Reflex vs Reasoning: A Dual-Process Examination of Implicit Decision-making in Problem Gamblers

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**Thesis Portfolio Abstract**

**Aims:** The focus of this thesis is to explore the role of implicit cognition and the dual-process relationship between conscious and unconscious decision-making processes in problem gambling. The systematic review aimed investigate the extent and nature of attentional bias as a phenomenon which exists within problem gamblers. The empirical project aimed to investigate the relationship between implicit measures of cognition and explicit self-report measures, and the relationship between these measures and loss of control of gambling behaviour.

**Methods:** The systematic review synthesised available research on attentional bias in problem gamblers, with 22 studies included in the final review following screening. The empirical research project utilised two implicit tasks in addition to several explicit self-report measures of cognition and other constructs. The study sample consisted of 48 participants who were categorised based on problem gambling severity scores.

**Results:** Attentional bias was demonstrated in 16 of the 22 studies included in the systematic review, with attentional bias effects varying across paradigms. In the empirical project, no significant differences were found between groups on implicit tasks. Analysis of self-report measures revealed a significant relationship between problem gambling severity and measures of erroneous cognitions and impulsivity.

**Conclusions:** Results of the systematic review provide support for the role of attentional bias as a potential maintaining factor in problem gambling behaviour. Findings of the empirical project did not support a relationship between loss of control of gambling behaviour and implicit cognitive processes, however results did provide evidence for the role of erroneous cognitions and impulsivity as factors related to

problem gambling. Further research needed to explore the role of implicit decision-making processes in problem gambling.

## List of Contents

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Lastly, I would like to pay tribute to my dad, who sadly passed away from COVID-19 in 2020 and was not able to share in my success of achieving a place on the Doctorate in Clinical Psychology.

# Chapter 1: Introductory Chapter

The purpose of this chapter is to offer an introduction to the origins of gambling behaviour and the concept of Gambling Disorder, from both theoretical and clinical perspectives. Furthermore, it aims to provide a summary of the theoretical underpinnings of the thesis portfolio, with a particular focus on dual process theory as the key theoretical framework. Finally, the chapter provides an overview and rationale of the systematic review and empirical research project that constitute the main body of the portfolio.

## Gambling throughout history

Gambling is a universal practice and dates back for centuries. The Greek philosopher Plutarch wrote of Mercury 'playing tables with the Moon' (Ashton, 1898, p.3) and the Chinese are believed to have played an elementary lottery as far back as the tenth century A.D. (Schwartz, 2013). The first Western gambling establishment, the Ridotto Pubblico, opened in 1638 in Venice, Italy, and the first Grand National was run in England in 1839. Historically, gambling activity in the UK had been viewed as immoral and at odds with the protestant work-ethic (Banks & Waters, 2022) and was criminalized by early legislation. Further legislation in the mid-nineteenth century saw the legalisation of racetracks, but it was not until The Gambling Act of 1960 that licensed betting shops were legally allowed to operate under certain conditions (Pratten & Walton, 2008). This cultural position of disapproving tolerance evolved into active endorsement towards the end of the twentieth century where gambling provision became more accessible and saw an increased focus on individual self-regulation in the management of gambling behaviour. The Gambling Act of 2005 further rescinded regulatory constraints on the gambling industry, authorizing increased advertising and the expansion of online betting (Banks & Waters, 2022), alongside the formation of the UK Gambling Commission, an independent regulatory body introduced to monitor gambling businesses and prevent public harm.

In the modern era individuals can engage freely in gambling behaviour in a variety of different formats, with online gambling services making engagement accessible without needing to leave the house. The British Gambling Prevalence Survey (Wardle et al., 2010) highlights the National Lottery as the most popular method of gambling among both men and women over 16 years of age, with 59% of those surveyed participating in the last 12 months. This was followed by other lotteries (25%), scratch cards (24%), betting on horse races (16%), playing slot machines (13%) and private betting (11%). Industry statistics published by the Gambling Commission in May 2021 highlight the increased popularity of remote or online gambling which generated the greatest gross gambling yield between April and September 2020, no doubt largely attributable to the COVID-19 pandemic and the associated national restrictions.

**Gambling-related harms**

Beyond the vast financial profits and commercial gain, there has been increasing recognition of the public harm borne through the gambling industry. A review conducted by Public Health England (2021) estimated that 0.5% of the adult population have a problem with gambling, 3.8% are gambling at at-risk levels, and 7% are affected negatively by other people's gambling. The harms associated with problem gambling are various and abundant, including a detrimental impact on physical and mental health. Problem gambling has been associated with a number of physical health conditions, including obesity, arteriosclerosis, and heart conditions, (Håkansson & Karlsson, 2020) and psychiatric comorbidity in Gambling Disorder is well reported. High rates of anxiety, substance use and mood disorders have been observed (e.g. Rodriguez-Monguio et al, 2017) as well as an Increased risk of suicide and mortality, with Swedish researchers Karlsson & Håkansson (2018) reporting a 15-fold increase in suicide in adults with Gambling Disorder compared to the general population. Interpersonal relationships can be negatively impacted and can result in relationship problems, family breakdown, and poor familial mental health (Dowling, 2014). Not surprisingly, problem gambling can also have a significant impact on an individual's financial situation, often resulting in an accumulation of debt or even bankruptcy and homelessness. The Institute for Public Policy Research (IPPR) estimate the fiscal cost of problem gambling in Great Britain at between £260 million and £1.2 billion per year (Thorley et al, 2016).

**Gambling Disorder**

Pathological gambling was introduced into the third edition of the DSM in 1980 as an impulse control disorder, however was renamed to Gambling disorder in the DSM-5 and placed in a new category of behavioural addictions in response to the increasing evidence for etiological parallels with substance use disorders (Reilly & Smith, 2013). The DSM-5 (American Psychiatric Association, 2013) defines Gambling disorder as 'persistent and recurrent problematic gambling behaviour leading to clinically significant impairment or distress', indicated by an individual exhibiting at least four of nine diagnostic indicators in a 12-month period:

1. Needs to gamble with increasing amounts of money in order to achieve the desired excitement.
2. Is restless or irritable when attempting to cut down or stop gambling.
3. Has made repeated unsuccessful efforts to control, cut back, or stop gambling.
4. Is often preoccupied with gambling (e.g., having persistent thoughts of reliving past gambling experiences, handicapping or planning the next venture, thinking of ways to get money with which to gamble).
5. Often gambles when feeling distressed (e.g., helpless, guilty, anxious, depressed).
6. After losing money gambling, often returns another day to get even ("chasing" one's losses).
7. Lies to conceal the extent of involvement with gambling.
8. Has jeopardized or lost a significant relationship, job, or educational or career opportunity because of gambling.
9. Relies on others to provide money to relieve desperate financial situations caused by gambling.

The ratio of male to female problem gamblers is thought to be about 6:1 (Gambling Commission, 2019), and some research has indicated a disproportionate representation of Black ethnic groups in Gambling disorder (Conolly et al, 2016).

The clinical understanding and management of Gambling Disorder is at a stage of relative infancy within the National Health Service. According to annual Statistics from the National Gambling Treatment Service (2022), a total of 8,421 individuals received treatment within the service during the period of 2020 to 2021. This number represents less than 5% of adults diagnosed with Gambling Disorder in Great Britain (Bowden-Jones et al., 2022). The NHS Long Term Plan acknowledges the disparity between the demand for services and the current provision, and highlights a commitment to invest in the expansion of specialised problem gambling treatment services within the NHS (NHS, 2019).The National Institute for Health and Care Excellence (NICE) have yet to publish formal guidance on the assessment and management of gambling disorder, however released a final scope in March 2022 of guidelines due to be formally published in 2024 (NICE, 2022) which highlighted the lack of a coordinated system of early identification and intervention and no agreed model of care or referral pathways across England, concluding that '*treatment services for people with harmful gambling are lacking'.* There is a corresponding lack of randomised control trials of psychological treatment for Gambling disorder resulting in a scarce evidence base to inform clinical guidance. The Royal College of Psychiatrists provided a review of evidence-based psychological treatments for Gambling disorder based on National Health and Medical Research Council (NHMRC) guidelines (Bowden-Jones & Drummond, 2016), highlighting Cognitive Behavioural Therapy (CBT), Motivational Interviewing, and Motivational Enhancement therapy as more effective than no intervention, however no further distinctions were possible.

## Theories of problem gambling

The factors which determine whether an individual is able to engage in gambling behaviour recreationally without developing a gambling problem has become an increasing focus within research in line with heightened awareness of gambling-associated harms. Research into problem gambling has borne several different theories attempting to explain or provide some insight into the disorder, however it is increasingly viewed as the result of a complex interaction between multiple variables. For example, learning theories utilise classical and operant conditioning paradigms to explain persistent gambling behaviour through positive and negative reinforcement, and addiction models draw on the similarities between problem gambling and substance use disorders, including excessive preoccupations and persistent urges (Rickwood et al, 2010). Neuroimaging has provided insight into neural mechanisms of addiction in problem gambling; specifically, dysregulation of brain areas linked to reward and emotion, including reduced activity in the ventromedial prefrontal cortex, as well as alterations in dopamine neurotransmission (Grant et al, 2006). Several personality traits have also been associated with problem gambling, such as impulsivity, sensation-seeking and propensity for risk taking (Rickwood et al, 2010).

Cognitive theories emphasise biased thought processes and erroneous beliefs as central in the development and maintenance of problem gambling. A number of erroneous cognitions have been identified as common in problem gamblers, generally relating to misunderstanding of randomness and over-attribution of skill, and drawing faulty causal associations between chance events (Rickwood et al, 2010). One example of this is the ‘gamblers fallacy’, defined by Griffiths (1994) as the ‘expectation that the probability of winning will increase with the length of an ongoing run of losses' (p.352). Collectively, these distortions contribute to an 'illusion of control' which refers to a belief in one's own skills, knowledge, or other advantage which enables individuals to assert control over their gambling performance (Cowley et al, 2015). This over-evaluation of one's own skills or those they are acquiring through continued play coupled with an erroneous belief in the influence of skill on outcomes is said to allow gamblers to justify continued play (Clark, 2010). While wins tend to be viewed as evidence of skill and gambling ability, excuses are often manufactured in order to explain losses and relieve cognitive dissonance, further cementing cognitive biases and erroneous belief systems (Chóliz, 2010).

In contrast to traditional cognitive approaches which focus on thoughts and beliefs which are accessible within conscious awareness and measured via explicit self-reports, research into implicit cognition emphasises the role of unconscious cognitive processes which operate without awareness or reflective deliberation. Traditional theories of addiction have largely focussed on rational decision making in substance misuse, based on the idea that people make decisions through an assessment of benefits versus harm. However, this approach fails to acknowledge that many individuals are aware that the harm caused by continued use of substances is greater than the benefits, yet continue to use substances (Wiers & Stacy, 2006b). As such, an increased focus has been placed on the implicit, automatic processes which may contribute to the development and maintenance of addiction.

### *Dual Process Theory*

In line with increasing recognition of the role of implicit cognition in addiction, dual process theories of decision making have been applied to understanding addiction (e.g. Wiers & Stacy 2006b). The dual process theory of human cognition proposes an interaction of two different systems during the decision-making process (e.g. Kahneman, 2003). System 1 is a fast, impulsive system based on instincts, and System 2 is a slower more conscious system that takes more time and effort to consider options. The rapid and intuitive nature of System 1 means it requires little conscious effort and utilises pattern recognition to channel incoming information, however it is more vulnerable to bias and error. Conversely, System 2 employs careful processing, reflection and logic, but requires substantial cognitive effort and is often drawn upon where there is uncertainty, complexity, or a greater need for accuracy (Tay et al, 2016).

The dual process theory of addiction is based on the idea that loss of control is central to addiction in all forms. It is postulated that this loss of control is related to an over-active System 1 and an underactive System 2, leading to an impairment in the ability to supress impulses and cognitive biases, and to engage in conscious deliberation (Lannoy et al, 2018). Within a gambling context, Evans and Coventry (2006) argue that repeated addictive behaviour reinforces the recruitment of System 1 tendencies, while System 2 perpetuates these tendencies by providing post-hoc rationalisations of unconscious System 1 behaviour. This is in response to the need for a rational and causal explanation for behaviour which maintains a sense of autonomy and control, and results in confabulations in self-reports.

Within this framework, a distinction is drawn between explicit self-report measures, and implicit measures of decision-making processes. Self-report measures which examine conscious reporting of attitudes or beliefs would be understood as representing System 2 thinking, while implicit measures would assess automatic System 1 processes. While explicit self-report measures are widely used in research, these are vulnerable to social desirability bias and falsification, and are unable to access automatic processes which occur below conscious awareness. In contrast, implicit measures bypass System two rationalisation and control, allowing access to the implicit processes which may underlie addictive behaviour.

**The Thesis Portfolio**

The primary focus of this thesis is on the role of implicit cognition and the dual-process relationship between conscious and unconscious decision-making processes in problem gambling. This theme informs both the systematic review (Chapter 2) and the empirical project (Chapter 4). The systematic review provides a contemporary examination of the research on attentional bias in problem gambling, which is a specific implicit process widely associated with substance addiction (Marks et al., 2015) as well as other psychological and anxiety disorders (e.g. Lichtenstein-Vidne et al, 2016; Shafran et al., 2007). The empirical project subsequently investigates the relationship between implicit measures of cognition and explicit (self-report) measures, as well as the relationship between these measures and loss of control of gambling behaviour. Chapter three functions as a bridging chapter, outlining the findings of the systematic review with a brief discussion of the theoretical and conceptual links between the two papers. Finally, Chapter 5 integrates and critically evaluates the findings from both the systematic review and empirical project, alongside a discussion of theoretical and clinical implications and personal reflections on the research process.

## Chapter 2: Systematic Review

# A Systematic Review of Attentional Bias in Problem Gambling

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## ABSTRACT

**Aim:** A large body of previous research has provided support for the role of attentional bias as a maintaining factor in addiction. This systematic review aimed to investigate the extent and nature of attentional bias as a phenomenon which exists within problem gamblers **Methods:** Studies were identified through searches of three databases (MedLine, PSYCHINFO, and Web of Science) and examination of the reference lists of the final studies meeting criteria for inclusion. The scope of the review included empirical studies making experimental comparisons of problem gamblers and non-problem gamblers across a range of attentional paradigms. A comparison of effect sizes was conducted across studies comparing problem to non-problem gamblers within and between attention paradigms. **Results:** Twenty-two studies were reviewed systematically across ten experimental paradigms. Attentional bias was demonstrated in 16 of the 22 studies, with attentional bias effects varying across paradigms. Quality assessment revealed two main limitations across studies: lack of *a priori* power analysis, and failure to control for gambling frequency as a possible confounding variable. **Conclusions:** Findings support the role of attentional bias as a potential maintaining factor in problem gambling behaviour, in line with evidence for substance addiction. Recommendations for future studies are outlined alongside a discussion of clinical implications.



**Keywords:** Attention, attentional bias, problem gambling, gambling disorder, addiction, systematic review.

## INTRODUCTION

Gambling disorder is defined as ‘persistent and recurrent problematic gambling behaviour leading to clinically significant impairment or distress’ (1), and is thought to affect around 0.5% of British adults (2). The DSM-5 introduced Gambling disorder as the first and only behavioural addiction, representing a shift from the previous understanding of ‘pathological gambling’ as an impulse control disorder in response to the increasing evidence for etiological parallels with substance use disorders (3). Similarities between the disorders include behavioural manifestations (e.g. inability to stop, progression and patterns of escalation), shared comorbidities, genetic vulnerabilities, and responses to specific pharmacologic treatments (4). Traits such as impulsivity and compulsivity have also been associated with both problem gambling and substance use disorders, and similar areas of dysfunction have been identified in the brain (5).

In recent years attentional bias has become a significant focus in addiction research, with a burgeoning evidence base for the increased salience of substance-related stimuli in substance users compared to controls (6). In line with the numerous parallels between problem gambling and substance use disorders, theories of attentional bias related to substance misuse have been increasingly applied to problem gambling. For example, Brevers et al. (7) applied the incentive-sensitisation theory (8) to problem gambling, describing how sensitisation of the brain’s meso-limbic and meso-cortical dopamine systems generate incentive motivation for gambling behaviours, producing attentional bias as a means of reward-seeking. Similarly, Grant & Bowling (9) extended Tiffany’s cognitive model of drug use (10) to problem gambling, whereby continued participation in gambling produces automatic unconscious bias towards gambling-related stimuli. Cox et al. (11) also highlight the application of the ‘theory of current concerns’ (12) to the phenomena of attentional bias in addiction, noting that greater concern (motivational goal-striving) about an addictive substance or behaviour would translate in greater attentional bias for addiction related stimuli.

An empirical distinction has been drawn between attentional bias at the point of attention orientation (facilitated attention) contrasted with bias in maintenance of attention (difficulty with disengagement). This differentiation is typically accomplished via manipulation of the length of stimulus presentation, where presentations of ≤200ms measure a rapid automatic orienting of attention, and more sustained presentations of ≥500ms reflect a sustained maintenance of attention (13).

Attaining a comprehensive understanding of the role of attentional bias in problem gambling is crucial for enriching comprehension of the phenomenon's underlying mechanisms, potential contribution to the maintenance of problem gambling behaviour and guiding the development of effective psychological treatment approaches. Furthermore, distinguishing between attentional bias at the stage of orientation and maintenance of attention is fundamental in advancing our understanding of the phenomenon while also informing the development of clinical interventions. Specifically, understanding whether attentional bias occurs rapidly at initial orientation or presents as a delay in disengaging from gambling stimuli could guide the development of appropriately targeted attentional bias modification programs which reflect any potential differences in the degree of conscious control (14) (see Field & Cox (15) for further discussion).

### Objectives

The purpose of the current review was to investigate the extent and nature of attentional bias as a phenomenon which exists within problem gamblers. In doing so we wanted to establish the quality of the studies and outline the magnitude of any observed effects, while also considering the processes of initial orientation and maintenance of attention. It also aimed to provide recommendations for future research and discuss the clinical implications of the empirical evidence. A review was previously conducted by Hønsi et al. (16), however a number of relevant studies have been published since this time, and as such the current paper allows examination of a larger, more robust evidence base. Since the inception of this review, Takahashi et al. (17) published a systematic review of eye-tracking studies of gambling-related attentional biases, however this does not specifically address differences in attentional biases in problem gamblers and examined eye-tracking studies only.

## METHOD

The protocol for this systematic review was registered on PROSPERO on 23rd May 2022 (registration number CRD42022306333) and adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (18).

### Search Strategy

Searches were conducted across MedLine, PsycInfo, and Web of Science databases, in August 2022. The search strategy included the following terms: (gambling OR gambler OR gamblers OR gambling OR gambl*) AND (attention OR attentional OR attention*) AND bias (see Appendix C for full search strategy). The reference lists of the final studies which met criteria for inclusion were also reviewed.

### Eligibility Criteria

The review includes empirical studies which make experimental comparisons of problem gamblers and a control group (non-problem gamblers or non-gamblers). Intervention studies (e.g. RCT's) were excluded from this review.

### Study screening and Quality Assessment

In line with PRISMA guidelines (18) (see Figure 1), the selection process was completed by two reviewers (to reduce the likelihood of rejecting relevant studies). The second reviewer considered twenty percent of the studies screened by the primary reviewer at the first two stages, and fifty percent at the final stage. Out of the 202 titles screened, the second reviewer screened 40 achieving an agreement rate of 100%. Out of the 41 abstracts screened, the second reviewer screened 8 with a 100% agreement rate. Finally, of the 26 full text articles screened, the second reviewer screened 13 with a 76.9% agreement rate. Reviewers jointly examined inclusion and exclusion criteria for each article where there was a discrepancy to reach a final consensus.

