Gambling-think:

How game structures and cultural factors shape cognitive (gambling-related) biases

Matthew Lim Sheng Mian (林圣勉)

Department of Psychiatry and

Jesus College, University of Oxford

A thesis submitted in fulfilment of the degree of a Doctor of Philosophy (D.Phil.) in Psychiatry at the University of Oxford

Approximately 49,500 words

Trinity Term, 2013

For Pa, Ma, Kor, and Di

Table of Contents

Acknowledgements

First and foremost I would like to express my deepest appreciation for my doctoral supervisor, Robert Rogers – a brilliant experimentalist from whom I am *still* learning the art of detail and a balanced argument. Your commitment to good research has been inspiring; so is your ostensible delight with new discoveries and excellent story telling. My written papers and personal formation as a young scientist, have, and will continue to be, in many ways, in your likeness.

A BIG thank you also goes out to *Team-Rogers*: Amy Bilderbeck, Corin Bourne, Lucy Curtin, Tracy Lindsey, Joanne Lloyd, Anca Popescu, Kate Saunders, Roubing Shao, Charidimos (Haris) Tzagarakis, Judi Wakeley, Judah Weathers, Patrick Worhunsky, and Sarah Yip. The latter 2, whom I enrolled with, and whom I had the pleasure of celebrating their recent transition to Mr-and-Mrs-Worhunsky – joy! My failed experiments, computer crashes, lost files, computer programming blocks, and MATLAB laments, would have been qualitatively worse without *Team-Rogers*' collective companionship.

I love you guys!

Other Oxonian friends must also be mentioned: Morten Jønsson, for the sometimes intense discussions about politics, love and faith. Though we agree on many matters, on some matters, I have never had a friend I so agreeably disagree with; Regina Rini, for your warm friendship and superior (philosophical) mind, and of course, the occasional invitations to high table; Achim Wolf, for limiting my practice of eating lunch in front of my computer, and for bringing a little fun (almost illegal) to the Warneford.

I love you guys!

These 4 years at Oxford would have been impossible without the extended family I have found at St Ebbes Church: foremost for the chums at *Thesis* whom have supported me in these last days; also, Peppy Smeaton, Patricia Whelan, and Simone Campling for feeding, clothing and praying for this scrawny and clueless international student; Sung Woo Kang, for your humility and kindness; Ethan Yee, for your generosity and gentleness; Diane Lim, for your sensibility that keeps in check my clowning-around; Jamie-James Cook, for your dry (more like arid) wit; Robert Law, for your poetry-quoting-party-hosting flair; Dan-Man Johnson, for your structure and reliability around the house; Hughy B., for your empathy and love of the night life; Edward Brooks, for your lessons in life reoriented, and remarkable (tri-perspectival ☺) passion that has left its clear mark in my reoriented life; and of course, my trendy uncle Vaughan Roberts, for being surprisingly toler*able*, so far – your confidence and purity of heart have, and will be, encouragements in my own vulnerabilities.

I love you guys!

I am also deeply thankful for friends back home in Singapore including the church family that worships at *Tabernacle:* my ex-Toa Payoh house group, for your many, many encouragements these 4 years and sincere homecoming welcome whenever I return for holidays; in particular, Elvin Hing, Amy Phua, and Pastor Kian Cheng Lee for the comfort that comes from knowing I am not the only one *still* studying; and not least Pastor David Seah, for your humanity and will to see things through, that got me interested in psychology in the first place. Indeed, special thanks also goes out to Daniel Tan, *my bestest platoon mate*, for your letters that have brought much needed warmth to my many cold and wet days in the office.

I love you guys!

Closer to heart, I would also like to thank my paternal, extended-Lim, and maternal, extended-Tan, clans for their love and words of wisdom and instruction over these four years. Thank you also for exercising (some) restraint when checking on the progress of my love life; I know how difficult it must be for some. More importantly, to my *Pa, Ma, Kor* and *Di*, the warm fuzzy feeling I have when I think of you all has been a good weapon against the isolation that often accompanies graduate studies. It is for this reason that I have dedicated this thesis to you, my fantastic-four.

I love you guys!

Most of all, I want to thank the God of my parents for His gifts: foremost, for the opportunity to labour in the medical sciences, where the field can be nurtured for harm reduction; and also, the providence of a deeply satisfying interpretive system of knowing my *Dominus illuminatio mea.*

Abstract

Background: Cognitive perspectives suggest that gambling-related cognitive (GRC) biases contribute to the development and maintenance of gambling problems. Evidence has since accumulated to support these claims: GRCs tend to be stronger amongst problems (and pathological) gamblers, and can be effective therapeutic targets of talking treatments. However a richer account of how GRCs are conditioned by gamblers' game and group interactions might enhance their explanatory power and therapeutic value.

Methods: Here, I present the results of an extended programme of research involving: (i) laboratory-based experiments on action-based expressions of *illusions of control* (IOC; Studies 1-4) and value learning when making decisions under uncertainty (Study 5); (ii) online surveys of Chinese gamblers' participation patterns and beliefs in luck (Study 6); and finally, (iii) qualitative interviews of treatment-seeking professional footballers in the United Kingdom (Study 7).

Results: Studies 1-2 demonstrated that (non-problematic) gamblers displayed IOC biases by rolling a simulated die for longer when attempting to hit targets with larger prizes and numerical values. These action-based expressions of IOC were facilitated by congruent target numbers and prizes (Study 3), and heightened competition with gambling co-actors (Study 4). Additionally, computational models of gamblers' choices in Study 5 showed that self-report GRCs, and impulsivity, weaken gamblers' ability to learn the value of competing game options. Next, Study 6 reported that Chinese gamblers' GRCs were related to a broader range of gambling activities, and self-report IOCs mediated the association between beliefs in luck and the number of reported gambling problems. Finally, Study 7 found that social pressures, high income, and work-related frustrations precipitated problematic gambling involvement in treatment-seeking footballers.

Discussion: Overall, the results suggest that a richer account of GRCs can be achieved by considering the sensorimotor and sociocultural contexts of gamblers. My thesis concludes with a discussion of GRCs within more recent theoretical developments of the embodied and social cognitions paradigms.

List of abbreviations

ANCOVA	=	Analyses of covariance
CHQ	=	Chasing questionnaire
DV	=	Dependent variable
GLM	=	General linear models
GRC	=	Gambling-related cognitions
GRCS	=	Gambling-related cognitions scale
GBQ	=	Gambling beliefs questionnaire
IB	=	Interpretive biases
IV	=	Independent variable
IOC	=	Illusions of control
LCA	=	Latent class analyses
MANCOVA	=	Multivariate analysis of covariance
MV	=	Mediating variable
PC	=	Predictive control
PCA	=	Principal component analysis
PG	=	Pathological gambling
PrG	=	Problem gambling

List of tables

List of figures

Chapter 1.

Introduction and literature review

1.1 Gambling and health in society

Gambling, defined in broadest terms here as the commercial or private wagering of money on an ambiguous or uncertain outcome, continues to be a culturally ubiquitous recreational activity internationally. In the UK and East Asia, where most of my study samples were drawn, the national rates of past-year gambling participation rates have ranged between 54% - 81% (Fong & Ozorio, 2005; SSRC, 2005; Wardle et al., 2010); in the UK, these rates remain at 56% even when the National lottery is excluded (Wardle, et al., 2010). In these prevalence surveys, a majority of past-year gamblers have not reported any severe syndrome of problems associated with their gambling involvement. In fact some surveys have found better self-report health and social support, and fewer reported symptoms for depression, in individuals who gamble recreationally (e.g., Vander Bilt, Dodge, Pandav, Shaffer, & Ganguli, 2004).

Nevertheless, national prevalence surveys of ethnically Caucasian samples report a small, but significant, minority of between 0.9 - 1.1% people in the population that have experienced profound distress and disability as a result of their maladaptive gambling involvement (e.g., Shaffer, Hall, & Vander Bilt, 1999 - a meta-analysis of US and Canadian prevalence surveys; Wardle, et al., 2010 - a UK prevalence survey). However, gambling problems are much higher in some cultures and segments of society. For example, up to 4.0% of ethnic Chinese people in Hong Kong, Taiwan and Singapore (Fong & Ozorio, 2005; Hwu, Yeh, & Chang, 1989; MCYS, 2008; SSRC, 2005); and up to 5.7%

of youth in the US and Canada (Shaffer, et al., 1999), have reported severe clinical problems associated with their gambling involvement.

The clinical characteristics of disordered gambling includes symptoms of addiction like constant thoughts about gambling (i.e., preoccupation), the need to gamble with larger wagers to achieve the same excitement (i.e., tolerance), aversive experiences associated with abstinence (i.e., withdrawal), repeated failures to cut back or stop gambling, and gambling to escape or regulate their negative emotions. More descriptive symptoms of disordered gambling would include social or vocational disability like the committing of illegal acts to fund the habit, lying to family, threats to the gambler's significant relationships or careers, and finally, engaging in escalating patterns of behaviours in attempted to win back what has previously been lost (i.e., loss-chasing). Conventionally, the Structured Clinical Interview for Pathological Gambling (SCI-PG) has defined individuals with 3-4 of any of these symptoms as *problem gamblers* (PrG), and those with 5 or more of these symptoms as *pathological gamblers* (PG; Grant, Steinberg, Kim, Rounsaville, & Potenza, 2004). More recently, this cluster of symptoms have been redefined as a behavioural addiction in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V; Petry, 2006; Potenza, 2006; van Holst, van den Brink, Veltman, & Goudriaan, 2010), which was a move away from its historical conception as an impulse control disorder in the fourth edition (DSM-IV-TR; APA, 2000; Chambers & Potenza, 2003).

1.1.1 The 'technological revolution' of gambling

A contemporary angle to this public health concern is how the 'technological revolution' within the industry has increased access and removed the number of barriers to gambling outlets (Messerlian, Byrne, & Derevensky, 2004). International online gambling revenue has grown from about US$3 billion, in 2001, to an enormous US$419 billion, in

2011(CCA, 2004; GBGC, 2012). Using the UK to illustrate wider global trends, corporate gambling providers have now migrated online en masse because of the increasing pervasiveness of Internet use (e.g. Eurobet in 1996, William Hill in 1998, and Ladbrokes in 2000; Williams & Woods, 2007). The most recent British gambling prevalence survey indicates that online gambling rates have significantly increased from 6% in 2007, to 14% in 2010 (Wardle, et al., 2010). This probably reflects strategic commercial changes to the gambling industry during this time, where new innovations including online casinos and Internet bingo houses have been introduced, in addition to existing peer-to-peer betting exchanges.

In terms of gambling-related harm, it is not clear at the current time whether online gambling carries enhanced risks for gambling problems or whether particular risk factors for gambling problems also increase the broad use of gambling services on the Internet (Lloyd et al., 2010). However, there are reports of links between internet gambling and reports of gambling problems in adult and adolescent samples (e.g., Kairouz, Paradis, & Nadeau, 2012; Potenza et al., 2011). Additionally, online gamblers also tend to report more gambling problems, poorer school performance, greater substance use, and more gambling in isolation compared to terrestrial (or offline) gamblers (Potenza, et al., 2011).

Taken together, the growing popularity and acceptability of gambling, and the proliferation of commercial gambling media and diversification of delivery, suggest that gambling-related harm will remain an important public health concern (Korn & Shaffer, 1999; Messerlian, Derevensky, & Gupta, 2005; Office of Public Sector Information, 2010). To investigate possible targets for harm reduction, the current piece of work is part of a larger programme of gambling research that investigates the pathways that facilitate gambling involvement (Blaszczynski & Nower, 2002); in particular, why and how vulnerable gamblers transit from recreational to problematic patterns of involvement. Special focus will be given to the dynamics between gamblers' cognitive structures (i.e., thinking biases), and the broader context in which these cognitive biases develop.

1.2 Gambling and cognitive approaches

Cognitive perspectives upon gambling posit that mistaken beliefs, and biased judgements, about gambling games facilitate gambling participation (Delfabbro & Winefield, 2000; Walker, 1992); whereas in vulnerable individuals, they facilitate the development and maintenance of severe gambling problems (Delfabbro, 2004; Ladouceur, 2004b; Toneatto, Blitz-Miller, Calderwood, Dragonetti, & Tsanos, 1997).

Cognitive perspectives have become popular because they offer one way to understand why people persist in gambling despite losing money. Assuming that gamblers are partly extrinsically motivated by money, the financially negative value (Pascalian) of commercial gambling indicate that gamblers do not rely on normative statistical reasoning, but rather, their personal perceptions and beliefs about gambling (i.e., gambling-related cognitions; GRCs). In the most basic terms, GRCs limit gamblers' assessment of *randomness* in games, resulting in failures to recognise that game outcomes are independent of each other (i.e., plays outcomes are not contingent upon preceding outcomes); more importantly, GRCs limit gamblers' assessment of *skill* and *control* in games, resulting in failures to recognise that game outcomes are independent of personal ability or superstitious behaviours (i.e., plays outcomes are not contingent upon preceding choices or actions). For this reason, behavioural economists have conceived of these cognitive biases as heuristics or 'thought boundaries' (Kahneman, 2003) within which gamblers reason about game contingencies.

Drawing from past substance abuse research, cognitive theorists have recognised that intrinsic mood regulating motivations may also produce forms of GRCs that do not interfere with numerical reasoning specifically (Raylu & Oei, 2004a). Examples of such cognitive biases include unrealistic expectations that gambling involvement enhances positive moods and the capacity to cope with tensions. These biases towards the rewarding value of games are important because they have been found to predict increased gambling behaviour and severity (Clarke & Clarkson, 2009; Stewart & Zack, 2008).

Before going further, it is important to acknowledge that cognitive theories of gambling, though receiving substantial empirical support, is not likely to exhaustively explain all the variety of gambling involvement and the entire aetiology of PrG and PG. Cognitive perspectives, which describe the cognitive structural features of individuals, is complemented by behavioural and social-learning models of gambling. These latter models describe how game and social environments also likely contribute to the pattern of gambling involvement and severity observed (Blaszczynski & Nower, 2002 - a Pathways model; Brown, 1987 - a Social Learning model; Sharpe, 2002 - a Cognitive-Behavioural model). In any case, though the theoretical perspectives here will be limited to cognitive perspectives, I attempt to integrate these perspectives and explore how specific types of GRC structures are dependent on gamblers' interaction with their physical and social situations. Additionally I will explore how these *contingent* cognitive biases might precipitate, and perpetuate, recreational and problematic forms of gambling involvement.

1.2.1 Types of gambling-related cognitive (GRC) biases

Historically, qualitative reports of gamblers with different levels of involvement were the primary source information about the types of GRC biases that gamblers privately held (e.g., Delfabbro & Winefield, 2000 - regular gamblers; Ladouceur, Gaboury, Dumont, & Rochette, 1988 - occasional gamblers; Toneatto, et al., 1997 - problem gamblers). A small sampling of the wide variety of GRCs reported in these studies includes superstitious behaviours (e.g., 'I switch tables or machines if losing'); the use of luck (e.g., 'I'm lucky today, I should buy a lotto ticket'); and overconfidence in prediction (e.g., 'I won on three rows, I'm going to be on those rows again'), skill (e.g., 'I know I can do it'), and expectations for emotional reward (e.g., 'Gambling will make me happy').

Narrative reviews of the variety of GRCs have provided helpful summaries of these self-report GRCs (comprehensively reviewed in Raylu & Oei, 2002; see also Toneatto, 1999). Unfortunately, these descriptive typologies are qualitative and lacking in psychometric validity. More recent psychometric work has filled this gap with the development, and validation, of scales like the gambling-related cognitions scale (GRCS; Raylu & Oei, 2004a) and Gambling Beliefs Questionnaire (GBQ; Steenbergh, Meyers, May, & Whelan, 2002) in large community-based samples of PG and non-pathological gamblers. The former GRCS scale, in particular, contains a 5-factor structure, that has demonstrated strong validity and reliability across diverse samples including the French, Australians, and Taiwanese (Grall-Bronnec et al., 2012; Oei, Lin, & Raylu, 2007, 2008). In addition, this scale has been validated in samples with clinically significant problems (Raylu & Oei, 2004a). For these reasons, my thesis conceives of GRC types along Raylu and Oei's (2004a) typology, selecting the 4 factors that are most relevant to the current work; namely, the *illusions of control (IOC), predictive control (PC), interpretive biases (IB)*, and *gambling expectancies (GE)*. The *inability to stop* (IS) subscale of the GRCS was not used here because it measures gamblers' behavioural deregulation which would not typically be viewed as a cognitive trait.

I begin with the IOC and PC biases which have been considered the core set of inadequate cognitions that account for gambling regularity, and severity in some gamblers (Raylu & Oei, 2002; Toneatto, 2002).

Illusions of control (IOCs) were first given importance in the gambling literature in the seminal work of Ellen Langer (1975), and has since gained further attention in the human action contingency literature more broadly (Blanco, Matute, & Vadillo, 2011). In the broadest terms, IOC biases can be defined as a commitment to beliefs that one possesses the knowledge, skill, or luck necessary to alter fortuity in gambling games (Langer, 1975; Thompson, Armstrong, & Thomas, 1998; Wohl & Enzle, 2009). This can take a 'primary' form where gamblers alter their behaviours to change the environment (e.g., choosing to play or pass), or a 'secondary' form where gamblers align their behaviours to perceived environmental forces like luck (e.g., carrying a charm; Rothbaum, Weisz, & Snyder, 1982).

In the GRCS, IOC biases represent the mistaken belief that prayer, lucky objects or rituals can enhance the likelihood of winning (e.g. 'I have specific rituals and behaviours that increase my chances of winning'; Raylu & Oei, 2004a), and has received the most attention in recent years, albeit with varying emphases (Langer, 1975 – IOC is conceived as skill misattribution; Raylu & Oei, 2004a – IOC is conceived as superstition; Thompson, et al., 1998 – IOC is conceived as a cognitive heuristic).

Predictive control (PC) biases or *representative biases* are the mistaken beliefs about randomness and personal ability to forecast wins (e.g. 'A series of losses will provide me with a learning experience that will help me win later'; Raylu & Oei, 2004a). These inadequate beliefs are observed most famously in the 'gamblers' fallacy' (or *negative recency* effects) where a series of losses on a particular option are predicted, with more certainty than is warranted, to give way to impending wins if subsequently chosen (Jarvik, 1951; Kahneman & Tversky, 1972). These fallacies, possibly explain why preceding losses in games can result in what has been descriptively called loss-chasing behaviour where gamblers persist in escalating patterns of gambling participation in attempt to recover what they lost (Lesieur, 1979). Conversely, PC could be expressed in the 'hot hand fallacy' (or *positive recency* effects) where a series of wins on a particular option are predicted, with more certainty than is warranted, to give way to further wins (Gilovich, Vallone, & Tversky, 1985).

Interpretive biases (IB) represent the mistaken beliefs that past wins are due to personal ability whilst past losses are due to uncontrollable circumstances (e.g. 'Relating my losses to probability makes me continue gambling'; Raylu & Oei, 2004a). A related interpretive bias is were gamblers view some losing gambling outcomes as 'nearly winning' because they ostensibly look very much like winning outcomes (e.g., a slot machine outcome with only the last element different from a winning pattern; Reid, 1986).

Gambling expectancies (GE) represent the beliefs that pleasure can be derived from participation in gambling activities (e.g. 'Gambling makes the future brighter'; Raylu & Oei, 2004a). It has been suggested that GEs have received relatively less attention compared to other GRCs (Raylu & Oei, 2004a), which has probably been the case because there are no obvious behavioural methods of assessing these beliefs. Nevertheless, new psychometric developments for GEs, informed by the substance abuse literature, have already started to redress this disparity (Stewart & Wall, 2005; Walters & Contri, 1998; Wickwire, Whelan, & Meyers, 2010). Though the gambling motivations literature has mostly developed independent of cognitive perspectives for gambling (Chantal, Vallerand, & Vallieres, 1995), gambling that is motivated by a desire to regulate mood, will be conceived here as a set of cognitive biases that is subsumed within the GRCs framework.

In the following sections, I will first discuss the methods currently used to investigate GRCs; subsequently, I will present the growing body of evidence that GRCs, as conceived in this thesis, are central risk-factors for gambling severity and its treatment.

1.3 Methods in cognitive approaches

Protocols of past gambling research have traditionally relied on 2 methods to investigate the structures of game-specific GRCs, and how they operated during play. These include self-report measurements (i.e., 'think-aloud' records and subjective ratings) and behavioural wagering measurements (i.e., bet size and risk appetite).

1.3.1 GRCs and self-report measurements

In studies that have used self-report methods, gamblers were either instructed to provide verbal reports of their winning confidence at regular intervals during play (Delfabbro & Winefield, 1999), or to verbalise, continuously, any thoughts that come to mind (Delfabbro & Winefield, 2000; Griffiths, 1994; Ladouceur, Gaboury, Bujold, Lachance, & Tremblay, 1991; Walker, 1992). Beyond these 'think-aloud' protocols, gamblers were invited to rate their perceived level of control (Gino, Sharek, & Moore, 2011; Ladouceur & Mayrand, 1987), skill (Biner, Angle, Park, Mellinger, & Barber, 1995), or winning confidence (Golin, Terrell, & Johnson, 1977), in between plays, or as an aggregate measure at the end of games.

The utility of think-aloud measures are illustrated by findings that regular gamblers have consciously explicit erroneous belief about reward schedules whilst playing Electronic Gaming Machines (EGM; Delfabbro & Winefield, 1999), and the number of inadequate beliefs were not significantly different whether the EGM was played in the laboratory or in a natural setting (i.e., a grocery store; Ladouceur, et al., 1991). Conversely, rating methods have identified game reward incentives (Biner, et al., 1995; Gino, et al., 2011), and game behavioural response structures (i.e., throwing dice; Golin, et al., 1977), that can modulate IOC. However, a criticism of these self-report techniques is the, arguably inappropriate, assumption that gamblers are aware of the mediating psychological processes that explain their behaviours (reviewed in Nisbett & Wilson, 1977). Moreover, such procedures are intrusive, and could disturb the very processes under investigation.

A complementary line of research that does not encounter these methodological difficulties has been the protocols that infer GRCs from gamblers' actual game-relevant behaviours performed during play.

1.3.2 GRCs and behavioural measurements

For example gamblers' GRCs can be inferred from records of their wagering strategies within games (e.g., Bouts & Vanavermaet, 1992; Burger, 1986; Davis, Sundahl, & Lesbo, 2000; Gilovich & Douglas, 1986; Langer, 1975); specifically, these studies have demonstrated how the size of bets and level of risk increases with the familiarity of game sensory features (Bouts & Vanavermaet, 1992; Burger, 1986), active participation in games like throwing dice or the choosing of a lottery ticket (Davis, et al., 2000; Langer, 1975), and the incompetency of a gambling co-actor (Langer, 1975). A criticism of these methods, however, is how they aggregate gamblers' perception of game rewards and winning probabilities.

An advance in computational techniques developed within behavioural economics and neuroeconomics (Glimcher, Fehr, Camerer, & Poldrack, 2008) may allow researchers to amend these methods, and develop more sophisticated ways to mathematically account for differences in how individual gamblers perceive a range of winning rewards and probabilities (reviewed in Trepel, Fox, & Poldrack, 2005; see also, Prospect Theory by Tversky & Kahneman, 1992). Relevant applications of computational methods attempt to model (again mathematically) decision processes like prediction learning (Behrens, Woolrich, Walton, & Rushworth, 2007), and exploration and exploitation (Dayan & Daw, 2008).

Unfortunately, most of these psychophysical, computational experiments have relied on non-gambling student samples to understand decision-making in non-gambling contexts (e.g., computational parameters like learning rates, Behrens, et al., 2007; or probability and magnitude distortion, Tversky & Kahneman, 1992), limiting the generalizability of the identified habits of thinking, or cognitive heuristics, to gambling populations. Exceptions to this would be research that have reported how PrGs have a preference for large uncertain rewards as opposed to a small certain rewards (i.e., less probabilistic discounting; Madden, Petry, & Johnson, 2009), and a preference for small immediate rewards as opposed to a larger rewards at a later time (i.e., more delayed discounting; MacKillop, Anderson, & Castelda, 2006). Corroborative evidence for this comes from a study that showed PG with less delayed discounting reporting greater gambling abstinence up to 1-year after treatment (Petry, 2012).

Thus, delayed and probabilistic discounting offers a partial account of decisions-making cognitive processes involved in PG and its behavioural interventions. This suggests that a broader psychophysical programme to model psychological (maladaptive) processes in psychiatric disorders, including disordered gambling, may be possible and useful (reviewed in Montague, Dolan, Friston, & Dayan, 2012). Providing added support for this computational psychiatry approach, Study 5 explores the association between GRCs and quantitative descriptions of gamblers' value-learning in games.

In the next section (§ 1.4), I review the evidence from self-report and behavioural methods that support the merits of cognitive perspectives upon gambling research.

1.4 Evidence for cognitive approaches

Associations between GRCs and gambling severity have provided essential support for the utility of cognitive perspectives in PG research. Nevertheless an important caveat is how cognitive biases, as defined here, may not always be maladaptive. For example, normative beliefs in self-efficacy (control) are associated with adaptive and healthy functioning in a wide variety of situations (reviewed in Leotti, Iyengar, & Ochsner, 2010). In particular, meta-analyses indicate that self-efficacy beliefs are associated with better health (Holden, 1991), academic (Multon, Brown, & Lent, 1991), and work-related outcomes (Stajkovic & Luthans, 1998), likely because of their promotion of optimism and perseverance. However, unlike many human activities that improve with practice, the benefits of self-efficacy beliefs in gambling situations are limited since commercial games are structured such that losses displace wins with extended play.

1.4.1 GRCs and gambling problems

GRCs enhance risk for gambling problems. Qualitative reports from probable PrG, from student and general population samples, have described the presence of a large variety of GRCs (Baboushkin, Hardoon, Derevensky, & Gupta, 2001; Toneatto, et al., 1997). This is not surprising since the diagnostic criteria for PG within the DSM tradition (e.g., DSM-IV-TR; APA, 2000), contains clinical symptoms that indicate a more general cognitive bias (i.e., preoccupation) as well as more specific *predictive control* biases (i.e., loss-chasing).

A comprehensive narrative review of current findings identified GRCs as one of the central risk factors for problematic patterns of gambling involvement, in comparison with non-problematic gamblers (Johansson, Grant, Kim, Odlaug, & Gotestam, 2009). Specifically, PrG have endorsed more GRCs on all the 4 cognitive categories that I am interested in – i.e., *illusions of control (IOC)*, *predictive control (PC)*, *interpretive bias (IB)*, and *gambling expectancies (GE)* – and this has been replicated on multiple occasions, and in both Caucasian and Chinese samples (Emond & Marmurek, 2010; Joukhador, Blaszczynski, & Maccallum, 2004; Oei, et al., 2007, 2008; Raylu & Oei, 2004a). Importantly, conceptions of GRCs as a risk factor underscore how current associations between cognitive biases and gambling-related harm are merely correlational and not causal.

To understand how GRCs perpetuates gambling problems, a large population-level survey of about 11,500 Canadians revealed that GRCs, like IOC and IB, moderates the impact of risky gambling practices (i.e., borrowing money, loss-chasing, and gambling more than they could afford to lose), on gambling intensity (i.e., a greater proportion of incomes spent on gambling) and gambling tolerance (i.e., larger wagers needed to enjoy gambling; Miller & Currie, 2008). Experimental data has further demonstrated that PGs are more likely to be convinced by these illusory beliefs (i.e., superstition, near-misses, inappropriate attribution, and personal control) than non-problem gamblers (Ladouceur, 2004b).

1.4.2 GRCs and gambling treatment

Critically, treatment studies provide some support for the causal role of GRCs in PrG and PG. A Cochrane meta-analysis of 4 Randomised Controlled Treatment (RCT) studies revealed that talking therapies targeting gamblers' erroneous cognitions and behavioural patterns are efficacious in the short-term (relative risk = 0.44; Oakley-Browne, Adams, & Mobberly, 2005). Using less rigorous selection criteria, narrative reviews corroborated the efficacy of cognitive therapies to treat PrG relative to gamblers in a waiting list control group (Toneatto & Ladouceur, 2003). Specific mechanisms that may explain the positive effects of talking therapies include gambling abstinence and reductions in subjective gambling urges and pleasure (Jimenez-Murcia et al., 2008; Sylvain, Ladouceur, & Boisvert, 1997; Wohl, Young, & Hart, 2007). Treatments targeting cognitive biases may also reduce disordered gamblers' negative attitudes towards further help seeking (Wohl, et al., 2007).

