 homogeneity of variance values.*

| Variable | Levene's Statistic | Significance value |
|---|---|---|
| Reaction time | .920 | .459 |
| Response Inhibition | 1.669 | .170 |
| Arousal | .450 | .772 |
| Valence | .134 | .969 |

| | | |
|---|---|---|
| Dissociation | .146 | .963 |
| Self-control | .114 | .977 |
| BIS overall | .313 | .868 |
| BIS attention | 1.334 | .269 |
| BIS motor | .219 | .927 |
| BIS non-planning | 1.200 | .321 |

## Experiment 3

## Normality testing

**Table A.19.** *Control condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| RTmean | -.427 | .597 | .114 | 1.154 |
| Response inhibition | .220 | .597 | 1.012 | 1.154 |
| Arousal | -.777 | .597 | -.717 | 1.154 |
| Valence | 1.023 | .597 | .442 | 1.154 |
| Dissociation | .171 | .597 | 1.356 | 1.154 |
| Self-control | -.613 | .597 | -.424 | 1.154 |
| MCQ overall K-value | -.722 | .597 | -1.536 | 1.154 |
| P-correct mean | 1.331 | .597 | -.052 | 1.154 |
| IST decision time | .332 | .597 | 1.650 | 1.154 |
| Balls sampled | .312 | .597 | .628 | 1.154 |
| BIS overall | -.040 | .597 | .923 | 1.154 |
| BIS attention | 1.730 | .597 | .459 | 1.154 |
| BIS motor | -.781 | .597 | -.413 | 1.154 |
| BIS non-planning | -.240 | .597 | -.418 | 1.154 |

**Table A.20.** *Emotive message condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| Reaction time | 1.662 | .597 | 1.933 | 1.154 |
| Response inhibition | -.151 | .597 | -1.261 | 1.154 |
| Arousal | .308 | .597 | -.694 | 1.154 |
| Valence | -.031 | .597 | -.933 | 1.154 |
| Dissociation | .676 | .597 | .146 | 1.154 |
| Self-control | -.322 | .597 | -.670 | 1.154 |
| MCQ overall k-score | 2.620 | .597 | -3.617 | 1.154 |
| P-correct mean | .130 | .597 | -1.269 | 1.154 |
| IST decision time | .122 | .597 | -.202 | 1.154 |
| Balls sampled | -.726 | .597 | -.668 | 1.154 |
| BIS overall | -.227 | .597 | -1.162 | 1.154 |
| BIS attention | -.026 | .597 | -1.085 | 1.154 |
| BIS motor | .370 | .597 | -1.603 | 1.154 |
| BIS non-planning | -.503 | .597 | -.991 | 1.154 |

**Table A.21.** *Informative message condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| Reaction time | .253 | .597 | .012 | 1.154 |
| Response inhibition | -.253 | .597 | -.750 | 1.154 |
| Arousal | -.666 | .597 | .187 | 1.154 |
| Valence | -.283 | .597 | 1.299 | 1.154 |
| Dissociation | .099 | .597 | -1.195 | 1.154 |
| Self-control | -.308 | .597 | -.694 | 1.154 |
| MCQ overall k-score | 1.252 | .597 | .950 | 1.154 |
| | -.312 | .597 | -.145 | 1.154 |

| | | | | |
|---|---|---|---|---|
| P-correct mean | | | | |
| | 1.074 | .597 | 1.471 | 1.154 |
| IST decision time | | | | |
| | .723 | .597 | -.235 | 1.154 |
| Balls sampled | | | | |
| | -.453 | .597 | 1.258 | 1.154 |
| BIS overall | | | | |
| | .351 | .597 | .950 | 1.154 |
| BIS attention | | | | |
| | -.039 | .597 | -677 | 1.154 |
| BIS motor | | | | |
| | -.902 | .597 | .626 | 1.154 |
| BIS non-planning | | | | |

**Table A.22.** *Structure change condition skewness and kurtosis values.*

| | **Skewness** | | **Kurtosis** | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| Reaction time | -.609 | .597 | .238 | 1.154 |
| Response inhibition | .374 | .597 | -.728 | 1.154 |
| Arousal | .325 | .597 | -1.641 | 1.154 |
| Valence | .001 | .597 | -1.183 | 1.154 |
| Dissociation | .802 | .597 | 1.136 | 1.154 |
| | .644 | .597 | .699 | 1.154 |
| Self-control | | | | |
| | 2.085 | .597 | 3.075 | 1.154 |
| MCQ overall k-score | | | | |
| | -.286 | .597 | .522 | 1.154 |
| P-correct mean | | | | |
| | .331 | .597 | -.320 | 1.154 |
| IST decision time | | | | |
| | -.135 | .597 | -1.737 | 1.154 |
| Balls sampled | | | | |
| | -.433 | .597 | -.584 | 1.154 |
| BIS overall | | | | |
| | 1.030 | .597 | 1.301 | 1.154 |
| BIS attention | | | | |
| | -.409 | .597 | -660 | 1.154 |
| BIS motor | | | | |
| | -.422 | .597 | -.254 | 1.154 |
| BIS non-planning | | | | |

**Table A.23.** *Double response condition skewness and kurtosis values.*

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| **Variable** | Statistic | Std. Error | Statistic | Std. Error |
| Reaction time | .398 | .597 | -.118 | 1.154 |
| Response inhibition | -.233 | .597 | -.395 | 1.154 |
| Arousal | -.278 | .597 | -.327 | 1.154 |
| Valence | .492 | .597 | 1.295 | 1.154 |
| Dissociation | .790 | .597 | .026 | 1.154 |
| Self-control | .951 | .597 | .340 | 1.154 |
| MCQ overall k-score | -.284 | .597 | -.968 | 1.154 |
| P-correct mean | -.532 | .597 | -.028 | 1.154 |
| IST decision time | 1.302 | .597 | .785 | 1.154 |
| Balls sampled | 1.405 | .597 | 1.524 | 1.154 |
| BIS overall | .904 | .597 | -.492 | 1.154 |
| BIS attention | .658 | .597 | -.444 | 1.154 |
| BIS motor | -.431 | .597 | -.429 | 1.154 |
| BIS non-planning | .291 | .597 | .063 | 1.154 |

## Homogeneity of variances

**Table A.24**. *Experiment 3 homogeneity of variance values.*

| Variable | Levene’s Statistic | Significance value |
|---|---|---|
| Reaction time | .230 | .921 |
| Response Inhibition | .665 | .619 |
| Arousal | 2.582 | .052 |
| Valence | .306 | .873 |
| MCQ overall k-score | .465 | .761 |
| P-correct mean | .464 | .762 |
| IST decision time | .701 | .594 |

| | | |
|---|---|---|
| Balls sampled | 2.199 | .079 |
| Dissociation | .307 | .872 |
| Self-control | .872 | .486 |
| BIS overall | 2.014 | .103 |
| BIS attention | 1.332 | .267 |
| BIS motor | .219 | .927 |
| BIS non-planning | 1.200 | .321 |