To appraise the quality of included studies, a checklist of eleven questions was formulated based on existing quality assessment checklists (see Appendix D for checklist and rationale), specifically the Appraisal tool for Cross-Sectional Studies (AXIS) (19), which address the quality of reporting, study design quality, and biases. The most relevant seven questions from the AXIS were selected jointly between the two reviewers, a further two questions were adapted from Critical Appraisal Skills Programme (20, 21) and one question was adapted from the Scottish Intercollegiate Guidelines Network (SIGN) checklist for case-control studies (22). One additional question pertaining to the inclusion of control conditions was generated by the reviewers as an assessment of internal validity (23). A third reviewer undertook quality assessment for 11 of the 22 studies (50%) with a 74% agreement rate, following which discrepancies were discussed to reach a final consensus. Each study received an overall percentage rating based on the proportion of checklist criteria met (M = 80.56%, SD = 7.05). Quality assessment for each study is presented in Table 1, with studies grouped by paradigm and ordered chronologically.

**Data extraction and analysis**

Data were extracted on participant numbers and gender, measurement of problem gambling severity (e.g. PGSI, SOGS), and study design. Effect sizes (Cohen's *d*) were calculated for each study to demonstrate the magnitude of any reported effect. Where the relevant data was not available in published papers the authors were contacted to request this. Details of the final 22 included studies are outlined in Table 2.

It was not feasible to conduct a meta-analysis within the current review due to methodological heterogeneity across paradigms. Cochrane advises a minimum of two studies to conduct meta-analysis (24), and whilst there are 22 studies included with the review, these exist across 10 attentional bias paradigms, with four paradigms including only one study.

*Table 1*. Results of quality assessment.

| | Assessment quality criteria | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Study | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total |
| **Stroop** | | | | | | | | | | | | |
| McCusker & Gettings (1997)(25) | + | - | - | - | + | - | + | + | + | + | + | 63.63% |
| Atkins & Sharpe (2003) (26) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| Boyer & Dickerson (2003) (27) | + | - | + | + | + | + | + | + | + | + | + | 90.90% |
| Molde et al. (2010) (28) | + | + | + | - | + | + | + | + | + | + | + | 90.90% |
| Cutter (2016) (29) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| **Attentional Blink** | | | | | | | | | | | | |
| Brevers et al. (2011b) (30) | + | - | + | - | + | - | + | + | + | + | + | 72.72% |
| Hudson et al. (2016) (31) | + | - | + | - | + | + | + | + | + | - | + | 72.72% |
| **Dual Task** | | | | | | | | | | | | |
| Diskin & Hodgins (1999) (32) | + | - | + | - | - | - | + | + | + | + | + | 63.63% |
| Diskin & Hodgins (2001) (33) | + | - | + | - | - | + | + | + | + | + | + | 72.72% |
| **Lexical Salience** | | | | | | | | | | | | |
| Zack & Poulos (2004) (34) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| Zack & Poulos (2007) (35) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| **Flicker-induced change blindness** | | | | | | | | | | | | |
| Brevers et al. (2011a) (7) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| **EEG cue reactivity** | | | | | | | | | | | | |
| Wölfling et al. (2011) (36) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| **Approach avoidance** | | | | | | | | | | | | |
| Boffo et al (2018) (37) | + | - | + | + | + | + | + | + | + | + | + | 90.90% |
| **Posner** | | | | | | | | | | | | |
| Ciccarelli et al. (2016a) (38) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| Ciccarelli et al. (2016b) (39) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| Ciccarelli et al. (2019) (40) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| Ciccarelli et al. (2020) (41) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| **Eye tracking** | | | | | | | | | | | | |
| McGrath et al. (2021) (42) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |
| Kim et al. (2021) (43) | + | + | + | - | + | + | + | + | + | + | + | 81.81% |
| Kim et al. (2022) (44) | + | + | + | - | + | + | + | + | + | + | + | 90.90% |
| **Visual Probe** | | | | | | | | | | | | |
| Vizcaino et al. (2013) (45) | + | - | + | - | + | + | + | + | + | + | + | 81.81% |

Criteria: (1) Were the aims/objectives of the study clear? (2) Was the sample size justified? (3) Was membership in a 'problem gambling' group established through use of a reputable screening tool (e.g. PGSI/SOGS/DSM-5)? (4) Were the gambling and control group(s) matched for gambling frequency as a confounding variable? (5) Were additional conditions included to offer a comparison to performance in gambling conditions? (6) Were the experimental and control groups sampled from the same population? (7) Was the selection process likely to select subjects/participants that were representative of the target/reference population under investigation? (8) Were the outcome variables measured appropriate to the aims of the study? (9) Is it clear what was used to determined statistical significance and/or precision estimates (e.g. p-values, confidence intervals)? (10) Were the basic data adequately described? (11) Were the results presented for all the analyses described in the methods? + = yes; - = no.

*Figure 1.* PRISMA flow diagram of the selection process.

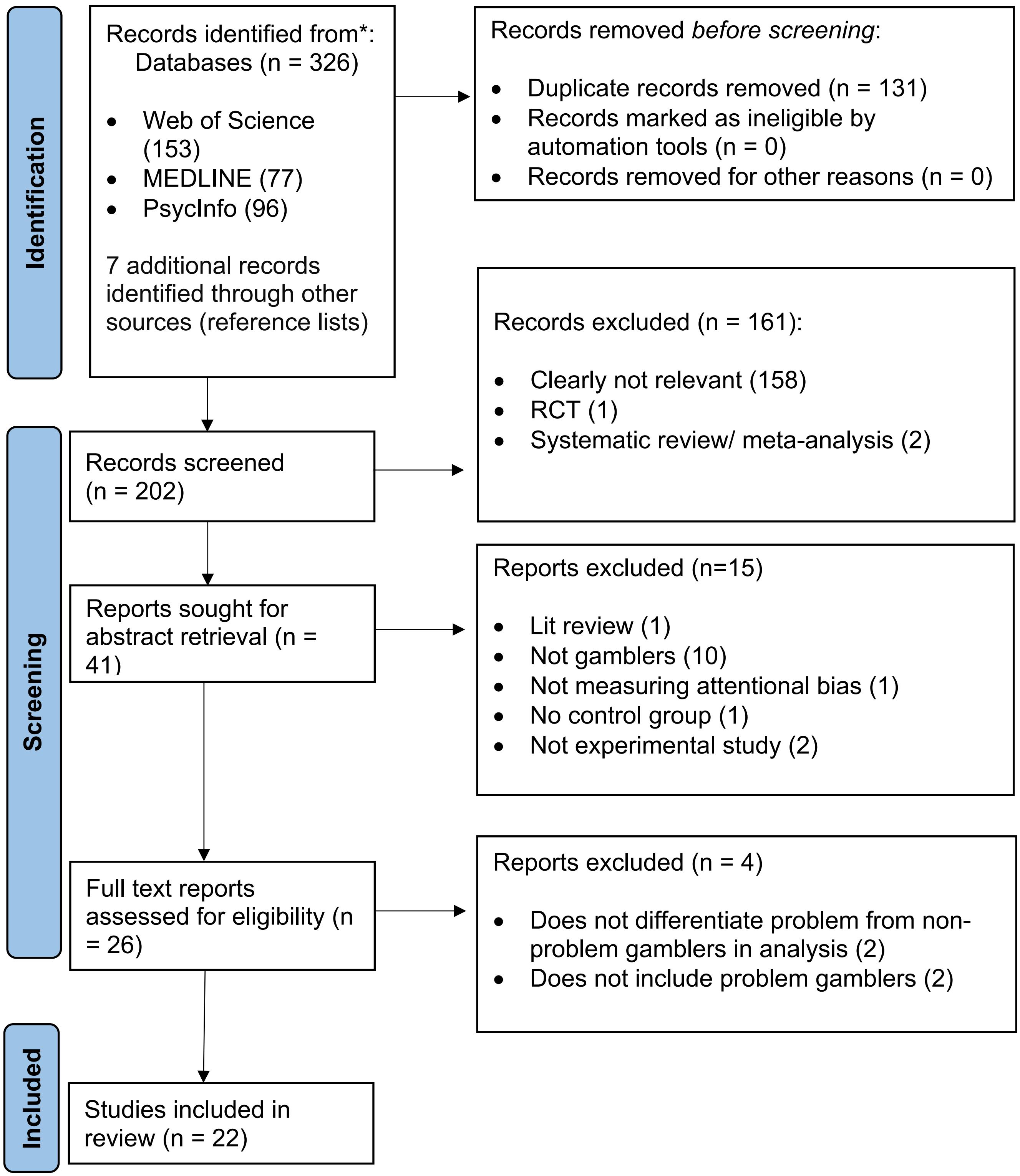

*Table 2*. Summary of studies

| Method and Study | Participants | Scores on measure of gambling severity (SD) | Measure | Attentional bias | Effect size (Cohen's d) |
|---|---|---|---|---|---|
| **Stroop Task** | | | | | |
| McCusker & Gettings (1997) (25) | PG = 15, all males<br>PG's spouses = 15, 0 males<br>HC=15, 8 males | None | Gambling, drug-related and neutral word stimuli | Attentional bias among PG at orienting of attention for gambling-related stimuli; PG significantly slower than HC/spouses to respond to gambling stimuli | PG/spouses*: d* = $1.43_1$<br><br>PG/HC*: d* = $2.08_1$ |
| Atkins & Sharpe (2003) (26) | PG = 12, 8 males<br>HFG = 12, 8 males<br>LFG = 12, 8 males | SOGS:<br>PG = 10.92 (1.50)<br>HFG = 1.17 (0.898)<br>LFG = 0.25 (0.60) | Positive and negative gambling-related, emotional and neutral word stimuli | Significant interaction effect between group and condition. Reverse interference effect: PG responded *more quickly* to positive gambling words in comparison to controls | PG/Controls: *d* = - $0.74_{2a}$<br><br>PG/HFG: *d* = $1.55_1$<br><br>PG/LFG: *d* = $1.09_1$ |
| Boyer & Dickerson (2003) (27) | Low control = 30, 13 males<br>High control = 30, 7 males | Scale of gambling choices (SGC)<br>Low control = 23.93, (4.17)<br>High Control = 50.70, (11.11) | Gambling, drug-related and neutral word stimuli | Significant interaction effect between group and condition. Attentional bias for gambling stimuli among low control group at orienting of attention | *d* = $0.52_2$<br><br>*d* = $0.19_1$ |
| Molde et al. (2010) (28) | PG = 33, 26 males<br>HC = 22, 16 males | SOGS<br>PG = 11.75 (2.49)<br>HC = 0.59 (1.01) | Win-related and neutral pictorial stimuli, supraliminal and subliminal conditions | Significant interaction effect between group and condition. Attentional bias at orienting of attention among PG for win-related stimuli in both conditions | *d* = $0.63_2$<br><br>PG/HC win-related stimuli *d* = $0.67_1$ |
| Cutter (2016) (29) | PG = 10<br>MPG - 26<br>LPG - 18<br>NPG – 6<br>Total sample: 44 males, 16 females | PGSI<br>PG = ≥ 8<br>MPG = 3-7<br>LPG = 1-2<br>NPG = 0 | Gambling related, negative and neutral word stimuli | No significant interaction between group and condition. No attentional bias effect | N/A |

PG = problem gamblers, HC = healthy controls, MPG = moderate problem gambling, LPG = low problem gambling, NPG = non problem gambling, HFG = high frequency gamblers, LFG = low frequency gamblers. Cohen's *d* effect size: small (d = 0.2), medium (d = 0.5), and large (d = 0.8)

*Table 2*. continued

| Method and Study | Participants | Scores on measure of gambling severity (SD) | Measure | Attentional bias | Effect size (Cohen's d) |
|---|---|---|---|---|---|
| **Attentional Blink** Brevers et al. (2011b) (30) | PG = 40, 22 males<br>HC = 35, 20 males | SOGS<br>PG = 4.6 (2.71)<br>HC = Not administered | Gambling- related and neutral word stimuli | Significant interaction effect between group, condition, and lag. Attentional bias among PG for gambling-related words at orienting of attention (200ms) | $d = 0.59_2$<br>$d = 0.53_1$ |
| Hudson et al. (2016) (31) | High risk gamblers – 31, 21 males<br>Low risk gamblers – 26, 14 males | PGSI<br>High-risk = 7.45 (4.26)<br>Low-risk = 1.04 (0.82) | Gambling and non-gambling pictorial stimuli (positive, negative and neutral) | No significant attentional bias effect | N/A |
| **Dual-Task** | | | | | |
| Diskin & Hodgins (1999) (32) | PG = 12, 6 males<br>Occasional gamblers = 11, 4 males | SOGS:<br>PG = 9.8 (3.0)<br>OG = 1.7 (1.4) | Video lottery play while responding to external light | No significant interaction between group and condition (time period). Attentional bias among PG at maintenance of attention | $d = 1.18_3$ |
| Diskin & Hodgins (2001) (33) | PG = 20, 9 males<br>Occasional gamblers = 22, 10 males | SOGS:<br>PG = 9.8 (3.0)<br>OG = 1.7 (1.4) | As in Diskin and Hodgins, (1999) with inclusion of a baseline measure | Significant interaction between group and condition order. No significant difference between groups on reaction times; no attentional bias effect | $d = 1.25_2$<br>$d = 0.05_4$ |
| **Lexical Salience** Zack & Poulos (2004) (34) | PG = 10, 7 males<br>PG + D = 6, 4 males<br>D = 8, 5 males<br>HC = 12, 9 males | SOGS<br>PG = 8.4 (3.4)<br>PG + AD = 8.0 (3.3)<br>AD = 0.6 (1.1)<br>HC = 0.2 (0.4) | Gambling-related, alcohol-related, positive, negative and neutral word stimuli. AMPH D2 agonist and placebo conditions | No attentional bias in placebo for gambling related stimuli between PG and HC | N/A |
| Zack & Poulos (2007) (35) | PG = 20, 17 males<br>HC = 18, 14 males | DSM diagnosis, no SOGS/ PGSI score reported | As described in Zack and Poulos (2004) Haloperidol DA D2 antagonist and placebo conditions | No attentional bias in placebo for gambling related stimuli between PG and HC | N/A |

PG = problem gamblers, HC = healthy controls, PG + D = gambler-drinkers, D = drinkers. Cohen's *d* effect size: small (d = 0.2), medium (d = 0.5), and large (d = 0.8)

*Table 2*. continued

| Method and Study | Participants | Scores on measure of gambling severity (SD) | Measure | Attentional bias | Effect size (Cohen's d) |
|---|---|---|---|---|---|
| **Flicker-induced change blindness** Brevers et al. (2011a) (7) | PG = 40, 22 males<br>HC = 35, 20 males | SOGS<br>PG = 4.6 (2.71)<br>HC = 0.0 (0.0) | Flicker task with eye-movement monitoring; gambling-related and neutral pictorial stimuli Flicker task with eye-movement monitoring; gambling-related and neutral pictorial stimuli | Significant interaction effect between groups on change detection latency, proportion of fixation count and fixation length. Difference between means on first eye movement percentages. Attentional bias among PG at orientation and maintenance of attention | Change detection latency: $d = 0.76_2$<br><br>Direction of first eye movement toward gambling pictures: $d = 1.09_1$<br><br>Proportion of fixation count: $d = 0.58_2$<br><br>Fixation length: $d = 0.73_2$ |
| **EEG cue-reactivity** Wölfling et al. (2011) (36) | PG = 15, 12 males<br>HC = 15, 13 males | SOGS<br>PG = ≥5<br>HC = not reported | Gambling and non-gambling stimulus material (positive, negative and neutral) | Significant interaction effect between group and stimulus category. Attentional bias (LPP's) among PG at maintenance of attention | $d = 1.37_2$ |
| **Approach avoidance** Boffo et al. (2018) (37) | Moderate/ high risk gamblers = 22, all male<br>Non-PG = 26, all male | PGSI<br>Moderate/ high risk = 5.32 (2.48)<br>Non-PG = 1.08 (0.84) | Gambling and neutral pictorial stimuli | Significant interaction effect between group and stimulus. Attentional bias (approach bias) among PG (moderate- to high-risk gamblers) for gambling stimuli at orientation of attention | Baseline:<br>$d = 0.64_2$<br>$d = 0.38_5$<br><br>Follow-up:<br>$d = 0.75_5$ |

PG = problem gamblers, HC = healthy controls. Cohen's *d* effect size: small (d = 0.2), medium (d = 0.5), and large (d = 0.8)

*Table 2*. continued

| Method and Study | Participants | Scores on measure of gambling severity (SD) | Measure | Attentional bias | Effect size (Cohen's d) |
|---|---|---|---|---|---|
| **Posner** | | | | | |
| Ciccarelli et al. (2016a) (38) | PG =25, all male<br>Non-PG =25, all male<br>Abstinent PG =25, all male | SOGS<br>PG = ≥3<br>Non-PG = ≤2<br>Abstinent PG = DSM diagnosis of GD | Gambling related and neutral pictorial stimuli | Significant interaction between group, validity, and stimulus valence Attentional bias (facilitation bias) among PG for gambling stimuli at orientation of attention (100ms) | $d$ = 1.03$_6$ |
| Ciccarelli et al. (2016b) (39) | PG = 54, all male<br>Non-PG = 54, all male | SOGS<br>PG= ≥ 3<br>Non-PG = ≤2 | Gambling related and neutral pictorial stimuli | No significant interaction effects between group and valence. Attentional bias (facilitation bias) among PG compared for gambling stimuli at orientation of attention (100ms) | $d$ = 0.87$_6$ |
| Ciccarelli et al. (2019) (14) | PG = 33<br>Non-PG = 54<br>Total sample: 82 males, 5 females | SOGS<br>PG = ≥ 2<br>HC = ≤1 | Gambling related and neutral pictorial stimuli | No significant interaction effects. Attentional bias among PG at maintenance of attention (500ms) | $d$ = 0.70$_2$ |
| Ciccarelli et al. (2020) (41) | PG = 28, all male<br>HC = 42, all male | SOGS<br>PG = ≥ 2<br>HC = ≤1 | Gambling related and neutral pictorial stimuli | Significant interaction between group and time. Attentional bias among PG at orienting of attention (100ms) | $d$ = 0.70$_2$ |
| **Eye tracking** | | | | | |
| McGrath et al. (2021) (42) | No-risk = 38<br>Low-risk = 24<br>Moderate/High-risk = 25<br>Gender of sample not specified | No risk = 0.0<br>Low risk = 2.4<br>Moderate/ High-risk = 6.6 | Gambling related and neutral pictorial stimuli | Significant interaction between group and attentional bias scores. Attentional bias among PG (Moderate/High risk group) at maintenance of attention | $d$ = 0.78$_6$<br>PG/No-risk: $d$ = 1.36$_7$<br>PG/ Low-risk: $d$ = 0.64$_7$ |

PG = problem gamblers, HC = healthy controls, EGM = electronic gaming machine, GD = gambling disorder. Cohen's *d* effect size: small (d = 0.2), medium (d = 0.5), and large (d = 0.8)

*Table 2*. continued

| Method and Study | Participants | Scores on measure of gambling severity (SD) | Measure | Attentional bias | Effect size (Cohen's d) |
|---|---|---|---|---|---|
| Kim et al. (2021) (43) | PG EGM players = 25, 13 males<br>Non-PG EGM players = 52, 26 males<br>HC = 60, 28 males | PG = ≥ 5<br>Non-PG = 0-4<br>HC = Not reported | Gambling (EGM) and neutral images | Significant interaction between group and stimulus type.<br>Attentional bias among PG orientation of attention | *d* = 1.33[2]<br><br>PG/HC: *d* = 2.55[7] |
| Kim et al. (2022) (44) | PG = 25<br>Non-PG = 50<br>Total sample: 38 males, 37 females | PG = ≥ 5<br>Non-PG = 0-4 | Gambling (EGM) and neutral images | Attentional bias among PG at orientation of attention | PG/Non-PG: *d* = 1.38[7] |
| **Visual Probe** | | | | | *d* = 1.02[7] |
| Vizcaino et al. (2013) (45) | PG = 23, 21 males<br>Non-PG = 21, 16 males | SOGS<br>PG = 11.9 (2.7)<br>Non-PG = 1.2 (0.4) | Gambling related and neutral pictorial stimuli | Attentional bias among PG at maintenance of attention | |

1 Between group performance on gambling stimuli. 2 Interaction effect. 3 Between group reaction times. 4 Between group difference score (baseline vs VLT reaction time). 5 Between groups gambling approach bias, 6 Attentional bias for problem gamblers (within group), 7 Between group attentional bias for gambling stimuli over neutral stimuli. a Value is calculated from a combination of two control groups, and the reporting of analysis is of poor quality.