However, due to a lack of transparency in reporting (e.g., failure to compare effects with patients who dropout, or detail how patients are randomly assigned to treatment groups) the results of many of these treatments studies remain uncertain (Fink et al., 2012). Additionally, studies on the long term effects of treatment, or the type of gamblers they are most effective for, are still not available.

1.5 Broader structures facilitating GRC biases

To better understand how gamblers' GRCs develop and how they influence gamblers' wagering behaviours, I conceive of GRCs here not only as 'boundary' conditions that constrain how gamblers reason about gambling outcomes (Kahneman, 2003), but also as cognitive structures that are themselves 'bounded', and therefore shaped, by a wider sensorimotor and sociocultural context. Such ideas have been proposed by gambling theorists in their reviews of the structural characteristics of gambling games (Parke & Griffiths, 2006), and the interpersonal characteristics within which these games are played (specifically, elite sports culture - Nelson et al., 2007; and Chinese culture - Raylu & Oei, 2004b). Nevertheless, understanding of such contingent conceptions of GRCs remains preliminary and will be explored with more detail in this thesis. The following sections (§§ 1.5.1 - 1.5.2) summarises what is currently known about the sensorimotor and sociocultural dependence of GRCs.

1.5.1 GRCs and game features

Parke & Griffiths (2006) have used modern electronic gambling machines (EGMs) to illustrate the numerous, and an ever expanding, 'game attractions' that electronic game designers use to enhance gambling involvement; however, empirical investigations into the risks of most of these features have not caught up with these commercial developments. In any case, specific visual-display and behavioural-response game features have, in recent years, been studied for their roles in modulating gamblers' GRCs.

Visual-display features. Aesthetic features of games and their environments have been shown to facilitate GRCs. Non-specific bright flashing lights on slot machines (Griffiths, 1990), and red as opposed to blue coloured lighting in gaming halls (Stark, Saunders, & Wookey, 1982), have been reported to increase monetary bets and losses, or subjective ratings of enjoyment in some regular gamblers.

More specifically, games with familiar display stimuli (e.g., a standard deck of cards) have been shown to promote greater risk-taking in players compared to games with unfamiliar stimuli (e.g., an Egyptian-themed deck of cards; Bouts & Vanavermaet, 1992; see also Langer, 1975). Corroborating findings from laboratory and naturalistic studies that investigate the 'exposure effect', has shown that players take more risks as games progress, presumably because their winning confidence increased with familiarity (reviewed in Ladouceur, et al., 1991). Critically, a recent series of studies demonstrated that familiar game stimuli (i.e., numbers based on personally 'special' dates and names) induced gambling risk-taking because it heightened *gambling expectancies* of self-report enjoyment, rather *illusions of control* (Goodman & Irwin, 2006).

Other than familiar game visual stimuli, the extent to which display-outcomes are structured to look like winning outcomes or *near-misses*, have also been shown to promote gambling persistence in slot machine players (Cote, Caron, Aubert, Desrochers, & Ladouceur, 2003; Strickland & Grote, 1967). Recent data suggests that *interpretive biases* of nearly winning elicits increased physiological arousal (Clark, Crooks, Clarke, Aitken, & Dunn, 2012; Dixon, Harrigan, Sandhu, Collins, & Fugelsang, 2010), probably reflecting how the neural processing of near-misses are more aversive than complete misses (Clark, Lawrence, Astley-Jones, & Gray, 2009).

The preceding studies have revealed that certain visual-display features of computerised games that are familiar, or look like wins, to gamblers can promote GRCs. However, it remains unclear whether aesthetic game features *shape* GRCs structures that gamblers have. This will be explored further in Studies 1-3.

Behavioural-response features. Moving on from game visual-display features, there is also a growing body of evidence that have demonstrated how choice and motor responses in games have also promoted gamblers' GRCs.

Firstly, giving gamblers the behavioural option to choose in games has been demonstrated on multiple occasions to increase *illusions of control* in gambling games (reviewed in Frederic Martinez, Bonnefon, & Hoskens, 2009); for example, laboratory-based lotteries that give players the option to choose their own winning numbers or prizes (Langer, 1975; Wortman, 1975).

Secondly, previous gambling research has also used action or motoric response behaviours to promote GRCs. In positive cases, players given the opportunity to actively participate in games – like picking up cards, balls, and dice – report greater feelings of self-efficacy (i.e., greater appraisals of skill and control, or taking greater risks) compared to the players not given this behavioural prospect (Chau & Phillips, 1995; Davis, et al., 2000; Dunn & Wilson, 1990; Fernandez-Duque & Wifall, 2007; Frederic Martinez, et al., 2009;

Strickland, Lewicki, & Katz, 1966). Similarly, experimental studies that increase active physical involvement in games, like the prospect of a stopping device (e.g. Ladouceur & Sevigny, 2005), or a higher frequency of responding (Blanco, et al., 2011), have induced greater gambling persistence and appraisals of control after play. More striking has been the evidence that getting players to perform ritualistic behaviours after losing a lottery (i.e., drawing their feelings of loss on a piece of paper; sprinkling salt on it; then tearing it up and counting to ten), can induce stronger ratings of control independent of whether they believed in rituals or not (Norton & Gino, 2013). Conversely, in negative cases where motor caution was introduced, risk-taking choices were moderated downwards for up to 2 hours after the motor control training (Verbruggen, Adams, & Chambers, 2012).

The preceding evidence of strong links between motoric behaviours and specific GRCs like *illusions of control (IOC)* suggest that motor actions could be used as an outcome measure of cognitive biases within gambling games. To my knowledge, this line of research has, so far, only been undertaken once (i.e., players' election of a braking device to stop a spinning roulette wheel; Friedland, Keinan, & Regev, 1992), and could be a promising development in GRC measurement. More broadly, the representational (cognitive) links between the visual-display and behavioural-response features of games found in previous studies (Kornblum, Hasbroucq, & Osman, 1990; Tucker & Ellis, 1998; Walsh, 2003) suggests that game display and response features could be working in tandem to shape how GRCs develop in gamblers. These research questions will be pursued in this thesis.

1.5.2 GRCs and sociocultural features

Beyond these sensorimotor contexts of gambling, there is also some evidence that sociocultural contexts also shape the development of GRCs in gamblers. At the interpersonal level, gambling activities can be viewed as both a means to socialise as well as a consequence of socialisation (reviewed in Brown, 1987; Raylu & Oei, 2004b), where the social context of gambling facilitates stronger GRCs; for example, seeing more people gamble (Rockloff, Greer, & Fay, 2011), or the learning of the wins of another gambler (Le Floch, Martinez, & Gaffie, 2005), is sufficient to induce more risky betting strategies in gamblers.

In addition to these social facilitation effects, broader cultural factors may also facilitate the development of GRCs biases. This is observed in survey data that have reported increased gambling volume and intensity if peer and family social networks model and approve of gambling (Felsher, Derevensky, & Gupta, 2003; Hurt, Giannetta, Brodsky, Shera, & Romer, 2008; Langhinrichsen-Rohling, Rohde, Seeley, & Rohling, 2004; Magoon & Ingersoll, 2006; Vachon, Vitaro, Wanner, & Tremblay, 2004; K. C. Winters, Stinchfield, Botzet, & Anderson, 2002). For the purposes of this thesis, I will explore more closely the cultural features of ethnic Chinese people in Study 6 and elite sports athletes in Study 7.

Ethnic Chinese culture. The facilitation of GRCs within ethnic Chinese culture is evident from survey data that have reported stronger cognitive biases within this ethnic group compared to ethnic Caucasians (Oei, et al., 2008; Zheng, Walker, & Blaszczynski, 2010). National prevalence surveys confirm that high rates of pathological gambling exist amongst the ethnic Chinese residing in various western and far-eastern jurisdictions (1.2% to 4.0%; Blaszczynski, Huynh, Dumlao, & Farrell, 1998; CPAC, 2000; Fong & Ozorio, 2005; Hwu, et al., 1989; MCYS, 2008; SSRC, 2005); these rates are more than two times those reported within Caucasian-majority jurisdictions (0.4% to 1.1%; NORC, 1999; Shaffer, et al., 1999; Wardle, et al., 2010).

These observations are consistent with findings that Chinese culture facilitates greater gambling involvement because it sustains norms that view gambling as an acceptable recreation activity that promotes social integration (Fong & Ozorio, 2005; NCPG, 2007). Nevertheless, little is known of how Chinese culture exactly heightens GRC biases amongst Chinese gamblers. One possible mechanism is the Chinese cultural disposition and partiality towards beliefs in luck which may be providing a greater menu of alternative explanations for gambling outcomes. Luck in Chinese culture can broadly be conceived as the metaphysical believe that there are impersonal forces that determine personal 命 (/*ming*/; destiny) and 运 (/*yun*/; fortuity) (Papineau, 2005). Importantly, these beliefs are not just held privately, but are socially embodied in the linguistic and customary traditions of the Chinese people, and thus passed down to posterity (e.g., Chinese New Year traditions; Fong, 2000). In other words, it is possible that GRCs have flourished within Chinese culture because they are sustained by strong sociocultural representations (e.g., conceptions of luck as a property of objects, numbers and events) and structures (e.g., human services like the Feng-Shui and Palmistry industries).

Elite sports culture. Moving on from cultural beliefs systems that may constrain the development of GRCs, I review here the vocational aspects of culture that may also play a role in shaping GRCs. In particular, the occupational aspects of elite sports participation.

At the moment, research into the pattern and distribution of GRCs amongst elite sports athletes is lacking. Nevertheless there is evidence that high profile sports participation is related to gambling involvement; a US cohort survey of more than 20,000 students reported that athletes in high profile sports like American football, are more likely to report gambling problems compared to athletes in other sports like track & field or volleyball (Ellenbogen, Jacobs, Derevensky, Gupta, & Paskus, 2008). In another large survey of US more than 10,000 students, it has been reported that colleges with a greater proportion of students who rated attendance at sporting events to be important, are also more likely to have students who engage in sports betting (Nelson, et al., 2007).

To account for the relationship between involvement in elite sports and gambling, theorists have suggested that sports environments facilitate the development of a 'competitive spirit' in elite athletes (Curry & Jiobu, 1995). Survey data of current and retired professional athletes have supported this view with reports that they are more likely to gamble on skill-oriented games or the sports that they formally played (Kerber, 2005; Weiss & Loubier, 2010). If competition does indeed facilitate GRCs, then one way sports culture enhances GRCs like IOC could be the misapplication of a skill-orientations when gambling (Langer, 1975).

Additionally, unique to elite sporting cultures, GRCs could be facilitated by stronger motivations to gamble for emotional excitement or stress relief (i.e., gambling because of heightened gambling expectancies; Raylu & Oei, 2004a). This is more pointed when considering how professional athletes frequently experience frustrations like early and sudden career disruptions because of injury or poor performance (Hughes & Leavey, 2012; Weiss & Loubier, 2008, 2010). In such stressful circumstances, the positive emotional *expectancies* of gambling GRCs could render gambling uncharacteristically attractive.

Admittedly, the influence of elite sporting cultures on GRCs remains speculative. Therefore, a deeper understanding of the unique situations that have led to and sustained gambling problems in vulnerable elite athletes may advance out understanding of this particular sociocultural facilitation effect. Without measuring GRCs directly, I explore qualitatively in Study 7 the vocational factors associated with gambling problems in a group of treatment-seeking professional footballer in the United Kingdom.

1.6 Summary of aims

This thesis will investigate a series of research questions. Study 1 aims to experimentally explore how the motor actions of gambling games in a simulated game of dice could facilitate actions that express GRCs; in particular, the *illusions of control* (IOC). The measurement of GRCs has traditionally depended on self-reports and behavioural wagering measurements methods (e.g., Ladouceur, et al., 1991; Langer, 1975), and little work has been done to extend this measurement repertoire to game-specific behavioural prospects. To achieve this aim, Study 1 invited players to click on a standard computer mouse to 'roll' (or 'shoot') an animated die to resolve die outcomes for a range of targets at varying prizes.

Study 2 aims to refine Study 1's measurement of action-based expression of IOC by getting non-problematic gamblers to shake, rather than click, a standard computer mouse to resolve die outcomes. In particular, participants shook a standard computer mouse to control an animated die, and the parameters of these hand movements were compared with their self-report IOCs.

Study 3 aims to investigate if action-based expression of IOC in gambling games would be augmented by the relationship between sensory and motor game features. Previous studies have demonstrated how both visual-display (Parke & Griffiths, 2006) and motor-response (Ladouceur & Sevigny, 2005) characteristics of games can augment GRCs, and at times, can share cognitive representations including magnitude (Kornblum, et al., 1990; Walsh, 2003). Nevertheless, little work has been done to understand how these display and response features interact to facilitate GRCs. To this end, non-problematic gamblers were invited to play a simulated die-rolling game where they were either given games that had congruent or incongruent sensorimotor configurations.

Study 4 concludes this series with the aim of demonstrating how action-based expression of IOC in gambling games can be augmented by the competitive betting behaviours of playing partners. A growing number of experimental studies have now demonstrated that the presence and performance of gambling partners can induce heightened GRCs as measured by risky betting strategies (Le Floch, et al., 2005; Rockloff, et al., 2011); nevertheless, it is uncertain whether competitive betting behaviours of a gambling partner influences gamblers' GRCs. To better understand these competitive effects, dyads of non-problematic gamblers were invited to play a modified 2-player simulated die-rolling game with a competitive feature where betting partners can choose to bet with, or against, the die-throwing gambler.

Study 5 extends these findings by investigating how self-report GRC biases and impulsivity interfere with gamblers' ability to learn and perceive game reward values. Previous studies have reported stronger GRCs in gamblers with severe gambling problems compared to non-problematic gamblers (Emond & Marmurek, 2010; Joukhador, et al., 2004; Oei, et al., 2007, 2008; Raylu & Oei, 2004a). However, it is not known exactly how GRCs disrupt psychological processes of learning and action evaluation whilst playing games with ambiguous winning schedules. To explore this further, I got participants to play a one-armed bandit game and explored how their decision processes associated with self-report GRCs and impulsivity.

The remainder of my thesis examines how sociocultural factors shape the operation of GRC biases in their facilitation of gambling problems. Study 6a aims to subtype gamblers of ethnic Chinese origin based on their past-year gambling activities, and to describe how self-report GRCs and gambling problems distribute across these groups. Chinese culture is of particular descriptive interest since stronger self-report GRC biases and higher prevalence rates of pathological gambling are found in this population compared to Caucasian samples (Oei, et al., 2008; Zheng, et al., 2010). To better understand gambling within this particular population, Chinese gamblers residing in Hong Kong, Singapore, and the UK were invited, using web and email advertisements, to complete either an English or Chinese (traditional) scripted online survey.

Study 6b aims to examine how Chinese gamblers' self-report GRCs like *interpretive biases* operate within broader social, cultural and linguistic traditions that promotes belief in luck (Fong, 2000). To investigate this, I explored how GRCs mediated the links between beliefs in luck and reported gambling problems.

Finally, Study 7, without investigating GRC biases directly, aims to give a detailed first-person account of the sociocultural features that have facilitated gambling-related harms in vulnerable British professional footballers. Previous studies have attributed gambling risk of elite sports athletes to a 'competitive spirit' or vocational frustrations (Curry & Jiobu, 1995; Hughes & Leavey, 2012). However, to date, there has been no qualitative inquiry into the problematic gambling experience of British professional footballers, presumably because of the challenges to access such a population. Qualitative interviews with treatment-seeking British professional footballers were conducted, for the first time, to investigate how features of this elite and high-profile sporting culture, have facilitated their gambling involvement.

Chapter 2.

Rolling dice to win prizes – Study 1

To begin my investigation, I focused upon sensory-motor structures of games that shape gamblers' GRCs. A series of experiments using games of dice are presented here to detail how GRCs, like *illusions of control* (IOC), are expressed in motor responses in games; in particular, when gamblers throw dice for monetary prizes. A brief theoretical background is first sketched out.

2.1 Introduction

Cognitive perspectives on gambling emphasize that mistaken beliefs and biased thinking play a significant role in sustaining gambling participation and, in vulnerable individuals, facilitate the development and maintenance of gambling problems (Toneatto, et al., 1997). These cognitive distortions include: faulty estimates of the probabilities of gaming events; beliefs in the ability to predict or control gambling outcomes; belief in luck and the intervention of fate; erroneous interpretation of near-win outcomes that are taken to signal imminent gambling success; and heightened expectations about the positive effects of gambling for mood and/or well-being (Raylu & Oei, 2004a; Rogers, 1998). Although cognitive biases associated with gambling can readily be observed in individuals with only limited gambling participation (Benhsain, Taillefer, & Ladouceur, 2004), they are significantly strengthened in people with gambling problems (Raylu & Oei, 2002). As such, cognitive biases represent an important therapeutic target for psychological treatments for pathological gambling (Ladouceur et al., 2001; Pallesen, Mitsem, Kvale, Johnsen, & Molde, 2005).

Traditionally, gambling-related cognitive distortions have been measured using questionnaire methods (Raylu & Oei, 2004a; Steenbergh, et al., 2002), or inferred from the observation of betting strategies following experimental manipulations that strengthen (or weaken) biased thinking about risky prospects (gambles) or games of chance (Burger & Cooper, 1979; Langer, 1975; Strickland, et al., 1966). These methods reflect the conceptualisation of gambling-related cognitive biases as mental structures that represent (non-veridical), but more or less explicit, beliefs about gambling games and their properties. Here, I present evidence that gambling-related cognitive distortions find expression in the motor behaviours of gambling games; specifically, in the way that gamblers throw dice for monetary prizes. My results suggest that the strength of distorted thinking about gambling can be measured by paying closer attention to its motor expression.

One prominent set of biases include gamblers' false beliefs about their ability to influence (somehow) the outcomes of chance events and increase the likelihood of gambling successes (Ladouceur, et al., 1988; Langer, 1975). Previously, these 'illusions of control' have been characterised in terms of their tendency to increase risky betting strategies when given active roles in gambling games such as the opportunity to throw dice (Davis, et al., 2000; Dunn & Wilson, 1990; Strickland, et al., 1966), draw balls from urns (Frederic Martinez, et al., 2009), or draw cards from a deck (Chau & Phillips, 1995; Fernandez-Duque & Wifall, 2007), compared to circumstances in which these actions are unavailable. Moreover, earlier sociological investigators noted that street-side and casino gamblers sometimes throw dice in different ways in attempts in order to achieve desired gambling outcomes (Davis, et al., 2000; Henslin, 1967), and the belief amongst some 'craps' players that throwing dice harder tends to produce larger number outcomes while throwing gently produces smaller number outcomes (Henslin, 1967). These reports are also linked to the practice of 'dice-setting', and/or dice-control as described on various dice-coaching websites (e.g., http://www.dicecoach.com/dicesets.asp). Dice-setting purports to offer techniques for increasing the probabilities of certain game outcomes by careful orientation and throws of the dice. Overall, beliefs that it is possible to influence the outcomes of dice throws in real gambling settings, through associated motor behaviours, give credence to the proposal that gambling-related cognitive biases can be expressed in the way that people throw dice in gambling games; however, at the current time, experimental evidence to support this idea is lacking.

To investigate this possibility, I invited a sample of individuals with a broad range of gambling participation to roll a fair and computer-simulated (single) die for monetary prizes. I wished to test 2 hypotheses about the psychological factors that influence the time that gamblers allow the die to roll for, before revealing gaming outcomes. First, I wished to test whether die-roll times in a gaming situation are related to features of the specific gambles that players elect to play; for example, the monetary value of bets at stake during a gambling game. Second, I wished to test the hypothesis that die-roll times are influenced by cognitive and motivational characteristics of gamblers themselves; in particular, their endorsement of gambling-related cognitions involving IOC, or the tendency to chase after winning outcomes, losing outcomes or near-misses. My data suggest that the dice-rolling behaviour can be influenced by the beliefs or cognitions that underpin gambling participation, and, in vulnerable individuals, the development of gambling problems.

2.2 Methods

The study was approved by the Central University Research Ethics Committee (CUREC) of the University of Oxford. All participants gave written informed consent.

Table 2.1. Descriptive statistics of 60 gamblers

	Mean(*SD*)		*N*(%)
Age	32.45 (12.37)	Gambling losses	
Years of education	14.10 (2.93)	*£0*	7 (11.70)
		< £100	35 (58.30)
Gambling Cognition		*£100 - £500*	14 (23.30)
Gambling expectancies	12.80 (5.32)	*> £500*	4 (6.70)
Illusions of control	7.80 (5.09)		
Predictive control	16.18 (7.83)	Gambling frequency	
Perceived inability to stop	9.85 (5.84)	*Few times a year or less*	20 (33.30)
Interpretive control/bias	12.67 (6.23)	*1-3 times a month*	6 (10.00)
Total score	59.55 (24.69)	*Once a week or more*	34 (56.60)
Chasing questionnaire			
Big wins	13.62 (6.60)		
Big losses	10.73 (6.28)		
Near-misses	4.62 (2.30)		
Total	28.97 (14.21)		

Note: Gambling cognitions – Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a); Chasing Questionnaire (CHQ; O'Connor & Dickerson, 2003); Gambling problems – Past year problems as measured by the National Opinion Research Centre DSM IV Screen (NODS; Wickwire, Burke, Brown, Parker, & May, 2008); Gambling losses – Past year gambling losses; Gambling frequency – Past year gambling frequency.

2.2.1 Participants

Sixty individuals (51 males; 9 females) with varying gambling experience were recruited from the local community using advertisements placed on a local website. The mean age of the sample was 32.45 years (range = 18–60). All participants were screened using a semi structured interview to ensure an absence of current DSM-IV mood and substance misuse disorders (First, Spitzer, Gibbon, & Williams, 2002). 'Craps' is not a prominent form of gambling in Europe, and my sample was selected to include individuals who reported participation in a broad range of gambling forms (e.g., private bets, electronic gambling machines, sports betting, or horse/dog racing), and a reasonable distribution of gambling-related cognitions. Thirty-four of my participants (56.6 %) reported gambling at least once a week, six (10.0 %) gambled 1–3 times a month, and twenty (33.3 %) gambled a few times a year or less. The mean number of past year gambling problems reported was 1.10 (range = 0–7), as measured with the National Opinion Research Centre Gambling DSM-IV Screening instrument (NODS; Wickwire, et al., 2008) (Table 2.1). Two of my participants were identified as probable pathological gamblers (NODS score ≥ 5); these were retained to maximise the distribution of cognitive biases. Their removal does not substantially change the pattern of results reported here. Therefore, my data provide new information about the motor expression of gambling-related cognitive biases in individuals who report varying levels of involvement in a relatively broad range of gambling forms beyond 'craps' or dice-gambling games.

2.2.2 Psychometric questionnaires

Participants provided information about the extent of their gambling participation, including past-year gambling frequency (1-few times a year or less; 2-one to three times a month; 3-once a week or more), past-year gambling losses (1-£0; 2-less than £100; 3-£100 to £500; 4-more than £500), and past-year gambling problems (NODS; Wickwire, et al., 2008). They also completed assessments of the cognitive and behavioural traits that influence gambling behaviour. These included a questionnaire about the tendency to keep gambling following different gambling outcomes – so-called chasing behaviour – in commercial gambling situations (CHQ; O'Connor & Dickerson, 2003), and the Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a). Both these scales showed high internal reliability in this sample (as indicated by Cronbach's α(s) of .96 and .93 respectively); whilst their subscales had moderate to high reliability (all Cronbach's α(s) between .75 and .94).

The CHQ (O'Connor & Dickerson, 2003) required participants to rate, using 7-point Likert scales, 12 statements about how they usually react to three gambling outcomes: near-misses, large wins, and large loses (e.g., 'I continue betting" or 'I increased the size of my bets'). The GRCS (Raylu & Oei, 2004a) required participants to rate, using 7-point Likert scales, 23 statements about gambling. This scale has 5-factor structure that includes: illusions of control (IOC) – the belief that prayer, lucky objects or rituals can enhance the likelihood of winning (e.g., 'I have specific rituals and behaviours that increase my chances of winning'); interpretive biases (IB) – the belief that past wins are due to personal ability whilst past losses are due to circumstance (e.g., 'Relating my losses to probability makes me continue gambling'); gambling expectancies (GE) – the belief that gambling participation can elevate mood and be good for well-being (e.g., 'Gambling makes the future brighter'); predictive control (PC) – the belief one has the skill to forecast wins (e.g., 'A series of losses will provide me with a learning experience that will help me win later'); and finally, inability to stop gambling – the belief that the desire to gamble is so strong that one will never be able to stop (e.g., 'I'm not strong enough to stop gambling').

2.2.3 Die-rolling game

Participants were asked to click the left button on a standard computer mouse to roll a simulated (3-dimensional) dice for monetary prizes (see Figure 2.1(a)). On each play, participants were first shown a 'buy-in' that was paid regardless of whether they subsequently decide to gamble or not. The size of the 'buy-ins' ranged between £0 and £80 from play-to-play and was presented in order to increase participants' sense that they were gambling with their own money. Next, participants saw the standard 6 outcomes of a single fair (6-sided) die arrayed in a row just above the middle of the display, ordered 1–6 from left-to-right. The probability of winning on each play was indicated by setting the background colour of the one or more winning numbers to blue, and the background colour of losing numbers to red. Therefore, the probabilities of winning outcomes ranged from 0.16 to 0.83, and varied randomly from play-to-play.

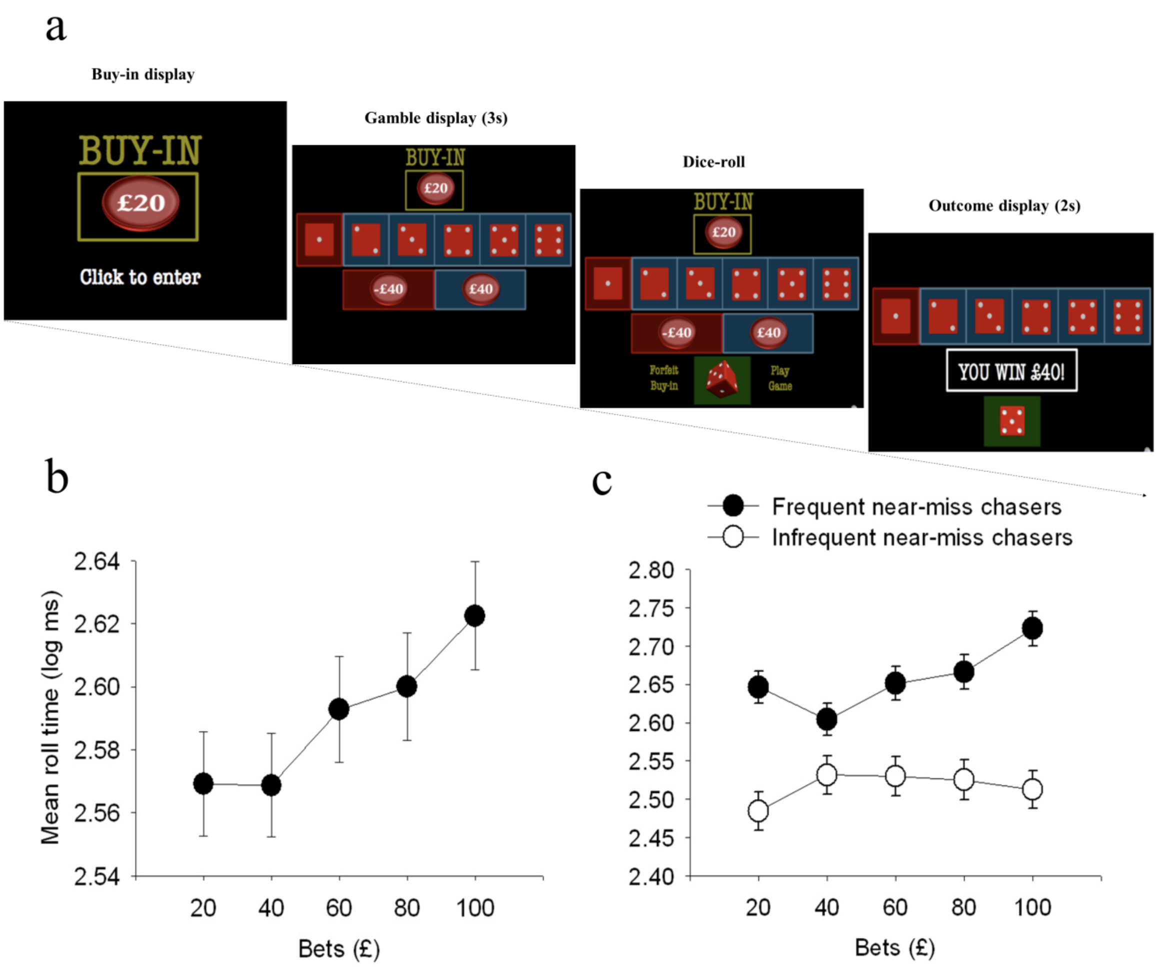


Figure 2.1. (**a**) Example display for one play of the die-rolling game; in this instance, participants would win £40 if they rolled the (winning) numbers between 2 and 6 but lose £40 if they rolled the (losing) number 1. They forfeit the £20 buy-in if participants chose to quit the play; (**b**) Mean roll-time (logarithm milliseconds) as a function of bet value; (c) Mean roll-time (logarithm milliseconds) as a function of bet value in 2 groups of gamblers assigned as those with high scores on the CHQ measure of tendency to chase near-misses (*n*= 30) and those with low scores on the CHQ (*n*= 30) (Median split of 4.5) (O'Connor & Dickerson, 2003).

Following this, participants chose between playing to win or lose a bet displayed underneath the six numbers of the die (e.g., £40 in the example shown in Figure 2.1(a)). The value of these bets varied from play-to-play and ranged between £20 and £100. If participants decided to play, they used their mouse to click the button 'Play Game' in order to roll the die (an animated spin sequence) for as long as they liked before releasing the click to 'throw' the die and reveal the play outcome. Participants won the bet if the die landed with a face value inside a blue background but lost if the die landed with a value inside a red background. If participants chose not to play, they used their mouse to click the button 'Forfeit buy-in' and surrender its value. A single die was used here, as there is evidence that rolls of a single a die maximise subjective IOC compared to throwing multiple dice (Koehler, Gibbs, & Hogarth, 1994), providing a simplified analogous measure of dice-rolling best suited to capture cognitive biases. Before starting the game, participants were assured that the single die was fair. To maximise engagement, participants were told that 1 play out of the 125 plays in the entire game (5 buy-in values × 5 bet value × 5 probabilities of winning) would be randomly selected, played out for real money a tenth of its value, and be deducted (or added) from their £10 participation fee. Finally, all participants were also told that the participant with the highest total prize money at the end of the experiment would be awarded a £50 iTunes/ Amazon token.

2.3 Data analysis

The die-rolling game yielded 2 dependent variables: (i) proportion of plays on which participants elected to roll the die rather than forfeit the buy-in ('Decisions to gamble'); and (ii) mean length of time (ms) that participants allowed the die to roll while attempting to win the monetary prizes. These roll-times were log (10) transformed to reduce positive skew ('die-roll times'). Modelling participants' behaviour on the die-rolling game was first completed on an individual level followed by the group level.

2.3.1 Single participant analysis

First, decisions to gamble were simultaneously regressed against features of the gambles presented on each play of the game using a simple logistic general linear model (GLM). Die-roll times (in log milliseconds) were also simultaneously regressed against game features using a simple GLM. In both cases, the standardised regression coefficients for the following regressors were obtained: (i) the value of the 'buy-in' (£0, £20, £40, £60 or £80); (ii) the probability of winning outcomes (0.16, 0.33, 0.50, 0.66 or 0.83); and (iii) the value of bets offered (£20, £40, £60, £80 or £100). I also included a regressor to capture (iv) information about the value of the 'winning numbers' needed to win monetary prizes with the die. On half of the plays, winning numbers were coded as small (1,2 or 1,2,3 or 1,2,3,4 or 1,2,3,4,5) while, for the remainder of the plays, winning numbers were coded as large (5,6 or 4,5,6 or 3,4,5,6 or 2,3,4,5,6). Finally, in order to control for fluctuating engagement across the 125 plays of the game, I included a regressor to capture (v) the game play number.

2.3.2 Group level analysis

Participants' mean proportions of decisions to gamble and mean die-roll times were regressed against the cognitive and behavioural traits of the participants in my experiment using an exploratory backward entry method. These regressors included (i) sub-scale scores for participants' tendency to chase following near-miss, winning, and losing outcomes, as measured with the CHQ (O'Connor & Dickerson, 2003) and (ii) sub-scale scores for gambling cognitions including illusions of control, predictive control, gambling expectancies, interpretative bias and inability to stop, as measured with the GRCS (Raylu & Oei, 2004a). The significant regressors from these backward regressions were entered simultaneously into a final model, together with covariates age and past year gambling losses, only if it they did not render the overall model fit non-significant. These were entered to ensure that any significant effects of gambling cognitions and traits were not confounded by gross differences in demographics or levels of gambling involvement. Finally, one-sample t-tests with a baseline of zero were used to test the significance of the regression coefficients (β-values) obtained from the individual-participant GLMs. The significant (die-roll time) β-values from the individual-participant GLMs were then regressed against the above list of cognitive and behavioural traits using an exploratory backward entry method. Significant regressors from the backward regression were then entered simultaneously in a final model, which controlled for age and past year gambling losses, only if it they did not render the overall model fit non-significant. All regressions at the group level were tested for collinearity and found satisfactory (VIFs $<$ 2.14; Tolerance $>$ .47).

2.4 Results

2.4.1 Gamble features

2.4.1.1 Decisions to gamble

Overall, my sample of gamblers decided to gamble and roll the die rather than forfeit the buy-in significantly more frequently as the probability of rolling winning numbers increased ($t(59) = 10.41$, $p < .001$, $d = 1.34$; also shown in Table 2.2 and in Figure 2.2). Gamblers also decided to roll the die more frequently when the numeric value of the winning numbers were large compared to when the numeric values of the winning numbers were small ($M = 0.64 \pm 0.008$ vs. 0.63 ± 0.009, $t(59) = 4.17$, p<.001, $d = 0.54$). By contrast, gamblers' decisions to roll the die were not significantly influenced by the value of the buy-in requested before each play of the die-rolling game ($t(59) = 0.92$, $p = .36$), or by the value of the bets offered ($t(59) = -0.97$, $p = .33$). Finally, gamblers' decisions to roll the die were not significantly increased or decreased across the course of the game, ($t(59)= -1.31$, $p= .20$).

Figure 2.2. Mean proportion of decisions to play as a function of probability of winning

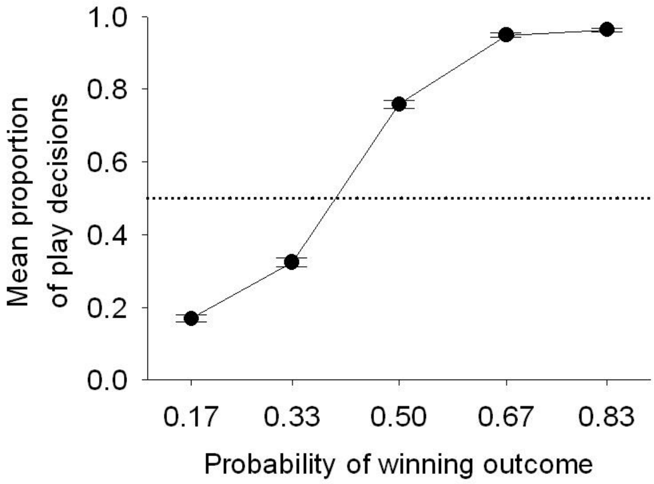


Table 2.2. Participant-level regression (entry method) of decisions to roll a simulated die to win monetary prizes, or forgo a buy-in, against gamble features in 60 gamblers

	Mean *B* (*SE*)	*t*	*p*
Constant	- 7.12 (0.72)	-9.94	<.001
Value of buy-in	<0.01 (0.01)	0.92	.36
Value to bets	- 0.01 (0.01)	-0.97	.33
Probability of winning	18.32 (1.76)	10.41	<.001
Value to winning numbers	0.38 (0.09)	4.17	<.001
Game phase	-0.11 (0.08)	-1.31	.20

Note: Value to buy-in (£0, £20, £40, £60 or £80); value of bets (£20, £40, £60, £80 or £100); probability of winning (0.16, 0.33, 0.50, 0.66 or 0.83); value of winning numbers (small - 1,2 or 1,2,3 or 1,2,3,4 or 1,2,3,4,5; large - 5,6 or 4,5,6 or 3,4,5,6 or 2,3,4,5,6); game phase (5 consecutive phases of 25 plays each).

Table 2.3. Single-participant level regression of die-roll times against gamble features of presented to 60 individuals with established gambling participation

	Mean *β* (SE)	*t*	*p*
Value of buy-in	0.01 (0.02)	0.41	.96
Value to bets	0.06 (0.02)	4.00	<.001
Probability of winning	-0.01 (0.02)	-0.32	.75
Value to winning numbers	0.07 (0.02)	3.76	<.001
Game trial number	-0.11 (0.05)	-2.31	.02

Note: Value to buy-in (£0, £20, £40, £60 or £80); value of bets (£20, £40, £60, £80 or £100); probability of winning (0.16, 0.33, 0.50, 0.66 or 0.83); value of winning numbers (small - 1,2 or 1,2,3 or 1,2,3,4 or 1,2,3,4,5; large - 5,6 or 4,5,6 or 3,4,5,6 or 2,3,4,5,6); game trial number (1 to 125).

2.4.1.2 Die-roll times

Consistent with sociological reports of 'craps' and other dice-throwing games (Henslin, 1967), gamblers increased the length of their computerised die-rolls when trying to win larger value bets ($t(59)= 4.00$, p<.001, $d= 0.52$; see Table 2.3 and Figure 2.1(b)). Transforming the logarithmic values of Fig. 1b back into untransformed milliseconds, shows that an increase from £20 to £100 in bet value equated to ≈50ms lengthening of gamblers' mean die-roll times. Gamblers also allowed the die to roll for longer when trying to hit larger compared to smaller value winning numbers ($M= 2.62 \pm 0.01$ vs. 2.56 ± 0.01, $t(59)= 3.76$, $p< .001$, $d= 0.48$). By contrast, die-roll times were not much influenced by the value of buy-ins ($t(59)= 0.41$, $p= .69$), or probability of winning on each play ($t(59)= -0.32$, $p= .75$). Die roll times were also shortened over the course of the game ($t(59)= -2.31$, $p= .02$, $d= 0.30$).

2.4.2 Gambler features

2.4.2.1 Decisions to gamble

Controlling for age and past-year gambling losses (all *t*s< 1.68), gamblers who reported stronger IOC as measured by the sub-scale of the GRCS ($t(59) = 2.45$, $p < .05$) made more decisions to roll the die (as opposed to forfeit the buy-in) compared to gamblers who reported weaker IOC (see Table 2.4).

Table 2.4. Group-level regression of decisions to roll a computer-simulated die to win monetary prizes, or forgo a buy-in, against demographic characteristics, gambling cognitions and participation, and psychological state measures in 60 gamblers

	B	SE *B*	*β*
Constant	0.49	0.05	
Age	<0.01	<0.01	.17
Gambling losses (past year)	0.03	0.02	.21^{+}
Illusions of control/GRCS	0.01	<0.01	.30*

Note: $R^2 = .20$ ($p < .01$); $^{+}p < .10$; GRCS - Gambling-related cognitions scale (Raylu & Oei, 2004a).

Table 2.5. Group-level regression of dice-roll times against demographic characteristics, gambling participation, and gambling cognitive and behavioural traits in 60 gamblers

	B	SE *B*	*β*
Constant	2.44	0.15	
Age	<0.01	<0.01	-.01
Gambling losses (past-year)	0.13	0.06	.26^{+}
Near-miss chasing traits/CHQ	0.05	0.02	.34*
Illusions of control/GRCS	0.03	0.01	.43**
Interpretive bias/GRCS	-0.04	0.01	-.68***

Note: $R^2 = .29$ ($p < .01$); $^{+}$ $p < .10$;*$p < .05$; **$p < .01$, ***$p < .001$; CHQ - Chasing Questionnaire (O'Connor & Dickerson, 2003); GRCS - Gambling-related cognitions scale (Raylu & Oei, 2004a).

2.4.2.2 Die-roll times

Controlling for age (t< 0.05), gamblers who reported stronger IOC (t(59)= 3.06, p< .01), and gamblers with stronger behavioural tendencies to chase near-misses (t(59)= 2.27, p< .05), allowed the die to roll for significantly longer than gamblers with weaker IOC and weaker tendencies to chase near-misses. Gambling who reported greater past-year gambling losses also showed a trend for allowing the die to roll for longer than gamblers who reported lower past-year losses (t(59) = 2.00, p= .05). In contrast, stronger interpretative bias, involving the tendency to attribute losses to external sources, were associated with significantly shorter die rolls (t(59)= -4.05, p<.001; see Table 2.5 and Figure 2.3). To ensure that these associations were not artefacts of low scores on the IOC and interpretive bias sub-scales in some of the gamblers, I repeated the analysis but removed all participants who scored lower than the mean GRCS total score of 36 points reported in a comparable sample (Raylu & Oei, 2004a). This test replicated the significant relationships between illusions of control, chasing near-misses, interpretive bias and die-roll times (this is not reported here because of space constraints).

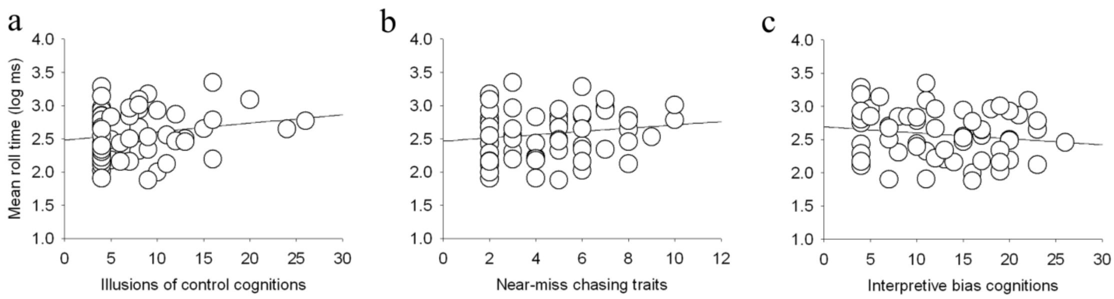


Figure 2.3. Mean roll-time (logarithm milliseconds) as a function of subscales on the Gambling-related Cognitions Scale (Raylu & Oei, 2004a): (**a**) illusions of control; (**b**) near-miss chasing; and (**c**) interpretive bias cognitions, in 60 gamblers

Table 2.6. Group-level regression of roll-time *β*-values (for the value of bets) from the single participant GLMs against age, and gambling cognitive and behavioural traits in 60 gamblers

	B	SE *B*	*β*
Constant	0.14	0.06	
Age	<-0.01	<0.01	-.27*
Gambling losses (past year)	0.02	0.02	.14
Near-miss chasing traits/CHQ	0.02	0.01	.33*
Gambling expectancies/GRCS	-0.01	<0.01	-.33*

Note: R^2 = .18 (*p*< .05); **p* < .05; CHQ - Chasing Questionnaire (O'Connor & Dickerson, 2003); GRCS - Gambling-related cognitions scale (Raylu & Oei, 2004a).

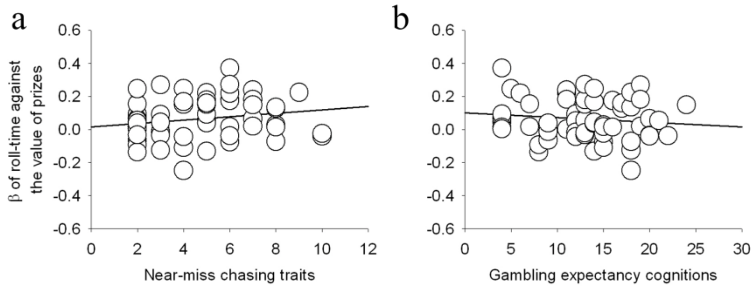


Figure 2.4. Associations between die-roll times (logarithm milliseconds) and value of prizes as a function of: (**a**) score on the CHQ measure of chasing near-misses (O'Connor & Dickerson, 2003) and (**b**) score on the gambling expectancy subscale of the GRCS (Raylu & Oei, 2004a).

Critically, the characteristics of gamblers moderated the extent to which their die-rolling behaviours were influenced by gamble features. Controlling for gambling losses (*t*< 1.02), gamblers who reported stronger tendencies to chase near-misses while gambling allowed the die to roll for significantly longer when attempting to win larger value bets (*t*(59)= 2.20, *p*< .05; See Table 2.6 and Figure 2.1(c)). In contrast, gamblers who had higher scores on the gambling expectancies sub-scale of the GRCS (and had higher expectations about the positive effects of gambling for mood and/or well-being; *t*(59)= -2.23, *p*< .05), as well as older gamblers (*t*(59)= -2.10, *p*< .05), significantly reduced their die-roll times when attempting to win larger value bets (see Table 2.6). Individual gamblers' β-values for die roll-times against the value of bets plotted as a function of scores on the CHQ (near-miss) subscale are shown in Figure 2.4(a). Individuals' β-values for die roll-times against the value of bets plotted as a function of scores on the GRCS (gambling expectancy) subscale are shown in Figure 2.4(b).

2.5 Discussion

My findings demonstrate that the way people roll a die for monetary prizes is influenced by features of the gambles that they elect to play as well as their beliefs about gambling. Participants in the experiment reported a broad range of gambling participation in commercial gambling activities. Survey data report that over 50 % of the United Kingdom adults have gambled within the last year excluding the National Lottery (Wardle, et al., 2010), with similar rates across Western Europe. Therefore, my findings suggest that gambling-related cognitive biases influence the motor expression of gambling behaviour in a broad gambling population and are not confined to those who gamble heavily or who report gambling problems.

I acknowledge that the operationalization of die-rolling in this experiment as the computer-simulated roll of a single die necessarily limits the relevance of my findings for understanding the full richness of cognitive biases in commercial gambling games, such as craps, that employ multiple dice and afford opportunities to throw dice in different ways to achieve different game outcomes (Henslin 1967). Such commercial games also allow gamblers opportunities to influence game outcomes through other forms of interaction with the dice (rubbing or talking/whispering), reflecting superstition. Nevertheless, the computer-simulated rolls of a single die provided a single dependent measure that reflected psychometric measurements of *illusions of control* (IOCs) (Koehler, et al., 1994) which could be used to test the operation of cognitive biases when gamblers use dice to play gambling games.

2.5.1 Die-rolling behaviour, outcome value, and stimulus–response (S-R) compatibility

These results inform the understanding of gambling-related cognitive biases in several complementary ways. First, my finding that gamblers allowed the computer-simulated die to roll for longer when attempting to win higher value prizes compared to lower value prizes is directly analogous to naturalistic observations that street-side and casino gamblers throw dice in different ways in order to achieve different outcomes (Davis, et al., 2000; Henslin, 1967). Previous experiments show that the induction of stress can induce preferences for gambling activities that afford IOCs as a coping mechanism (Friedland, et al., 1992); while outcomes with higher incentive-value can enhance preference for actual physical involvement in the resolution of uncertain prospects (Biner, Huffman, Curran, & Long, 1998). My findings go significantly further by indicating that even apparently simple gambling actions, such as the universal act of rolling dice, familiar to everyone in commercial gambling games and family board games, can also express the monetary value of gambling outcomes.

In addition, gamblers allowed the die to roll for significantly longer when attempting to hit larger winning numbers (5,6 or 4,5,6 or 3,4,5,6 or 2,3,4,5,6) compared to smaller winning numbers (1,2 or 1,2,3 or 1,2,3,4 or 1,2,3,4,5). This is reminiscent of observations amongst some dice game players that harder (and longer) dice rolls tend to produce larger (face) value outcomes (Henslin, 1967). The observations that die-roll times were coupled to both the value of bets and magnitude of winning numbers is consistent with evidence that aspects of numerical processing have embodied cognitive substrates (Domahs, Moeller, Huber, Willmes, & Nuerk, 2010; Walsh, 2003), including shared representations of number and action repertoires (Andres, Davare, Pesenti, Olivier, & Seron, 2004; Dehaene, Bossini, & Giraux, 1993). Here, I found that certain stimulus configurations, such as large or small winning die numbers, more easily elicited motor actions that share relevant dimensional features; in this instance, magnitude and duration of die-roll (Kornblum, et al., 1990). My results also show that this kind of stimulus–response compatibility effect can actually increase gambling involvement because gamblers in the study elected to gamble and roll the die, rather than forfeit the buy-in, more frequently when trying to roll larger winning numbers (see Table 2.2).

2.5.2 Die-rolling behaviour and gambling-related cognitions

The durations of die-rolls were also sensitive to characteristics of the gamblers playing the die-rolling game. In the first instance, individuals who reported stronger IOCs, as measured by the IOC subscale of the GRCS (Raylu & Oei, 2004a), tended to allow the die to roll for longer than gamblers who reported weaker IOCs. The IOCs subscale includes statements such as 'Specific numbers and colours can help increase my chances of winning' and 'I have specific rituals and behaviours that increase my chances of winning'. These statements identify charms or actions that gamblers believe enhance the likelihood of winning outcomes in gambling games. Gamblers who actively handle dice tend to report more confidence in the eventual delivery of winning outcomes in gambling games (Burger & Cooper, 1979; Davis, et al., 2000; Fleming & Darley, 1990; Golin, et al., 1977; Strickland, et al., 1966). Therefore, my findings suggest that stronger IOCs are linked to the tendency to modulate dice rolls as a putative form of control over gaming outcomes. By contrast, I also found that die-roll times tended to be shorter in gamblers with higher scores on the 'interpretive bias' sub-scale of the GRCS (Raylu & Oei, 2004a). In contrast to the IOCs subscale, the interpretive bias subscale include statements such as 'Relating my losses to bad luck and bad circumstances makes me continue gambling' and 'Relating my losses to probability makes me continue gambling'. These statements capture beliefs that losing (but not winning) gambling outcomes can be explained away through the intervention of chance or events beyond the gambler's control.

Thus, the association between higher interpretive bias scores and shorter die-rolls may also reflect gamblers' perceived personal control over gambling outcomes. Moreover, my findings that gamblers' IOCs over gambling outcomes tended to increase die-roll times while their interpretive bias (that rationalises gambling losses away) tended to decrease them constitutes divergent validity for the proposal that gambling-related cognitive distortions serve to shape gamblers' motor behaviours while throwing dice for monetary prizes, possibly reflecting embodied substrates (Wilson, 2002).

2.5.3 Die-rolling behaviour, outcome value and gambling-related cognitions

Finally, my findings also showed that gamblers' self-reported tendency to continue gambling or increase their betting after the experience of almost-winning in gambling games ('near-misses') was associated with tighter coupling of roll times to bet (or prize) values in the game. An important experimental tradition suggests that, under some conditions, near-misses can prolong gambling behaviour (Dixon & Schreiber, 2004; Griffiths, 1990; Kassinove & Schare, 2001), possibly by enhancing gamblers' expectations of winning outcomes (Reid, 1986). Here, gamblers who responded positively to near-miss outcomes by 'chasing' tended to let the die roll for longer when attempting to win higher value bets, suggesting sensitivity to near-misses is associated with stronger expressions of outcome value in the motor actions of gambling games.

Conversely, gamblers who expected more positive emotional benefits from gambling in terms of mood and well-being, as measured by the *gambling expectancies* subscale of the GRCS (Raylu & Oei, 2004a), tended to shorten their die-roll times on plays with large bets. The gambling expectancy subscale includes statements such as 'gambling makes me happier' or 'having a gamble helps reduce tension and stress'. These statements identify individuals who tend to gamble to regulate their emotional states, which is associated with severe gambling problems in at least some gamblers (Blaszczynski & Nower, 2002). Thus, my data suggest that the way that individuals who gamble to regulate their mood throw dice for monetary prizes is less sensitive to the monetary value of gambling outcomes, presumably reflecting the predominance of emotional rather than financial gambling motivations. Collectively, the data suggest that particular complexes of gambling-related biases and cognitions (e.g., chasing near-misses vs heightened gambling expectancies) can have opposing effects on the way individuals roll dice in response to specific features of gambling games.

To my knowledge, this is the first experimental demonstration that dice-rolling behaviours express both the incentive-value of gambling outcomes and cognitions that enhance or sustain gambling participation. Further work needs explore its use in clinically pathological samples. Nevertheless, this method moves us beyond traditional self-report, wagering and choice measures, and introduces motor behaviours in gambling games as expressions of, possibly, embodied gambling-related cognitive biases and motivations. Therefore, these results point to new ways of measuring cognition biases as risk factors for gambling problems.

The current die-rolling paradigm using computer mouse button clicks involves only simulated motor behaviours, limiting the repertoire of motor actions in which IOCs can be instantiated. To address this issue of validity and to enhance the realism of the laboratory preparation, Study 2 introduced a *die-shaking* approach where gamblers' waving of a computer mouse are used to simulate the shooting of a real die.

Chapter 3.

Shaking dice to win prizes – Study 2

3.1 Introduction

40 years on from the seminal work of Langer (1975), the *illusions of control* (IOC) remains a prominent research target in the study of human action contingency (Blanco, et al., 2011), and more specifically, the development and maintenance of problematic patterns of gambling in vulnerable individuals (Joukhador, et al., 2004; Oei, et al., 2007, 2008; Raylu & Oei, 2004a). IOC cognitive biases include beliefs that one possesses sufficient knowledge, or skill, to actively manipulate outcomes in games of chance (Langer, 1975). In particular circumstances, IOC biases can also take on a luck-oriented quality that appropriates the use of lucky rituals, objects, and environments, to promote winning outcomes (Raylu & Oei, 2004a; Rothbaum, et al., 1982).

During this time, investigators have devised a number of ways to explore IOCs. Questionnaire measures provide psychometric assessments, that successfully separate IOCs from other gambling-related cognitive biases (Raylu & Oei, 2004a; Steenbergh, et al., 2002), as well as distinguishing between samples with and without gambling problems (Joukhador, et al., 2004; Oei, et al., 2007, 2008; Raylu & Oei, 2004a). These methods reflect the conceptualisation of IOC as mental structures that represent stable (non-veridical), but more or less explicit, beliefs about personal agency within gambling games. However, questionnaires do not tell us much about how these beliefs influence gambling behaviour in either laboratory or commercial games.

More direct methods of finding out how IOCs relate to gambling games involve 'think-aloud' techniques. In these studies, experimental participants are invited to provide verbal reports of the thoughts that come to mind whilst playing gambling games (Delfabbro & Winefield, 1999, 2000; Griffiths, 1994; Ladouceur, et al., 1991; Walker, 1992). These 'online' reports are then analysed for content indicative of IOCs and have successfully captured in-play gambling cognitive biases as they are experienced during gambling games. Other related measurements of IOC include gamblers' ratings of their perceived control, skill and winning confidence (Biner, et al., 1995; Gino, et al., 2011; Golin, et al., 1977; Ladouceur & Mayrand, 1987).

Like questionnaire measures, these 'thinking-aloud' and rating methods limit their assessments to explicit cognitions (biases and otherwise) and loosely-articulated impressions that are available to conscious awareness.