## RESULTS

10 measures of attentional bias were used across the 22 included studies. The studies under each paradigm will be examined in turn.

### *Addiction Stroop Task*

The Stroop task is one of the most widely used neuropsychological assessments of attentional bias. The traditional colour-word Stroop task requires participants to read colour-words which are either congruent or non-congruent to measure the impact of cognitive interference (46). Since the development of the initial paradigm in 1935 (47) the Stroop task has subsequently been adapted for use in studying various populations and psychopathologies. In contrast to the traditional Stroop paradigm, the addiction Stroop task measures the interference of addiction-related stimuli compared to neutral stimuli, where attentional bias is gauged through comparing colour-naming reaction times between the word categories (48). The cognitive interference observed in the addiction Stroop task is largely considered to reflect attentional bias at the initial orienting of attention, where difficulty suppressing gambling related information results in slower reaction times (25). However, Field et al. (48) reason that the addiction Stroop task should be considered as a variant of the emotional Stroop task, highlighting carry-over effects in the relevant literature which signal a slow disengagement of attention.

McCusker & Gettings (25) employed a Stroop task with gambling, neutral, and drug-related words with 15 male recruits from Gamblers Anonymous. Controls were spouses of the gamblers and 15 additional controls comprised of eight male and seven female staff and students from a university. No screening tools were utilised to establish gambling psychopathology and group allocation was reliant on self-reports of gambling behaviour, with the parameters of group membership not clearly defined in the research paper. Gamblers demonstrated a significant increase in reaction times for gambling-related words as compared to controls demonstrating greater cognitive interference ($d$ =

2.08), and a further post-hoc analysis revealed an additional effect of gambling type specificity, with racing gamblers and fruit machine players demonstrating greater attentional bias to gambling stimuli of individual relevance, though the sample size was limited (n=11). Moreover, the analyses reported no significant interaction effect between groups and stimulus type, indicating slower reactions times for gamblers overall (not specific to gambling stimuli). Based on methodological limitations, this study received a quality rating of 63.6% (see Table 1).

Atkins & Sharpe (26) compared problem gamblers (n=8) with high (n=8) and low frequency (n=8) non-problem gamblers with a modified Stroop task including positive and negative gambling-related, emotional and neutral word stimuli, in addition to a general Stroop task. In contrast to expectation, the sample of problem gamblers within this study demonstrated faster reaction times across conditions, including significantly quicker responses to positive gambling words in comparison to controls ($d$ = -0.735) (reverse interference effect). The authors suggested that the lack of specificity in gambling stimuli may have prevented elicitation of the expected attentional bias effect.

Boyer & Dickerson (27) sought to replicate and extend the methodology of McCusker & Gettings (25) using gambling (poker), neutral, and drug-related words, with a focus on exploring impaired control over gambling behaviour rather than clinical diagnosis. They recruited 60 poker machine players, categorised into high control (n=30) and low control groups (n=30) based on the Scale of Gambling Choices (SGC) (49). They uncovered significantly slower colour naming times for gambling-related words in the low control group as compared to the high control group ($d$ = 0.189) with a significant interaction effect between group and condition ($d$ = 0.517).

Molde et al. (28) recruited problem slot-machine gamblers (n=33) to complete a Stroop task using win-related and neutral pictorial stimuli with both subliminal and supraliminal presentations of gambling stimuli to investigate the unconscious automatic nature of attention. Increased cognitive interference for win-related stimuli was indicated for problem gamblers, who had significantly longer reaction times and reduced accuracy compared to neutral stimuli, and when compared to control subjects (n=22) ($d$ = 0.668).

Lastly, Cutter (29) designed a gambling-related Stroop task encompassing words related to a broad range of gambling activities alongside negative and neutral words. Participants were categorised according to PGSI scores into problem gamblers (n=10), moderate problem gamblers (n=26), low problem gamblers (n=18), and non-problem gamblers (n=6). Analysis revealed slower reaction times for gambling words than for neutral words across the whole sample, with no significant interaction between group and condition. Cutter (29) speculated that this lack of effect may be due to the generic nature of gambling stimuli used within the task, suggesting that specific gambling stimuli related to individual preference may be required[1].

Overall, studies utilising the addiction Stroop paradigm produced mixed findings. Three reported attentional bias among problem gamblers for gambling-related stimuli (25, 27, 28), although there was no interaction effects in the research conducted by McCusker & Gettings (25). One study reported a reverse interference effect (26), and one study did not reveal any attentional bias effects (29). Studies ranged in quality assessment ratings from 63.6% (25) to 90.9% (27, 28) (Table 1), with the studies with

[1] In some studies, gambling-related stimuli is specific to forms of gambling in which participants engage e.g. images of fruit machines for fruit machine gamblers. In other studies, stimuli are not specific to gambling forms and may encompass a range of gambling-related cues, such as terms like 'win' and 'lose'.

the larger sample sizes (and highest quality ratings) reporting interaction effects (27, 28).

### *Attentional Blink Task*

The ‘attentional blink’ coined by Raymond et al. (50), refers to the temporary suppression of visual attention mechanisms following allocation of visual attention to ‘important’ stimuli. Attentional blink tasks involve the presentation of two masked stimuli within a rapid serial visual presentation (RSVP) stream, and participants are tasked with identifying the second stimuli. The attentional blink typically results in poor identification of the second stimuli, although this effect is attenuated (blink survival) when this stimulus is personally salient. Blink survival is proposed to represent attentional bias at the stage of initial attention orientation, given the conscious perception of salient stimuli within the context of limited attentional resources during processing of the first stimulus (48).

Brevers et al. (30) utilised the attentional blink paradigm to examine attentional bias in problem gamblers when presented with gambling related and neutral word targets. They found a diminished attentional blink effect ($d$ = 0.532) at 200ms (orienting of attention) for gambling-related words compared to neutral targets in problem gamblers (n=40), which was not observed in controls (n=35). A key limitation of the study was the distinct populations from which the experimental and control groups were sampled (casinos vs hospital employees) raising the possibility of confounding factors.

Hudson et al. (31) sought to expand on the research of Brevers et al. (30) by employing additional comparison stimuli alongside neutral items (negative and positive items) and using pictorial rather than word stimuli. They presented targets at either 200ms or 800ms to examine attentional bias at orientation and disengagement respectively. They distinguished between high (n=31) and low risk gamblers (n=26) in a sample of regular gamblers. In line with PGSI scoring guidelines, participants scoring 0 to 2 were deemed 'low risk', however all participants scoring ≥3 were included in the 'high risk' group. Although the authors reported attentional bias in high-risk gamblers at the level of maintenance/ sustained attention (800ms) the effect did not quite reach statistical significance ($p$ = 0.06). While Hudson et al. (31) briefly comment on their decision to relax alpha in their results, the lack of clarity in reporting is reflected in the quality assessment rating of this study (72.7%; see Table 1).

### *Dual Task Paradigms*

Dual task experiments draw upon Cognitive Load Theory (51), which describes the limited capacity of working memory, and the prioritisation of resources when multiple processing demands are imposed. Dual task paradigms therefore involve two tasks occurring concurrently to allow for measurement of performance and allocation of attention under increased cognitive load.

Diskin & Hodgins (32) employed a dual task paradigm to examine attentional bias in problem gamblers (n=12) compared to non-problem occasional gamblers (n=11). Participants were tasked with responding to the presence of an illuminated LED light while playing a video lottery terminal (VLT) game. Although not specifically stated by the authors, the paradigm employed appears to reflect delayed disengagement/ maintenance of attention. Problem gamblers were slower than non-problem gamblers in reacting to light stimuli while playing the VLT game, suggesting a greater narrowing of attention ($d$ = 1.179). A key weakness of this study was the absence of baseline performance measurements, leading the authors to replicate the study with a baseline reaction time measurement where responses to LED lights were recorded independently (33). Problem gamblers (n=20) and controls (n=10) did not demonstrate the same overall narrowing of attention in this later study ($d$ = 0.052), however a significant interaction between group and condition order was identified ($d$ = 1.248). For problem gamblers only, experiencing the baseline condition first resulted in significantly faster response times, which may suggest that the absence of attentional bias in the baseline-first condition may be the result of a practice effect. Additionally, given the intrinsic differences between the baseline and experimental condition in terms of stimulus and difficulty level, the risk of confounding variables cannot be overlooked. While the second study received a greater quality assessment rating (72.7%) than the original study (63.6%), the methodological limitations across both studies are reflected in an average (M) rating of 68.15% (Table 1).

***Lexical Salience Task***

Zack & Poulos (34) developed the Lexical salience task as an amalgamation of the traditional semantic priming task and pharmacological priming in order to investigate the priming effect of a psychostimulant (oral D-amphetamine, AMPH) on the motivation to gamble in problem gamblers (n=10), who were compared against comorbid gambler-drinkers (n=6), problem drinkers (n=8), and healthy controls (n=12). They employed a modified rapid reading task encompassing five semantic domains (Gambling, Alcohol, Positive Affect, Negative Affect, Neutral). The task required participants to read aloud a series of randomised target (gambling) and control words under AMPH and placebo conditions, with faster reading times denoting greater attention due to motivational salience. In the placebo condition (without psychostimulant), problem gamblers did not demonstrate a significant difference in reading speed across word categories.

The authors conducted a further study examining the priming effect of dopamine D2 agonist haloperidol on performance on a lexical salience task (35), comparing reading reaction times of problem gamblers (n=20) with controls (n=18) on gambling and neutral words. Consistent with their earlier study, the authors did not discover any significant differences in reading reaction times in the placebo condition. It is of note that both of these studies employed small samples which were not justified in terms of statistical power, although overall quality assessment ratings were good (81.8%; see Table 1).

***Flicker-induced Change Blindness Paradigm***

As defined by Attwood et al. (52), 'change blindness is a phenomenon of visual perception that occurs when a stimulus undergoes a change without this being noticed by its observer.' (p.151). This phenomenon has been discovered in various contexts, including eyewitness identification (53), insomnia (54), and alcohol intoxication (55).

Brevers et al. (7) utilised a flicker-induced change blindness paradigm, in which 'two images differing in only one aspect were repeatedly flashed on the screen until the participant was able to report the changing item' (neutral/gambling-related). Measures of change detection latency revealed significant attentional biases toward gambling-related visual cues (e.g. poker chips) in problem gamblers (n=22) compared to controls (n=35) (*d* = 0.76). Additional eye-gaze tracking data revealed that problem gamblers directed initial eye movements towards gambling stimuli more than neutral stimuli (*d* = 1.09), demonstrated more gaze fixations on gambling stimuli (*d* = 0.577), and looked at them for longer (*d* = 0.734). Taken together, Brevers et al. (7) concluded that the behavioural and eye-tracking data indicated attentional bias at both orientation and maintenance stages of attention in problem gamblers. This study received a quality assessment rating of 81.8%, although was limited by the lack of an *a priori* power analysis and the absence of inclusion of gambling frequency as a potential confounding variable (see Table 1).

### *EEG Cue-reactivity*

Event related potentials (ERP's) represent a direct measure of attentional bias through measurement of neural activity in response to stimuli. Higher amplitude ERP components during stimulus processing denote attentional bias, with early ERP components thought to indicate bias at orientation, and late positive waves understood to signify delayed disengagement (48).

Wölfling et al. (36) examined emotional processing of gambling and non-gambling stimulus material (positive, negative and neutral) in problem gamblers (n=15) and non-gambling controls (n=15) using an EEG cue-reactivity paradigm. Late positive potentials (LPP's) were measured, based on the premise that larger LPP's are elicited in response to high arousal stimuli which hold greater emotional significance. Non-gambling stimuli were processed similarly across the two groups, however problem gamblers showed significantly larger LPP's in response to gambling stimuli than controls (*d* = 1.373) indicating attentional bias in the maintenance of attention. This study received a quality assessment rating of 81.8% (see Table 1).

### *Approach Avoidance Task*

Boffo et al. (37) adapted the approach avoidance task developed by Rinck & Becker (56) in their research into fear of spiders. The task requires participants to either approach ("pull") or avoid ("push") neutral and target stimuli using a joystick or keyboard keys, appearing to reflect attentional bias at orientation of attention. Boffo et al. (37) adapted this task to examine attentional bias in problem gamblers using gambling-related and neutral pictorial stimuli in a sample of moderate to high-risk gamblers (n=22) and non-problem gamblers (n=26). Approach bias scores were calculated by subtracting median reaction times in each stimulus category for both approach and avoid trials, where a faster 'pull' response to gambling stimuli relative to neutral stimuli indicates a stronger approach tendency. Analysis revealed a greater approach bias towards gambling stimuli in moderate to high-risk gamblers relative to non-problem gamblers (*d* = 0.38). This study received a quality assessment rating of 90.9% (Table 1).

### *Posner Paradigm*

The Posner paradigm (57) requires participants to indicate the location of a target stimulus in one of two locations following a visual cue, which either appears in the same location as the visual stimulus (valid trial), or in the other location (invalid trial).

Customarily, response times on the Posner task are quicker for valid trials, in line with the hypothesis that cues orient visual attention. In addiction research, attentional bias for substance-related cues is established by shorter reaction times to probes that appear in the location of substance-related stimuli as opposed to probes which replace neutral/control stimuli (48). Ciccarelli and colleagues (14, 38, 39, 41) modified the Posner task for use with a gambling population, examining attentional bias at both orientation and maintenance of attention by manipulating the length of stimulus presentation. It is of note that none of the studies within this paradigm provided an *a priori* power analysis, nor did they match for gambling frequency as a potential confounding variable. All four studies subsequently received quality assessment ratings of 81.8% (see Table 1)

Ciccarelli et al. (38) employed a modified Posner task to investigate attentional bias in problem gamblers (n=25), non-problem gamblers (n=25) and abstinent ‘pathological gamblers’ who had a DSM-5 diagnosis of Gambling Disorder and were undergoing treatment (n=25). They used gambling and neutral images as ‘cues’ for the target stimulus and calculated facilitation and disengagement biases. Problem gamblers demonstrated a facilitation bias at 100ms ($d$ = 1.028) but no disengagement bias, and abstinent problem gamblers were slower to detect neutral stimuli following presentation of gambling cues in valid trials only (attentional avoidance).

Ciccarelli et al. (39) repeated this task with a sample of 108 problem and non-problem gamblers with consistent results. They found that problem gamblers (n=54) were faster to respond to gambling-related stimuli when presented at 100ms (initial orientation) ($d$ = 0.865), whereas non-problem gamblers (n=54) did not differ in their response times between neutral and gambling-related stimuli. The same authors conducted a further study (41) in which the modified Posner task was completed by 28 problem gamblers and 42 non-problem gamblers. In accordance with their earlier studies, Ciccarelli et al. (41) reported facilitation bias for gambling-related stimuli at 100ms in problem gamblers ($d$ = 0.701) with no bias at disengagement (500ms).

Ciccarelli et al. (14) replicated this task with adolescent problem gamblers (age 16-20; $M$ = 17.54 years; $SD$ = 0.89), producing interesting results. In contrast to adult problem gamblers, adolescents demonstrated facilitation bias at 500ms, demonstrating bias at the maintenance of attention rather than initial orientation ($d$ = 0.742). The authors postulated that the findings support a conscious and intentional orientation of attention to gambling stimuli in adolescents, as compared to an unconscious automatic process in adults as familiarity with gambling stimuli is greater.

### ***Eye-gaze Tracking***

Eye-gaze tracking involves the use of a computer or other video device to record eye movements as a direct measure of attention. It allows continuous measurement of eye movements in response to stimuli, both spatially and temporally to identify fixations and saccades (58). The average (M) quality assessment rating across the three studies conducted within this paradigm was 84.8% (see Table 1).

McGrath et al. (42) utilised eye-gaze tracking to measure attentional bias in undergraduate students categorised by PGSI scores into no risk (n=38), low risk (n=24), and moderate/high risk groups (n=25). Participants were presented with 25 pairs of images (neutral/gambling) along with 31 pairs of neutral images (filler trials). Analysis revealed no difference in initial orientation to stimuli (gambling vs neutral), however the moderate/high risk group demonstrated sustained attentional bias during the last 4 seconds of the 8 second image presentations compared to the no risk ($d$ = 1.361) and low risk ($d$ = 0.638) groups.

Kim et al. (43) employed a similar methodology in their examination of attentional bias in Electronic Gaming Machine (EGM) gamblers. Participants were presented with four images per trial, which consisted of either three neutral images and one EGM image (experimental trials), or four neutral images (filler trials). Participants were classified as either non-gambling disorder (non-GD, n=52) or gambling disorder (GD, n=25) EGM players based on PGSI scores (GD = ≥5), alongside a control group of non-gamblers (n=60). Both non-GD and GD EGM players demonstrated attentional bias towards EGM images (orientation of attention), with a significantly larger effect present in GD players compared to both non-GD players ($d$ = 1.38) and controls ($d$ = 2.55). A further study by Kim et al. (44)using the same experimental task found that PGSI scores were a significant predictor of attentional bias ($d$ = 1.023).

### ***Visual probe Task***

The visual probe task has been employed in research into substance use for more than two decades. The task involves the simultaneous presentation of a substance-related and neutral visual stimulus, followed by a visual probe which appears in the location of one of the previous stimuli. Participants are required to respond as quickly as possible to the appearance of the probe, and reaction times form the basis for analysis, where faster responses to probes appearing in the location of the substance-related stimuli indicates attentional bias (15).

Vizcaino et al. (45) used gambling and neutral images in a visual probe task with 'pathological gamblers' (n=23) recruited from an outpatient gambling treatment clinic. In this study, pathological gamblers demonstrated attentional bias at the maintenance of attention for gambling-related stimuli ($d$ = 0.815) which was not observed in controls (n=21), however there was not a significant correlation between attentional bias and gambling severity as measured by SOGS scores. The authors attributed the absence of a correlation to the lack of variation in SOGS scored among pathological gamblers and highlighted the binary nature of the sample as a key weakness of the research. As non-problem gamblers were not represented in the sample, the presence of attentional bias in pathological gamblers was not established as distinct from potential bias in non-problem social gamblers. This study received a quality assessment rating of 81.8%.

## Discussion

Significant attentional bias effects for gambling-related stimuli in problem gamblers was demonstrated in 16 of the 22 studies examined. Five of the 22 studies utilised direct measures (ERP, eye-gaze tracking) (7, 36, 42-44), all of which reported significant attentional bias in problem gamblers.

Differences in attentional bias effects across studies can be observed at a paradigm level. Zack & Poulos (34, 35) found no attentional bias using a lexical salience task, however there is still a lack of clarity regarding the involvement of attentional processes in this experimental paradigm. The authors refer to Robinson & Berridge's theory of incentive salience (8), which suggests that faster reading times may reflect increased salience or motivational relevance, but the specific relationship with attentional bias remains unclear. Consequently, there are doubts regarding the effectiveness of this method as a measure of attentional bias. Studies using the Stroop Task produced mixed findings, with three of five studies noting an attentional bias effect in problem gamblers for gambling-related stimuli. Where an effect was found in the expected direction, studies utilised specific gambling stimuli related to activity preference (25, 27, 28), whereas those employing non-specific gambling stimuli found either no attentional bias effect (29), or the effect was observed in the opposite direction (26).

Diskin & Hodgins (32) reported attentional bias using a dual task paradigm, however the absence of a baseline performance measure or control condition call into question the validity of the results. The same effect was not found in their later study (33) following introduction of a baseline condition. While Brevers et al. (30) demonstrated a significant attentional bias effect for gambling-related words in problem gamblers using an attentional blink paradigm, the same results were not demonstrated by Hudson et al. (31) with effects falling short of statistical significance.

The remaining experimental paradigms consistently revealed attentional bias among problem gamblers for gambling related stimuli, with Ciccarelli et al. (14, 38, 39, 41) reporting large effect sizes on four studies employing a modified Posner task.

The reviewed studies provide evidence for attentional bias at both orientation and maintenance of attention, with eight studies producing effects relevant to attention orientation (25, 27, 28, 30, 37-39, 41) and seven reporting attentional bias at the maintenance level (14, 31, 32, 36, 42-45). The study by Brevers et al. (7) concluded that effects indicated attentional bias at both orientation and maintenance of attention.