By contrast, other experiments that conceives of IOC in behavioural terms, has circumvented these limitations. These include decision-based measures like betting and wagering strategies (e.g., Bouts & Vanavermaet, 1992; Burger, 1986; Davis, et al., 2000; Gilovich & Douglas, 1986), or the selling of chosen lottery tickets (Langer, 1975) following manipulations that heighten or diminish IOCs in experimental participants. Otherwise, they are measured using performance-based indicators such as post-reward latencies (Martinez, Le Floch, & Gaffie, 2005), as well as action repertoires that promote personal agency in the derivation of game outcomes (e.g., the applying of brakes to a spinning roulette wheel or to slot machine reels; Friedland, et al., 1992; Ladouceur & Sevigny, 2005).

More recently, it has been demonstrated that inducing motor inhibition in a ‘go/ no go’ task can reduce risks-taking is a separate game that got participants to make risky choices under time constraints (Verbruggen, et al., 2012). In light of the close link between motor control and gambling choices that reflect IOC, I have explored the possibility of extending this behavioural conceptualisation of IOCs by investigating how IOCs might be observable in the selection and expression of motor actions within games of dice (Lim, Bowden-Jones, & Rogers, 2013). Dice-throwing behaviours are useful for these purposes as they allow for gradations in motor biases to be studied, and are familiar response features of many gambling games like Craps, and non-gambling games like Backgammon and Monopoly (it is familiar to recall how family members shake dice harder when trying to achieve double sixes). Previous studies suggest that using dice-throwing behaviours have added benefits because it can facilitate stronger IOC in participants. Where participants are given the prospect rolling a dice themselves (Burger & Cooper, 1979; Friedland, et al., 1992; Golin, et al., 1977; Strickland, et al., 1966), or vicariously (Fleming & Darley, 1990), they tend to bet more frequently, prefer high risk options, and endorsed higher ratings of winning confidence, compared to participants who did not have this instrumental prospect. In an ecological valid sample, the discreet recording of actual betting behaviours in casino Craps gamblers confirmed that they tended to bet more frequently, and on riskier options, on their turn to throw the dice, compared to when the dice was thrown by someone else (Davis, et al., 2000).

In Study 1, I extended these data by showing that individuals with a range of gambling habits allowed a computer-simulated single 'fair' die to roll for longer when trying to 'hit' larger winning numbers or win larger value bets (Lim, et al., 2013). This was the first experimental evidence to support observational reports where back-alley and casino Craps gamblers expressed IOCs in their dice-throwing behaviours where they rubbed, blew, knocked, and even, talked to their dice (Davis, et al., 2000; Henslin, 1967).

In the present study, I sought to take this motor paradigm of IOC a step further by demonstrating that these cognitive biases are apparent in actions that more closely approximate actual dice-rolling (i.e., die-shaking). To develop and validate an experimental model of IOCs as expressed in motor behaviours, I deliberately limited the study to a simple, tractable and common belief amongst gamblers – that is, 'a hard throw produces a large number, and a soft or easy throw produces a low number' (Henslin, 1967, p.319).

I invited gamblers to play a computerized game where they had the opportunity to throw a single animated die to win small prizes by shaking a standard computer mouse. A single die was used here because previous studies suggest that throwing multiple dice at once (30 in this case) can diminish the IOC (Koehler, et al., 1994). I wished to test the hypothesis that gamblers' die-shaking patterns will respond to changing game events. In particular, gamblers would shake a die with greater intensity for larger targets and gentler for smaller targets. Additionally, these motor response biases would be stronger in gamblers who readily identify with statements about the use of ritual and charms, as measured by the IOCs sub-scale of the Gambling-related Cognitions Scale (Raylu & Oei, 2004a).

3.2 Methods

Table 3.1. Descriptive statistics of 55 participants from the community

	Mean (*SD*)	*N* (%)
Age	31.69(11.14)	
Non-verbal IQ/Ravens	50.65(7.40)	
Past year gambling losses		
≤ £10		25.00(45.40)
£11 - £100		21.00(38.20)
> £100		9.00(16.30)
Gambling-related Cognitions Scale/GRCS		
Gambling expectancies	12.33(5.04)	
Illusions of control	8.18(5.19)	
Predictive control	17.07(6.23)	
Perceived inability to stop	8.80(5.59)	
Interpretive control/bias	12.45(5.37)	
Total score	59.25(21.04)	
Gambling Beliefs Questionnaire/GBQ		
Luck and perseverance	66.02(12.48)	
Illusion of control	30.89(9.25)	
Total	96.91(19.00)	

Note: Ravens = Non-verbal IQ on the Raven's Progressive Matrices (Raven, 2000); Gambling problems = Number of endorsed gambling problems on the National Opinion Research Centre DSM IV Screen (NODS; Wickwire, et al., 2008); GRCS = Gambling-related Cognitions Scale (Raylu & Oei, 2004a); GBQ = Gambling Beliefs Questionnaire (Steenbergh, et al., 2002).

3.2.1 Participants

A community sample of 55 participants (47 males and 8 females) was recruited using online advertisements and posters in various pubs around Oxford city district. None of these participants were recruited for the previous study. The experiment was approved by the Central University Research Ethics Committee (CUREC) of the University of Oxford. All participants gave written informed consent.

Participants were screened using the Structured Clinical Interview for the DSM-IV to ensure an absence of any current psychological disorders (SCID; First, et al., 2002). Twenty-seven participants (49.1%) reported gambling at least once a week within the past year, eleven (20.0%) gambled between 1-3 times a month, and the remaining seventeen (30.9%) gambling a few times or less. The mean number of past year gambling problems reported was 0.71 (range= 0-4), as measured with the National Opinion Research Centre Gambling DSM-IV Screening instrument (NODS; Wickwire, et al., 2008). Therefore, my results provide new information about IOCS in the context of broadly non-clinical patterns of gambling behaviour (see Table 3.1).

3.2.2 Procedure and psychometric questionnaires

On arrival at the laboratory, gamblers completed an assessment of nonverbal cognitive ability using Raven's Progressive Matrices (Raven, 2000), and were assessed with the Gambling-Related Cognitions Scale (GRCS; Raylu & Oei, 2004a). Gamblers then played a practice version of the die-shaking game to get acquainted with shaking a die using a computer mouse. When judged competent with the mouse, participants completed the die-shaking game proper. Following the experiment, gamblers were debriefed, and paid and thanked for their participation.

Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a). This is a 23-item trait questionnaire with a 5-factor structure has been described in Study 1. In this sample, the total score on the GRCS and the *illusions of control* subscale had good internal reliability, Cronbach's $\alpha > .76$. The *predictive control* subscale had poor reliability, Cronbach's $\alpha=$ .56, whilst the remaining subscales had moderate to good reliability with Cronbach's α values between .65 and .82.

3.2.3 Die-shaking game

Participants were given a computer mouse and asked to shake and roll a 6-sided, simulated die on a screen for monetary prizes. Figure 3.1(a) shows a typical sequence of events for one play. Participants were shown an array of the standard 6 die faces arranged from left-to-right. They heard an aural indication of the target for the current play, and the participant ('shooter') was then required to acknowledge the announced target by clicking on the corresponding die face. Following this, the shooter was given the opportunity to shake and throw a simulated die using a standard computer mouse: the participant used the left button of the mouse to pick the die; he/she shook the dice by moving the mouse rapidly from side-to-side (allowing the die to spin through an animation on the display). Finally, the shooter 'threw' the die by releasing the left-button click, setting into motion a throwing sequence where the animated spins of the die slows down to reveal the play outcome.

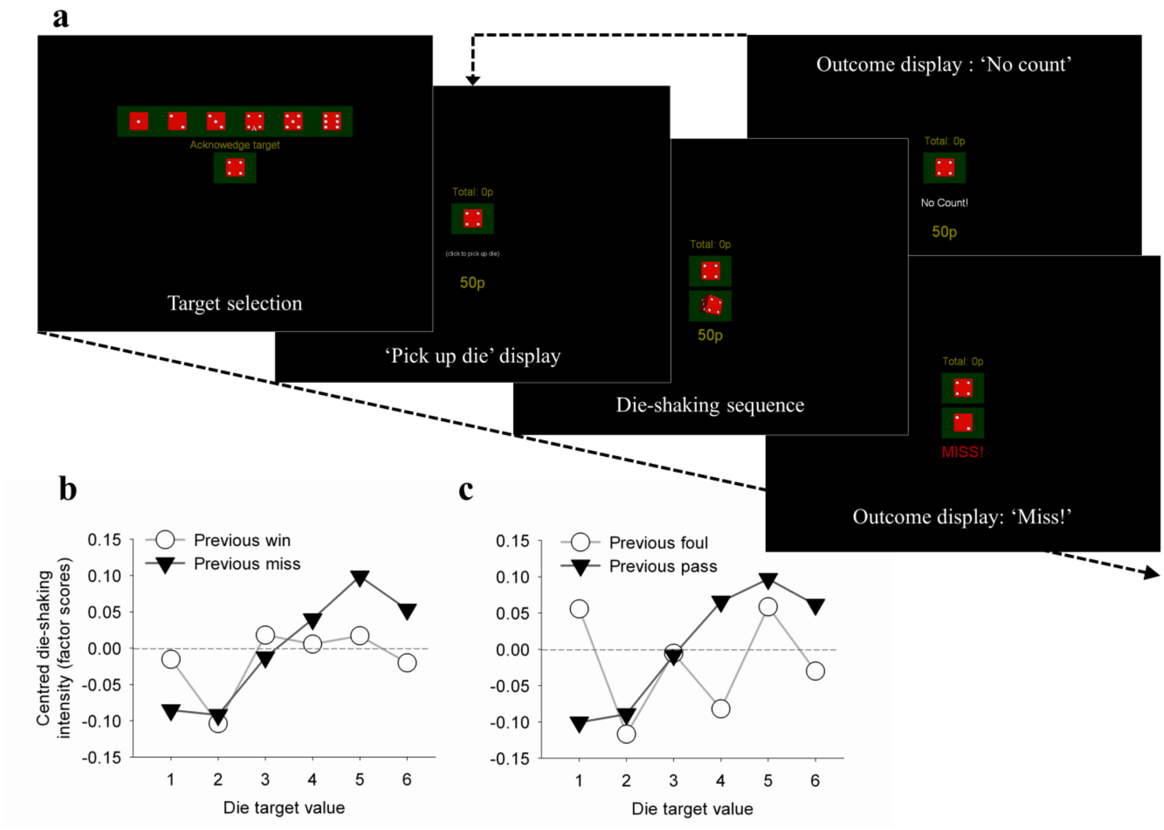


Figure 3.1. (**a**) Example display for one play of the die-shaking game. On this play, the shooter is given the opportunity to win 40p by achieving the target number 4. In the lower instance, the toss is counted and the number 2 is achieved, so the shooter does not win the prize. In the upper instance, the toss is not counted and the shooter is given as many attempts as necessary to obtain a shake that passes (the criteria for a foul throw are described in the methods); (**b**) Shooter centred die-shaking intensity (factor scores) as a function of dice target values and grouped by immediately preceding wins or misses; (**c**) Shooter centred die-shaking intensity (factor scores) as a function of dice target values and grouped by immediately preceding foul or passing tosses

Pilot testing with 6 participants showed that participants sometime 'threw' the die using idiosyncratic methods: using circular hand motions, unidirectional sweeps of the hand, or releasing the die without shaking it. To reduce this variability, a 44cm x 19 cm mouse pad was provided and a new feature of 'foul' plays was added to the game. Any single play was called a 'foul' throw whenever the die was thrown with any of the following : (i) unidirectional sweeps (i.e., hand movement of less than 40 screen units in either direction on the x-axis); screen units were defined by splitting the width and height of the display into 3000 divisions each; (ii) overly quick or extended shakes (i.e., 'holding' the die for less than 500ms or over 7000ms); (iii) intermittent shakes (i.e., where the movement on the x-axis stops for periods of longer than 340ms any time after die had been 'picked up'). Every time a shooter fouled, a white-coloured 'No Count!' message was displayed and shooters were given the opportunity to roll again for that play. The shooter was given as many repeat attempts as necessary to complete any of the 60 plays (Mean number of fouls per participant = 11.47 (19.11%), *SD*= 8.81, Range= 0.0 -36.0)

If the shooter hit the target winning number, a blue-coloured 'WIN 50p!' text was displayed and accompanied with auditory feedback of a coin hitting a table. Alternatively, if the die landed with a number other than the winning number, a red-coloured 'MISS!' text was displayed, accompanied with auditory feedback of a losing jingle; there was no monetary loss associated with missing targets. The game came to an end when the shooter completed all 60 plays (10 plays for each die face as winning target). The frequency of winning outcomes approximated the actual contingencies of a fair die (1 in 6 plays), where 10 wins were randomly distributed within these 60 plays, so that every participant won 500 pence (10 x 50 pence) by the end of the game.

Before starting, participants were assured that the rolled die was fair and that winning outcomes from this game would be added to their attendance fee.

3.3 Data Analysis

Our game afforded 5 indices to characterise the motor features of each shake of the computer-simulated die. These included: (i) *die-shake time* – length of time (in milliseconds) that gamblers shook the die; (ii) *hand displacement* – screen displacement of the (invisible) mouse cursor; (iii) *complete hand waves* – number of oscillation cycles of the mouse cursor; (iv) *average amplitude* – mean screen displacement between the starting cursor position and the maximum point of each wave for each die-shake; and finally (v) *release speed* – screen displacement divided by time in the last 32ms of each shake.

I tested a hierarchy of powers to find the best transformation by which to normalise each of the above motor indices. An exponential of -½ (followed by an inverse function to correct for the sign change) was used for index (i), natural logs for indices (ii), (iii) and (v), and an exponential of ½ for index (iv). Shooters' mean values on all 5 indices were then submitted to a Principle Component Analysis (PCA) using a direct oblique rotation method, in order to identify any correlating underlying factor(s) in the data. Factor extraction was based on the inflection point of the eigenvalue scree plot and a Kaiser's criterion of 1.

Modelling gamblers' die-shaking behaviour was completed in 2 further stages. First, factor scores from the above PCA were computed for each play. Multilevel regressions with play-level factor scores as dependent variables were then regressed against game features as predictors; shooters were added as a 2^{nd} level grouping (random) variable. Game features included: (i) the play number to account for fluctuating engagement across plays of the game (1 to 60); (ii) shooter's winning number (1 to 6); (iii) immediate preceding outcome (1, previous win; 0, previous miss); (iv) immediate preceding foul (1, previous shake was void; 0, previous shake was counted). Additional analyses tested (v) the interaction between shooters' target values and the immediate preceding play outcome; and (vi) the interaction between shooters' target size and immediate preceding foul. Using the above variables, 4 multilevel models with this increasing complexity were estimated. Model 1 is a basic model with shooters as a random intercept term and no further predictors. In model 2, regressors (i) to (iv) were added to the basic model. In model 3, the slopes (or coefficients) of regressors (i) and (ii) were allowed to vary across shooters. Finally, in model 4, in interaction regressors (v) and (vi) were added. Significant fixed and random effects were determined by one-sample t-tests and changes to the -2×loglikelihood statistic respectively.

Second, the random coefficients of regressor (ii) from the multilevel model 3 were regressed against gamblers' total scores on the GRCS and the illusions of control subscale, with the inclusion of age, sex, past year gambling problems, and non-verbal IQ as covariates.

3.4 Results

3.4.1 Principle Component Analysis (PCA) of die-shaking indices

PCA of the die-shaking indices revealed that the die-shaking indices *average amplitude* (individual item Kaiser-Meyer-Olkin (*KMO*) value= .33) and *release speed* (individual item KMO= .39), were poorly correlated with the other die-shaking indices and were removed from the analysis (i.e., poor factorability). I repeated the PCA with the remaining three die-shaking indices (i.e., *die-shake time*, *hand displacement*, and *complete hand waves*) and verified a sampling adequacy for these indices (overall *KMO*= .72; all individual item *KMO*> .69). All correlations between variables were substantial, suggesting that the 3 remaining die-shaking indices shared an underlying dimension (Barlett's test of sphericity, χ^2 (3)= 64.79, p< .001). Conversely, these correlations were not so high that the multicollinear assumptions of PCA were violated (Haitovsky's $\chi^2_H(3)$= 17.79, p< .001). With the Kaiser's criterion set to 1, the analysis revealed a 1-factor solution that explained 76.08% of the variance. The scree plot confirmed this with an inflexion that would suggest a 1-factor structure in the data (see Figure 3.2). The loading of the 1-factor solution after rotation can be found in Table 3.2. The indices *die-roll time*, *hand displacement*, and *complete hand waves* all loaded more or less equally onto the single component labelled *die-shaking intensity*.

Table 3.2. Summary of Principle Component Analysis (PCA) results for the die-shaking indices in 55 participants

Items	Rotated Factor Loadings
	Factor 1: Die-shaking intensity
Duration of roll	.89
Distance of movement	.87
Number of complete hand waves	.85
Eigenvalues	2.28
% of variance	76.08
Cronbach's α [a]	.84

Note: Factor loadings over .60 are in bold; [a] z-scores of die-shaking variables were used for this analysis because indices were of different scales.

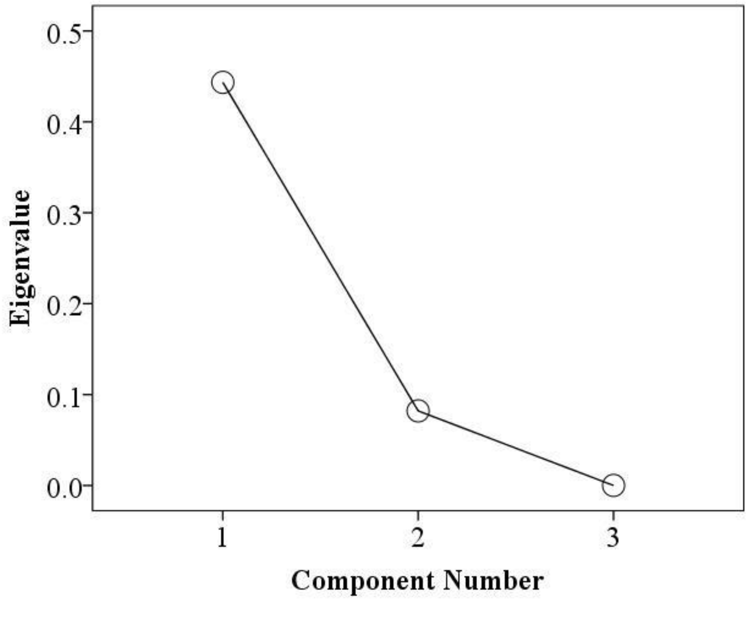


Figure 3.2. Scree plot indicating a 1-factor solution for the Principal Component Analysis (PCA) of the die-shaking indices

3.4.2 Multilevel models of die-shaking against game features

As seen from Table 3.3, the inclusion of games features as regressors in Model 2 improved its fit compared to the intercept-only Model 1 (Δ-2×loglikelihood= 185.55, Δ df= 6, *p*< .0001). In model 2, I found that shooters increased their die-shaking intensity when trying to hit larger target values as opposed to smaller target values (coefficient= 0.033, SE= 0.006, *z*= 5.50, *p*< .0001; see Figure 3.3). However, shooters were not more likely to alter their die-shaking intensity following winning compared to losing outcomes (coefficient= -0.013, SE= 0.029, *z*= 0.45, *p*= .33) or fouls (coefficient= -0.025, SE= 0.029, *z*= 0.86, *p*= .19).

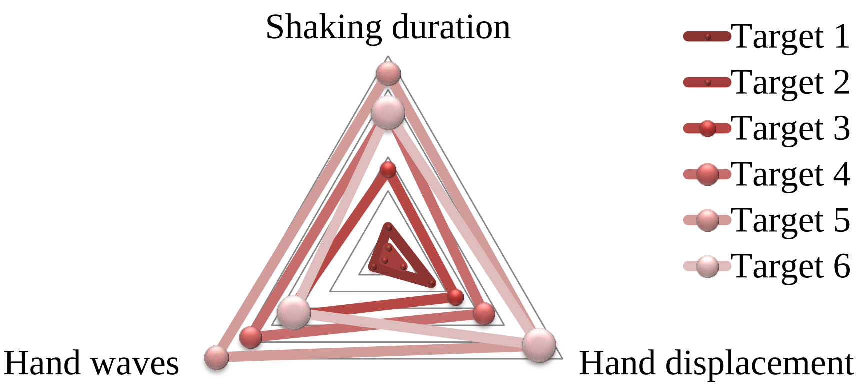


Figure 3.3. Spider plot of shooter centred z-scores for dice-shaking duration (exponentially transformed milliseconds), complete hand waves (log transformed number of waves), and hand displacement (log transformed screen units) as a function of winning target value (1 to 6)

Table 3.3. Multilevel regression model of die-shaking factor scores against game features in 55 participants

Regressors	Model 1 B(SE)	Model 2 B(SE)	Model 3 B(SE)	Model 4 B(SE)
B_0: Constant	-0.005(0.108)	-0.048(0.112)	-0.039(0.133)	-0.071(0.134)
B_1: Play no.	-	-0.002(0.001)*	-0.002(0.002)	-0.002(0.002)
B_2: Shooter's target	-	0.033(0.006)****	0.030(0.006)****	0.040(0.007)****
B_3: Previous win	-	-0.013(0.029)	-0.007(0.027)	0.085(0.060)
B_4: Previous foul	-	-0.025(0.029)	-0.032(0.027)	0.058(0.059)
B_5: Shooter's target x Previous win	-	-	-	-0.027(0.016)*
B_6: Shooter's target x Previous foul	-	-	-	-0.026(0.015)*
Random intercepts (means)	u_{0j}****	u_{0j}****	u_{0j}****	u_{0j}****
Random coefficients (slopes)	-	-	u_{1j}****, u_{2j}	u_{1j}****, u_{2j}

Note: *p< .05; **p< .01; ***p< .001; ****p< .0001; Significance of fixed and random effects are determined by a normal and χ^2 distribution respectively; Play no. = Play number to account for fluctuating engagement across plays of the game; Shooter's target = Shooter's target size (i.e., 1 to 6); Previous win = Immediate preceding outcome (1, previous win; 0, previous miss); Previous foul = Immediate preceding foul (1, previous shake was void; 0, previous shake was counted); Shooter's target x Previous win = Interaction between shooter's target size and the immediate preceding outcome; Shooter's target x Previous foul = Interaction between shooter's target size and immediate preceding foul; Subscript numbers = fixed effects; Subscript letters = random effects; u = Shooter-level regression residuals.

Additionally, the inclusion of random coefficients for play number and target winning numbers in Model 3 further improved the model's fit with the die-shaking data compared to Model 2 (Δ-2×loglikelihood= 440.90, Δ df= 5, *p*< .0001). In this model, shooters demonstrated no significant variability in their tendency to increase their shaking-intensity when attempting to obtain large die target values (σ^2_{u2}; Δ-2×loglikelihood= 1.73, Δ df= 3, *p*= .63). However, there was significant variability across shooters in their mean (intercept) die-shaking intensity (σ^2_{u0}; Δ-2×loglikelihood= 2915.28, Δ df= 1, *p*< .0001), and their die-shaking intensity as the game progressed (σ^2_{u1}; Δ-2×loglikelihood= 441.85, Δ df= 2, *p*< .0001).

Adding the interaction terms in Model 4 revealed that participants tended to increase the intensity of their die-shaking when trying to 'hit' larger target values immediately following losing outcomes compared to winning outcomes (coefficient= -0.027, SE= 0.016, *z*= 1.69, *p*< .05; see Figure 3.1(b)). Conversely, this behavioural tendency to increase die-shaking intensity when trying to 'hit' larger target values was reduced following disallowed foul throws (coefficient= -0.026, SE= 0.015, *z*= 1.73, *p*< .05; see Figure 3.1(c)). However, by contrast, shaking intensity was not significantly influenced by the number of plays across the game (coefficient= -0.002, SE= 0.002, *z*= 1.00, *p*= .16), indicating that there was no overall disengagement pattern as the game progressed.

3.4.3 Die-shaking and gambling cognitions

Controlling for sex, non-verbal IQ, and past year gambling problems (all |*ts*| < 1.68), I found that shooters' endorsements of gambling-related cognitive biases on the GRCS significantly predicted their tendency to increase their die-shaking intensity to achieve larger dice target values (β= .30, *t*= 2.11, *p*< .05; see Table 3.4). Younger shooters were also more likely to express this behaviour when trying to hit higher targets (β= -.35, t= -2.68, p= .01).

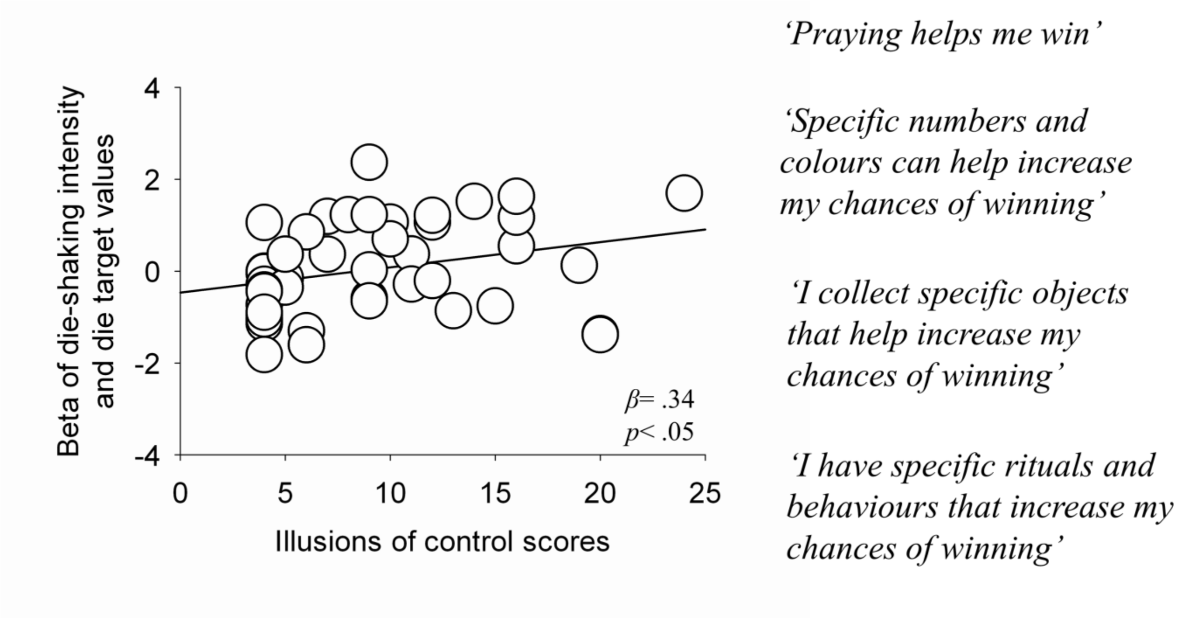


Figure 3.4. Plot of the relationship between participant-level *B*-values (for shooter's target values) against illusions of control cognitions, as measured by the Gambling-related cognitions scale (GRCS; Raylu & Oei, 2004a), after removing 7 participants who scored -1 S.D. lower than the mean GRCS total score of this sample; items on the illusions of control subscale are printed on the right

Table 3.4. Group-level regression of participant-level *B*-values (for shooter's target values) against gambling-related cognitions as measured by the GRCS, controlling for age, sex, non-verbal IQ and past year gambling problems in 55 participants

	B	SE *B*	β
Constant	1.26	1.15	
Age	-0.03	0.01	-.35*
Sex	0.48	0.37	.17
Non-verbal IQ/Ravens	-0.03	0.02	$-.22^{+}$
Past year gambling problems	-0.04	0.14	-.04
Total score/GRCS	0.02	0.01	.30*

Note: R^2 = .50 (p< .05); Ravens – Raven's Progressive Matrices (Raven, 2000); Past year gambling problems - National Opinion Research Centre DSM IV Screen (NODS; Wickwire, et al., 2008); GRCS - Gambling-related cognitions scale (Raylu & Oei, 2004a).

Table 3.5. Group-level regression of participant-level *B*-values (for shooter's target values) against illusions of control cognitions as measured by the GRCS, controlling for age, sex, non-verbal IQ and past year gambling problems in 55 participants

	B	SE *B*	β
Constant	1.86	1.04	
Age	-0.03	0.01	-.37**
Sex	0.75	0.38	$.26^{+}$
Non-verbal IQ/Ravens	-0.04	0.02	-.28*
Past year gambling problems	-0.02	0.14	-.02
Illusions of control/GRCS	0.06	0.03	.33*

Note: R^2 = .51 (p< .01); Ravens – Raven's Progressive Matrices (Raven, 2000); Past year gambling problems - National Opinion Research Centre DSM IV Screen (NODS; Wickwire, et al., 2008); GRCS - Gambling-related cognitions scale (Raylu & Oei, 2004a).

Similar results were obtained using the IOC subscale of the GRCS. Controlling for sex and past year gambling problems (all $|ts| < 1.98$), I found that shooters' endorsements of IOC significantly predicted their tendency to increase their die-shaking intensity to achieve larger dice target values (β= .33, t= 2.36, p< .05; see Table 3.5). Younger shooters (β= -.37, t= -2.93, p< .01) and those scoring lower non-verbal IQ (β= -.28, t= -2.20, p< .05) were also more likely to increase die-shaking intensity for larger winning targets. To be sure that these associations were not artefacts of low scores on the IOC sub-scale in some shooters, I repeated the analysis but removed 7 participants who scored < 1 S.D. below the mean GRCS total score of this sample. This test replicated the significant relationships between IOC and the behavioural bias of linking higher target winning numbers and shooters' shaking intensity (β= .34, t= 2.26, p< .05; see Figure 3.4).

3.5 Discussion

Consistent with previous observations (Davis, et al., 2000; Henslin, 1967; Lim, et al., 2013), this experiment provides experimental evidence that gamblers shake an animated die with greater intensity when attempting to achieve larger dice target values, as opposed to smaller target. Additionally, I extend previous findings of isolated correspondences between target numbers and simulated die-roll times by capturing hand shaking movements in die-rolls. Finally, I also present here evidence for the validity of the behavioural method by showing that these numerically-primed behaviours were augmented following specific game events like losing outcomes and foul throws of the die. Critically, I showed that these action-based expressions of IOCs were heightened in gamblers who endorsed stronger IOC traits on the GRCS. In doing so, I demonstrate that that die-shaking behaviours function as a paradigmatic case to illustrate how the motoric behaviours of games can be appropriated to investigate in-play IOCs. Therefore, I propose that the motor behaviours afforded by gambling games are a promising area of enquiry where the instrumental prospects of games constrain how embodied IOCs develop and are expressed.

I acknowledge that the present results were obtained by measuring simulated, rather than actual, die-throwing behaviours using in a computerised game, and likely limited the kinds of dice-related IOC expressions observed amongst Craps players. This would have included blowing, rubbing and talking to dice (Davis, et al., 2000; Henslin, 1967). Nevertheless, I deliberately limited the ways in which gamblers could interact with the die because I wanted to identify the regular and experimentally tractable ways in which IOCs are expressed in motor actions. The current pattern of results suggests that this minimal case has been achieved. A further limitation is the possibility that my results do not generalize to non-gamblers. However, this is unlikely for 2 reasons: first, previous experiments have found that the induction of motor caution influences betting strategies in student samples (Verbruggen, et al., 2012); second, dice-rolling is a ubiquitous method for resolving uncertainty in family-board games. However, in order to check, future studies could confirm my findings by exploring the pattern of instrumental IOCs in non-gamblers.

3.5.1 Die-shaking biases as an expression of the IOC

Our finding that gamblers shake a die with greater intensity when attempting for larger target values is consistent with previous finding of shared cognitive representations involving the processing of numerical information and motor behaviour (Walsh, 2003). Just as hand grasping actions (or 'power grips') are executed faster and with more force when large numbers, rather than small numbers, are presented (Andres, et al., 2004; Lindemann, Abolafia, Girardi, & Bekkering, 2007), I find that motor behaviour was constrained by numeric processing. Thus, my findings suggest that the stimuli and response features of gambling games that have compatible or 'overlapping dimensions' (S-R compatibility; Kornblum, et al., 1990; Walsh, 2003), such as prize ladders on electronic gaming machines (EGMs; Parke & Griffiths, 2006), may also be involved in the development and expression of IOCs in at least regular but non-pathological gamblers.

Further support for the validity of these conclusions was found in the demonstration that the coupling of higher target values and shaking intensity was heightened following specific game events that enhance IOCs. I found that these behavioural biases were more pronounced after outcomes that have been found previously to increase motivations to win; for example, missing a target rather than 'hitting' it. This is consistent with previous reports of how IOCs, measured by increased betting behaviour, are enhanced when participants are given a greater incentive to win (i.e., by manipulation of anticipated or experienced physical pain; Biner, et al., 1995; Biner, et al., 1998; Friedland, et al., 1992). Additionally, the coupling of large dice target values and intense die-shaking diminished when gamblers were distracted from their focus on winning by the previous throw being ruled a foul. Fouled throws will have increased the shooters' attentional focus upon the real contingencies between behaviour and outcome; while allowed or 'no foul' throws may have fostered mistaken instrumental beliefs of control of the die by facilitating an 'implemental' frame of mind where the focus is upon winning (Gollwitzer & Kinney, 1989).

Critically, these numerically-primed behaviours likely reflected gamblers' beliefs in control since they were more pronounced in gamblers who also reported a tendency to hold magical beliefs in rituals (e.g., 'I have specific rituals and behaviours that increase my chances of winning') and charms (e.g., 'I collect specific objects that help increase my chances of winning'), as measured by the IOCs subscale of the GRCS (Raylu & Oei, 2004a). This finding provides strong face validity for my measure of gambling-related

IOCs in motor behaviour and helps account for the pervasive behavioural attempts to control fair dice outcomes (Davis, et al., 2000; Henslin, 1967).

3.5.2 Die-shaking biases and the study of IOC

The proposed motoric paradigm of IOC proposed here is the latest addition to an already strong tradition of research targeting both gamblers' and non-gamblers' IOCs more broadly. It complements psychometric methods that identify general structural characteristics of explicit GRCs biases (Raylu & Oei, 2004a; Steenbergh, et al., 2002) by assessing IOCs that are specific to games. It also goes beyond aggregative pre- and post-game ratings of control, confidence and skill (Biner, et al., 1995; Gino, et al., 2011; Golin, et al., 1977; Ladouceur & Mayrand, 1987) by assessing the dynamics of IOCs on each gambling play. It goes beyond indirect inferences of IOCs through gamblers' poor betting strategies (e.g., Bouts & Vanavermaet, 1992; Burger, 1986; Davis, et al., 2000; Gilovich & Douglas, 1986; Langer, 1975) by assessing IOC as instrumental actions that is directly observed. Finally, it goes beyond 'think aloud' methods that are uncharacteristic of gambling play (Delfabbro & Winefield, 1999, 2000; Griffiths, 1994; Ladouceur, et al., 1991; Walker, 1992) by assessing IOC in response characteristics that are more naturally afforded by the game under investigation.

Additionally, the current paradigm of using motor response features has unique value in that its action prospects can itself augment the psychological construct that it is designed to measure. Previous studies demonstrate that the mere prospect of rolling a dice is sufficient to induce in participants greater IOCs in terms of betting frequency and risk, and stronger winning confidence, compared to participants who did not have this instrumental prospect (Burger & Cooper, 1979; Davis, et al., 2000; Friedland, et al., 1992; Golin, et al., 1977; Strickland, et al., 1966); whilst the exercise of motor control can do the reverse of inducing more conservative playing strategies (Verbruggen, et al., 2012).

Future studies of IOC in gambling needs to recognise that specific games may 'embody' physical features and boundaries that influence the development of IOCs (Proffitt, 2006). The use of games of dice here is merely an illustration that supports the broader effort amongst researchers to study how the action features of specific games can facilitate the development and idiosyncratic expression of IOCs. For example, games that afford instrumental actions like the drawing, shuffling and dealing of cards (Chau & Phillips, 1995; Fernandez-Duque & Wifall, 2007), the throwing of a roulette ball and the braking of a roulette wheel (Friedland, et al., 1992), or the pressing of buttons and pulling of handles on a one-arm bandit machine (Ladouceur & Sevigny, 2005).

In conclusion, I used the behavioural features of games of dice to demonstrate the potential utility of motoric paradigms to study game-specific IOCs; when gamblers attempted for larger target values, they intensified their die-shaking vigour. These numerically-primed behaviours were heightened in gamblers who reported more structural cognitive traits for IOCs, and were most clearly observed following game events that increased motivations to win, and did not distract gamblers' focus on winning. Forty years on from Langer's (1975) seminal work, I propose here a promising complimentary method to advance the understanding of how IOCs are embodied within specific game contexts.

My die-shaking results here in Study 2 were broadly similar to the die-rolling patterns reported in Study 1: Gamblers lengthen die-rolls (or use more vigour) for larger die target values. In study 3, I take this a step further by exploring how structural characteristics of games facilitate the observed behavioural expressions of IOCs.

Chapter 4.

Rolling dice and congruent prize structures – Study 3

Study 3 used the behavioural dice paradigm developed in Study 1 and 2, and investigated here how GRCs emerge from the sensory-motor organisation of gambling games; specifically, how game features exploit sensory-motor cognitive systems to promote *Illusions of Control* (IOCs).

4.1 Introduction

Recent theorising about gambling behaviours has postulated that particular structural characteristics of gambling games could enhance the likelihood of gambling-related harm in vulnerable individuals (Ladouceur & Sevigny, 2005; Parke & Griffiths, 2006). This idea has also been discussed in the context of the addictive potential of video gaming (Stetina, Kothgassner, Lehenbauer, & Kryspin-Exner, 2011).

For example, structural features like stopping devices (Ladouceur & Sevigny, 2005) familiarity (e.g., Bouts & Vanavermaet, 1992), high speed, and aural feedback (Loba, Stewart, Klein, & Blackburn, 2001), have been demonstrated to strengthen subjective enjoyment and lengthen players' persistence within games. However, little is known about the psychological mechanisms that increase the risk of gambling-related harm brought through the operation of these game characteristics.

Cognitive perspectives of gambling behaviour emphasise that biased judgments about gambling games mediate the transition from controlled to uncontrolled heavy gambling

(Delfabbro, 2004; Toneatto, et al., 1997). Therefore, one mechanism that might allow game characteristics to enhance gambling involvement is the way that these characteristics foster erroneous beliefs about the game (and gambling more generally).

One particular set of cognitive distortions that might be altered by interactions with the game features are the illusions of control (IOC; Langer, 1975). These are mistaken beliefs about the actual contingencies for winning in games of chance (Ladouceur, 2004a; Wegner & Wheatley, 1999). Typically, in a broader-life context, IOCs can be beneficial, where a general sense of self-efficacy over events improves psychological wellbeing (reviewed in Leotti, et al., 2010). However, the operation of IOCs in gambling games may foster suboptimal decision-making (Langer, 1975).

Previous experimental studies have reported how the prospect of physical involvement in games can heighten IOC in individuals (e.g., Chau & Phillips, 1995; Fernandez-Duque & Wifall, 2007; Ladouceur & Mayrand, 1987; Frederic Martinez, et al., 2009). In gambling games of dice more specifically, IOC are sometimes articulated in explicit beliefs such as 'gentle rolls produce small numbers and hard rolls produce large numbers' (Henslin, 1967). Similar to how 10-pin bowlers lean their bodies sideways in attempt to direct their ball towards the pins at the end of the lane (Knuf, Aschersleben, & Prinz, 2001), gamblers perform an instrumental, but ineffectual, act of 'shooting' dice harder (or longer) hoping to guide dice towards their targets (Henslin, 1967). Observation confirms, for example, that casino craps players will place heavier bets, on riskier options, on their own rolls of the dice rather than on a betting partners' roll of the dice (Davis, et al., 2000).

In Studies 1-2, I used a simulated die-throwing game to show that regular, non-problematic gamblers allow a computer-simulated single fair die to roll or shake for longer when trying to 'hit' larger numbers compared to smaller numbers (Lim, et al., 2013). These findings are consistent with the proposal that IOCs probably depend upon overlaps or congruencies between the representation of information in games and its motor response features (Tucker & Ellis, 1998). In particular, the 'overlapping dimensions' of magnitude representations between the stimuli and response features of games of dice (S-R compatibility; Kornblum, et al., 1990; Walsh, 2003), may account for the behavioural attempts to control fair dice outcomes (Henslin, 1967). However, these findings do not tell us much about how *combinations* of game features influence motor behaviours in gambling game, or their role in the formation these IOCs.

To explore whether IOCs in simple die-rolling games develop from the 'embodied', S-R compatible structures of these games, I invited gamblers with light to moderate gambling involvement to roll a simulated single 6-sided die to 'hit' winning numbers for small monetary prizes. Reflecting previous findings (Henslin, 1967; Lim, et al., 2013), I hypothesised that gamblers would allow the computerised die to spin for longer when they were attempting to hit larger winning numbers, and that this motor expression of value is more pronounced in gamblers with strong beliefs in their ability to control game outcomes (i.e., IOCs).

I also hypothesised that these motor expression of value are strengthened where multiple game features have the some representational overlap with each other, and with motor actions. For example, some EGMs offer 'ladders' whose higher steps offer larger prizes (Parke & Griffiths, 2006). By contrast, these motor expressions of value will be reduced when game features of winning numbers and prize values are incongruent with each other. Accordingly, gamblers were assigned to 3 groups. In the 'congruent' group, participants rolled a single die where the winning numbers and prize values increased together (10p for rolling winning numbers of '1'…and 60p for rolling winning numbers of '6'); in the 'incongruent' group, the winning numbers increased from 1 to 6 but the prize values decreased (60p for numbers of '1'…and 10p for numbers of '6'). Finally, in the third 'neutral' group, prizes were of the same value across the range of winning numbers (i.e. 35p for numbers between '1' and '6').

Finally, and critically, in order to explore if motor expressions of value facilitates the development of IOC, I also hypothesised that the strength of these behavioural biases (i.e., to roll dice for longer when attempting to achieve larger targets) will mediate the relationship between traits for IOC on game-control beliefs after the experiment.

4.2 Methods

4.2.1 Participants

Sixty males with varying degrees of gambling involvement were recruited from the local community using advertisements placed on a local Oxford website. None of these participants were recruited in the previous experiments. The experiment was approved by the Central University Research Ethics Committee (CUREC) of the University of Oxford and all participants gave written informed consent. Participants were screened using a semi-structured interview to ensure an absence of Axis I DSM-IV psychological disorders in the past month (First, et al., 2002). They also completed a number of psychometric assessments of personality and gambling-related cognitions that have been validated in gambling populations

Table 4.1. Descriptive statistics of 60 gamblers

	Neutral (*n*=20)	Congruent (*n*=20)	Incongruent (*n*=20)	*p*-value
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	
Age $_a$	28.85 (9.14)	28.45 (11.15)	28.30 (11.15)	$p > .05$
Ravens $_a$	49.45 (8.22)	45.60 (12.84)	46.05 (11.04)	$p > .05$
Gambling problems $_b$				
Past month	0.60 (2.01)	0.65 (1.42)	0.65 (1.66)	$p > .05$
Lifetime	1.60 (2.66)	1.05 (1.76)	1.65 (2.62)	$p > .05$
Total score/GRCS $_a$	56.10 (17.92)	55.65 (15.59)	62.20 (20.87)	$p > .05$
	N (%)	*N* (%)	*N* (%)	
Past year gambling losses $_c$				$p > .05$
<£50	9 (45.00)	9 (45.00)	10 (50.00)	
>£50	11 (55.00)	11 (55.00)	10 (50.00)	
Past year gambling frequency $_c$				$p > .05$
<Once a week	9 (45.00)	9 (45.00)	4 (20.00)	
>Once a week	11 (55.00)	11 (55.00)	16 (80.00)	

Note: Subscript $_a$ One-way Analysis of Variance (ANOVA) was performed; Subscript $_b$ the non-parametric Kruskal-Wallis test were performed because the distribution within groups was non-normal; Subscript $_c$ chi-square tests were performed with fewer than 20% of the cells in the contingency tables having expected frequencies < 5; Ravens – non-verbal IQ on the Raven's Progressive Matrices (Raven, 2000); Gambling problems – Structured Clinical Interview for Pathological Gambling (SCI-PG; Grant, et al., 2004); GRCS – Gambling Related Cognitions Scale (Raylu & Oei, 2004a).

Thirty eight participants (63.4%) reported gambling at least once a week, 18 (20%) gambled 1-3 times a month, and 4 (6.7%) gambled a few times or less in the past year. The mean number of past month and lifetime gambling problems was 0.63 (*SD*= 1.69) and 1.43 (*SD*= 2.36) respectively, as measured with the Structured Clinical Interview for Pathological Gambling (SCI-PG; Grant, et al., 2004). Three participants were identified as probable pathological gamblers (SCI-PG score ≥ 5), one in each of the congruent, incongruent and neutral groups. Since their removal from the data analyses did not change the pattern or the statistical reliability of the findings reported here, these participants were retained in order to maximise the distribution of cognitive biases in my sample. Therefore, my results provide new information about the role of die-rolling action in the development of IOC in individuals at varying levels of gambling involvement (see Table 4.1).

4.2.2 Procedure and psychometric questionnaires

Participants completed an assessment of nonverbal cognitive ability on the Raven's Progressive Matrices (Raven, 2000), and were assessed with the Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a). Participants then played one of three Die-rolling games (i.e., congruent, incongruent, or neutral) which took 6-mins to complete. After the experiment, participants completed a brief questionnaire (Game-control Beliefs Questionnaire) that measured how much control the participants believed they were able to exert over the game outcomes of the die-rolling game.

Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a). Statistical analysis of my participants' scores demonstrates moderate to high reliability of the subscales of the GRCS, Cronbach's α between .66 and .91.

Game-control Beliefs Questionnaire. This was a 4-item questionnaire adapted from a previous study (Ladouceur & Sevigny, 2005). Participants rated on a 7-point Likert scale (with anchor points of 1-strongly disagree and 7-strongly agree) how much they agreed with the following statements: (i) 'Players can influence the die after having activated the play button'; (ii) 'There is a method for controlling the outcome of the die after the play button has been activated'; (iii) 'A winning outcome is due to skill or a combination of skill and chance'; and (iv) 'There are strategies that could enable players to increase their chances of winning after the play button has been activated'. Participants' scores demonstrate high reliability, Cronbach's α = .91.

4.2.3 Die-rolling game

Figure 4.1(a) shows a typical sequence of events for one play. Participants were asked to click on a standard computer mouse to roll a 6-sided simulated die for monetary prizes. On each play, participants were shown an array of the standard 6 die faces displayed from left-to-right in middle of the computer monitor. Next, participants heard a voice that spoke the winning number for the current play. Participants were asked to respond to this target number by clicking on the prize value indicated in the display above the winning number (see Figure 4.1(a)); this ensured that participants had processed the winning number and understood the value of the prize available on this play. After clicking on the prize value, participants clicked the die to initiate a simulated roll for as long as they liked before releasing the click to 'throw' the die and reveal the die-number thrown and the outcome of the play. If the thrown number matched the winning number, 'WIN #p' was displayed in white, accompanied by the sound of a falling coin, to indicate that prizes were won. Conversely, if the thrown number missed the winner number, 'LOSE #p' was displayed in red, accompanied by an audio jingle, indicating a loss. In the latter case, no penalty was given. The game was programmed such that 18 (25%) of the 72 plays would result in a win that was randomly distributed amongst die target values. Before starting on the game, players were told that the rolled die was fair and that the value of their winning outcomes would be added to their experimental payment.

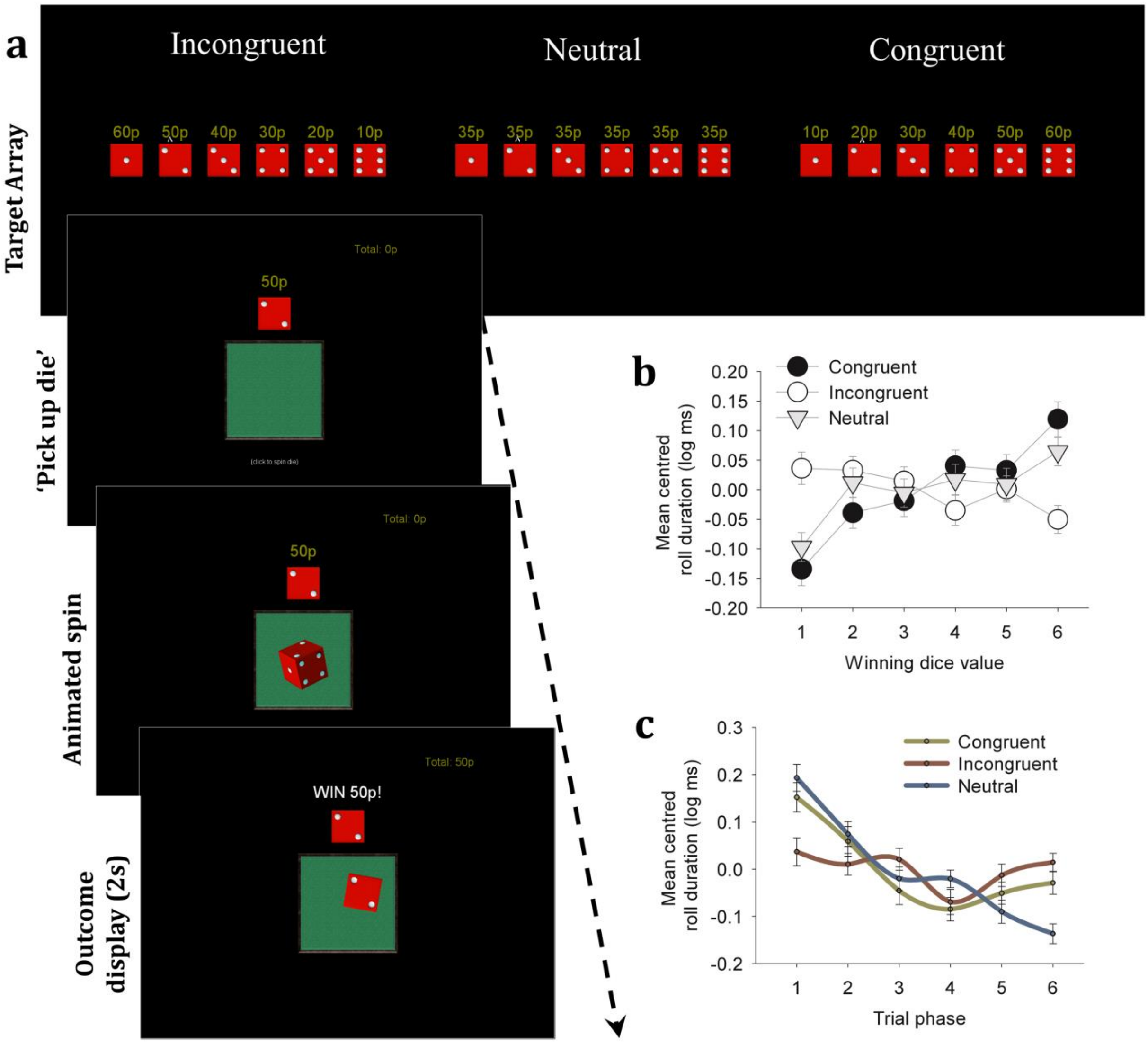


Figure 4.1. (**a**) The top panel indicate illustrate the 3 different experimental conditions of the Die-rolling game; the incongruent, neutral and congruent groups. The arrow indicates a play sequence of the incongruent experimental condition in the Die-rolling Game. The computer reads out '2' as the target and gamblers acknowledge the target by clicking on the prize above the announced target (50p in this case). Once this is done, the option to click and spin a die is given. Participants click to spin the die, and upon release, the animation slows and presents the outcome. In this play, the participant obtains the target 2 and wins the 50p prize; (**b**) plot of gambler-centred roll-time (log ms) as a function of size of die targets; and (**c**) plot of gambler-centred roll-time (log ms) as a function of blocks of 12 plays (i.e., trial phase) in 60 gamblers.

Participants were randomly assigned to one of the three groups: in the congruent group, prize values perfectly mapped onto die target values (e.g., 10p above target 1; 60p above target 6); in the incongruent group, the converse was presented were prize values were incongruous with die target values (e.g., 10p above target 6; 60p above target 1); finally, in the neutral group, prize values were always 35p regardless of die target values. Experimental groups were comparable across age, non-verbal IQ, gambling-related cognitive biases, and past year gambling frequency and losses (all ps> .05; see Table 4.1). Any subsequent differences across groups thus cannot be attributed to differences in demographical or gambling characteristics.

4.3 Data Analysis

4.3.1 Psychometric matching

To investigate how socio-demographic and gambling-related characteristics (including risk factors) differed across the experimental conditions, one-way Analysis of Variance (ANOVAs) and Pearson χ^2 tests are performed. If the distribution of these characteristics was not normal within any experimental group, non-parametric Kruskal-Wallis tests were used. Non-normality was based on the cut-off of Skewness and Kurtosis z-scores greater than ±2 and all significance values were taken at $p < .05$.

4.3.2 Modelling die-rolling behaviour

Roll-times were log (natural) transformed to normalise the data, and past-month gambling problems was spilt into a binary variable because a majority of the sample reported no problems (0-no gambling problems; 1-at least one problem).

Modelling participants' die-rolling behaviour was completed in 2 stages. First, a multilevel regression, with player die-roll times (log ms) as dependent variables, were regressed against game features, with gamblers as random effects. Game features included: (i) the target values (i.e., 1 to 6); (ii) the values of prizes won or lost on the previous play (i.e., -60p to +60p) (to capture changes in roll-times following the immediately preceding play outcome); and (iii) the trial number from 1 to 72 plays in order to control for fluctuating engagement across the entire length of the game. Gamblers' intercepts and slopes (or coefficients) of this multilevel model were then modelled as random effects and allowed to vary if they improved the fit with the data (i.e., significant reductions in -2×loglikelihood statistics, $p < .05$).

Second, the participant-level *B*-values from the above multilevel model were regressed against 2 dummy variables created for game conditions (i.e., neutral vs. congruent and neutral vs. incongruent), and the total score on the game-control scale using a simple multiple linear regression. The variables of this final model were entered simultaneously together with the covariates age, non-verbal IQ, and past-month gambling problems.

Finally, to investigate how the coupling, of die-roll times with game features, mediates the operation of trait illusions of control (on the GRCS) on players' belief that they can control game outcomes, I performed a bootstrapping indirect effects analyses (Preacher & Hayes, 2008). This model employed game-control scores as a dependent variable, the GRCS-IOC scores (Raylu & Oei, 2004a; Steenbergh, et al., 2002) as an independent variable, and the *B*-values (indicating the strength of the relationship between die-rolling times and winning numbers) as the mediating variable; age, non-verbal IQ and gambling problems were added as covariates. Using 5000 bootstrap samples, significant mediation (or indirect) effects were taken to be a point estimate that had a bias corrected (BC) bootstrap confidence intervals (CI) that did not contain the zero point (Preacher & Hayes, 2008).

4.4 Results

4.4.1 Die-rolling and game features

As expected, players tended to allow the die to roll for longer when attempting to achieve larger target values (coefficient= -0.018, SE= 0.009, z= 2.00, p< .05; see Figure 4.1(b)). Conversely, overall die-roll times were shortened as the game progressed (coefficient= -0.003, SE= 0.001, z= 3.00, p< .01; see Figure 4.1(c)). However, die-roll times were not significantly influenced by whether the previous play ended in a winning or losing outcome (p> .05).

All players also demonstrated significant random effects, where their mean (intercept) roll-times (Δ-2×loglikelihood= 3519.16, Δ df= 1, p< .0001), and how much they shortened their die-rolls as the game progressed (Δ-2×loglikelihood= 457.68, Δ df= 2, p< .0001) differed significantly from each other. Additionally, most critically, players' tendency to lengthen their roll-times when attempting to obtain large die target values also significantly differed from each other (Δ-2×loglikelihood= 268.076, Δdf= 3, p< .0001).