The majority of studies did not use experimental methods which assess for both orientation and maintenance and as such it is not possible to determine whether an attentional bias effect would have been observed at both stages. The five studies reporting significant effects through implementation of such methods yielded varying results. Ciccarelli et al. (38, 39, 41) consistently found attentional bias at the stage of attentional orientation in adult problem gamblers, however reported bias at the level of maintenance of attention in adolescent gamblers (14). The authors suggest that this may reflect a move from conscious intentional attentional orientation in the initial stages of problem gambling, to a more automatic unconscious attentional bias in line with increased familiarity with gambling. In contrast, Brevers et al. (7) assessed for both orientation and maintenance of attention using a combination of direct and indirect measures (eye gaze tracking and change detection latency) and observed attentional bias at both orientation and maintenance.

Two main quality limitations were identified across studies. Only three of the 22 studies justified their sample size through a priori power analysis (28, 43, 44) Therefore, in studies where attentional bias was not found, this may be reflective of low statistical power rather than the absence of an effect (59). Secondly, only two studies took into account gambling frequency as a possible confounding variable (27, 37). Therefore, it is plausible that any differences observed between groups may be attributed to or moderated by gambling frequency where this was not controlled for. Overall, studies ranged in quality ratings from 63.6% to 90.9%, with the average (M) quality rating across studies at 80.6%.

## Limitations

By nature of adherence to a stringent systematic search protocol, this systematic review is limited to studies meeting specific eligibility criteria and therefore does not consider all studies relating to attention in gambling. For example, two studies were excluded from the current review due to lack of differentiation between problem and non-problem gamblers in the analysis. A further limitation relates to the heterogeneity in control groups across studies. There is variation in the way in which studies define the control group(s), such as whether control groups are composed of non-gamblers, or those who gamble but not problematically. Additionally, it was not possible to conduct a meta-analysis as part of the review due to methodological heterogeneity across studies, and as such effect sizes are only available on an individual basis and it is not possible to provide an overall statistical synthesis of reported effects. Similarly, conclusions drawn are limited by the lack of available studies and heterogeneity across paradigms. Significant variability in experimental methods presents a challenge in making comparisons, and as such the outcomes of current review are more heavily focussed on recommendations for future research rather than drawing meaningful conclusions.

## Implications for treatment of Problem Gambling

Attentional bias modification (ABM) has been used in the treatment of anxiety disorders, aiming to reduce pathology by diminishing attentional bias to threat (60). Given the potential role of attentional bias as a maintaining factor in addiction and substance use disorders, the utility of ABM interventions has also been explored as a tool for reducing alcohol consumption (61) and targeting opiate addiction (62). Heitmann et al. (63) conducted a systematic review of ABM interventions in substance use disorders, reporting inconsistent results across studies in relation to changes in substance-related symptoms. Based on the available evidence, the authors concluded that multi-session ABM interventions may be clinically useful in targeting symptom reduction in addictive behaviour, however emphasised the need for further research.

Given the significant parallels between substance misuse and problem gambling, there has been an emerging interest in exploring the feasibility and effectiveness of ABM interventions in problem gambling. Research into this area is in its infancy with regards to the evidence base, with only one published ABM pilot trial (64), and one study protocol (65). The pilot trial conducted by Wittekind et al. (64) explored the efficacy of an Approach Bias Modification (AppBM) intervention in reducing gambling-related symptoms in problem slot-machine gamblers. The AppBM was a training task based on the approach-avoidance task (37), where gambling (slot-machine) related pictures had to be pushed and all neutral pictures had to be pulled. Participants were randomly assigned to the AppBM or the Sham condition, in which push and pulls were 50:50 for both stimulus categories. Both groups showed a similar reduction in gambling-related symptoms, which the authors postulated may be due to expectancy effects.

Given the significantly limited evidence base for ABM interventions at present, it is not possible to draw conclusions in relation to their potential clinical impact in the treatment of problem gambling. However, the results of the current review provide robust support for the presence of attentional bias in problem gambling maintenance, and as such it is likely to be beneficial to further explore interventions of this type.

## Conclusions and recommendations

The findings of this review support the role of attentional bias as a potential maintaining factor in problem gambling behaviour, in line with evidence for substance addiction. While a small proportion of studies did not report an attentional bias effect, this may plausibly be associated with methodological shortcomings or insufficient statistical power. As such, it is recommended that future studies prioritise power analyses to ensure sufficient recruitment of participants. Methodologically, we advocate for the use of gambling specific stimuli related to activity preference in line with the observed findings in gambling Stroop tasks. Additionally, future studies should endeavour to control for gambling frequency as a potential confounding variable, and further investigation into the role of gambling frequency in attentional bias is necessitated. Despite increasingly robust support for the role of attentional bias in problem gambling there is still a limited evidence base for the phenomena, particularly at a paradigm level. As such, we advocate for replication of studies with the inclusion of various control groups including abstinent problem gamblers to allow examination of variations in attentional bias across the gambling spectrum. We also recommend further investigation of attentional bias utilising direct measures, which are widely regarded as more sensitive than indirect behavioural measures (66) and are less vulnerable to confounding variables such as motor speed in measures of reaction time (67). There remains a lack of clarity around the specific nature of attentional allocation (orientation/

maintenance), necessitating further examination through manipulation of stimulus presentation times. Optimally, studies will incorporate stimulus presentations at different time points to allow simultaneous examination of orientation and facilitation, and permit identification of bias at both time points where this exists. Such an approach has the potential to provide valuable insights into the cognitive mechanisms that drive attentional bias and to further elucidate the complex interplay between attentional processes and gambling behaviour. Furthermore, in light of the divergent findings concerning problem gambling behaviour in adolescents versus adults, as presented in the seminal works of Ciccarelli and colleagues (14, 38, 39, 41), it is imperative to conduct further research to delve into the intricate dynamics of attentional bias and the temporal aspects of gambling engagement.

In summary, the review supports attentional bias as a potential factor in the maintenance of problem gambling behaviour. Future studies should prioritize power analyses, gambling-specific stimuli, replication with control groups, and direct measures to examine attentional bias. Additionally, investigations should focus on the specific nature of attention allocation and its relationship with duration of gambling career. Overall, further research is necessary to understand the interplay between attentional processes and gambling behaviour.

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# Chapter 3: Bridging Chapter

The broad aim of this thesis is to explore the relationship between implicit and explicit decision-making processes in problem gambling in line with dual process theory and includes both a systematic review and empirical project. The dual process understanding of addiction proposes an interplay between unconscious and automatic System 1 and conscious reflective System 2 processes (e.g. Wiers & Stacy, 2006b), and as such these processes are explored in both the systematic review and empirical project. The systematic review examined the extent and nature of attentional bias as a phenomenon which exists within problem gamblers, while the empirical project seeks to explore the relationship between implicit measures of cognition and explicit (self-report) measures, as well as the relationship between these measures and loss of control of gambling behaviour. While attentional bias at the level of sustained maintenance of attention has been suggested to indicate a level of voluntary control (Grant & Bowling, 2015), attentional bias is generally regarded as an automatic process which operates below conscious awareness (System 1) and is not accessible to System 2 explicit reporting.

The systematic review explored attentional bias as a distinct implicit process associated with loss of control of gambling behaviour. 22 empirical papers were examined, revealing attentional bias toward gambling-related stimuli in problem gamblers in 16 of the included studies, with equal evidence for attentional bias at both orientation and maintenance of attention. The findings of the review support the role of attentional bias as a potential maintaining factor in problem gambling behaviour, in line with evidence for substance addiction.

While this thesis does not aim to provide conclusions regarding the complex relationship between conscious and unconscious processes in problem gambling, the empirical project in the next chapter (Chapter 4) presents a piece of research exploring the relationship between implicit and explicit processes in problem gambling, including a measure of attentional bias in line with the apparent relationship with loss of control of gambling behaviour.

## Chapter 4: Empirical Project

# Reflex vs Reasoning: A Dual-Process Examination of Implicit Decision-making in Problem Gamblers

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## Abstract

**Background and aims:** Differences in the cognitive processes of gamblers at varying degrees of loss of control have traditionally been explored via explicit self-report measures. The current study aimed to explore the relationship between implicit measures of cognition and explicit self-report measures, and the relationship between these measures and loss of control of gambling behaviour. **Methods:** A sample of 48 participants were categorised according to gambling severity scores on the Problem Gambling Severity Index (PSGI, Ferris & Wynne, 2001). Decision-making processes were examined using a Roulette Mouse-tracker task, in which participants were presented with binary sequences of reds and blacks, ending with a run of three on experimental trials. Maximum deviation trajectories, binary decision-making, and reaction times were recorded. A change-blindness task was also employed, examining attentional bias through differences in change detection latency between gambling and neutral stimuli. Self-report measures of cognition (erroneous cognitions and cognitive processing style), and other constructs (impulsivity, sensation seeking, and depression) were examined against PGSI scores and performance on implicit tasks. **Results:** No significant differences were revealed between groups on implicit tasks. Analysis of self-report measures revealed a significant relationship between problem gambling severity and measures of erroneous cognitions and impulsivity. A negative recency/ gamblers fallacy effect was demonstrated across groups on the Roulette Mouse-tracker task. **Conclusions:** The current study does not provide evidence for a relationship between loss of control of gambling behaviour and implicit decision-making processes. Results offer support for the role of erroneous cognitions and impulsivity as factors related to problem gambling.

**Keywords:** Gambling, dual-process, implicit, decision-making, attentional bias.

## Introduction

Gambling disorder is the only behavioural addiction in the DSM-5, defined as 'persistent and recurrent problematic gambling behaviour leading to clinically significant impairment or distress' (American Psychiatric Association, 2013). Gambling disorder is associated with increased suicide risk (Karlsson & Håkansson, 2018), psychiatric comorbidity (Monguio et al., 2017), family breakdown (Dowling, 2014), and physical health conditions (Håkansson & Karlsson, 2020). The Gambling Commission (2018) estimate that there are 373,000 problem gamblers in England, 30,000 in Scotland, and 27,000 in Wales, with the estimated fiscal cost of problem gambling in Great Britain falling between £260 million and £1.2 billion per year (Thorley et al., 2016).

While gambling is a universal practice dating back centuries, the increased availability, variety and normative status of gambling activities within Western culture has fostered widespread participation within the general population. Participation in gambling activities contingent on chance (or at least minimal skill) negates the normative understanding of rational human decision making, where this involves the equation of utility and monetary value (Wagenaar, 1988). Despite inequitable odds, it is estimated that around 80% of the Western population gamble (Walker, 1992), and most gamblers do not choose to employ the most efficient strategies to increase their odds of winning (Wagenaar, 1988). As such, defining problem gambling as the result of faulty decision-making processes would fail to explain the transition from regular to problem/disordered gambling. However, understanding differences in decision-making of gamblers across the spectrum of gambling behaviour may help to elucidate the processes which initiate loss of control over gambling behaviour.

Differences in the decision-making processes between problem gamblers and non-problem gamblers have been well established through tasks such as the Iowa gambling task, which examines decision making in a simulated card game where different decks vary in their level of potential risk and reward (Bechara et al., 1994). Problem gamblers habitually perform worse in this task due to a persistent inclination towards high-risk immediate rewards (Brevers et al., 2013), which is postulated to be associated with dysregulation of brain areas linked to reward and emotion, including reduced activity in the ventromedial prefrontal cortex (Grant et al., 2006). A plethora of evidence supports an increased tendency in problem gamblers to 'chase losses' by amplifying betting (e.g. Breen & Zuckerman, 1999; Zhang & Clark, 2020) which has been linked to impulsivity. A large body of research has also focused on the role of erroneous cognitions and fallacious beliefs as central in the development and maintenance of problem gambling (e.g. Clark, 2010; Vergura, 2016).

While erroneous cognitions have also been observed in low-risk and infrequent gamblers, the cognitive theory is based on the notion that these are more prevalent in problem gamblers and provide a rationale to continue engaging in gambling behaviour despite potential significant losses (e.g. Walker, 1992; Griffiths, 1994; Joukhador et al., 2003). For example, the 'illusion of control' (Langer, 1975) refers to a belief in one's own skills, knowledge, or other advantage which enables increased assertion of control over gambling performance (Cowley et al., 2015). This over-evaluation of one's own skills or those being acquired through continued play, coupled with an erroneous belief in the influence of skill on outcomes allows gamblers to justify continued play (Clark, 2010).

Studies exploring cognitive processes during gambling behaviour have traditionally employed explicit self-report measures. While self-report measures of gambling beliefs and cognitions offer efficiency and reliability (Yi & Kanetkar, 2010), the validity of these is limited by their vulnerability to socially desirable responding. This is of particular relevance given the stigma often linked with addiction and the associated shame often experienced by those afflicted (e.g. De Ridder & Deighton, 2021; Schlagintweit et al., 2017). Such measures are also unable to tap into unconscious (implicit) attitudes, beliefs and processes, limiting our ability to develop a comprehensive understanding of the development and maintenance of problem gambling. Investigations of unconscious processes related to gambling behaviour have previously centred primarily on explorations of attentional bias, with a small number of researchers attempting to investigate implicit attitudes to gambling through the use of a modified Implicit Association Test (IAT; Greenwald et al., 1998). A plethora of studies have found a link between attentional bias and problem gambling (e.g. Molde et al., 2010; Boffo et al., 2018; McGrath et al., 2021) suggesting that such biases are likely to play a role in the maintenance of problem gambling, in line with the evidence base in substance addiction (e.g. Field & Cox, 2008). The most commonly used measure of attentional bias in addiction has been the modified Stroop task, in which participants are asked to colour name addiction-related (e.g. alcohol) and neutral words (e.g. school), with a hypothesised slower colour naming for addiction related stimuli, as attention is drawn to the salient word meaning. However studies have produced mixed results (see Hønsi et al., 2013 for a systematic review). Brevers et al. (2011) produced robust findings utilising a flicker-induced change blindness task, based upon the well-established change blindness paradigm which has been widely utilised in various fields of psychological research (e.g. Fitzgerald et al, 2016; Marchetti et al, 2006; Colflesh & Wiley, 2013). Participants were presented with a grid of neutral and gambling images that changed in one element (one specific stimulus change) following a brief mask. The original and changed grid repeatedly flashed on the screen until the change was detected. Measures of change detection latency revealed significant attentional biases toward gambling-related visual cues in problem gamblers compared to controls. Additional eye-gaze tracking data revealed that problem gamblers directed initial eye movements towards gambling stimuli more than neutral stimuli, demonstrated more gaze fixations on gambling stimuli, and looked at them for longer. In regard to implicit attitudes, only three studies are known to have been published which investigate implicit attitudes in problem gambling (Yi & Kanetkar, 2010; Plotka et al, 2016; Brevers et al., 2013) and methodological heterogeneity across these studies makes it challenging to compare the results. Two of the studies indicate that problem gamblers exhibit more pronounced positive implicit attitudes towards gambling compared to controls (Yi & Kanetkar, 2010; Brevers et al., 2013), however the most recent study by Plotka et al. (2016) revealed equally pronounced positive and negative associations (ambivalence).

Wiers and Stacey (2006) applied the dual process theory of decision making to addiction, providing a framework for consideration of both implicit and explicit processes. Dual process theories of decision making (e.g. Kahneman, 2011) propose an interplay of two distinct reasoning systems differentiated by function and level of consciousness, typically referred to as System 1 and System 2 (Stanovich & West, 2000). System 1 is generally considered a primitive, instinctive system shared by both humans and animals. It is fast, impulsive, and automatic in nature, meaning processing is completed below consciousness, with only the outcome accessible to the conscious mind (Evans, 2003). In contrast, System 2 is a slower more conscious system that takes more time and effort to consider options and is thought to be unique to humans (Evans & Coventry, 2006). System 2 employs careful processing, reflection and logic, but subsequently requires substantial cognitive effort and places significant demands on the working memory system (Evans, 2003). As such, System 2 processing is often drawn upon where there is uncertainty, complexity, or a greater need for accuracy (Tay et al., 2016). Within this model, addiction is maintained by imbalance between the intuitive and deliberative systems and a subsequent loss of control (Lannoy et al., 2018), congruent with neurobiological theories of addiction which emphasise the role of impulsivity and poor executive control (Stacy & Wiers, 2010). It is postulated that this loss of control is related to an over-active System 1 and an underactive System 2, leading to an impairment in the ability to supress impulses and cognitive biases and engage in conscious deliberation (Lannoy et al., 2018). Within a gambling context, System 1 drives gambling behaviour through misapplication of heuristics (Kahneman & Tversky, 1972), which can result in the perception of patterns and sequences which do not exist in games of chance (e.g. roulette), while an individual's confidence in their ability to predict patterns and outcomes is increased with greater gambling frequency.

Evans & Coventry (2006) argue that the potential conflict between automatic behaviours and conscious cognitive processes generates a subsequent need for a rational and causal explanation for behaviour which maintains a sense of autonomy and control. That is, where one has engaged in gambling behaviour, System 2 seeks to rationalise this behaviour by forming beliefs congruent with the behaviour. While cognitive distortions are widely understood as underlying the development of problem gambling (e.g. Clark, 2010), this dual-process understanding posits that erroneous beliefs develop subsequent to gambling behaviour through System 2 rationalisations, although these are likely to serve a function in the maintenance of the behaviour. The Cognitive Reflection Test (CRT; Frederick, 2005) was introduced as a possible means of determining individual ability to override System 1 impulse responding and engage in System 2 deliberative responding. The CRT is comprised of three questions designed to elicit incorrect intuitive answers, with correct answers therefore indicative of greater deliberation and reflection. Although limited in scope, research has suggested an increased tendency for problem gamblers to provide instinctive System 1 responses on the CRT (e.g. Stange et al, 2018), as well as an association between System 1 CRT responses and greater gambling-related erroneous cognitions (Armstrong et al, 2020).

Drawing on the dual process understanding of problem gambling, Cutter (2016) explored implicit decision-making processes in problem gambling using a novel Roulette Mouse-tracker task (RMT), in which real-time computer mouse movements were tracked during participation in a simulated roulette task. Mouse tracking has been increasingly utilised over recent years as a method of examining the temporal dynamics of cognitive and decision-making processes (e.g. Resulaj et al., 2009; Koop & Johnson, 2013; Dale & Duran, 2011) beyond a discrete choice outcome (Maldonado et al., 2019). By recording motor movements in real-time, mouse tracking software allows more detailed examination of how individuals navigate and interact with stimuli on computer-based tasks (Freeman & Ambady, 2010) by recording maximum deviations from a straight line (MD) and Area Under the Curve as well as reaction times (see Figure 1). In the Roulette Mouse-tracker task, previous ‘roulette’ outcomes were manipulated to include runs of reds or blacks to create the perception of sequences as less random and elicit a response in keeping with the gamblers’ fallacy, which refers to the erroneous belief that if an outcome has occurred more frequently in the past then it is less likely to occur in the future.