4.4.2 Game structural characteristics and die-rolling behaviour

One-sample t-tests revealed that gamblers in the neutral groups (t(19)= 2.43, p< .05, d= .65) and the congruent groups (t(19)= 2.89, p< .01, d= .54) both extended their die-rolls for large die target values. However, gamblers in the incongruent condition did not roll the die for longer or shorter when trying to hit large target winning values (corrected p> .05).

Controlling for age, non-verbal IQ and past month gambling problems (all $|t|$s< 1.25), a simple multiple linear regression showed that gamblers in the neutral group (Mean B= 0.02, SE= .01) showed significantly longer die rolls for larger winning targets compared to gamblers in the incongruent group (Mean *B*= -.01, *SE*= 0.01; *t*(59)= -2.56, *p*< .05; see Table 4.2 and Figure 4.1(b)). Conversely, gamblers in the neutral and congruent groups did not significantly differ from each other in their roll-times for various die targets (*p*> .05). Critically, however, gamblers from all 3 groups who reported stronger beliefs of control over the die after the game tended rolled die for longer when attempting to achieve larger winning numbers (*t*(59)= 4.15, *p*< .001).

Table 4.2. Regression of participant *B*-values (for die target values) against experimental conditions and game-control scores, controlling for age, non-verbal IQ and past month gambling problems in 60 gamblers

	B	SE *B*	*β*
Constant	-.084	.048	
Age	.001	.001	.116
Non-verbal IQ/Ravens	.001	.001	.150
Gambling problems/SCI-PG	-.005	.016	-.037
Neutral vs. congruent	.024	.016	.192
Neutral vs. incongruent	-.042	.017	-.333*
Total score/Game-control Beliefs Scale	.006	.001	.493***

Note: R^2 = .35 (*p*< .001); *p< .05; ***p< .001; Ravens – Raven's Progressive Matrices (Raven, 2000); SCI-PG – Past month gambling problems on the Structured Clinical Interview for Pathological Gambling (0-no gambling problems; 1-at least one problem; Grant, et al., 2004); Congruent, Incongruent, Neutral – experimental conditions of the Die-rolling game; Game-control Beliefs Questionnaire – Adapted state measure of mistaken beliefs that the animated die can be controlled (Ladouceur & Sevigny, 2005).

4.4.3 Die-rolling behaviour as a mediator of trait IOC on game-control beliefs

The preceding findings demonstrated that the strength of motor expressions of winning number values in the die-rolling game were not different between the neutral and congruent groups (*p*> .05). Therefore, I pooled participants from the congruent and neutral conditions (*n*= 40) for the following mediation analyses. Participants in the incongruent condition were excluded because they failed to show statistically significant motor expressions for value (see above). Additionally, a one-way Analysis of Variance (ANOVA) revealed that the 3 experimental groups did not significantly differ in their game-control beliefs after the playing the die-rolling game ($F(2,57)= 1.09$, $p > .05$).

After controlling for age, non-verbal IQ and past-month gambling problems (all $|t|$s< 0.59), the GRCS-IOC scores were significantly related to participants' beliefs that they could influence the outcomes of the die-rolling game (i.e., a significant total effect; $\beta= .57$, $t= 3.72$, $p< .001$). Adding the coefficients for the positive relationship between winning numbers and die-roll times did not change this association (i.e., a significant direct effect; $\beta= .43$, $t= 3.01$, $p< .01$). Finally, as hypothesised, I found that the motor expressions winning target values significantly mediated the relationship between trait IOCs and the formation of game-control beliefs (i.e., a significant mediation effect; bias-corrected 95% CI [.004, .329]; see Figure 4.2).

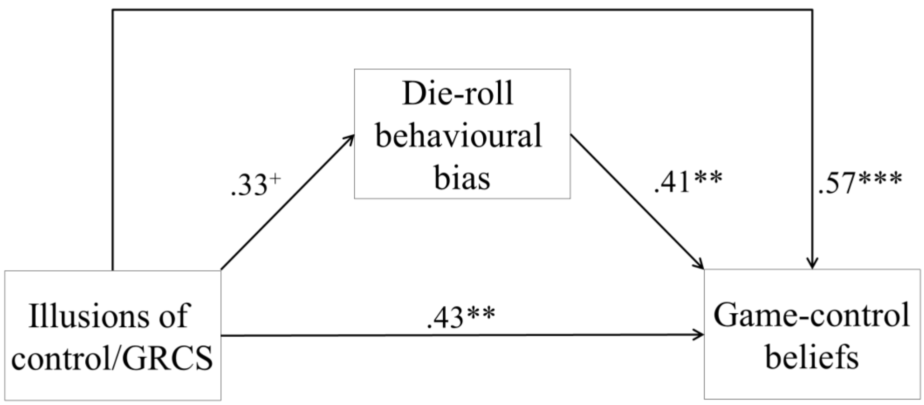


Figure 4.2. Illustration of die-rolling behavioural biases (*B*-values of roll-time regressed against die target values) as a significant mediator of trait illusions of control as measured by the Gambling Related Cognitions Scale (GRCS-IOC; Raylu & Oei, 2004a) on game-control beliefs; only participants in the congruent and neutral conditions of the Die-rolling game were included in this analysis (n= 40)

4.5 Discussion

This experiment demonstrates how game structural features facilitate behavioural expressions of illusions of control (IOC) in gamblers with various levels of commercial gambling participation. This replicates and extends a qualitative report, and my previous experimental demonstrations in Studies 1-2, of gamblers rolling harder (longer) when attempting to 'hit' higher winning outcomes (Henslin, 1967; Lim, et al., 2013). I have, however, also shown that these motor expressions of value are extinguished if functional congruencies between game features and motor behaviours are altered. And, critically, the degree to which gamblers' motor behaviours mediated the relationship between their reported trait IOC beliefs (as measured by an independent psychometric scale; Raylu & Oei, 2004a) and their acquisition of beliefs that they had control over the die in my experimental task. As such, these data enhance the understanding of how structural characteristics of gambling games provide limiting conditions under which embodied IOCs are behaviourally expressed and, possibly, developed in gamblers (Ladouceur & Sevigny, 2005; Parke & Griffiths, 2006).

4.5.1 Die-rolling behaviours and winning target size

Our findings of extended die-rolls for large winning numbers (i.e., motor expressions of value) are consistent with previous reports that aspects of numeric processing are expressed in motor behaviour (Andres, et al., 2004; Lindemann, et al., 2007). This is demonstrated by participants' quicker hand-grasping and hand-releasing speeds in response to smaller and larger numbers respectively (Andres, et al., 2004). Similarly, participants tend to execute small finger actions ('precision grip') faster when they saw small numbers, and executed large grasping actions ('power grips') faster, and with more force, when they saw large numbers (Lindemann, et al., 2007). Our data , and these reports, reflect how the behavioural features of games activate a shared, and underlying, mental representations of magnitude (Walsh, 2003).

Our findings go one step further, however, by showing that die-rolling behaviours are not merely perception-induced motor biases but are linked to the beliefs (or ideomotor acts) of gamblers who seek to exercise control over outcomes in games of chance (Knuf, et al., 2001). Specifically, I found that gamblers, whose motor behaviour is most strongly tied to the numeric aspects of the game, were more likely to endorse statements of control at the end of the game.

4.5.2 IOCs, congruency features, and activity levels in games

Our experiment also provided positive evidence to support the hypothesis that discrepant (or incongruent) game characteristics would extinguish gamblers' motor expressions of value. Diminished numerically-aligned die-rolling behaviours in the incongruent group suggest that it is the games' S-R compatible, instrumental activity in games (Kornblum, et al., 1990) that facilitates gamblers' acquisition of IOCs. Critical evidence for this comes from my demonstration that the tendencies for higher target values to lengthen rolls, mediated the association between trait IOCs and the development of state beliefs in control over the actual game outcomes. Specifically, gamblers with strong trait IOC beliefs – that behaviours like praying, charms, and rituals are instrumental in altering their fortunes (GRCS-IOC; Raylu & Oei, 2004a) – were more likely to believe they could control die outcomes if they also displayed evidence of greater S-R compatible motor expressions of these biases in their die-rolling behaviours.

Since I found incongruent game characteristics did not alter overall game-control beliefs across experimental groups, this suggests that game-induced IOCs develop during play only in so far as it promotes increased motor activity. In particular, action repertoires specific to the structure of the game played (in the present case, behaviours that naturally align to features of the games).

Previous studies support this view, demonstrating that increased instrumental activity like playing with balls, cards and dice (Chau & Phillips, 1995; Fernandez-Duque & Wifall, 2007; Golin, et al., 1977; Ladouceur & Mayrand, 1987; Frederic Martinez, et al., 2009), or increased frequency of responding (Blanco, et al., 2011), can be sufficient to increase IOC in players, as indicated by larger risk-taking behaviours (e.g., choosing larger of more difficult wagers) and stronger beliefs in control or winning. Conversely, reduced instrumental activity in players reduces their subsequent IOCs as measured by the level of risk-taking (Verbruggen, et al., 2012).

Here, this link between motor activity and IOCs cannot be accounted for by increased fortuity or frequency of wins (Wegner, 2004) since all participants received the same proportion of rewards in my task. Rather, the data collectively raises the possibility that motor biases within games of dice provide gamblers with a *plausibility structure* of instrumental action that allows them to make sense of their die outcomes; 'gentle rolls produce small numbers and hard rolls produce large numbers' (Henslin, 1967). In this way, the constraints of player-game interactions, in combination with pre-existing IOCs, facilitate the development of IOCs in actual games. Since the substrates of this process involve the constraints placed upon motor expression by game features, I propose that the resultant IOCs are, in this precise sense 'embodied' (Proffitt, 2006).

In conclusion, my findings propose a tractable on-line behavioural metric to measure 'embodied' IOCs, complementing previous research that have primarily relied on self-report methods that use questionnaire and thinking-aloud procedures (Ladouceur, 2004b; Raylu & Oei, 2004a). Our finding demonstrates that these embodied beliefs can be reinforced, or weakened, by the perceptual configurations of game stimuli in relation to game response features. Further, it is instrumental activity occasioned by congruent game and response features that mediate the expression, and development, of game-control beliefs in gamblers who have traits for IOCs. The emphasis here on how behavioural prospects of congruent gambling game features facilitate the development of IOC, adds to previous research and public policy that conceives of risky commercial game features in terms of wager size, return rate, 'near-misses' and sensory features (Loba, et al., 2001; Office of Public Sector Information, 2010; Parke & Griffiths, 2006; Reid, 1986). Further, the present work also proposes that action configurations afforded by games are a promising area in the study of embodied gambling-related cognitive biases more broadly.

Study 3 established how game features tap the sensory-motor system to facilitate action-based IOC. In the next step, I investigated whether the interface between game features and motor expression of GRCs are sensitive to social factors known to enhance IOCs.

Chapter 5.

Rolling dice under competition – Study 4

To complete this experimental series, Study 4 tested how social factors in gambling – specifically changing degrees of competition – might influence the way motor actions express IOCs.

5.1 Introduction

A large body of research has demonstrated that the presence of other people can facilitate, or inhibit, performance on complex motor tasks including gymnastics and cycling, or simple motor tasks including handle bar turning and balance (see review Strauss, 2002). More broadly, any changes to performance occasioned by co-actors, or passive observers, has been termed 'social facilitation' effects (Allport, 1924). In the context of gambling, social facilitation has mostly been studied with respect to shifts in risky wagering behaviours while playing games of chance. For example, female children (aged between 9 and 13) and adult roulette gamblers have been found to choose higher stakes, and gamble at riskier odds, when gambling with co-actors rather than alone (Cole, Barrett, & Griffiths, 2011; Hardoon & Derevensky, 2001). Most strikingly, Electronic Game Machine (EGM) gamblers progressively heightened their rates of bets, and received lower game pay-outs, as the size of the gambling social environment got larger (i.e., gambling either alone, in groups of 5, or in groups of 25; Rockloff, et al., 2011).

Social cognitive theory has been a prominent account used to explain social facilitation effects in gambling (Brown, 1987; Walker, 1992). According to this view, social environments in gambling are an important factor in the development of GRCs biases that lower perceptions of risk; as people engage in self-reflective processes to improve their performance (Bandura, 2001), they somehow also learn the erroneous habits and beliefs of their gambling co-actors.

A growing number of experimental studies do support this claim. Simply directing gamblers' attention to the success, or luck, of gambling co-actors has been found to increase risk-taking in both 4 to 5 years old children and university students (Kearney & Drabman, 1992; Wohl & Enzle, 2009). Studies have also demonstrated that merely giving university students information about the wins of another gambler in a game of French Roulette, can induce shifts in risk-taking that reflect the size of wins that the alleged co-acting gambler won (Le Floch, et al., 2005). EGM gamblers also tend to wager larger bets, and lose more money at the end of the gaming session, if they received visual and aural feedback that players in adjacent rooms were winning (Rockloff & Dyer, 2007).

In fact, it has been reported that the poor performance of gambling co-actors also induce this risky shift in behaviours (Dykstra & Dollinger, 1990; Le Floch, et al., 2005). These findings suggest that gamblers not only vicariously learn mistaken contingencies of games, but possibly develop mistaken beliefs about personal efficacy or skill. In Langer's (1975) seminal work, she suggested that one such cognitive bias is the belief that games of chance are controllable. In particular, she suggested that the salience of skill-based factors in games is a central contributor to illusory beliefs that they have some control over the game (i.e., illusions of control; IOC).

In support of this view, adults who have information about the incompetency or losses of another player in games of chance, were more likely to endorse higher ratings of *skill* in these games (Dykstra & Dollinger, 1990; Le Floch, et al., 2005). More striking is the evidence that shifts in risk-taking can be heightened if another gambler's losing performance is attributed to *skill* rather than random chance (Caron & Ladouceur, 2003).

However, to my knowledge, no experimental gambling studies using a social cognition paradigm have directly assessed the role of competition in the promotion of IOC beliefs. This is unfortunate since skill-related elements of competitive gambling, like score keeping and strategy, are likely to promote IOCs. Although Langer's (1975) first experiment does included a competitive element, it is argued that competition was not manipulated there. Gamblers were put into a 2-player competitive card game where they either played against an awkward and nervous opponent, or an attractive and confident one. Both groups in this study were under competition and the observed shifts in risk-taking could be viewed as a function of poor opponent aptitude rather than competition. In fact, a later study confirmed that information about an incompetent co-actor was alone sufficient to elicit greater confidence in personal success (Dykstra & Dollinger, 1990). Thus, experimental evidence for direct competitive (social) facilitations of cognitive biases is still lacking.

The development of a computerised die-rolling game in Studies 1-3 have demonstrated that IOCs can be expressed in gamblers' motor behaviours, as observed by the tendency for gamblers to align their die-roll durations to reflect the size of winning target and prize values (Lim, et al., 2013). To explore how competitive factors in gambling environments could modulate these action-based expressions of IOC biases, I recruited here dyads of student gamblers and gave them a novel 2-player game of dice where they took turns to roll an animated die to win prizes. Here, I hypothesise that the expression of IOC in gambling behaviours, such as rolling a computer-simulated die for small monetary prizes, will be enhanced by the competitive behaviours of betting co-actors (i.e., a larger proportion of wagers against, rather than with, the die-throwing or 'shooting' gambler). Finally, to explore individual differences, I predict that gamblers, who report stronger traits for GRCs biases and post-game die-control beliefs, would demonstrate both more pronounced attempts to control die point values, and more pronounced reactions to competition.

5.2 Methods

The study was approved by the Central University Research Ethics Committee (CUREC) of the University of Oxford. All participants gave written informed consent.

5.2.1 Participants

Thirty young male regular gamblers were recruited from amongst the student body of Oxford University by the personal contact of an undergraduate research assistant. None of these participants have been recruited in previous experiments. One participant was excluded from the final analysis because of the idiosyncratic behaviour of his playing partner. See Table 5.1 for the demographic and psychometrics scores of the sample. Participants were screened with the semi-structured interview to ensure an absence of current or past-year DSM-IV psychological disorders. Gambling behaviour and any difficulties with gambling were assessed with the Structured Clinical Interview for Pathological Gambling (SCI-PG; First, et al., 2002; Grant, et al., 2004). Eleven participants (36.7%) reported gambling at least once a week and the remaining 19 (63.3%) gambled between 1-3 times a month in the past year. Therefore, my results provide new information about the impact of cognitive biases upon the dice-rolling behaviour of individuals at varying levels of gambling involvement. None of my participants reported clinically significant gambling problems.

Table 5.1. Descriptive statistics of 29 gamblers

	Mean (*SD*)	*N* (%)
Age	20.41(1.05)	
Non-verbal IQ/Ravens	53.31(6.03)	
Past year gambling losses		
≤ £10		18 (62.10)
£11 - £20		6 (20.70)
> £20		5 (17.20)
Gambling-related Cognitions Scale/GRCS		
Gambling expectancies	10.31(4.18)	
Illusions of control	6.24(2.64)	
Predictive control	13.69(5.23)	
Perceived inability to stop	6.24(2.06)	
Interpretive control/bias	13.10(5.73)	
Total score	49.59(15.74)	
Gambling Beliefs Questionnaire/GBQ		
Luck and perseverance	29.52(10.80)	
Illusion of control	27.59(9.72)	
Total	57.10(19.22)	

Note: Ravens = Raven's Progressive Matrices (Raven, 2000); GRCS = Gambling-related Cognitions Scale (Raylu & Oei, 2004a); GBQ = Gambling Beliefs Questionnaire (Steenbergh, et al., 2002)

5.2.2 Procedure and psychometric questionnaires

Participants completed the Raven's Progressive Matrices (Raven, 2000) as a measure of non-verbal cognitive ability. Cognitive biases were measured by the self-report Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a). Gamblers then played a 2-min practice round of the 2-player game of dice in pairs to acquaint themselves with the response keys before starting on the experimental task. Each game lasted for about 10mins.

Upon completion of the 2-player die-rolling game, gamblers completed a state Die-control Scale that measured how much control over outcomes they believed they had during the game

Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a). In this sample, the total score of the GRCS has good internal reliability, with Cronbach's α= .86. However, the *illusions of control* (Cronbach's α= .37) and *inability to stop gambling* (Cronbach's α= .27) subscales of the GRCS have poor reliability whilst the remainder have moderate reliability with Cronbach's α values between .62 and .79.

Game-control Beliefs Questionnaire. In this sample, the total score on this scale had a moderate reliability with Cronbach's α = .63.

5.2.3 2-player Game of Dice ('Bone'-dice)

Two participants were given a computer mouse. Figure 5.1(a) shows a typical sequence of events for one play. On each play, player 1 would be shown a standard array of 6 die faces arranged in ascending order from bottom-to-top on the screen. The computer then reads out the target for the current play and player 1 (the 'shooter') has to acknowledge the announced target by clicking on the corresponding die face. By clicking on this target number, the shooter also places a bet of 35p on his target. Next, player 2 (the 'betting partner') is given the opportunity to bet with or against the shooter. To bet with the shooter, the betting partner has to click on the '?' sign beside the *shooter's target*. To bet against the shooter, the betting partner clicks on the '?' sign beside an *alternative target* randomly selected by the computer. After the betting partner has decided to bet with or against the shooter, the shooter is then given the opportunity to roll a simulated die for as long as he liked before releasing the mouse button to 'throw' the die and reveal the play outcome.

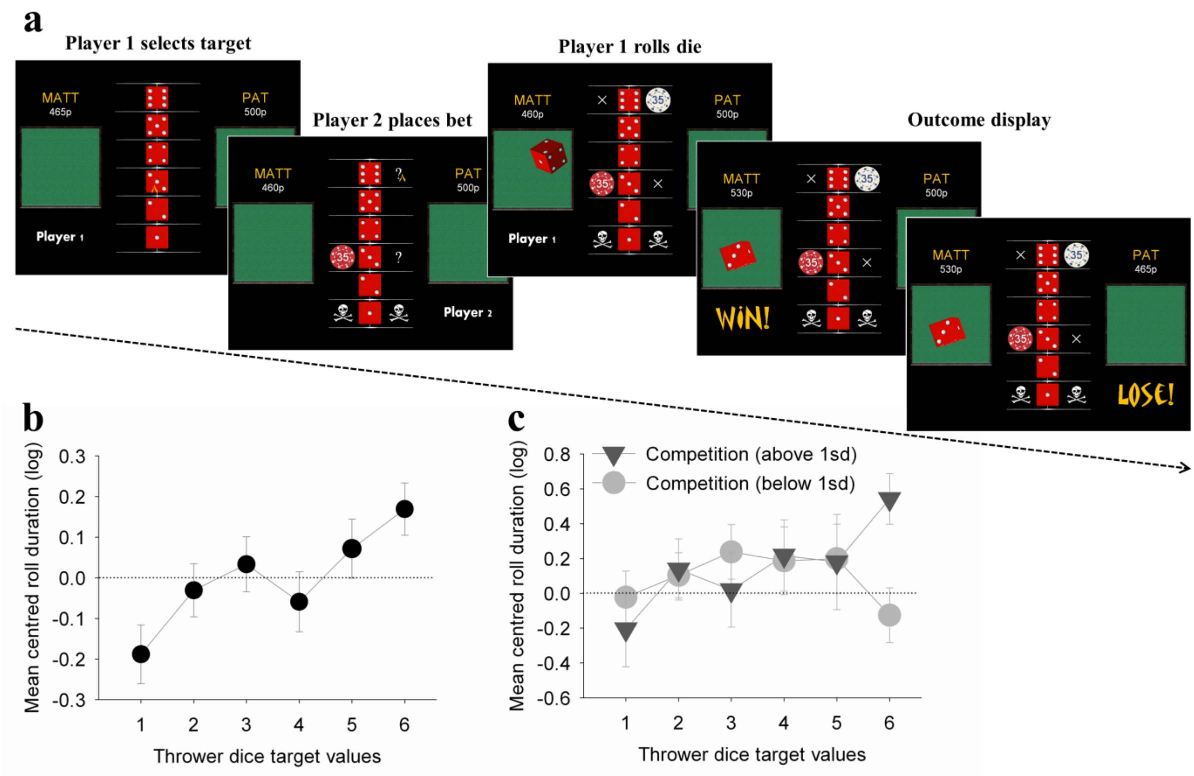


Figure 5.1. (**a**) Example display for one play of our 2-player game of dice; in this instance, player 1 (thrower) would win 70p if he rolled the number 3, but lose 35p if he the number 6; conversely, player 2 (betting partner) would win 70p if the player 1 rolled the number 6, but lose 35p if the number 3 is rolled. All bets are returned if the numbers 2, 4, and 5 and rolled, and all bets are forfeited if the skull and crossbones target of 1 is rolled. In this go, the number 3 is obtained, so player 1 wins and player 2 loses; (**b**) Mean centred roll-time (logarithm milliseconds) as a function of dice target values; (**c**) Mean centred roll-time (logarithm milliseconds) as a function of dice target values and partner competitiveness (score 1sd above and below the mean)

Hitting winning numbers delivered bets with a 2-to-1 pay out only when they are placed on the *shooter*'s *target* or the *alternative target*; bets are lost if they are not placed on the *shooter*'s *target* or the *alternative target* that is 'hit'; bet are returned if both the *shooter*'s *target* and the *alternative target* are missed. The final feature of the game is the inclusion of 'skull and crossbones'. If the die lands on this outcome, both players lose their bets and they switch roles, with the shooter now becoming the betting partner, and vice versa.

Before starting on the game, players were assured that the rolled die was fair and every roll of the die costs the shooter 5p. They were then given 500p of 'house money' to play with. The game came to an end when both players have at least 30 goes at the die.

5.3 Data Analysis

The dependent measures of the game were the length of time (in milliseconds) that gamblers allowed the die to roll for while attempting to hit target numbers, and their beliefs about control over the computerised die, as measured by the Game-control Beliefs Questionnaire.

Modelling gamblers' dice rolling behaviour was completed in 2 stages. First, I used multilevel models to regress roll-times (log ms) against game features nested within gamblers and games. The game features included: (i) shooter's target number (i.e., 1 to 6); (ii) partner's chosen target number (i.e., 1 to 6); (iii) the value of the skull and crossbones' outcome (i.e., 1 to 6); (iv) the partner's competitiveness (i.e., the proportion of partner's decisions to bet against thrower at every successive point of the game); (v) the serial number of the play to account for fluctuating engagement across plays of the game; and (vi) the interaction between shooter's target size and their partner's competitiveness.

Regressors (ii) and (iii) were centred at every level of the regressor (i). Using these regressors, 3 multilevel models with increasing complexity were estimated. In model 1, a basic model included an intercept that was allowed to vary across gamblers and games. In model 2, regressors (i) to (vi) were added. Finally, in model 3, the slopes (or coefficients) of regressors (i) and (vi) were allowed to vary across gamblers, and only random variables that further improved data fit (i.e., significant reductions in the -2×loglikelihood statistic) were kept.

Second, the gambler-level coefficients of regressors (i) and (vi) from the final multilevel model were regressed against gamblers' dice-control ratings using a simple multiple linear regression. Additionally, to explore the relationship between trait and state measures of control, total scores on the Game-control Beliefs Questionnaire were regressed against the total scores on the GRCS. All final models included age and non-verbal IQ as covariates.

5.4 Results

Models 1 to 3 had improving fit with the die-rolling data, as indicated by significant reductions in the -2×loglikelihood statistics ($p < .05$; see Table 5.2). I report here the results of model 2 and 3 in turn.

5.4.1 Fixed factors of game features

The findings in model 2 replicate previous studies where gamblers lengthen their computerised die-rolls when trying to hit larger target values as opposed to smaller values (coefficient= 0.056, SE= 0.018, $z = 3.11$, $p < .001$; Figure 5.1(b)). Transforming the logarithmic values of roll-time in Figure 5.1(b) back into untransformed milliseconds, shows that an increase from 1 to 6 in target value equated to ≈150ms lengthening of gamblers' mean die-roll times. Additionally, gamblers were also more likely to shorten their die-rolls if a larger proportion of their partners' bets in all previous goes were wagered against rather than with them (coefficient= 0.391, SE= 0.218, $z = 1.79$, $p = .04$).

Table 5.2. Multilevel regression model of die-roll times (log transformed) against game features in 29 gamblers

Regressor	Model 1 B(SE)	Model 2 B(SE)	Model 3 B(SE)
B_0: Constant	6.077(0.165)****	6.137(0.219)****	5.876(0.277)****
B_1: Thrower's target		0.056(0.018)***	0.119(0.043)**
B_2: Partner's target		-0.004(0.019)	0.004(0.019)
B_3: Skull target		0.006(0.016)	0.010(0.016)
B_4: Competition		-0.391(0.218)*	-1.043(0.360)**
B_5: Play no.		-0.014(0.004)***	-0.014(0.004)***
B_6: Thrower's target x Competition			0.154(0.089)*
Random intercepts (means)	V_{0k}****, u_{0jk}****	V_{0k}****, u_{0jk}****	V_{0k}****, u_{0jk}****
Random coefficients (slopes)	-	u_{1jk}, u_{5jk}***	u_{1jk}, u_{5jk}***, u_{6jk}*
Δ -2×loglikelihood	-	173.63****	12.79*

Note: *p< .05; **p< .01; ***p< .001; ****p< .0001; Thrower's target = value of thrower's target (i.e., 1 to 6); Partner's target = value of partner's chosen target (i.e., 1 to 6); Skull target = value of skull and crossbones' target (i.e., 1 to 6); Competition = Proportion of partner's decisions to bet against, rather than with, thrower at any point of the game; Play no. = Play number across the game; Thrower's target x Competition = Interaction between thrower's target size and their partner's competitiveness; Subscript numbers = Order that regressors are added into the model; Subscript $_{jk}$ = Gambler-level variable; Subscript $_k$ = Game-level variable; u = Gambler-level regression residuals; v = Game-level regression residuals.

Model 3 showed a significant interaction effect. As partner's competitiveness increased, gamblers tended to lengthen their computerised die-rolls to achieve larger target values (coefficient= -0.154, SE= 0.089, z= 1.73, p= .04; Figure 5.1(c)). Die-roll times were not significantly influenced by the value of partners' chosen target (coefficient= 0.004, SE= 0.019, z= 0.21, p= .42), or the value of the skull and crossbones target (coefficient= 0.010, SE= 0.016, z= 0.63, p= .27). Conversely, die-roll times were significantly shortened over the course of the game (coefficient= -0.014, SE= 0.004, z= 3.50, p< .001).

5.4.2 Random factors of game features

As for the random effects of model 3, gamblers demonstrated significant variability in their tendency to lengthen die-rolls for large targets when facing strong competition (σ^2_{u6}; Δ-2×loglikelihood= 10.95, Δ df= 4, p= .03). Additionally, they also showed a significant difference in disengagement patterns over the course of the game (σ^2_{u5}; Δ-2×loglikelihood= 133.41, Δ df= 1, p< .0001). However, gamblers did not significantly vary their tendency to lengthen die-rolls for larger dice targets (σ^2_{u1}; Δ-2×loglikelihood= 1.68, Δ df= 3, p= .64; see Table 2).

As for random intercepts, games (σ^2_{v0}; Δ-2×loglikelihood= 133.41, Δ df= 1, p< .0001) and gamblers (σ^2_{u0}; Δ-2×loglikelihood= 382.98, Δ df= 1, p< .0001) had significantly different mean roll-times values in this study.

5.4.3 Die-control ratings and trait cognitive biases

Controlling for age and non-verbal IQ, gamblers' endorsements of state beliefs in die-control and endorsements of trait gambling-related cognitive biases were not associated with the slope of lengthened die-rolls for large dice targets (all ps> .05). Neither were they associated with the tendency to lengthen die-rolls for large targets when face strong competition (all ps> .05). Controlling for age and non-verbal IQ, I also found that gamblers' endorsements of state dice-control beliefs were not associated with trait measures of gambling cognitive biases (p> .05).

5.5 Discussion

This study demonstrates the specificity of the action-based expression of gamblers' cognitive biases, in Studies 1-3, to roll dice for longer when trying to achieve larger dice targets; that is, the editing of animated die-rolls map onto a shooter's own targets values rather than other salient dice targets of the game, like the chosen targets of betting partners', or targets with penalties ('skull & crossbones'). This pattern of results suggests that the motor biases I observed are not simply automatic responses to the magnitude of any game stimuli, but more likely reflects gamblers' IOCs over their pursued baited targets. Critically, as predicted, I demonstrate that these attempts to control the animated die are amplified with increased competition, in the form of antagonistic bets by a real gambling opponent. Such behaviours are strikingly similar to observational reports of how competitive craps players are willing to null the throw of a shooter by behaviourally 'catching the die' to in order to 'break' the opponents sway over fair dice (Henslin, 1967). However, failure to find associations between these motor expressions of IOCs, and the trait and state ratings of IOCs does limit my findings generalizability to previous conceptualisations of IOC as *propositional expressions* of gamblers' belief. Nevertheless, with regards to *motor expressions* of IOC biases, my findings provide strong evidence that the competitive aspects of social gambling environments can facilitate action-based cognitive biases in gambling games (Bandura, 2001; Brown, 1987; Walker, 1992).

5.5.1 Die-rolls and competition

Our finding that competition enhances behavioural biases for control over an animated die is consistent with previous gambling and non-gambling studies that indirectly report how competition heightens IOCs; previous experiments demonstrate that playing with competent partners, rather than incompetent ones, can increase gamblers' bet sizes (Experiment 1; Langer, 1975), and even increase players' subjective judgements of control over the movements of independent computer animations that they were, deceptively, asked to control (Experiment 1; Dewey, Seiffert, & Carr, 2010).

However, my results extend these findings by showing that direct and challenging acts of a competitor, can impact on gamblers behaviours. More importantly, conceiving competition as the proportion of wagers and opponent bets against a shooter has 2 additional benefits. Firstly, it approximates gambling competition in a game of casino craps, where betting partners can either bet that you hit, or miss, your points (i.e., 'pass line' bet versus 'don't pass' bets). The quasi-experimental results reported here, thus, likely reflect actual competitive effects in casino gambling. Secondly, the conceptions of competition here goes beyond traditional conceptions of it in terms of co-acting gamblers' competency, which has hitherto provided mixed results (Breen & Frank, 1993; Langer, 1975).

5.5.2 Die-rolls and social-cognitive biases

To account for greater IOC in competitive environments, Langer (1975, p.313) argued that competition introduces a 'skill-related factor into a chance setting'. If this view is right, then the competitive effect observed here suggests that skill-orientations in gambling games can be modulated by the social context. That is, betting partners' every wager against the die shooter, if taken seriously, can be viewed as an assertion by the gambling co-actor, that the die shooter is deficient in skill to achieve his outcome. Put positively, it is an assertion by the opponent of his own skills to predict die outcomes.

From a social cognitive perspective (Brown, 1987; Walker, 1992), I therefore speculate that the competitive effects in the game of dice could be conceived of as social contagions of mistaken beliefs, or 'rules', that maintain the inefficiencies in gamblers' decision-making (Lefrancois, Chase, & Joyce, 1988). Specifically, one way gamblers learn, and transmit, erroneous beliefs is through their own competitive choices, or the competitive choices of gambling co-actors (Bandura, 2001). Previous findings strengthen this view. Slot machine gamblers take greater risks after hearing a gambling co-actor endorse mistaken rules about the game, as if adopting for themselves those very beliefs (Caron & Ladouceur, 2003). Our results therefore present beginning evidence for an understudied behavioural account of how IOC biases are modelled and developed within gambling games (Delfabbro, 2004).

5.5.3 Die-rolls and die-control ratings

One limitation of the present results is the failure to show an association between behavioural expressions of IOC and questionnaire measures of it. One possible explanation for this is the poor psychometric properties of my questionnaire data. Internal reliability of the IOC subscale of the GRCS in this sample was poor (Cronbach's α= .37), which will explain the lack of statistical association between it and the state measuse of IOCs assessed by the Game-control Beliefs Questionnaire.

Unfortunately, this leaves die-roll behavioural biases without independent validation as a measure of IOCs. Nevertheless, it is argued that this is not a strong criticism of the present action paradigm. Behavioural measurements were introduced here as an alternative measure of in-play illusory beliefs because of the recognition that questionnaire-based measurements presumed the accessibility and accuracy of self-report cognitive biases. To find final validation for this action paradigm using questionnaire rating would thus be inappropriate and self-contradictory. Problems associated with my psychometric measures must be addressed in future research, yet better validation for the motor paradigm should come from how die-rolling behavioural biases respond in expected ways to the changing features and events within the game. This is in fact what I did find; gamblers express a behavioural bias to roll dice for longer when attempting to achieve larger winning target and prizes, replicating Studies 1-3. Moreover, I demonstrate here that competition enhances (in the expected direction) these motor expressions of IOCs over the animated die.

In conclusion, the presents study demonstrates specificity of the motor expressions of IOCs, where lengthen die-rolls are executed to achieve a player's own baited targets rather than other salient targets in the game. Though psychometric validation is still lacking here, the present results nevertheless critically demonstrates that motor expressions of IOC can be magnified by the intensity of competition between gambling partners. These results strengthens Langer's (1975) thesis of competition as a skill-orientating factor and suggests that competition in gambling games, affords opportunities for new, socially represented, rules about game contingencies to be learnt from gambling co-actors (Bandura, 2001; Brown, 1987; Walker, 1992). More broadly, it expands the remit of social facilitation research (Allport, 1924), from one of participatory *co-action* to that of participatory *competition*.

The preceding 4 experimental investigations of games of dice have demonstrated how sensory-motor, as well as competitive, features of games can facilitate action-based expressions of IOCs. IOCs are admittedly only one, though central, set of cognitive biases in gambling. Thus, the next step in my thesis examine how cognitive biases, and other generic risk factors for PG, influence the operation of computational (psychological) mechanisms as gamblers learn the value of action in gambling games.

Chapter 6.

Self-report GRCs, impulsivity and action-value learning under uncertainty – Study 5

Study 5 used quantitative (computational) models to describe individual variability in how gamblers make a series of decisions under uncertainty, and how this variability is influenced by specific risk factors for PG such as GRCs, and generic risk factors such as impulsive traits that reflect gamblers' poor forward planning. The focus now involves psychophysical measures of reward magnitude, probability and Bayesian learning.

6.1 Introduction

Recent developments in neuroscience suggest that computational models of psychological processes may aid the understanding and treatment of mental illnesses (Montague, et al., 2012). One challenge for this approach involves describing the relationships between the different risk factors for mental illnesses and the underlying computations that might enhance the likelihood of vulnerable individuals developing clinically significant symptoms. Here, I tested this approach by modelling how two central risk factors for pathological gambling – impulsivity and altered thinking about gambling outcomes (Ainslie, 1975; Michalczuk, Bowden-Jones, Verdejo-Garcia, & Clark, 2011; Toneatto, et al., 1997) – influence gamblers' ability to learn about action values, as characterised by the complementary computational models of action selection and reinforcement learning (Behrens, et al., 2007; Hsu, Krajbich, Zhao, & Camerer, 2009). Perturbations in the operation of these mechanisms can explain why some gamblers continue to play (losing) games, perhaps enhancing the likelihood of gambling-related harm.

Some risk factors for gambling problems are generic, in that they generalise to other related psychological problems. For example, significant evidence links elevated impulsivity to a number of addictive disorders including but not limited to problem gambling (Ainslie, 1975), possibly mediated by altered expression or function of dopamine $D_{2/3}$ receptors in the ventral striatum (Dalley et al., 2007). Individuals who gamble frequently, or who have problems controlling their gambling behaviour, tend to report heightened impulsivity, and impulsivity both complicates treatment and diminishes the likelihood of good clinical outcomes in samples of pathological gamblers (Adinoff et al., 2007; Goudriaan, Oosterlaan, De Beurs, & Van Den Brink, 2008). Other risk factors for gambling problems are specific, reflecting impaired reasoning about gambling games. Cognitive perspectives emphasize that judgment biases and misapplied heuristics can sustain gambling behaviour and even facilitate the development of gambling problems (Toneatto, 1999). Cognitive biases include mistaken thinking about randomness – most famously, in the Gambler's Fallacy (Ayton & Fischer, 2004), but also in false beliefs that it is possible to predict, or even influence, the outcomes of gambling games (Oei, et al., 2008).

Here, I investigated how impulsivity and gambling-related cognitive biases influence the way that gamblers select between, and learn about, actions with probabilistic rewards. First, I tested whether impulsivity and cognitive biases about gambling interfere with the way that gamblers use reward information to select between actions in a probabilistic gambling task. Second, I used a reinforcement-learning model to explore how impulsivity and cognitive biases alter the way that gamblers use choice outcomes to update action values, or are associated with altered representations of subjective probability and reward magnitude, as specified by prominent descriptive models of choice under uncertainty (Tversky & Kahneman, 1992).

6.2 Methods

6.2.1 Participants

Eighty-seven gamblers between 18-60 years of age with varying gambling involvement took part (see Table 6.1). These participants were a combination of the samples recruited in studies 1-3. In the previous year, 11 (12.6%) had gambled daily, 40 (46.0%) gambled 1-3 times a week, 12 (13.8%) gambled 1-3 times a month, and 24 (27.6%) gambled once to a few times a year. All gamblers were screened using a semi-structured interview to exclude any current DSM-IV psychological disorders including substance misuse disorders and pathological gambling (First, et al., 2002). The mean number of past year gambling problems, as measured by the NORC Gambling DSM-IV Screening instrument (Wickwire, et al., 2008) was low at 0.76 (ranging from 0 to 4). Thus, the observations about the impacts of impulsivity and cognitive biases upon action-values reported below cannot be attributed to the non-specific deleterious effects upon learning, attention and executive function of severe pathological gambling (Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2005).

Table 6.1. Demographic and psychometric characteristics of 87 regular (but non-pathological) participating gamblers

	Mean (SD)		N (%)
Age	32.78(11.49)	Gambling losses (past year)	
Years of education	14.47(2.92)	*< £100*	61(70.1)
		£100 - £500	19(21.8)
Affect		*> £500*	6(6.9)
State positive	33.01(6.29)		
State negative	12.17(3.70)		
Chasing Questionnaire			
Big wins	13.47(5.92)		
Big losses	10.38(5.23)		
Near-misses	4.45(1.85)		
Total	28.30(11.92)		
Impulsivity			
Attentional	12.38(3.05)		
Motor	22.87(3.56)		
Non-planning	23.67(4.64)		
Total score	59.26(9.61)		
Gambling-related cognitive biases			
Gambling expectancies	12.53(4.82)		
Illusions of control	7.38(4.30)		
Predictive control	16.87(6.47)		
Perceived inability to stop	8.82(5.09)		
Interpretive control/bias	12.11(5.04)		
Total score	57.90(19.70)		

Note: Gambling problems - National Opinion Research Centre (NORC) DSM-IV gambling screen (Hodgins, 2004); Affect – Positive and Negative Affective Scales (PANAS; Watson, Clark, & Tellegen, 1988); Chasing Questionnaire (CHQ; O'Connor & Dickerson, 2003); Impulsivity – Barratt's Impulsivity Scale (BIS-11; Patton, Stanford, & Barratt, 1995); Gambling-related cognitive biases – Gambling Related Cognitions Scale (GRCS; Raylu & Oei, 2004a).

6.2.2 Procedure

Demographical information, including age and years of formal education, were collected.

Participants also reported their past year gambling losses (1, no losses; 2, less than £100; 3, between £100 to £500; 4, more than £500), and past year gambling frequency (1, once a year or less; 2, few times a year; 3, one to three times a month; 4, one to three times a week; 5, daily). Participants completed psychometric assessments of cognitive, affective and behavioural traits that may influence their behaviour on the task. These included the Barratt's Impulsivity Scale (BIS-11) (Patton, et al., 1995); the Gambling-related Cognitions Scale (GRCS) (Raylu & Oei, 2004a); the Positive and Negative Affective Scales (PANAS) (Watson, et al., 1988), and the Chasing Questionnaire (CHQ) (O'Connor & Dickerson, 2003). Analysis of this psychometric data gathered from my sample of gamblers demonstrated good internal reliability: all Cronbach's $\alpha > .82$; whilst all subscales had at least moderate internal reliability: Cronbach's $\alpha > .65$. Only the motor impulsivity subscale of the BIS had relatively low reliability, Cronbach's $\alpha = .59$.

Our gamblers completed psychometrically-validated questionnaires before playing a simple binary-choice probabilistic-learning game for small monetary prizes (Behrens, et al., 2007). In this experiment, I focused specifically upon cognitive impulsivity, as measured by the 'non-planning' subscale of the BIS-11 (Patton, et al., 1995). Non-planning impulsivity is characterized by a tendency to orient to the immediate results of actions rather than longer-term consequences. I reasoned that this expression of impulsivity is the most likely to impact on the way that gamblers select between, and learn about, actions with uncertain outcomes (Goudriaan, et al., 2008). Our community sample of gamblers reported just slightly lower total BIS-scores ($M = 59.26$, $SD = 9.61$) relative to samples of (non-problem) gamblers described in the literature (e.g., $M = 62.14$, $SD = 10.05$; $t(144) = 1.74$, $p = .09$, $d = 0.29$), but significantly lower than samples of pathological gamblers ($M = 76.11$, $SD = 11.72$; $t(115) = 7.92$, p< .0001, $d = 1.42$) (Loxton, Nguyen, Casey, & Dawe, 2008) and general psychiatric patients ($M = 71.37$, $SD = 12.61$; $t(169) = 7.08$, $p < .001$, $d = 1.09$) (Patton, et al., 1995).

Cognitive biases were measured using the GRCS which has 5 psychometrically-validated subscales (Raylu & Oei, 2004a). In comparative terms, the GRCS scores of my sample of a wide variety of gamblers (M= 57.90, SD= 19.70), were somewhat higher than that reported in an Australian general community sample (M= 35.28, SD= 16.81; t(705)= 11.49, p< .001, d= 0.87); but marginally lower than a sample of problem gamblers (M= 64.17, SD= 22.31; t(156)= 1.87, p= .06, d= 0.30) (Raylu & Oei, 2004a).

6.2.3 Probability-tracking game

A full description of the task is available elsewhere (Behrens, et al., 2007). On each trial, participants made forced-choice decisions between a green and a blue box associated with point rewards (Figure 6.1(A)). Participants were told that one colour was more likely to be rewarded than the other but that this might vary over time. The probabilities of reward associated with each colour were not displayed so participants were required to estimate the likelihood of reward based on prior outcomes. The number of points associated with each option was displayed within each coloured box (varying between 0 and 100), but participants were also told that the probabilities of rewards were linked to the colours of the boxes and were independent of the reward magnitudes. If participants selected the rewarded colour, they won the points displayed in the box; however, if they selected the non-rewarded colour, they did not score any points and points were not deducted from their game total. A red bar at the bottom of the screen represented the cumulative sum of winnings over the course of the game. To increase participants' motivation, £10 was awarded if the red bar at the bottom of the display reached the silver mark and £15 if it crossed the gold mark. Unknown to the participants, blue was programmed to produce rewards 75% of the time over the course of the first 120 trials (i.e., the stable condition). In subsequent 30-40 trial blocks, the winning colour alternated between blue and green, with the winning colour now rewarded 80% of the time (i.e., the volatile condition; see Behrens, et al., 2007 for full details).

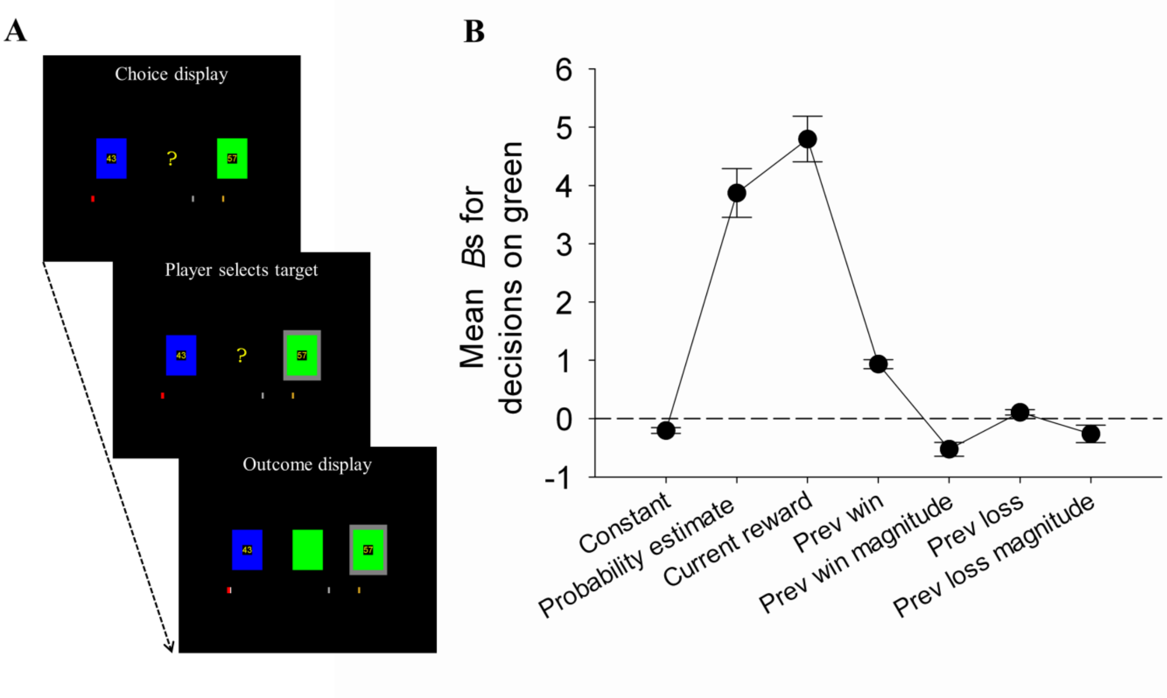


Figure 6.1. (**A**) An example of the probability-tracking task sequence (Behrens, et al., 2007). In this instance, the player chose the green option (indicated by a grey background) and wins the 57 points reward allotted to that option as signalled by the presentation of the correct option in the middle of the display; (**B**) Mean and S.E. of *B*s for all regressors from the single participant GLMs of 87 regular (but non-pathological) participating gamblers. Regressors include: (i) a constant term (ii) tracked probability for the green option on the current choice; (iii) reward magnitude for the green option on the current choice; (iv-v) wins and the magnitude of the wins on the preceding choice (i.e., 'win-stay' or 'win-big-stay' strategies); and (vi-vii) loss and the magnitude of the losses on the preceding choice (i.e. 'lose-shift' or 'lose-big-shift' strategies)

6.3 Analysis procedure

6.3.1 Participant-level analyses

I fit two models to subjects' choice behaviour. Individual decision parameters from the action-selection model were obtained by regressing, using a simple logistic General Linear Model (GLM), the binary variable choice (for the green options within the probabilistic reward-learning task) onto features of the options presented. Separate to this, I also fit a reinforcement-learning model to each subject's behaviour. Individual decision parameters for the reinforcement-learning model were obtained by direct numerical integration. Details of both models are described below.

6.3.2 Group-level analyses

One-sample t-tests were performed on the obtained regression coefficients (*B*s) from the single participant action selection GLMs to determine the significance of regression slopes across the population. These actions-selection parameters were entered into a Multivariate Analysis of Covariance (MANCOVA) as dependent variables (DV), with participants' individual scores from the psychometric assessment as independent variables (IV), and controlling for differences in demography (i.e., age, sex, and years of education), gambling (i.e., past year gambling problems and the tendency to 'chase' winning outcomes, losing outcomes or near-misses), and affect (i.e., positive state affect). I included these covariates to show that any relationships between model parameters and demographic and psychometric scores were not confounded by gross differences in demographics, gambling severity, or affect. Follow-up univariate Analyses of Covariance (ANCOVAs) were then performed on the significant predictors from the above MANCOVA to explore their associations with each of the action-selection parameters.

Next, reinforcement-learning decision parameters were normalised by a (natural) log transformation and entered into a MANCOVA as DVs, with gamblers' non-planning impulsivity and GRCS scores as IVs. Again, individual differences in demography, gambling, and affect were added as covariates. Follow-up univariate ANCOVAs were then performed on the significant predictors from the above MANCOVA to explore their association with each of the reinforcement-learning decision parameters.

6.3.3 Action-selection model

Participants' individual choices (of the arbitrarily chosen colour green) were regressed against: (i) a constant term; (ii) the optimally tracked probability for the colour green (described in detail below); (iii) the magnitude of reward on the green option for the current choice; (iv) winning on the green option with the preceding choice, coded as a 1, winning on the blue option with the preceding choice, coded as a -1, or a code of 0 where the subject lost on the previous choice; (v) the value of the reward on green on the previous choice if chosen and won (coded positively), the value of the value of the reward on blue on the previous choice if chosen and won (coded negatively), or a code of 0 where the subject lost on the previous trial; (vi) losing on the green option with the preceding choice, coded as a 1, losing on the blue option with the preceding choice, coded as a -1, or a code of 0 where the subject won on the previous choice; finally, (vii) the value of the reward on green on the previous choice if chosen and lost (coded positively), the value of the reward on blue on the previous choice if chosen and lost (coded negatively), or a code of 0 where the subject won on the previous choice. Demeaning of the regressors was done in two stages: first, to make regressor (iv) orthogonal to (v), and regressor (vi) orthogonal to (vii), I centred the green and blue choices for regressors (v) and (vii) separately for each participant; second, to reduce between participant noise, all the regressors (ii-vii) were subsequently centred again for each participant.

Parameter (ii) is the optimal probability estimate that players would make if they tracked the fluctuating probability of reward across the game in order to use reward (Pascalian) values to determine their choices. Using the forward (Markovian) model described by Behrens el al. (2007), I assumed that players following an optimal strategy do not take into account the whole reinforcement history at every play; rather, they update their prediction estimates using information from the preceding choice outcome (i.e. as a simple Bayesian learner). These prediction estimates are made by holding, in mind, the representations of rewards probability r_i, the variance of this reward probabilities v_i (i.e. estimating volatility), and the variance of this volatility k (i.e., estimating local changes in volatility; or distrust in its constancy). In Markovian terms, v_i controls the weight that decision outcome i+1 has on r_i; whilst k controls the weight that decision outcome i+1 has on v_i. The changeability of r and v from play i to play i+1 are probabilistic and are represented by Beta and Gaussian distributions respectively (see Behrens, et al., 2007 for a full algebraic description). Therefore, in order to estimate the probability distribution at r_{i+1} from the joint probability distribution of the 3 parameters $r_{i+1,}$ v_{i+1} and k, a numerical integration (marginalising) is done over v_{i+1} and k. The optimal probability estimate at any point of the game (i.e., parameter (ii) of the action selection model above) is then described by the mean value of the marginal probability distribution at r_{i+1}.

6.3.4 Reinforcement-learning model

A reinforcement learning model was fitted to each participant's choices. The model contains four parameters: the learning rate α, the probability distortion factor γ, the reward magnitude weighting factor η and the softmax inverse temperature β. Value for $\gamma < 1$ result in the typical curvature, with overweighting and underweighting of low and high probabilities, respectively. Values for $\eta < 1$ result the typical flattening of the utility curve, indicative of underweighting of higher magnitudes. Low values for β mean that even at very small differences between the options' values, the model is highly likely to select the better option.

On each trial, the model updates the estimated probability of the chosen option according to a simple delta rule (Rescorla & Wagner, 1972):

$$\boldsymbol{p_{i+1} = p_i + \alpha (r_i - p_i)}$$

where p is the estimated probability, r is the outcome (1, win; 0, no win). Only one outcome (green or blue) has to be tracked since p(Green) = 1 - p(Blue). From these estimates of reward probability, the subjectively distorted probabilities w were calculated as (Lattimore, Baker, & Witte, 1992):

$$\boldsymbol{w_i = p_i^{\gamma} / [\, p_i^{\gamma} + (1 - p_i)^{\gamma}\,]}$$

The objective reward magnitudes were transformed into subjective magnitudes (Tversky & Kahneman, 1991), v:

$$\boldsymbol{v_i = x_i^{\eta}}$$

where x_i is the objective reward magnitude on option i. Subjective expected values were then calculated as

$$\boldsymbol{sEV_i = v_i * w_i}$$

The model's probability to select the option chosen by the subject on any given trial was then given by a softmax rule (O'Doherty et al., 2004):

$$\mathbf{P(C{=}c) = 1 / (1 + exp(-\boldsymbol{\beta} * (s\boldsymbol{EV_c} - s\boldsymbol{EV_u})))}$$

where c and u denote the chosen and un-chosen option, respectively.

The parameters that provide the best account of participants' behaviour were estimated using a custom-implemented procedure in MATLAB. The parameter space was set up as a three-dimensional grid in log space with 30 points in each dimension. The joint posterior distribution of the unknown model parameters is then given by the product of choice probabilities over trials under each possible parameter combination in the grid. The marginal posterior distributions on each parameter were then obtained by marginalizing (numerical integration) over the three dimensions of the grid. The optimal parameters were then taken as the distribution means of those marginal posterior distributions. Overall, as Table 6.2 shows, this 4 parameter model provided a better fit to the observed data (BIC = 293.64) across my sample of gamblers compared to a 1 parameter model that assumed only variability in inverse temperature (BIC = 324.23), $t(86) = 5.91$, $p < .001$, $r = .71$.