**Figure 1**

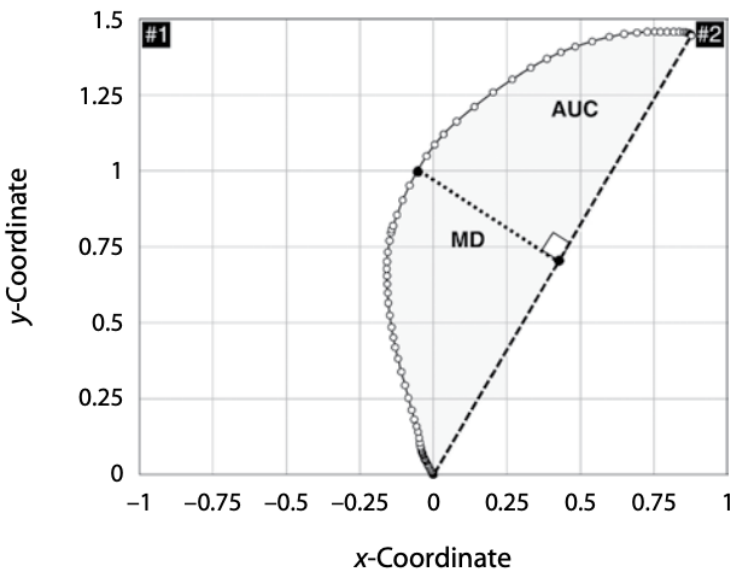



*Illustration of Maximum Deviation and Area Under the Curve (AUC) in MouseTracker.* Reprinted from “MouseTracker: Software for studying real-time mental processing using a computer mouse-tracking method,” by J.B. Freeman and N. Ambady, 2010, *Behavior Research Methods,* 42, 226–241. Copyright 2023 by Springer Nature Switzerland AG

The gambler’s fallacy or ‘negative recency’ effect is generally considered a normative response, in line with a plethora of research on biased perceptions of randomness (Bar-Hillel & Wagenaar, 1991; Hahn & Warren, 2009). As well as measuring stick or switch responses (selecting the same/ different binary outcome as the previous three outcomes), mean deviation trajectories were analysed to indicate the degree to which the alternative non-chosen option was considered. The gamblers' fallacy effect was demonstrated across participants regardless of gambler status and there was no significant difference in reaction times between groups, however mouse movement trajectories of low control gamblers deviated significantly less towards the non-selected outcome than controls during stick choices, indicating less consideration of the non-chosen outcome. Mean deviation trajectories were comparable on both stick and switch choices for the problem gamblers within the sample leading Cutter (2016) to speculate that intuitive System 1 decision making may increase in line with problem gambling symptomology, resulting in unwavering confidence in all gambling decisions.

The current study seeks to further investigate the role of decision making in loss of control of gambling behaviour, building upon previous research by using a combination of implicit and explicit measures. We employ the Roulette Mouse-tracker task as a measure of implicit decision making in conjunction with a replication of the change blindness task used by Brevers et al. (2011) as an additional implicit measure of attentional bias to enable consideration of the relationship between implicit tasks with regards to loss of control of gambling behaviour. In line with the dual process understanding of addiction as the result of a complex interplay of both implicit and explicit factors, we used a variety of explicit self-report measures of established constructs linked to gambling behaviour to allow exploration of the nature of these interactions; erroneous cognitions (e.g. Loo et al., 2011), cognitive processing style (e.g. McCarron, 2018), impulsivity and sensation seeking (e.g. Barrault & Varescon, 2013), and depression (e.g. Martin et al., 2014), While self-reported erroneous cognitions may reflect automatic System one decision making processes, these may also be understood as post-hoc rationalisations of gambling behaviour, and therefore reflective of System two (Evans & Coventry, 2006). Similarly, the dual process understanding of problem gambling emphasises reduced cognitive control in line with an overactive System 1, and as such overall differences in cognitive processing may be associated with loss of control over gambling behaviour (e.g. Stange et al., 2018; Brevers et al., 2016; Guerrero-Mosquera et al., 2017). Impulsivity is widely cited as a risk factor in the development of problem gambling (Blaszczynski & Nower, 2002) and is central in dual process theories of problem gambling as a possible indicator of one's ability to override automatic impulses and engage in System two deliberation. Moreover, sensation-seeking has been frequently linked to gambling behaviour (e.g. Estevez et al, 2015; Coventry & Hudson, 2001), and has been shown to be correlated with impulsivity (Zuckerman et al, 1993), and as such may be most relevant to System 1 decision making. Lastly, depression has been associated with problem gambling as both a consequence of the personal and financial difficulties which result from excessive gambling, and most pertinently, as a maintaining factor where gambling is used to provide relief from negative affect through dissociation (Blaszczynski & Nower, 2002; Gupta & Derevensky, 1998). Given the theoretical association between depression and unconscious dissociative states during problem gambling, and the established relationship between depression and executive functioning (e.g. DeBattista, 2005), depression may also be expected to relate to differences in System one decision making.

In summary, our objective was to explore implicit cognitive processes related to gambling behaviour during a binary decision-making task and change blindness task. We wished to investigate the relationship between implicit measures of cognition and explicit (self-report) measures, as well as the relationship between these measures and loss of control of gambling behaviour.

## Method

### Ethics

Ethical approval was obtained from the Faculty of Medicine and Health Sciences Research Ethics Committee at the University of East Anglia, and the research process was designed in compliance with the British Psychological Society code of ethics (2014). Written informed consent was gained from all participants in the study following provision of an information sheet, and confidentiality was ensured by storing anonymised data on the University of East Anglia OneDrive, accessible only by the researcher. On completion of the study tasks participants were offered the opportunity to debrief and provided with a Debrief sheet which included signposting information relevant to both gambling behaviour and emotional distress.

### Design

This study employed a between-participants experimental design. The predictor variable was the level of loss of control over gambling behaviour, with participants assigned to groups based on classification of at-risk gambling behaviour (no-risk, low-risk, moderate/high-risk)  The criterion variables were responses on explicit self-report measures of gambling-related constructs, and performance on two implicit tasks.

**Procedure**

Participants were required to attend the University of East Anglia to complete the experimental tasks within a laboratory, which took approximately 45 minutes. Following introductions, participants were provided with a Participant Information Sheet and Consent Form. Upon completion of the consent form and the answering of any questions, participants completed the Roulette Mouse Tracker task followed by the self-report measures and Change Blindness task through the Gorilla Experiment Builder online research platform.

**Participants**

Participants were recruited predominantly through online advertising via the University of East Anglia (UEA) Psychology Research Participation System which is accessible to an established public participation panel who have agreed to be contacted for research purposes, as well as undergraduate students from the School of Psychology. An advert was placed on the UEA School of Psychology social media accounts (Facebook, Twitter, and Instagram), and a radio interview was conducted on BBC Radio Norfolk to discuss the research and advertise for participants. Gambling establishments within Norwich were approached to request that advertising materials be displayed on the promises, however this was unanimously declined. Written advertising was also attempted on two online betting forums, however these were declined by the site administrators.

In order to be eligible for the study, participants had to be 18 years old or over and gamble at least once a month. Exclusion criteria were dependence on illicit substances or alcohol, significant cognitive/reading impairment, and physical disability impairing use of a mouse. Initial recruitment allowed participants to book themselves onto the study based on their self-assessed eligibility for the study. The second stage of recruitment employed a screening stage in order to increase the number of moderate-risk and high-risk/problem gamblers in the sample. In this stage, all potential participants were asked to independently complete an online Problem Gambling Severity Index (PGSI, Ferris & Wynne, 2001), where eligibility was dependent on scoring 3 or above in line with PGSI categorisation. All participants were compensated via a £10 amazon voucher which was sent electronically via email from the researchers' university email address. Undergraduate psychology students who participated through the UEA School of Psychology Research Participation System were also offered course credits as an alternative method of compensation.

The final sample of 48 participants was comprised of 41 gamblers, varying in gambling frequency and degree of problem gambling behaviours as defined by the PGSI (problem gamblers (n=4), moderate-risk gamblers (n=16), low-risk gamblers (n=9), and non-problem gamblers n=12). A further seven participants were classified as 'non-gamblers' as they had not gambled in the last three months; three had not participated in any form of gambling in the last twelve months. Participants were assigned to groups (no-risk, low-risk, moderate/high-risk) based on their PGSI scores, with moderate and high risk/problem gamblers combined in line with previous research using the PGSI (i.e. Hudson et al., 2016; McGrath et al., 2021) and SOGS (i.e. Lawrence at al., 2009; Brevers et al., 2011) as measures of gambling severity (see Table 1 for final groupings). Non-gamblers and non-problem gamblers were also combined due to identical PGSI score criteria (no-risk group). While non-gamblers were not part of the intended sample, examination of demographic data revealed this additional category of participants.

**Table 1**

*Group Distributions for Gender, and Means and Standard Deviations for Age, Education, Gambling Severity, Gambling Time and Gambling Spend of Participants in No risk, Low risk and Moderate/High risk Groups*

| | No risk (SD) (n = 19) | Low risk (SD) (n = 9) | Moderate/High risk (SD) (n = 20) |
|---|---|---|---|
| Age (years) | 19.84 (0.74) | 23.89 (9.17) | 26.50 (13.25) |
| Gender | 14 Female, 4 male, 1 not specified | 5 female, 4 male | 8 female, 11 male, 1 not specified |
| Education (years) | 14.47 (1.14) | 15.22 (2.05) | 15.95 (2.42) |
| PGSI | 0.00 (0.00) | 1.44 (0.53) | 5.60 (2.33) |
| Time[a] | 11.32 (29.06) | 48.50 (59.39) | 95.88 (90.39) |
| Money[b] | 1.41 (3.20) | 8.80 (7.35) | 14.63 (14.78) |

[a] minutes per week spent on gambling activities
[b] pounds per week spent gambling activities

The final sample consisted of 27 females, 19 males, and 2 participants who did not wish to state their gender or did not identify with a binary gender. The mean age was 23.38 years (SD 9.92), and participants had a mean average of 15.23 years of formal education (SD 2.04) (see Table 1). 11 categories of gambling activities were identified based on the gambling behaviour of the sample over the 12 months prior to study participation. Information on the frequency of participation in different gambling formats is presented in Table 2. The mean number of gambling formats for participants in the no-risk, low-risk, and moderate/high risk groups were 1.6 (SD 0.88), 3 (SD 1.83), and 3.8 (SD 1.42), respectively.

**Table 2**
*Frequency of Participation in Different Gambling Formats by PGSI Group*

| Gambling format (12 months) | No-risk (n =19) | Low-risk (n=9) | Moderate/ High-risk (n=20) |
|---|---|---|---|
| Electronic gaming machines | 5 | 4 | 5 |
| Lottery (National/ other) | 1 | 2 | 13 |
| Private betting with friends or colleagues | 6 | 4 | 12 |
| Races (Horse/ Dog) | 1 | 2 | 3 |
| Scratch cards | 6 | 6 | 11 |
| Bingo | 3 | 3 | 5 |
| Betting with a bookmaker (not online) | 1 | 0 | 2 |
| Table-top games in a casino | 1 | 1 | 2 |
| Football pools | 0 | 3 | 4 |
| Online betting with a bookmaker/Betting exchange | 0 | 0 | 3 |
| Online gambling | 0 | 2 | 11 |

## Materials and measures

### *Self-report measures*

The following self-report measures were completed by each participant:

1) Demographic information was collected via a questionnaire based on the British Gambling Prevalence Survey (Wardle et al., 2010), including questions on gambling frequency and expenditure.
2) Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001)

The PGSI is a standardised and measure of at-risk behaviour in problem gambling which has become increasingly used in empirical research as an alternative to the earlier South Oaks Gambling Screen (SOGS) (Lesieur & Blume, 1987). The PGSI is considered a highly reliable measure of problem gambling with good internal consistency (alpha = .84; Ferris & Wynne, 2001) and factor structure (Orford et al, 2010; Miller et al, 2013). It is formed of a subset of nine items from the Canadian Problem Gambling Inventory (CPGI). The PGSI was specifically developed for use with the general population and uses a four-point Likert scale with total scores ranging from 0 to 27. A score of 8 or higher on the PGSI indicates problem gambling, 3-7 represents moderate risk problem gambling, 1-2 is low-risk problem gambling, and 0 is categorised as non-problem gambling.

3) Gambling Related Cognitions Scale (GRCS) (Raylu & Oei, 2004)

The GRCS measures gambling-related erroneous cognitions within non-clinical problem gamblers and is widely used in gambling research (e.g. Emond & Marmurek, 2009; Ruiz de Lara, 2019). It has been shown to have good psychometric properties (Raylu & Oei, 2004), and 'excellent' concurrent validity and internal reliability (Kale & Dubelaar, 2013). The GRCS scores responses to 23 items on an 8-point Likert scale, where higher overall scores indicate a greater amount of gambling related cognitions.

4) The Impulsive Sensation Seeking Scale of the Zuckerman-Kuhlman Personality Questionnaire III (Zuckerman et al., 1993)

The Impulsive Sensation Seeking Scale (ImpSS) is one of five subscales of the Zuckerman–Kuhlman Personality Questionnaire, including an 8-item impulsivity scale and an 11-item sensation seeking scale with maximum scores of 8 and 11 respectively. Reliability of the ImpSS total scale is .82 (Zuckerman et al., 1993), and between .84 and .87 for the subscales (Barrault & Varescon, 2013).

5) Patient Health Questionnaire (PHQ-9) (Kroenke et al., 2001)

The PHQ-9 is a brief, 9-item measure of depression severity. It has been widely validated and is commonly used in both primary and secondary care mental health services (Constantini et al., 2021). Score ranges of 5-9, 10-14, 15-19, and 20-27 represent mild, moderate, moderately severe and severe symptoms of depression, respectively.

6) Cognitive Reflection Test (CRT) (Frederick, 2005)

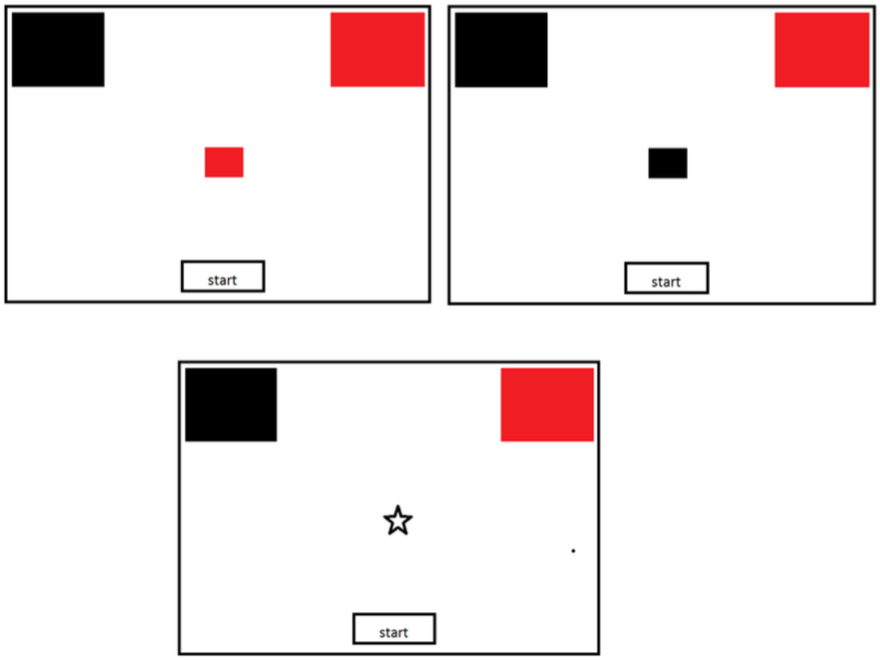
The Cognitive Reflection Test (CRT) was designed to examine individual disposition to override instinctive System 1 responses. To answer questions on the three-item measure correctly, individuals are required to suppress the instinctive answer which these questions are designed to elicit. The CRT is the most widely used measure of cognitive processing style and is largely considered as a reliable predictor of reasoning performance and decision-making (Sirota & Juanchich, 2018).

### *Implicit Tasks*

#### **Roulette Mouse-tracker (RMT) Task.**

The Roulette Mouse-tracker task developed by Cutter (2016) was utilised. In summary, participants were asked to watch a series of outcomes as part of a simulated game of roulette (red or black). There were 40 trials in total (20 experimental and 20 random), where experimental trials ended in a run of three reds (ten trials) or three blacks (ten trials) and random trials were not recorded. At the end of each trial, participants were cued to select which outcome they believed was most likely to be next in the sequence by the presentation of a star in the place of the previous roulette outcomes (see Figure 2).

**Figure 2**




Screenshot of Roulette Mouse-tracker task illustrating the selection squares, outcome sequences, and star signalling the end of a trial. Reprinted from "A longitudinal study mapping changes in explicit and implicit measures of gambling behaviour," by R. Cutter, 2016, Retrieved 7 November 2022, from https://www.begambleaware.org/sites/default/files/2020-12/Richard%20Cutter%20PhD%20010317.pdf. Copyright [2023] by GambleAware.

The Mouse-tracker software package aims to assess real-time cognitive processing (Freeman & Ambady, 2010) by recording trajectories of mouse movements during experiment participation where participants must choose between alternative responses. Measurements of maximum deviation (MD) from a straight line were extracted as a measure of the degree of consideration given to the non-chosen option, as well as reaction times and decision type.

### Gambling Change Blindness (GCB) Task

A flicker-induced change blindness monitoring task was utilised, based on the task used by Brevers et al. (2011). We employed the same stimuli as used by Brevers et al. (2011), but the task was modified. Given that Brevers et al. (2011) found no effect of the side in which a change was presented, each participant took part in two trials; one gambling stimulus change on one side of the array and a neutral stimulus on the other side. The order of gambling and non-gambling changes was randomised, and the side in which the changes occurred (e.g. gambling on left, neutral on right versus gambling on right, neutral on left) was also randomised across participants. The dependent measure in this paradigm was the change detection latency, measured by the amount of time taken for the change to be detected.

### Data analysis

Data analysis was conducted using IBM SPSS Statistics (version 28.0.1.0). Descriptive statistics were employed to report demographic data and values for self-report measures. Explicit self-report measures were analysed using two-tailed Pearson's correlations to investigate the degree of any relationship between PGSI scores (continuous variable) with outcomes on self-report measures, following which one-way analysis of variance (ANOVA) calculations were completed with explicit cognitive measures to explore group differences. For implicit tasks, two-way repeated measures ANOVAs were used to compare performance on tasks between groups. Finally, the association between PGSI and all cognitive measures (implicit and explicit) were explored using two-tailed Pearson's correlational analysis. On the GCB and RMT, trials with reaction times greater than two standard deviations from the mean were excluded from analysis. In the GCB, this excluded five participants (10.42%), and in the RMT, 30 trials were excluded (3.13%).

A statistical power analysis (*a priori*) was performed for sample size estimation using G*Power. With power = 0.9 and an alpha = .05, and the effect sizes reported in Cutter (2016) and Brevers et al., (2011), the projected sample size required was approximately N = 87 for the RMT, and N = 69 for the GCB. Recruitment was conducted based on *a priori* power analysis, however it was not possible to achieve the required number of participants (see 'Limitations').

## Results

### Explicit Self-report Measures

Values for self-report measures by PGSI group are presented in Table 3. Table 4 shows the pattern of correlations (Pearson's R) between PGSI scores and self-report measures. The PGSI correlated with time and money spent on gambling per week, as well as erroneous cognitions and impulsivity.  Time spent on gambling per week also correlated with money spent per week, and both time and money correlated with erroneous cognitions. Lastly, impulsivity was significantly correlated with sensation-seeking and depression.

**Table 3**

*Values for self-report measures by PGSI group*

| | No risk (SD) (n = 19) | Low risk (SD) (n = 9) | Moderate/high risk (SD) (n = 20) |
|---|---|---|---|
| Time per week (minutes) | 11.32 (29.06) | 48.5 (59.39) | 95.88 (90.39) |
| Spend per week (£) | 2.17 (4.40) | 8.8 (7.35) | 14.63 (14.78) |
| Erroneous cognitions (GRCS) | 1.34 (0.46) | 2.86 (0.85) | 2.67 (0.84) |
| Impulsivity (IMPSS) | 1.84 (1.84) | 2.22 (2.62) | 4.15 (2.13) |
| Sensation-seeking (IMPSS) | 4.89 (2.75) | 5.00 (2.98) | 6.35 (3.13) |
| Depression (PHQ-9) | 11.21 (5.85) | 6.44 (6.04) | 13.2 (4.28) |
| Cognitive Processing (CRT) | 1.35 (1.13) | 1.56 (1.13) | 1.05 (1.12) |

**Table 4**

*Correlations (Pearson's R) Between PGSI and Self-Report Measures*

| | Time per week | Spend per week | Erroneous cognitions (GRCS) | Impulsivity (IMPSS) | Sensation-seeking (IMPSS) | Depression (PHQ-9) | Cognitive processing (CRT) |
|---|---|---|---|---|---|---|---|
| PGSI | .54** | .32* | .53** | .49** | .26 | .21 | -.06 |
| Time per week | | .58** | .41** | .10 | .09 | -.19 | -.09 |
| Spend per week | | | .33* | -.01 | .03 | -.22 | -.25 |
| Erroneous cognitions (GRCS) | | | | .26 | .12 | -.06 | .11 |
| Impulsivity (IMPSS) | | | | | .49** | .33* | -.03 |
| Sensation-seeking (IMPSS) | | | | | | -.04 | .11 |
| Depression (PHQ-9) | | | | | | | .00 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Due to the higher proportion of males in the moderate/high-risk group compared to the other two groups (see Table 1), an additional correlational analysis was run including female participants only to determine whether the effects observed were the result of sex differences. The analysis revealed duplicate results in relation to statistically significant relationships, with the exception of the correlation between impulsivity and depression, which was no longer significant ($p = 0.557$).

***Explicit Cognitive Measures***

One-way analysis of variance (ANOVA) calculations were completed with explicit measures of cognition (erroneous cognitions, GRCS; cognitive processing, CRT) with PGSI group (non-problem gamblers, low-risk gamblers, and moderate/high-risk gamblers) as the factor and explicit measures as the dependent variable. Statistically significant differences between groups were found on the GRCS, $F(1, 47) = 21.986$, $p = <.001$), however no significant differences were identified on the CRT, $F(1, 47) = .328$, $p = .722$, in line with correlational data.

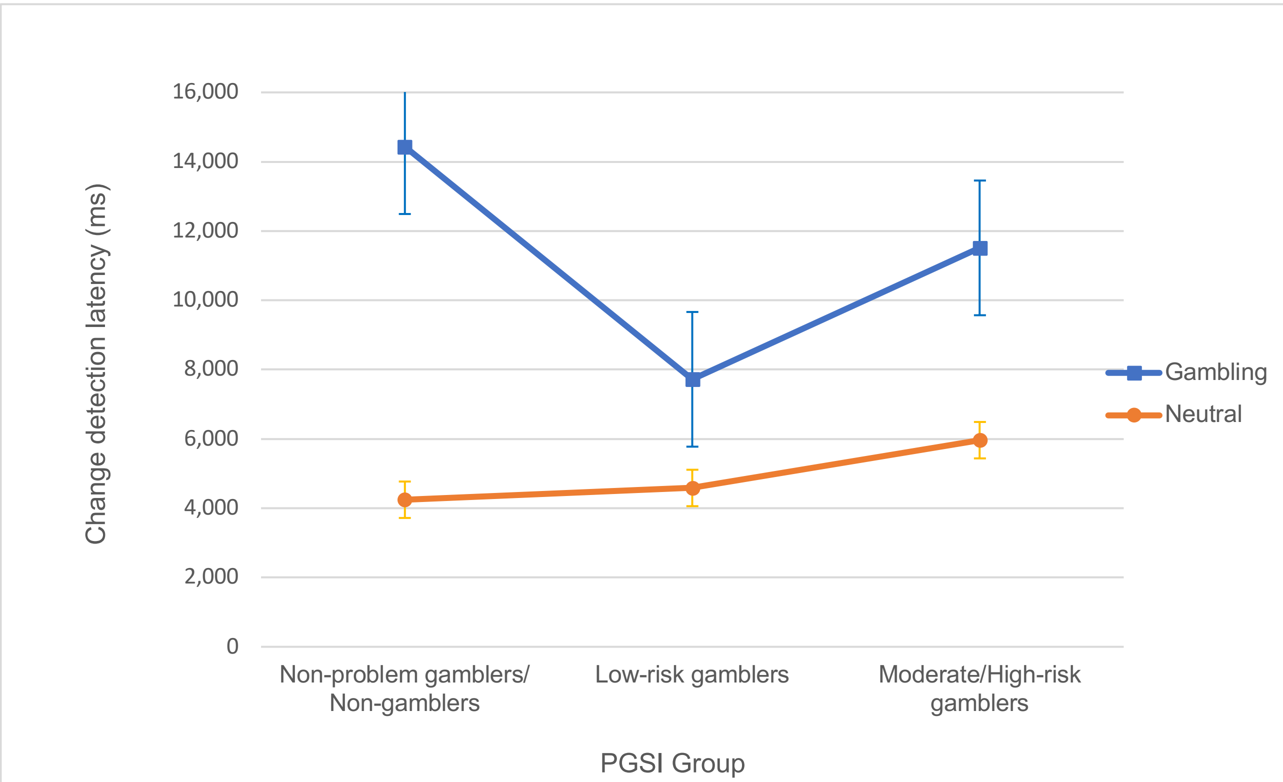
**Implicit Cognitive Measures**

***Gambling Change Blindness Task***

Change-detection latency was measured by the amount of time from initial stimulus change to detection (ms). A two-way repeated measures ANOVA was conducted with group (non-problem gamblers, low-risk gamblers, and moderate/high-risk gamblers) and stimulus change (neutral vs gambling) as between-subjects factors, and change detection latency as the dependent variable. A significant main effect of stimulus change was found, $F(1, 39) = 22.657$, $p = <.01$, *partial* $\eta^2 = .367$, with all groups faster to detect changes in neutral stimuli than changes in gambling stimuli (Figure 3). There was no significant main effect of group, $F(1,39) = 1.288$, $p = .287$, *partial* $\eta^2$ = .062, and the interaction between group and stimuli was also non-significant, $F(1,39) = 2.580$, $p = 0.089$, *partial* $\eta^2$ = .367.[2]

**Figure 3**

*Change Detection Latency for Gambling and Neutral Stimuli by PGSI Group with Standard Error Bars*




## ***Roulette Mouse-tracker Task***

On experimental sequences, the sample as a whole chose to switch to a different colour outcome on the majority of trials (63.5%). There was no significant difference

[2] A Shapiro-Wilk test highlighted potential violations of normality assumptions across datasets for implicit tasks (p = <0.05), however given the limited sample size and robustness of ANOVAs to normality violations (Schmider et al., 2010), this analysis was selected as the most appropriate method. A series of one-way between groups Kruskal-Wallis tests were run on data from implicit tasks as a non-parametric alternative, however no significant results were returned (p = >0.05).

between groups on the amount of switch choices on experimental trials, $F(2,47) = 1.864$, $p = 0.16$.

Mean values for reaction times (RT) and mouse trajectories (MD) were calculated for each participant, separated by trial type (stick/switch). This distinction was drawn to examine any differences between trial type, given that switch responses (selecting the alternative binary response after a run of three) would be the expected response in line with the negative recency/ gambler's fallacy effect (see Ayton & Fischer, 2004; Barron & Leider, 2009). We compared mean MD and RT values separately using two-way repeated measures ANOVA's with group (non-problem gamblers, low-risk gamblers, and moderate/high-risk gamblers) as a between-subjects factor, and response type (stick/switch) as the dependent variable. Analyses of mouse trajectories found no significant effect of PGSI group, $F(1,38) = 1.340$, $p = 0.274$, *partial* $\eta^2 = .066$, however there was a significant main effect of trial type, $F(1,44) = 3.974$, $p = 0.05$, *partial* $\eta^2 = .083$, with all participants demonstrating significantly less consideration of the non-chosen option on switch trials. The interaction between PGSI group and trial type was not significant, $F(1,44) = 1.142$, $p = 0.329$, *partial* $\eta^2 = .049$, indicating that groups did not differ on their motor movements between trial types.

There was no significant main effect of PGSI group or trial type on reaction times, $F(1,38) = 1.340$, $p = 0.274$, *partial* $\eta^2 = .066$, and $F(1,44)= 2.444$, $p = 0.125$, *partial* $\eta^2 = .053$ respectively. Additionally, no interaction was found between group and trial type $F(1,44) = 1.801$, $p = 0.177$, *partial* $\eta^2 = .076$.

**Figure 4**

*Mean Deviation Values by Response Type and PGSI Group*

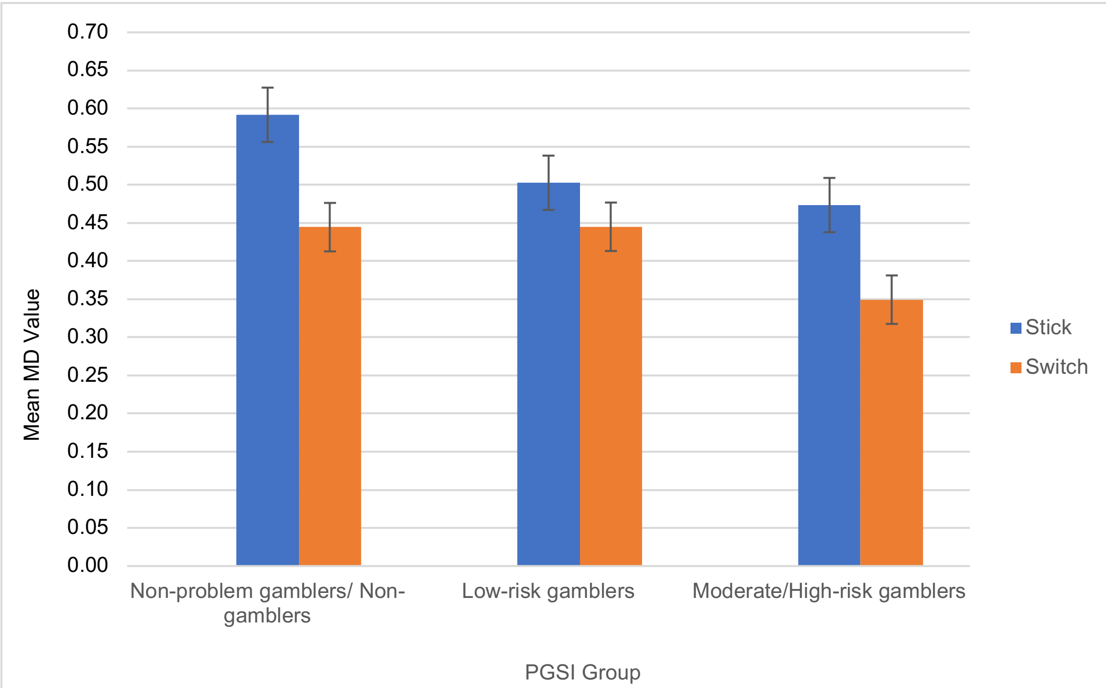
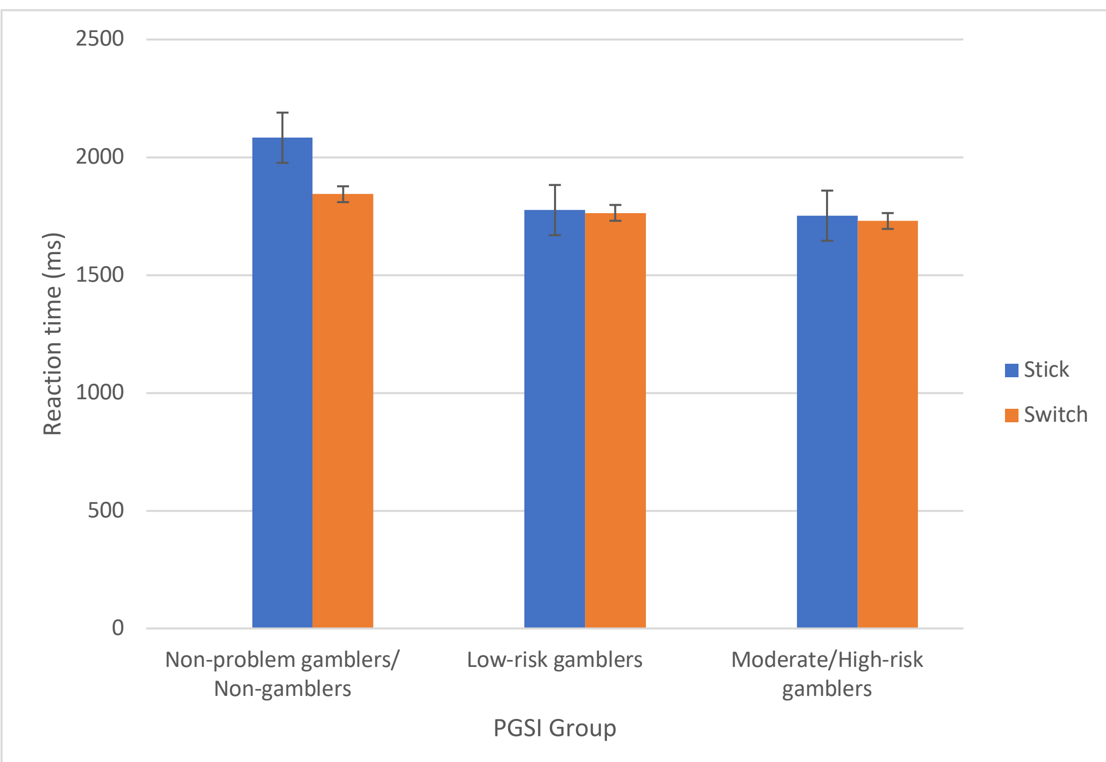



**Figure 5**

*Reaction Time Values by Response Type and PGSI Group*



***PGSI and Cognitive Measures***

**Relationship Between Implicit and Explicit Cognitive Measures and PGSI**

Table 5 shows the pattern of correlations (Pearson's R) between PGSI scores and cognitive measures. The PGSI positively correlated with reaction times (RT) for neutral stimulus changes on Gambling Change Blindness (GCB) task ($p$ = 0.003) indicating that reaction times were significantly slower in those with higher risk gambling behaviour, and erroneous cognitions (GRCS) ($p$ = <.001) and the correlation between PGSI and gambling-related stimulus changes approached significance ($p$ = 0.063). No other significant correlations were found between the PGSI and cognitive measures, and as such a further regression analysis was not deemed appropriate.

**Table 5**
*Correlations (Pearson's R) Between PGSI Scores and Cognitive Measures*

| | GCB gambling | GCB neutral | RT (Stick) | RT (Switch) | MD Stick | MD Switch | Cognitive Reflection Test | Gambling Related Cognitions Scale |
|---|---|---|---|---|---|---|---|---|
| PGSI | .27 | .42** | -.11 | -.03 | -.13 | -.12 | -.07 | .53** |
| GCB gambling | | .13 | -.11 | -.18 | -.07 | -.12 | -.22 | .19 |
| GCB neutral | | | -.12 | .02 | -.26 | -.07 | -.24 | .28 |
| RT Stick | | | | .62** | .60** | .13 | -.11 | -.02 |
| RT Switch | | | | | .31* | .37** | -.01 | .02 |
| MD Stick | | | | | | .41** | .03 | .12 |
| MD Switch | | | | | | | .18 | .10 |

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Reaction times on stick trials were positively correlated with reaction times on switch trials (*p* = <.001) as well as mouse trajectories (mean deviation; MD) on stick trials (*p* = <.001). Reaction times on switch trials were positively correlated with mouse trajectories on both stick (*p* = .032) and switch trials (*p* = .009). Lastly, mouse trajectories on stick trials were positively correlated with mouse trajectories on switch trials (*p* = .004).

## Discussion

The purpose of this study was to investigate the relationship between implicit decision-making processes and loss of control of gambling behaviour, as measured by the Problem Gambling Severity Index (PGSI), and the relationship between these measures and other constructs linked to problem gambling in the literature. Contrary to our expectations, the analysis did not reveal a significant difference between PGSI groups on either the Roulette Mouse-tracker or Gambling Change Blindness task. The results of these tasks are discussed below, alongside correlational data examining the relationship between the PGSI, self-report, and cognitive measures.

Preliminary analysis of self-report measures revealed significant correlations between the PGSI and measures of impulsivity and erroneous cognitions, and impulsivity was also positively correlated with both sensation-seeking and depression. Increased impulsivity has been frequently associated with problem gambling (Barrault & Varescon, 2013; Devos et al., 2020), congruent with the dual process understanding of impulsivity as an indicator of an over-active System 1, leading to misapplication of heuristics (e.g. Kahneman & Tversky, 1972) and an impaired ability to engage in conscious deliberation. In addition, a large body of previous research has demonstrated the link between erroneous cognitions and loss of control of gambling behaviour, including studies using the Gambling Related Cognitions Scale (GRCS) (Cosenza et al., 2014; Tang & Wu, 2012) . The correlation between impulsivity and sensation-seeking is in keeping with previous research (e.g. Zuckerman et al., 1993), however sensation-seeking was not correlated with the PGSI or any other explicit self-report measure, suggesting a possible indirect relationship between sensation-seeking and problem gambling severity, or a weaker relationship which was not detected due to insufficient sensitivity (Haw, 2017; Blain et al., 2015).  Similarly, while a positive relationship between impulsivity and depression is in keeping with previous empirical literature (e.g. Corruble et al., 2003; Swann et al., 2008), depression did not correlate directly with problem gambling severity as measured by the PGSI. It is of note that in the current sample, average PHQ-9 scores of both the no-risk/non-gambler group and the moderate/high risk group fell into the clinical range ('moderate symptoms of depression'; Kroenke et al., 2001), and as such the absence of a relationship with PGSI scores may be the result of greater overall depression symptomology within the current sample.

In line with previous research into the gambler's fallacy (e.g. Ayton & Fischer, 2004), the majority of participants chose to switch following a sequence of three repeated outcomes on the Roulette Mouse-tracker task, with no significant difference between groups. Correspondingly, mouse trajectories deviated significantly less towards the non-selected outcome during switch choices, demonstrating significantly less consideration of the non-chosen option on switch trials regardless of problem gambling severity. There was no difference in reaction times between groups on either trial type, and in contrast to the results found by Cutter (2016), no differences were found between groups in relation to mouse trajectories. Although not statistically significant, it is of note that Figure 4 appears to demonstrate an emerging trend between PGSI groups and MD values, with less deviation in trajectories in higher risk gamblers. It could be postulated that such an effect, if found to be significant with a sufficiently powered sample, would indicate increased impulsive System 1 decision making with higher risk gambling behaviour. A similar, though less convincing trend is also demonstrated with reaction times in Figure 5.

Examination of attentional bias using the Gambling Change Blindness task produced surprising results. In contrast with the findings of Brevers et al. (2011), measures of change detection latency revealed significant attentional biases toward neutral stimuli across groups. This may theoretically suggest the presence of confounding variables such as increased salience of the neutral stimuli used in the task. However, the same stimuli were used as in Brevers et al. (2011) which were closely matched in terms of physical properties. The absence of the expected attentional bias effect for gambling related stimuli in higher risk gamblers may be explained by insufficient statistical power, and as such an effect between groups may plausibly have been found with a larger sample (see ‘Limitations’) in line with previous research evidence in this area (Hønsi et al., 2013).

Correlational analysis of PGSI scores and implicit and explicit cognitive measures revealed a positive correlation between the PGSI and reaction times for neutral stimulus changes on the Gambling Change Blindness task, indicating that reaction times were slower in those with higher risk gambling behaviour (see Figure 3), and the correlation between PGSI and gambling-related stimulus changes approached significance (p = 0.063). Interestingly, the Cognitive Reflection Test did not correlate with any of the cognitive or self-report measures of gambling behaviour which appears inconsistent with the dual-process understanding of problem gambling as the result of overall differences in cognitive processing. Though previous research has supported an increased tendency for problem gamblers to provide instinctive System 1 responses using the CRT (e.g. Stange et al., 2018), a robust relationship between the CRT and impulsivity (key to System 1 processing) has not been established in the literature (Littrell et al.,2020), and the CRT has been criticised as being dependent on numerical (Welsh et al., 2013) and broader cognitive ability (Toplak et al., 2011). Conversely, it could be speculated that there is something specific to cognition during gambling which is not represented in day-to-day cognitive processing. While there may not be a generalised deficit in one's ability to employ System 2 reasoning as a moderator of instinctive System 1 processes, it is possible that this difference in processing may occur specifically during engagement in gambling behaviour.

In summary, this study provides empirical support for the role of impulsivity and erroneous cognitions in relation problem gambling severity, however, no significant differences in implicit cognition were observed between groups during gambling tasks. The significant relationships between measures of impulsivity and erroneous cognitions and problem gambling severity observed in the current sample aligns with the dual process understanding of erroneous cognitions as post-hoc rationalizations (System 2) of impulsive gambling behaviour (System 1). This suggests that cognitive differences between gamblers at varying levels of control may not manifest at the implicit level during gambling, but rather exist as conscious beliefs that emerge to maintain a sense of control and reduce psychological discomfort through addressing cognitive dissonance (Festinger, 1957), thereby perpetuating gambling behaviour. If erroneous cognitions are fundamental in the transition from non-problematic to problematic gambling, it implies that clinical interventions should target these conscious cognitive processes that rationalise ongoing engagement in gambling behaviour. Cognitive therapies like Cognitive Behavioural Therapy (CBT) may hold potential in treating problem gamblers, although the evidence supporting their efficacy in reducing gambling behaviour is limited (e.g. Bowden-Jones & Drummond, 2016; Cowlishaw et al., 2012). Additionally, it highlights the potential value of considering techniques to reduce or manage impulsivity in clinical interventions aimed at reducing gambling behaviour. However, due to the study's statistical limitations, the results should be interpreted cautiously. Furthermore, it is essential to acknowledge the complex interplay of various factors contributing to the development of problem gambling (Blaszczynski & Nower, 2002). While these findings support the cognitive understanding of problem gambling behaviour in relation to erroneous cognitions, the temporal role of these cognitions in the development and maintenance of problem gambling remains uncertain.

## Limitations

Recruitment was the most significant challenge within the current research, leading to an unbalanced sample which did not include sufficient problem gamblers, and was largely comprised of undergraduate students. While various methods of advertising were used (see ‘Participants’), these were perhaps not optimal for the target population. Bookmakers were approached in Norwich, however every establishment either declined to take an advertising flyer or advised that they could only keep this behind the counter which would not be visible to patrons. Attempts were also made to contact charitable gambling organisations, however these attempts were either wholly unsuccessful, or feasibility issues prevented further cooperation beyond initial discussions. An additional barrier to recruitment in the research was the requirement for in person participation. While the majority of tasks could be completed remotely, the Roulette Mouse-tracker task was only operational through installation of the program. Several members of the public registered their interest in participating in the research, however withdrew once they were made aware that there was no option to participate remotely, despite participation being compensated. As a result of recruitment difficulties, the study did not reach the required statistical power as determined by a priori power analysis. Additionally, only a small number of gamblers within the sample met the criteria for problem gambling according to the PGSI (n=4) and the low-risk group had proportionally fewer participants than the other two groups. As such the absence of effects may be attributable to inadequate sample size/ imbalanced proportion of groups. With a larger more proportionate sample, differences between groups may have been found on experimental tasks, and subsequent correlations between tasks and PGSI may have also been present.

## Conclusions

The present study sought to explore the relationship between implicit measures of cognition and explicit self-report measures, and the relationship between these measures and loss of control of gambling behaviour. Correlational data provided support for the role of erroneous cognitions and impulsivity as factors related to problem gambling severity, with an additional statistically significant distinction observed between groups in terms of the extent of erroneous cognitions. Examination of performance on the Roulette Mouse-tracker task (binary decision-making/ motor movements) provided results in congruence with previous empirical research on the negative recency/ gamblers fallacy effect as a normative response (e.g. Bar-Hillel & Wagenaar, 1991; Hahn & Warren, 2009). Results of implicit experimental tasks did not uncover any significant differences between gamblers at different levels of loss of control, however due to the limitations posed by the sample size and under-representation of problem gamblers, it is not possible to be conclusive regarding differences between groups on these tasks. The study therefore represents an uncertainty (given the sampling issues). Overall, findings of the current study support an understanding of problem gambling as associated with the degree of erroneous cognitions and fallacious beliefs around gambling, as well as a potential relationship with impulsivity. It is recommended that future studies prioritise recruitment of problem gamblers and ensure a sample size with sufficient statistical power.

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# Chapter 5: Discussion and critical evaluation

The current thesis explored the role of implicit cognition and the dual-process relationship between conscious and unconscious decision-making processes in problem gambling. This chapter summarises the main findings of the empirical project and systematic review, followed by a critical evaluation of findings and consideration of theoretical and clinical implications. Lastly personal reflections are offered on the experience of the research process.

## Main Findings

### Systematic review

The systematic review provided a contemporary examination of the literature relating to attentional bias in problem gambling, encompassing a number of studies which had not previously been subject to systematic review. 16 of the 22 studies examined revealed attentional bias in problem gamblers across ten different experimental paradigms. Direct measures (ERP and eye-gaze tracking) were used in five of the 22 studies and all reported significant attentional bias in problem gamblers, while other paradigms produced mixed results. The reviewed studies provided evidence for attentional bias at both the orientation and maintenance stages, however, only a limited number of studies used methods that assessed for both orientation and maintenance. Overall, the findings of the review supported the role of attentional bias as a potential maintaining factor in problem gambling behaviour, in line with evidence for substance addiction.

**Empirical Project**

The purpose of the empirical project was to investigate the relationship between implicit decision-making processes and loss of control of gambling behaviour, as measured by the Problem Gambling Severity Index (PGSI), and the relationship between implicit measures and other constructs linked to problem gambling in the literature. Contrary to expectations, analysis did not reveal a significant difference between PGSI groups on either implicit task (Roulette Mouse-tracker/ Gambling Change Blindness). Examination of mouse trajectories and reaction time data in the Roulette Mouse-tracker task indicated potential differences in implicit decision-making processes between groups, however these were not statistically significant. Correlational data supported the role of erroneous cognitions and impulsivity as factors related to problem gambling severity, and analysis of performance on the Roulette Mouse-tracker task (binary decision-making/ motor movements) provided results in congruence with previous empirical research on the negative recency/ gamblers fallacy effect as a normative response (e.g. Bar-Hillel & Wagenaar, 1991; Hahn & Warren, 2009).

## Critical evaluation

**Systematic review**

Due to methodological heterogeneity across the studies included in the systematic review it was not feasible to conduct a meta-analysis, and as such the review was conducted as a narrative synthesis which arguably lacks the scientific objectivity of a meta-analysis (Ahn & Kang, 2018). However, individual effect sizes were provided (Cohen's *d*) through extraction of the relevant data from empirical papers, allowing for statistical comparison between studies which is not widely presented within narrative syntheses.

Similarly, the conclusions drawn were constrained by the limited availability of relevant studies and the heterogeneity across paradigms. The significant variability in experimental methods posed a notable challenge when attempting to make meaningful comparisons between studies. Consequently, greater emphasis was placed on offering recommendations for future research, rather than drawing definitive conclusions. Another notable limitation identified within this review pertains to the absence of an appropriate established quality assessment checklist. The checklist employed in this study was developed by the authors through the extraction of pertinent questions from existing checklists. As a result, it lacked suggested cut-offs or thresholds for assessing study quality, although it did provide a means of comparing the quality of included studies. A particular strength of the review was its specific focus on differentiating between attentional bias at the stages of orientation and maintenance across studies, going beyond simply stating the presence or absence of an effect.

**Empirical Project**

The empirical paper's main strength lay in its inclusion of a variety of measures, enabling an exploration of the relationship between implicit and explicit measures. This presents an innovative approach to understanding decision-making in problem gambling, which has been little explored in previous research. Due to difficulties with recruitment and time constraints, the research conducted in the empirical project was not sufficiently statistically powered however. As such while no significant differences were observed between PGSI groups on implicit tasks, this may be due to poor sensitivity resulting from a limited sample size. The sample was also limited by the demographics of the sample, in that the majority of the population were undergraduate psychology students which presents issues in terms of generalisability. In addition, the study did not match for gambling frequency as a confounding variable, and as such any differences which may have emerged between groups could plausibly be due to, or confounded by, differences in gambling frequency (Mazar et al., 2020).

## Clinical Implications/ Future Research

As highlighted in the Introductory Chapter, the clinical understanding and management of Gambling disorder is at a stage of relative infancy, lacking published formal guidance on assessment and management, as well as having a limited evidence base for clinical interventions (Bowden-Jones & Drummond, 2016). Therefore, conducting research in this field is crucial to advance the clinical and theoretical understanding of the disorder and inform clinical guidance. Specifically, the role of implicit cognition has been relatively under-explored within the literature, and gaining insight into such processes may shed light on the mechanisms involved in the transition from recreational to problem gambling. Both the systematic review and empirical project therefore contribute to the existing knowledge base and have potential implications regarding clinical interventions and future research.

The systematic review highlights the burgeoning evidence base for attentional bias as implicated in the maintenance of problem gambling behaviour, both at the stage of orientation and maintenance of attention. The findings provide support for further investigation into attentional bias modification (ABM) interventions as a potential tool for reducing problem gambling severity. ABM interventions aim to modify attentional bias through retraining of attention and have been explored within other disorders where attentional bias is implicated in the maintenance of symptoms, including anxiety (Hakamata et al. 2010), depression (Xia et al., 2023), and substance abuse (Heitmann et al., 2018), though a limited evidence-base across disorders means only tentative conclusions about their usefulness have been drawn. The utility of ABM interventions within problem gambling is particularly sparse, with only one published pilot trial (Wittekind et al., 2019) and one additional study protocol (Boffo et al., 2017) available. The review also provides a number of recommendations for future research based on the limitations of reviewed studies, including increased use of direct measures, using gambling-specific stimuli, and replication with control groups.

Although the empirical project did not provide robust findings in relation to a relationship between implicit and explicit measures, it emphasises the need for replication/ extension of the study with the sampling limitations addressed, as well as further research exploring the relationship between established explicit measures and implicit tasks. Specifically, the Roulette Mouse-tracker task as a unique measure of implicit decision-making processes requires further empirical testing to establish its value as a potential predictor of problem gambling behaviour, as well as its relationship with existing implicit and explicit measures. Regarding clinical implications, the identified significant association between explicit erroneous cognitions and the severity of problem gambling indicates the potential usefulness of cognitive therapies like Cognitive Behavioural Therapy (CBT) in reducing gambling behaviour through correction of erroneous beliefs and cognitive biases. However, it is important to note that the current evidence base supporting the efficacy of CBT in treating problem gambling is limited (e.g., Bowden-Jones & Drummond, 2016; Cowlishaw et al., 2012). Furthermore, the observed relationship between impulsivity and loss of control over gambling behaviour suggests the potential value of incorporating techniques to decrease or manage impulsivity in interventions aimed at addressing problem gambling.

## Personal Reflections

Compiling a thesis portfolio has been a highly challenging and invaluable learning experience, given my limited previous experience in conducting empirical research. In my empirical project, I encountered significant difficulties in recruiting and accessing problem gamblers, which was unexpected in this unfamiliar research area. In addition to recruitment challenges, I also faced difficulty in gaining ethical approval, resulting in several months of delays that subsequently impacted the time available for recruitment and data collection. While the experience was burdensome given the limited time and academic pressures, it compelled me to rigorously consider the ethical implications of my research and ensure ethical practice. The experience provided me with a greater understanding of the stringent ethical considerations that must be upheld throughout the research process.

Additionally, the recruitment process for my empirical project has prompted me to reflect on the gambling industry as a whole with respect to social harm. Initially, my recruitment plan focused heavily on recruiting participants from gambling establishments. However, every establishment visited declined to display advertising flyers on their premises and attempts to contact the head offices of several large chains proved unsuccessful. Despite the increasing recognition of gambling-related harms and the emphasis on social responsibility within legislation, gambling corporations were not forthcoming in supporting research into problem gambling. The failure of these corporations to cooperate highlights the need for continued efforts to promote responsible gambling and to prevent harm in the industry. Moreover, it emphasises the need for regulatory bodies, operators, and other stakeholders to work together to address these challenges and ensure that the gambling industry operates in a manner that is both socially responsible and sustainable over the long term.

## Overall Conclusion

Aligned with the dual process understanding of addiction, the current thesis focuses on investigating the role of implicit cognitive processes and their association with problem gambling. The systematic review makes a valuable contribution by comprehensively examining the literature on attentional bias in problem gambling. It provides support for attentional bias as a potential factor contributing to the maintenance of problem gambling, while also identifying gaps in the existing evidence and offering recommendations for future research. Although the empirical project did not yield conclusive findings regarding implicit cognition between groups at different levels of loss of control over gambling behaviour, this may be attributed to limitations in sampling. Therefore, it emphasises the necessity for further research on the relationship between implicit and explicit processes.

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# Appendices

## Appendix A. Author Guidelines for *Addiction*

### Reviews

Reviews are highly valuable communications for our readers. They draw together a body of literature to summarise what research has been done on a specific topic and are a source of knowledge. Reviews are expected to be registered (**PROSPERO**) and be reporting according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (**PRISMA**). A PRISMA checklist must be submitted as an additional file for review. All reviews will be ‘systematic’, which means they will set out very clearly the search strategy (including key words where appropriate), the selection criteria for articles to include, the basis for integrating findings, and procedures used to evaluate quality and bias. Where possible we expect a suitable, bounded body of research to be subject to statistical meta-analysis; but we recognise that this is not always feasible, and a narrative synthesis should be the described approach. Reviews that do not conform fully to PRISMA may be considered if authors can provide a convincing case that the procedures used are not likely to lead to bias in the conclusions. We recognize that reviews often have a lot of material to present, but we ask authors to aim for 4,500 words (excluding abstract, tables, and references). Very long tables may need to be placed in the on-line appendix.

**Funding**

You should list all funding sources under Funding Information. Primary funding only should be given on the title page. You are responsible for the accuracy of their funder designation. If in doubt, please check the **Open Funder Registry** for the correct nomenclature.

**Your Main Document file should include:**

A title page containing

- A brief informative title containing the major key words. The title should not contain abbreviations (see Wiley's best practice SEO tips);
- A short running title of less than 40 characters;
- The full names of the authors - if authors exceed 20 please use a study group name or acronym;
- The author's institutional affiliations where the work was conducted, with a footnote for the author’s present address if different from where the work was conducted;
- Acknowledgments.
- Word count (excluding abstract, references, tables, and figures);
- Declarations of competing interest;
- Primary funding;
- Clinical trial registration details (if applicable).

Structured abstract (see further instructions below);

Six to ten keywords;

Main body;

References;

Tables (each table complete with title and footnotes);

Figure legends: Legends should be supplied as a complete list in the text. Figures should be uploaded as separate files (see below).

**NOTE:** There is no charge for using colour, so please consider the use of colour to enhance the clarity of figures whenever possible.

**Reference Style**

This journal uses Vancouver reference style. Review your **reference style guidelines** prior to submission.

As a convenience to authors, initial submissions can employ any widely-used reference format. Do not include citations to conference abstracts or unpublished work to support substantive claims but do use them if needed to give credit where appropriate. Papers may include systematic reviews and one or two of the pivotal studies that a review has summarised.

**Abstracts**

- **Abstracts for reviews** if purely descriptive, use the following headings: Aims (or Background and Aims, if appropriate), Methods, Results, Conclusions. All others reviews, including meta-analyses, should use these headings: Aims (or Background and Aims, if appropriate), Design, Setting, Participants, Interventions (if appropriate), Measurements, Findings, Conclusions.

Unless otherwise indicated, the maximum word length for abstracts is **300 words**. See also our guide to writing conclusions in abstracts **here**.

**Headings**

Please follow this guide to show the level of the section headings in your article:

- **FIRST-LEVEL HEADINGS** (e.g. Introduction, Method, Discussion) should be in bold, upper case.
- **Second-level headings** should be in bold, lower case with an initial capital letter.
- *Third-level headings* should be in italics, with an initial capital letter.
- *Fourth-level heading.* These should be in italics, at the beginning of a paragraph, with an initial capital letter. The text follows immediately after a full stop (full point, period).

**Please do not number headings**.

**Figures and Supporting Information**

Figures, supporting information, and appendices should be supplied as separate files. You should review the **basic figure requirements** for manuscripts for peer review, as well as the more detailed post-acceptance figure requirements. View **Wiley's FAQs** on supporting information.

**Declaration of interests**

These are required for all submissions. A declaration of interests does not indicate wrongdoing, but must be declared in the interests of full transparency. Authors should declare sources of funding, direct or indirect, and any connection of any of the researchers with the tobacco, alcohol, cannabis, pharmaceutical or gaming industries or any body substantially funded by one of these organisations. Authors are also required to declare any financial conflict of interest arising from involvement with organisations that seek to provide help with or promote recovery from addiction. Any contractual constraints on publishing imposed by the funder must also be disclosed. Declaring a conflict of interest is the responsibility of authors and authors should err on the side of inclusiveness In line with the ICMJE conflict of interest policy, the time window for these financial links is within 3 years of the date of article submission. *If an undeclared conflict of interest comes to light, we reserve the right to publish this prominently and to place it on a public register using words along the lines of '[name] has the following conflict of interest which h/she has not declared'.*

## Appendix B. PRISMA Checklist

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review. | 1 |
| **ABSTRACT** | | | |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. | 2 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | 3-4 |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | 5 |
| **METHODS** | | | |
| Eligibility criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | 6 |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | 6 |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | 5-6 |
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | 6 |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | 6 |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | 7 |
| | 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | - |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | 6-7 |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. | - |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | 6 |
| | 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. | 7 |
| | 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | 6 |
| | 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | - |
| | 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | - |
| | 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | - |
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | - |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | 6-7 |

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **RESULTS** | | | |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. | 9 |
| | 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | 9 |
| Study characteristics | 17 | Cite each included study and present its characteristics. | 10-14 |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | 8 |
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | 10-14 |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies. | 8 |
| | 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | - |
| | 20c | Present results of all investigations of possible causes of heterogeneity among study results. | - |
| | 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | - |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | - |
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | 8 |
| **DISCUSSION** | | | |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | 26-29 |
| | 23b | Discuss any limitations of the evidence included in the review. | 29-30 |
| | 23c | Discuss any limitations of the review processes used. | 30-33 |
| | 23d | Discuss implications of the results for practice, policy, and future research. | 30-32 |
| **OTHER INFORMATION** | | | |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | 4 |
| | 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | 4 |
| | 24c | Describe and explain any amendments to information provided at registration or in the protocol. | - |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | 1 |
| Competing interests | 26 | Declare any competing interests of review authors. | 1 |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | - |

*From:* Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: http://www.prisma-statement.org/

## Appendix C. Full Search Strategy

1. **Gambling**

   "gambling" OR "gambler" OR "gamblers" OR "gambl*"

2. **Attention**

   "attention" OR "attentional"

3. **Bias**

   Bias

**Additional limitations applied**

Publication Type: All Journals

Language: English

Population Group: Human

## Appendix D: Quality Checklist

### Introduction

1. Were the aims/objectives of the study clear? (AXIS, 2016)

### Methods

2. Was the sample size justified? (AXIS, 2016)
3. Was membership in a 'problem gambling' group established through use of a reputable screening tool (e.g. PGSI/SOGS/DSM-5)? (Adapted from SIGN (2012): '*Cases are clearly defined and differentiated from controls*')
4. Were the gambling and control group(s) matched for gambling frequency as a confounding variable? (Adapted from CASP (2018): '*Have the authors identified all important confounding factors?'*)

*Rationale: Gambling frequency was specified as a confounding variable due to the positive association with problem gambling (e.g. Mazar et al., 2020) and evidence for the predictive relationship of frequency in attentional bias to gambling cues (Grant & Bowling, 2015). Where gambling frequency is not controlled for, it is not possible to distinguish between differences due to frequency or problems, or both.*

5. Were additional conditions included to offer a comparison to performance in gambling conditions?

*Rationale: This question was created to assess internal validity – the absence of control conditions as a basis for comparison would make it impossible to draw conclusions about the impact of group membership (e.g. problem gamblers vs controls) (Torday & Baluška, 2019).*

6. Were the experimental and control groups sampled from the same population? (Adapted from CASP (2020): '*Were the study groups similar at the start of the randomised controlled trial?''*

7. Was the selection process likely to select subjects/participants that were representative of the target/reference population under investigation? (AXIS, 2016)

8. Were the outcome variables measured appropriate to the aims of the study? (AXIS, 2016)

9. Is it clear what was used to determined statistical significance and/or precision estimates? (e.g. p-values, confidence intervals) (AXIS, 2016)

**Results**

10. Were the basic data adequately described? (AXIS, 2016)

11. Were the results presented for all the analyses described in the methods? (AXIS, 2016)

## Appendix E. Author Guidelines for *Journal of Gambling Studies*

### Title Page

Please make sure your title page contains the following information.

### Title

The title should be concise and informative.

### Author information

- The name(s) of the author(s)
- The affiliation(s) of the author(s), i.e. institution, (department), city, (state), country
- A clear indication and an active e-mail address of the corresponding author
- If available, the 16-digit ORCID of the author(s)

If address information is provided with the affiliation(s) it will also be published.

For authors that are (temporarily) unaffiliated we will only capture their city and country of residence, not their e-mail address unless specifically requested.

Large Language Models (LLMs), such as ChatGPT, do not currently satisfy our authorship criteria. Notably an attribution of authorship carries with it accountability for the work, which cannot be effectively applied to LLMs. Use of an LLM should be properly documented in the Methods section (and if a Methods section is not available, in a suitable alternative part) of the manuscript.

**Abstract**

Please provide an abstract of 150 to 250 words. The abstract should not contain any undefined abbreviations or unspecified references.

*For life science journals only (when applicable)*

- Trial registration number and date of registration for prospectively registered trials
- Trial registration number and date of registration, followed by “retrospectively registered”, for retrospectively registered trials

**Keywords**

Please provide 4 to 6 keywords which can be used for indexing purposes.

**Statements and Declarations**

The following statements should be included under the heading "Statements and Declarations" for inclusion in the published paper. Please note that submissions that do not include relevant declarations will be returned as incomplete.

- **Competing Interests:** Authors are required to disclose financial or non-financial interests that are directly or indirectly related to the work submitted for publication. Please refer to “Competing Interests and Funding” below for more information on how to complete this section.

Please see the relevant sections in the submission guidelines for further information as well as various examples of wording. Please revise/customize the sample statements according to your own needs

**Acknowledgments**

Acknowledgments of people, grants, funds, etc. should be placed in a separate section on the title page. The names of funding organizations should be written in full.

## Text

**Text Formatting**

Manuscripts should be submitted in Word.

- Use a normal, plain font (e.g., 10-point Times Roman) for text.
- Use italics for emphasis.
- Use the automatic page numbering function to number the pages.
- Do not use field functions.
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.
- Use the equation editor or MathType for equations.
- Save your file in docx format (Word 2007 or higher) or doc format (older Word versions).

Manuscripts with mathematical content can also be submitted in LaTeX. We recommend using Springer Nature's LaTeX template.

**Headings**

Please use no more than three levels of displayed headings.

**Abbreviations**

Abbreviations should be defined at first mention and used consistently thereafter.

**Footnotes**

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

**Scientific style**

Please use the standard mathematical notation for formulae, symbols etc.:

- Italic for single letters that denote mathematical constants, variables, and unknown quantities

- Roman/upright for numerals, operators, and punctuation, and commonly defined functions or abbreviations, e.g., cos, det, e or exp, lim, log, max, min, sin, tan, d (for derivative)
- Bold for vectors, tensors, and matrices.

## References

### Citation

Cite references in the text by name and year in parentheses. Some examples:

- Negotiation research spans many disciplines (Thompson, 1990).
- This result was later contradicted by Becker and Seligman (1996).
- This effect has been widely studied (Abbott, 1991; Barakat et al., 1995; Kelso & Smith, 1998; Medvec et al., 1999).

Authors are encouraged to follow official APA version 7 guidelines on the number of authors included in reference list entries (i.e., include all authors up to 20; for larger groups, give the first 19 names followed by an ellipsis and the final author's name). However, if authors shorten the author group by using et al., this will be retained.

### Reference list

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text.

Reference list entries should be alphabetized by the last names of the first author of each work.

Journal names and book titles should be *italicized*.

If available, please always include DOIs as full DOI links in your reference list (e.g. “https://doi.org/abc”).

## Tables

- All tables are to be numbered using Arabic numerals.
- Tables should always be cited in text in consecutive numerical order.
- For each table, please supply a table caption (title) explaining the components of the table.
- Identify any previously published material by giving the original source in the form of a reference at the end of the table caption.
- Footnotes to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data) and included beneath the table body.

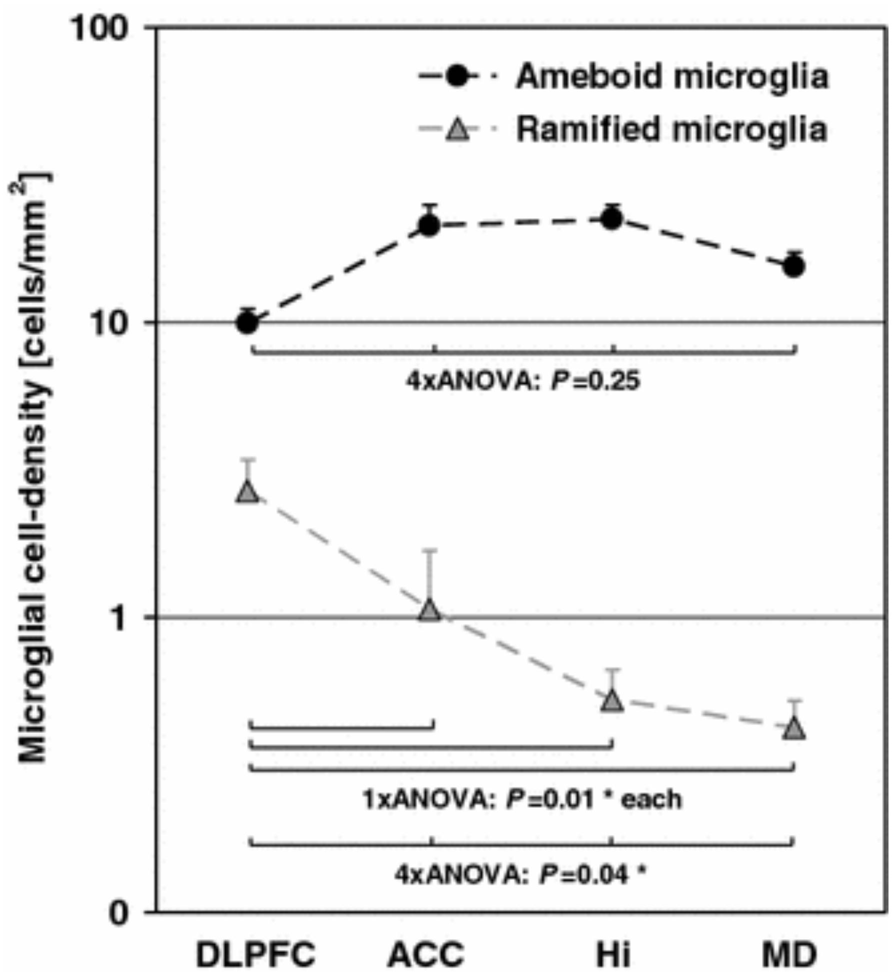
## Artwork and Illustrations Guidelines

### Electronic Figure Submission

- Supply all figures electronically.
- Indicate what graphics program was used to create the artwork.
- For vector graphics, the preferred format is EPS; for halftones, please use TIFF format. MSOffice files are also acceptable.

- Vector graphics containing fonts must have the fonts embedded in the files.
- Name your figure files with "Fig" and the figure number, e.g., Fig1.eps.

*Line Art*




- Definition: Black and white graphic with no shading.
- Do not use faint lines and/or lettering and check that all lines and lettering within the figures are legible at final size.
- All lines should be at least 0.1 mm (0.3 pt) wide.
- Scanned line drawings and line drawings in bitmap format should have a minimum resolution of 1200 dpi.

- Vector graphics containing fonts must have the fonts embedded in the files.

**Figure Numbering**

- All figures are to be numbered using Arabic numerals.
- Figures should always be cited in text in consecutive numerical order.
- Figure parts should be denoted by lowercase letters (a, b, c, etc.).
- If an appendix appears in your article and it contains one or more figures, continue the consecutive numbering of the main text. Do not number the appendix figures,"A1, A2, A3, etc." Figures in online appendices [Supplementary Information (SI)] should, however, be numbered separately.

**Figure Captions**

- Each figure should have a concise caption describing accurately what the figure depicts. Include the captions in the text file of the manuscript, not in the figure file.
- Figure captions begin with the term Fig. in bold type, followed by the figure number, also in bold type.
- No punctuation is to be included after the number, nor is any punctuation to be placed at the end of the caption.
- Identify all elements found in the figure in the figure caption; and use boxes, circles, etc., as coordinate points in graphs.
- Identify previously published material by giving the original source in the form of a reference citation at the end of the figure caption.

### Figure Placement and Size

- Figures should be submitted within the body of the text. Only if the file size of the manuscript causes problems in uploading it, the large figures should be submitted separately from the text.
- When preparing your figures, size figures to fit in the column width.
- For large-sized journals the figures should be 84 mm (for double-column text areas), or 174 mm (for single-column text areas) wide and not higher than 234 mm.
- For small-sized journals, the figures should be 119 mm wide and not higher than 195 mm.

### Permissions

If you include figures that have already been published elsewhere, you must obtain permission from the copyright owner(s) for both the print and online format. Please be aware that some publishers do not grant electronic rights for free and that Springer will not be able to refund any costs that may have occurred to receive these permissions. In such cases, material from other sources should be used.

### Accessibility

In order to give people of all abilities and disabilities access to the content of your figures, please make sure that

- All figures have descriptive captions (blind users could then use a text-to-speech software or a text-to-Braille hardware)

- Patterns are used instead of or in addition to colors for conveying information (colorblind users would then be able to distinguish the visual elements)
- Any figure lettering has a contrast ratio of at least 4.5:1

**Disclosures and declarations**

All authors are requested to include information regarding sources of funding, financial or non-financial interests, study-specific approval by the appropriate ethics committee for research involving humans and/or animals, informed consent if the research involved human participants, and a statement on welfare of animals if the research involved animals (as appropriate).

The decision whether such information should be included is not only dependent on the scope of the journal, but also the scope of the article. Work submitted for publication may have implications for public health or general welfare and in those cases it is the responsibility of all authors to include the appropriate disclosures and declarations.

## Appendix F. UEA Ethical Approval

University of East Anglia

University of East Anglia
Norwich Research Park
Norwich. NR4 7TJ

Email: ethicsapproval@uea.ac.uk
Web: www.uea.ac.uk

**Study title:** Reflex vs Reasoning: A Dual-Process Examination of Implicit Decision-making in Problem Gamblers

**Application ID:** ETH2122-1238

Dear Zoe,

Your application was considered on 26th May 2022 by the FMH S-REC (Faculty of Medicine and Health Sciences Research Ethics Subcommittee).

The decision is: **approved**.

You are therefore able to start your project subject to any other necessary approvals being given.

If your study involves NHS staff and facilities, you will require Health Research Authority (HRA) governance approval before you can start this project (even though you did not require NHS-REC ethics approval). Please consult the HRA webpage about the application required, which is submitted through the IRAS system.

This approval will expire on **29th September 2023**.

Please note that your project is granted ethics approval only for the length of time identified above. Any extension to a project must obtain ethics approval by the FMH S-REC (Faculty of Medicine and Health Sciences Research Ethics Subcommittee) before continuing.

It is a requirement of this ethics approval that you should report any adverse events which occur during your project to the FMH S-REC (Faculty of Medicine and Health Sciences Research Ethics Subcommittee) as soon as possible. An adverse event is one which was not anticipated in the research design, and which could potentially cause risk or harm to the participants or the researcher, or which reveals potential risks in the treatment under evaluation. For research involving animals, it may be the unintended death of an animal after trapping or carrying out a procedure.

Any amendments to your submitted project in terms of design, sample, data collection, focus etc. should be notified to the FMH S-REC (Faculty of Medicine and Health Sciences Research Ethics Subcommittee) in advance to ensure ethical compliance. If the amendments are substantial a new application may be required.

Approval by the FMH S-REC (Faculty of Medicine and Health Sciences Research Ethics Subcommittee) should not be taken as permission given by the Student Insight Review Group (SIRG) to send out university wide recruitment communication. Please await notification from student.survey.request@uea.ac.uk confirming whether the SIRG review has been successful.

Approval by the FMH S-REC (Faculty of Medicine and Health Sciences Research Ethics Subcommittee) should not be taken as evidence that your study is compliant with the UK General Data Protection Regulation (UK GDPR) and the Data Protection Act 2018. If you need guidance on how to make your study UK GDPR compliant, please contact the UEA Data Protection Officer (dataprotection@uea.ac.uk).

Please can you send your report once your project is completed to the FMH S-REC (fmh.ethics@uea.ac.uk).

I would like to wish you every success with your project.

On behalf of the FMH S-REC (Faculty of Medicine and Health Sciences Research Ethics Subcommittee)

Yours sincerely,

Katie Chambers

**Appendix G. Study Advert**

University of East Anglia

# Understanding Decision Making Processes in Gambling Behaviour


**What is this research about?**

Previous research into gambling behaviour has largely focussed on what people report about their thought processes and methods of decision making. There has been much less research into automatic ('implicit') decision making processes. To help improve our understanding of these processes, we want to compare gamblers who gamble at varying levels of frequency and intensity.

**What will participation involve?**

After initial screening questionnaires to confirm eligibility, the main study will involve completing some questionnaires which will ask about your gambling behaviour and your thoughts about gambling, as well as some other questions which look at personality traits and decision making. This will be followed by two different computer-based tasks, which will measure decision making processes related to gambling. This should take no more than one hour of your time, and you will be compensated for your time.

**Can I participate?**

In order to participate in this research you must be 18 years old or over and have engaged in some form of gambling behaviour in the past month. Unfortunately, you will not be eligible to participate if you meet any of the following criteria:

- Dependence on illicit substances or alcohol which may affect your ability to perform the necessary experimental tasks
- Significant cognitive impairment
- Significant reading impairment
- Physical disability impairing use of a mouse
- Lack capacity to give informed consent

**Want to know more?**

Please e-mail me at z.farr@uea.ac.uk if you would like to know more about this research or have any questions.

**Appendix H. Participant Information Sheet**

University of East Anglia

# Understanding Decision Making Processes in Gambling Behaviour

## Participant Information Sheet

**(1) What is this study about?**

Previous research into gambling behaviour has largely focussed on what people report about their thought processes and methods of decision making. There has been much less research into automatic ('implicit') decision making processes. To help improve our understanding of these processes, we want to compare gamblers gambling at varying frequencies and intensities.

This Information Sheet outlines the study to help you decide whether you would like to take part, please read it carefully and raise any questions you may have. Your participation is voluntary, and you retain the right to withdraw at any point during data collection.

By giving consent to take part in this study you are telling us that you:

- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

- ✓ You have received a copy of this Participant Information Statement to keep.

**(2) Who is running the study?**

This study is being conducted by Zoe Farr, Postgraduate Researcher, Norwich Medical School, University of East Anglia.

**(3) What will the study involve for me?**

We will ask you to complete some questionnaires which will ask about your gambling behaviour and your thoughts about gambling, as well as some other questions which look at personality traits and decision making. This will be followed by two different computer-based, which will measure 'implicit' processes related to gambling.

**(4) How much of my time will the study take?**

In total, these tasks should take no more than one hour.

**(5) Do I have to be in the study? Can I withdraw from the study once I've started?**

Participation is voluntary, your decision whether to participate will not affect current or future relationships with anyone associated with the University of East Anglia. You can withdraw from the study at any point during data collection and your data will not be saved.

### (6) Are there any risks or costs associated with being in the study?

This study is not expected to cause any distress, however you are able to stop completing the study tasks if at any time you feel uncomfortable. If you complete the study and then experience distress, please contact me by email (z.farr@uea.ac.uk) to discuss issues of concern and signpost you to further support if needed. You can also contact your GP for mental health support. Samaritans offer a 24/7 listening service via 116 123.

### (7) Are there any benefits associated with being in the study?

By participating in the study, you will be helping to develop the understanding of problem gambling, which aims to inform the assessment and treatment of affected individuals. You will be compensated for your time.

### (8) What will happen to information about me that is collected during the study?

By consenting to participate, you are agreeing to the personal information shared to be collected and used for the purpose of this research study. Any information provided will only be used for the purposes outlined in this Participant Information Statement. Your information will be stored securely, and the 2018 General Data Protection Regulation Act and the University of East Anglia Research Data Management Policy (2019) will be adhered to at all times. Findings from this study may be included in publication, but you will not be identifiable. All identifiable information (e.g. names) will be stored separately from other research data and deleted following project completion (within three months). Anonymised research data will be kept by the university for a minimum of ten years.

**(9) What if I would like further information about the study?**

When you have read this information, I will be available to discuss it with you further and answer any questions you may have. You can contact me via z.farr@uea.ac.uk.

**(10) Will I be told the results of the study?**

You have a right to receive feedback about the overall results of this study. You can request this by contacting me via z.farr@uea.ac.uk. Overall results will be provided upon request in the form of a one-page summary which you will receive after the study is finished.

**(11) What if I have a complaint or any concerns about the study?**

The ethical aspects of this study have been approved under the regulations of the University of East Anglia's Faculty of Medicine and Health Sciences Research Ethics Committee.

If there is a problem please let me know. You can contact me via the University at the following address:

Zoe Farr

Norwich Medical School

Faculty of Medicine and Health Sciences

University of East Anglia

NORWICH NR4 7TJ

z.farr@uea.ac.uk

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact Dr Peter Beazley, Deputy Programme Director for the UEA Clinical Psychology Doctorate programme (ClinPsyD): P.Beazley@uea.ac.uk

**Appendix I. Participant Consent Form**

University of East Anglia

# Understanding Decision Making Processes in Gambling Behaviour

## Participant Consent Form

By signing this consent form, I agree to take part in this research study.

In giving my consent I state that:

- ✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- ✓ I have read the Participant Information Sheet and have been able to discuss my involvement in the study with the researcher if I wished to do so.
- ✓ The researcher has answered any questions that I had about the study, and I am happy with the answers.
- ✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.
- ✓ I understand that I may withdraw from the study at any time during data collection and my data will not be saved.

✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes outlined on the Participant Information Sheet. I understand that information about me will only be told to others with my permission.

✓ I understand that the results of this study may be published, but these publications will not contain my name or any identifiable information about me.

| ____________________ | ____________________ | ____________________ |
|---|---|---|
| Name of Participant | Date | Signature |
| ____________________ | ____________________ | ____________________ |
| Name of Researcher | Date | Signature |

**Appendix J. Participant Debrief Sheet**

# Understanding Decision Making Processes in Gambling Behaviour

## Participant Debrief Sheet

We would like to thank you for taking the time to participate in this research into Gambling Behaviour. Some people gamble frequently while controlling their gambling behaviour, while some others experience problems with their gambling behaviour that can have a negative impact on physical and mental health. By developing our understanding of why some people struggle to control their gambling while others do not, we can improve the assessment and treatment process for those struggling with Gambling Disorder. We hope that as a result of you taking part in this research, we can develop a deeper understanding of the role of implicit processes in the development and maintenance of healthy gambling behaviour compared to gambling disorder.

You have a right to receive feedback about the overall results of this study. You can request this by contacting me via z.farr@uea.ac.uk. Overall results will be provided in the form of a one-page summary which you will receive after the study is finished.

If you have experienced distress as a result of this research, or have any other questions or concerns, please do not hesitate to get in touch with me using the contact details at the end of this document. If are you concerned about your gambling behaviour, signposting and support information is provided at the end of this document; your GP should also be able to provide information regarding other support available to you.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the Deputy Programme Director, Peter Beazley, at P.Beazley@uea.ac.uk.

Kind regards,

Zoe Farr

Norwich Medical School

Faculty of Medicine and Health Sciences

University of East Anglia

NORWICH NR4 7TJ

z.farr@uea.ac.uk

## Signposting and Support

**GamCare** offers free information, support and counselling for problem gamblers in the UK.

www.gamcare.org.uk

0808 8020 133

**Gordon Moody Association** The Gordon Moody Association offers residential courses for men and women who have problems with gambling. It also runs the Gambling Therapy website, which offers online support to problem gamblers and their friends and family.

www.gordonmoody.org.uk

help@gordonmoody.org.uk

01384 241292

**Gamblers Anonymous UK** Gamblers Anonymous UK runs local support groups that use the same 12-step approach to recovery from addiction as Alcoholics Anonymous.

www.gamblersanonymous.org.uk

info@gamblersanonymous.org.uk

**Samaritans** offer a 24/7 telephone listening service, and are also contactable via email

www.samaritans.org

jo@samaritans.org

116 123

University of East Anglia, Participant Debrief Sheet, v2 February 2022