Table 6.2. Comparing models for reinforcement learning in 87 regular (but non-pathological) gamblers

No.	Mag	Prob	Temp	Learn	BIC (M1)	BIC (M2)
1	0.0258	1.8182	5.0375	0.1687	356.47	153.93
2	0.6245	1.2327	0.7848	0.3022	325.32	277.63
3	1.1233	1.8634	0.0445	0.3393	276.28	264.32
4	0.0502	1.2211	2.8197	0.1897	348.97	280.94
5	0.6322	0.8279	0.5100	0.5633	303.5	207.12
6	0.1528	1.3797	1.0532	0.3978	385.13	349.91
7	0.0890	1.2464	1.4035	0.5495	385.17	308.45
8	1.2755	0.4285	0.1163	0.3151	324.45	341.73
9	1.0832	0.3067	5.4977	0.0444	262.28	188.41
10	1.0636	0.3786	3.0874	0.0457	356.66	371.35
11	0.8650	0.6210	2.9110	0.1234	238.48	258.38
12	0.0457	0.9736	4.5388	0.0761	344.63	296.36
13	0.3276	0.7681	4.4349	0.0639	287.87	311.23
14	0.4544	0.7727	6.9611	0.2671	283.58	225.26
15	1.0892	0.9540	0.7731	0.2043	284.49	310.68
16	0.4007	0.1746	7.9284	0.1628	405.74	422.97
17	1.1422	1.0364	0.4722	0.1772	254.21	270.53
18	0.5553	0.2201	20.4675	0.0279	384.87	398.54
19	0.4902	0.3458	14.0087	0.1345	249.53	258.45
20	0.6355	1.5279	0.3042	0.3678	350.53	343.73
21	0.6618	1.4908	0.4260	0.2254	264.28	198.81
22	0.2550	0.3719	18.0572	0.2772	332.00	273.18
23	0.5230	0.2983	19.2278	0.2064	196.45	187.43
24	0.0441	1.3047	2.2530	0.2912	373.30	295.16
25	1.2415	0.1364	17.7857	0.0220	341.98	325.53
26	0.5792	0.7637	2.0075	0.3282	388.25	399.31
27	1.0521	0.6852	0.9056	0.1936	162.00	194.97
28	0.8351	1.7097	0.2998	0.2009	232.76	155.72
29	1.3411	0.1288	12.7369	0.0318	368.05	369.60
30	0.7277	0.7102	4.2390	0.2273	322.13	336.90
31	0.1645	0.5478	1.8149	0.5965	390.10	367.36
32	0.3629	0.5813	0.3141	0.9447	407.26	401.38
33	0.8970	0.3926	2.5297	0.2450	205.24	214.15
34	0.6706	1.4306	0.2129	0.2403	359.25	341.75
35	0.6174	0.1821	24.6101	0.2252	245.11	260.30
36	0.4204	0.9168	4.9418	0.1171	283.39	209.55
37	1.3514	0.3483	0.5210	0.2864	261.00	263.16
38	1.5367	0.1291	11.8882	0.0242	302.32	194.53
39	0.1581	1.4161	2.5307	0.2150	344.77	196.11
40	0.0875	1.1067	1.1857	0.7394	371.42	319.75
41	1.3633	0.1169	14.9825	0.0288	378.38	380.62
42	0.1900	0.3313	21.7035	0.3031	320.66	281.24
43	0.0773	1.6073	2.7738	0.2231	359.03	217.26
44	0.1877	0.5467	13.764	0.1508	312.13	290.14
45	0.9055	1.1166	0.5442	0.2355	277.10	296.78
46	0.5562	1.9499	0.7896	0.0111	256.71	248.91
47	0.0559	1.1683	3.2540	0.3549	356.03	237.98
48	1.3691	0.1395	9.0733	0.1661	374.77	376.21
49	0.4899	0.5757	10.8444	0.1660	250.28	209.38
50	0.0730	0.5050	22.4189	0.1560	360.07	231.98
51	0.0768	0.3754	5.7914	0.5765	341.43	282.71
52	0.1888	1.5034	1.1162	0.3853	376.34	295.03
53	1.2582	0.1460	13.5510	0.0661	359.56	377.98
54	0.8771	0.5339	3.8463	0.1920	243.15	247.25
55	0.2897	1.3237	0.8792	0.2270	358.39	336.31
56	0.6880	1.6897	0.3436	0.2318	297.00	203.81
57	1.2557	0.1620	10.7337	0.0753	331.04	310.55
58	0.3844	1.6381	0.8036	0.2070	330.25	257.88
59	0.1993	0.9355	0.7860	0.8430	365.53	310.39
60	0.9511	1.2625	0.9841	0.1920	292.93	281.10
61	1.2049	0.1960	10.4672	0.0615	376.39	362.10
62	0.4035	0.3304	19.3018	0.0226	368.29	377.30
63	0.5392	0.2020	22.4371	0.0427	394.47	411.69
64	0.8771	0.5339	3.8463	0.1920	243.15	247.25
65	1.4138	0.1237	14.4553	0.0671	322.20	306.42
66	0.0840	0.5806	23.4635	0.0102	345.55	356.76
67	0.5086	0.9132	0.8270	0.2083	337.34	316.78
68	1.0859	0.1990	9.0138	0.1096	278.66	284.38
69	0.8395	0.8038	2.7301	0.0151	333.76	311.61
70	0.1796	0.7897	1.3570	0.5022	366.19	331.83
71	0.3487	0.2144	7.6621	0.1870	405.85	422.00
72	0.4804	0.9568	1.4161	0.3217	307.43	246.13
73	0.8540	0.2419	10.0070	0.0977	320.72	336.87
74	0.3878	0.2317	9.2637	0.1716	404.95	418.51
75	1.5912	0.1083	16.3987	0.0436	289.22	254.00
76	0.7910	1.0202	0.1506	0.3840	350.54	337.61
77	0.3094	0.2237	7.4193	0.1707	405.53	422.70
78	1.6296	0.0854	20.9018	0.0504	356.01	347.92
79	1.7028	0.0899	24.005	0.1471	292.43	164.38
80	0.4619	1.6674	0.6548	0.1859	329.31	245.11
81	0.8746	1.5377	0.0785	0.4347	347.36	327.13
82	0.6157	0.4035	9.9208	0.2028	244.37	243.03
83	0.8569	0.2689	12.8204	0.0408	306.84	286.62
84	0.1801	1.7156	1.9221	0.2599	353.38	214.02
85	0.9432	1.1399	0.0844	0.2881	304.21	293.20
86	0.5856	1.4803	0.3897	0.2677	357.51	305.86
87	1.3221	0.1247	13.1612	0.1044	366.47	357.31

Note: Mag – Magnitude distortion; Prob – Probability distortion; Temp – Inverse temperature; Learn – Learning rate; BIC - Bayesian information criterion; Model 1(M1) includes the inverse temperature free parameter and assumes an optimal Bayesian learner (see parameter (ii) of the action-selection model above; for a full algebraic description see Behrens, et al., 2007); Model 2 (M2) contains all 4 free parameters and does not assume an optimal Bayesian learner; M2 (BIC= 293.64) has an overall better fit than M1 (BIC = 324.23), $t(86) = 5.91$, $p < .001$, $r = .71$.

6.4 Results

Two different approaches to understand gamblers' behaviour were used in this analysis. Normative accounts of choice posit that decision-makers combine each action's estimated probability of reward with the magnitude of its reward in order to select the option with the higher expected value (Kahneman & Tversky, 2000). In my first analysis (describing an action-selection model), I used logistic regression to determine the extent to which participants' choices (green versus blue) reflected the optimally-tracked reward probabilities and the magnitude of the rewards to identify the expected value of candidate actions, as well as simple strategies such as sticking with responses that produced winning outcomes ('win-stay') switching away from responses that produced bad outcomes ('lose-shift'). In my second analysis, a reinforcement-learning model was fitted to allow the estimation of individual learning rates as my gamblers acquired and then adjusted action values; this descriptive model also incorporated estimates of the subjective over- or underweighting of reward probabilities to facilitate subjective expected values (Kahneman & Tversky, 2000).

6.4.1 Action-selection model

At the single participant-level, each gambler's choice (of the colour 'green') was regressed against: (i) the optimally estimated probability of that option (as modelled by an ideal Bayesian learner (Behrens, et al., 2007)); (ii) the magnitude of reward associated with that option; (iii-iv) the winning or winning magnitude of the preceding choice (i.e., 'win-stay' or 'win-big-stay' strategies); and, finally, (v-vi) the losing or losing magnitude on the preceding choice (i.e. 'lose-shift' or 'lose-big-shift' strategies).

Consistent with a previous report using this probabilistic-learning task in a student sample (Behrens, et al., 2007), my gamblers used both the optimally-tracked probabilities of reward, ($t(86)= 9.23$, $p< .001$, $d= 0.99$), and their magnitudes when deciding between actions, ($t(86)= 12.23$, $p< .001$, $d= 1.31$; see Figure 6.1(B) and Table 6.3). In addition, however, gamblers tended to stick with a selection if it had been successful on the preceding choice (instantiating enhanced 'win-stay' behaviour; $t(86)= 11.88$, $p< .001$, $d= 1.27$), except when the prize won was large (instantiating diminished 'win-big-stay' behaviour; $t(86)= -4.40$, $p< .001$, $d= 0.47$). Gamblers also tended to stick with a selection if it had been unsuccessful on the preceding choice (illustrating decreased 'lose-shift' behaviour; $t(86)= 2.33$, $p< .05$, $d= 0.25$), but tended to switch responses if the loss was large (illustrating increased 'lose-big-shift' behaviour; $t(86)= -1.78$, $p= .08$, $d= 0.19$). Together, these behaviours suggest that the Gambler's Fallacy – the belief that winning (or losing) outcomes are clustered together – can be reversed by the delivery of large reward (or punishment) magnitudes.

Table 6.3. One-sample t-tests of action-selection regression coefficients (*B*s) from single participant GLMs of 87 regular (but non-pathological) gamblers while playing a probabilistic reward-learning task (Behrens, et al., 2007)

	Mean *B*	SE	*df*	*t*
Constant	-0.20	.05	86	-4.16***
Optimal probability-tracking	3.87	.42	86	9.23***
Current reward magnitude	4.80	.39	86	12.23***
Preceding win	0.93	.08	86	11.88***
Preceding win magnitude	-0.53	.12	86	-4.40***
Preceding loss	0.11	.05	86	2.33*
Preceding loss magnitude	-0.26	.15	86	-1.78^{+}

Note: $^{+}p< .10$; $*p< .05$; $***p< .001$.

At the group level, the *B*-values of all the parameters of the action-selection model were entered into a Multivariate Analysis of Covariance (MANCOVA) with gamblers' non-planning impulsivity and their total gambling-related cognitive biases scores as predictors. This analysis also controlled for the influence of differences in demography (i.e., age, gender, and years of education), past year gambling problems, their tendency to 'chase' winning outcomes, losing outcomes or near-misses, and state positive affect. The inclusion of these covariates means that any changes in the information that gamblers use to select between actions associated with impulsivity or cognitive biases cannot be accounted for simply by demographics, variations in gambling and state affect (reviewed in Trepel, et al., 2005). In those cases, where impulsivity or cognitive bias scores were identified as significant predictors of action-selection parameters in the above MANCOVA, follow-up tests were conducted using standard univariate Analyses of Covariance (ANCOVA).

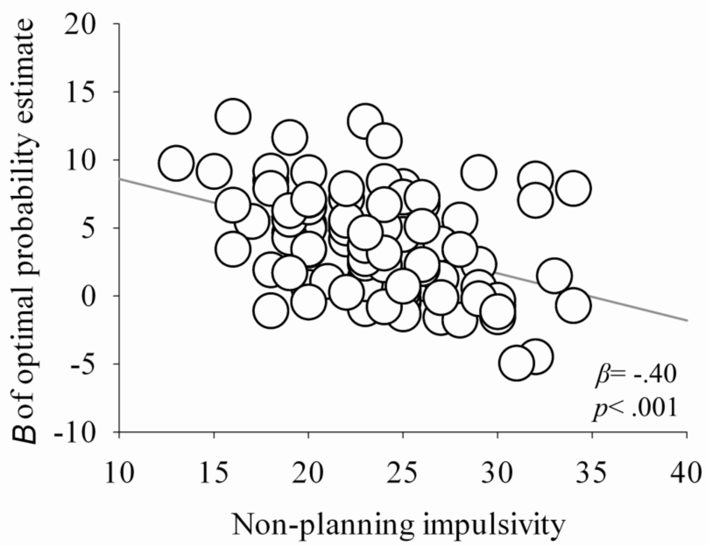


Figure 6.2. Individual *B*s indicating the use of the optimal (Bayesian) probability estimate in making choices as a function of non-planning impulsivity score from the Barratt's Impulsivity Scale (BIS-11)(Patton, et al., 1995).

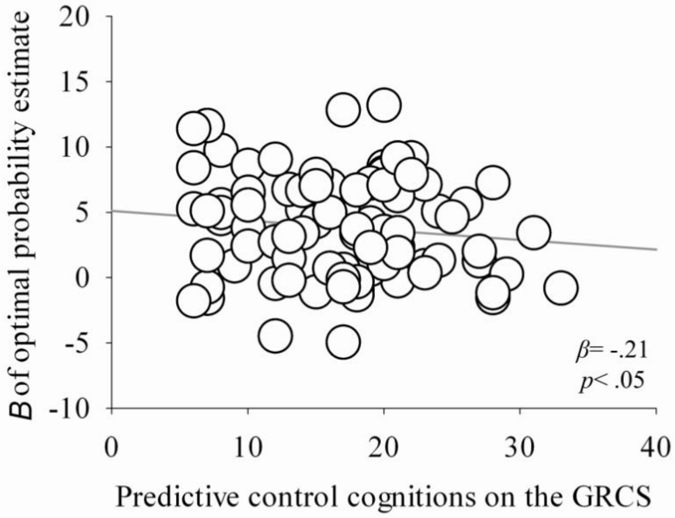
First of all, I found that higher levels of impulsivity (β= -.34, p< .01) and stronger gambling-related cognitive biases (β= -.35, p< .01) both tended to go along with lower final scores on the game, suggesting that these features hampered probabilistic learning in these individuals (see Table 6.4). Additionally, gamblers' impulsivity scores (V= 0.19, F(6, 73)= 2.93, p= .01, η^2= .19), their gambling-related cognitive biases (V= 0.15, F(6, 73)= 2.29, p< .05, η^2= .16), and their ages (V= 0.27, F(6, 73)= 4.52, p< .001, η^2= .27) were all significant predictors of how much gamblers used different action-selection parameters. Impulsive gamblers (F(1,78)=14.73, p< .001, η^2= .16; see Figure 6.2), as well as older gamblers (F(1,78)=8.66, p< .01, η^2= .10), exhibited diminished use of the (optimal) Bayesian estimates of the probability of reward when selecting between actions. Rather, impulsive gamblers tended to stick with response options that had delivered larger rewards on the preceding play (i.e. increased 'win-big-stay' behaviour; F(1,78)=3.02, p= .09, η^2= .04). Heightened impulsivity is strongly linked to heavy (and broad) gambling participation (Leeman & Potenza, 2012), high rates of comorbid alcohol and substance misuse (N. M. Petry, 2001), and poorer clinical outcomes (Adinoff, et al., 2007). The data presented here add to this picture by demonstrating that impulsivity in gamblers diminishes the use of accurate probability estimates that might help to identify the optimal actions in terms of expected value.

Table 6.4. Group-level regression of game total score against demographic and psychometric scores in 87 regular (but non-pathological) gamblers while playing a probabilistic reward-learning task (Behrens, et al., 2007)

	B	SE *B*	β
Constant	13824.88	1204.90	
Education	86.80	37.62	.23*
Age	-18.61	9.53	-.19^{+}
Sex	52.79	300.12	.02
Past year gambling problems	226.55	121.46	.21^{+}
Total score/CHQ	14.27	10.82	.15
State positive affect/PANAS	-32.27	17.99	-.18^{+}
Total score/GRCS	-20.00	6.80	-.35**
Non-planned impulsivity/BIS-11	-80.66	26.10	-.34**

Note: R^2 = .57 (p< .001); Covariates shaded in grey; ^{+}p < .10; *p < .05; **p < .01; CHQ – Chasing Questionnaire (O'Connor & Dickerson, 2003); PANAS – Positive and Negative Affective Scales (Watson, et al., 1988); GRCS – Gambling-related cognitions scale (Raylu & Oei, 2004a); BIS-11 – Barratt's Impulsivity Scale (Patton, et al., 1995).

Gambling-related cognitive biases also appear to impede the selection of optimal actions. Gamblers who reported strong cognitive distortions about gambling exhibited diminished use of optimal probability estimates when deciding between the two response options in the game (F(1,78)=4.80, p< .05, η^2= .06). Instead, gamblers with stronger gambling-related cognitive biases tended to shift from options that they previously won (decreased 'win-stay' behaviour; F(1,78)=3.93, p= .05, η^2= .05), and a tendency to shift from options that they previously lost (increased 'lose-shift' behaviour; F(1,78)=6.67, p< .05, η^2= .08). Cognitive distortions and faulty beliefs about randomness are strengthened in individuals with problematic patterns of gambling (Joukhador, et al., 2004; Toneatto, 1999); these data demonstrate, for the first time, that gambling-related cognitive biases diminish the tracking of accurate probability estimates, increasing the weight given to recent choice outcomes when selecting between actions with probabilistic rewards and punishments.



'A series of losses will provide me a learning experience that will help me win later'

'I have some control over predicting my gambling wins'

'Losses when gambling are bound to be followed by a series of wins.'

'When I have a win once, I will definitely win again'

'If I keep changing my numbers, I have less chance of winning than if I keep the same numbers every time.'

'There are times that I feel lucky and thus, gamble those times only'

Figure 6.3. Individual *B*s indicating the use of the optimal (Bayesian) probability estimate in making choices as a function of predictive control cognitions on the Gambling-related cognitions scale (GRCS)(Raylu & Oei, 2004a) alongside items on the predictive control subscale displayed on the right of the figure

Table 6.5. Group-level regression of *B*s from the single participant GLMs (for optimal probability-tracking) against demographic and psychometric scores in 87 regular (but non-pathological) participating gamblers

	B	SE *B*	*β*
Constant	13.56	4.05	
Education	0.30	0.13	.22*
Age	-0.10	0.03	-.29**
Sex	0.82	1.01	.08
Past year gambling problems	-0.13	0.38	-.03
Total score/CHQ	0.05	0.03	.16
State positive affect/PANAS	-0.08	0.06	-.17
Predictive control/GRCS	-0.13	0.06	-.21*
Non-planned impulsivity/BIS-11	-0.34	0.09	-.41***

Note: R^2 = .62 (p< .001); Covariates shaded in grey; *p < .05; **p < .01; ***p < .001 CHQ – Chasing Questionnaire(O'Connor & Dickerson, 2003); PANAS – Positive and Negative Affective Scales(Watson, et al., 1988); GRCS – Gambling-related cognitions scale(Raylu & Oei, 2004a); BIS-11 – Barratt's Impulsivity Scale(Patton, et al., 1995).

Further analysis, regressing the optimal probability estimates against the predictive control subscale of the GRCS, indicated the failure to use the optimal (Bayesian) tracked probability of reward when making choices was particularly clear in those gamblers who endorsed cognitions associated with 'predictive control' (β= -.21, p< .05; see Figure 6.3 and Table 6.5). Predictive control involves those beliefs that it is possible, within the context of commercial gambling games, to identify winning opportunities, typically reflecting the conviction that it is possible to use recent gambling outcomes (i.e. a game's reinforcement history) to estimate the likelihood of future success. In this experiment, gamblers who report strong predictive control endorsed statements such as: 'When I have a win once, I will definitely win again', 'A series of losses will provide me a learning experience that will help me win later' and 'I have some control of predicting my gambling wins'. Our data indicate that, contrary to these claims, gamblers who endorse these statements specifically fail to read reinforcement histories in ways that might identify the most valuable actions.

6.4.2 Reinforcement-learning model

The above findings tell us that impulsivity and cognitions that promote gambling involvement – specifically, the belief that it is possible to predict winning opportunities – impede the use of tracked probability estimates information that might identify normatively valuable actions. However, these data do not in themselves indicate whether this impairment involves changes in *learning* about probabilities, or other changes in the subjective representation of probability information while processing value. To learn more, I fitted a reinforcement learning model to gamblers' choices during performance of the probabilistic-learning task. Descriptive accounts such as Prospect Theory (Kahneman & Tversky, 2000; Tversky & Kahneman, 1992) indicate that decision-makers display characteristic distortions of probability and reward magnitudes. In particular, subjective probabilities often involve an S-shaped curvature, involving the overweighting and underweighting of low and high probabilities, respectively; while the subjective representation of rewards are usually underweighted with increasing magnitude, resulting in a concave utility curve. Therefore, at the participant-level, my second model included 4 parameters: (i) the learning rate to indicate how much each outcome was used to update the estimated reward probabilities (i.e. the rapidity of adjusting action values); (ii) the subjective distortion of probabilities to demonstrate overweighting and underweighting of low and high probabilities (Tversky & Kahneman, 1992); (iii) the underweighting of increasing magnitudes to describe a concave utility curve (Tversky & Kahneman, 1992); and, finally, (iv) the randomness (i.e., stochasticity) of gamblers' choices as quantified by the softmax inverse temperature.

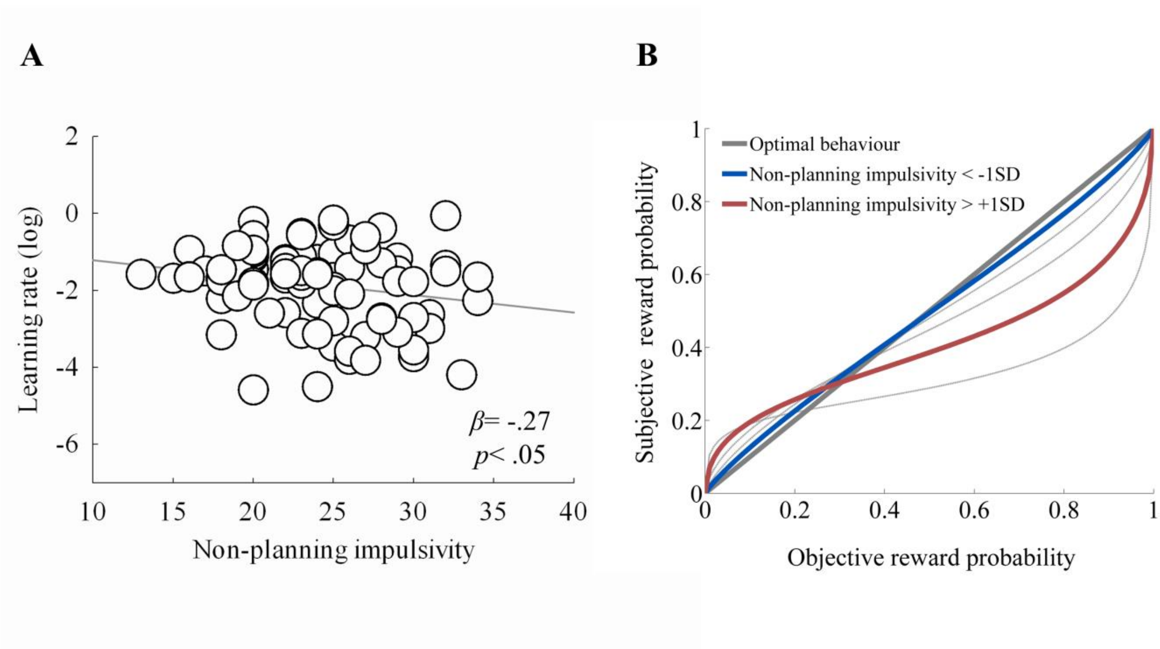


Figure 6.4. (**A**) Learning rates (natural log) as a function of non-planning impulsivity score on the Barratt's Impulsivity Scale (BIS-11) (Patton, et al., 1995); (**B**) Probability distortions as indicated by overweighting and underweighting of low and high probabilities in participants with low and high non-planning impulsive participants (≈ +/- 1 S.D.)

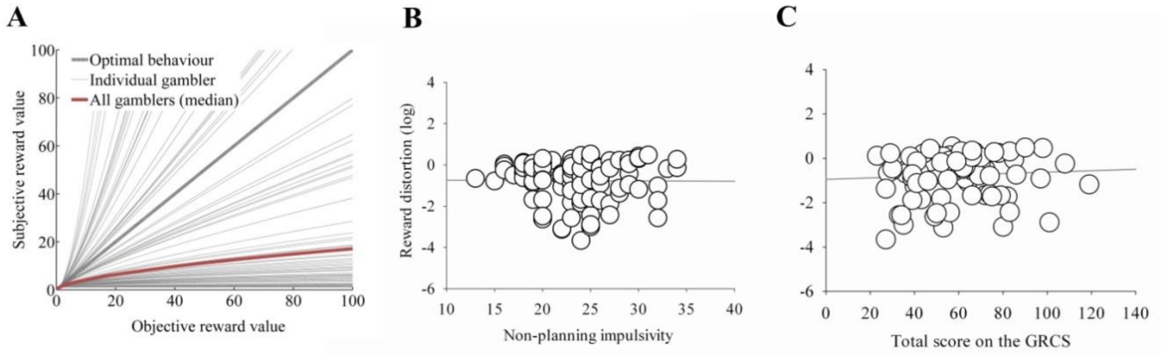


Figure 6.5. (**A**) Plot of weighted value against objective value for all 87 regular gamblers; (**B**) Plot of reward distortion (natural log) against non-planning impulsivity on the Barratt's Impulsivity Scale (BIS-11; Patton, et al., 1995); (C) Plot of reward distortion (natural log) against the total score on the Gambling-related cognitions scale (GRCS; Raylu & Oei, 2004a)

Entering the parameters of the reinforcement learning model into an MANCOVA revealed significant effects of impulsivity ($V= 0.14$, $F(4,75)= 3.09$, $p< .05$, $\eta 2= .14$), but not cognitive biases ($V= 0.04$, $F(4,75)= 0.82$, $p> .05$). Gamblers who reported heightened impulsivity exhibited smaller learning rates compared to gamblers with lower impulsivity ($F(1,78)=4.15$, $p< .05$, $\eta 2= .05$; see Figure 6.4(A)), indicating that such individuals were slower to learn from previous outcomes. They also tended to overweight low probable outcomes and underweight high probable outcomes ($F(1,78)=4.87$, $p< .05$, $\eta 2= .06$; see Figure 6.4(B)). Conversely, high impulsive gamblers did not underweight larger value outcomes compared to low impulsive gamblers (see Figure 6.5(A) and (B)); neither was there was any indication that impulsivity was associated with enhanced randomness in gamblers' choices across the probability-tracking task (see Figure 6.6(A) and (B)). In contrast to the impacts of impulsivity on my model parameters, there was no consistent evidence that stronger gambling-related cognitive biases were associated with gamblers' learning rates, probability distortion, reward weighting, or randomness of choice behaviour (see Figure 6.5(C) and Figure 6.6(C)).

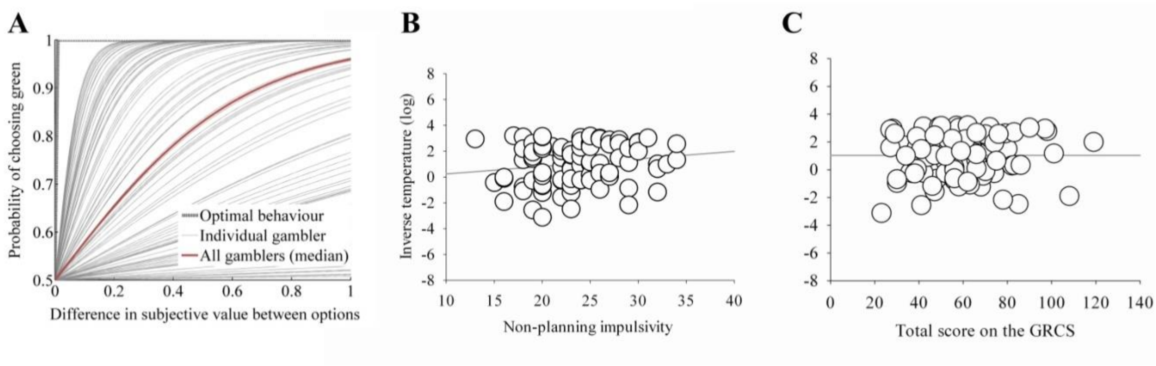


Figure 6.6. (**A**) Plot of gamblers' probability of choosing the green option against the difference in subjective value between the green and blue options for all 87 regular (but non-pathological) participating gamblers; (**B**) Plot inverse temperature (natural log) against non-planning impulsivity on the Barratt's Impulsivity Scale (BIS-11; Patton, et al., 1995); (C) Plot of inverse temperature (natural log) against the total score on the Gambling-related cognitions scale (GRCS; Raylu & Oei, 2004a)

6.5 Discussion

These data illustrate how computational models can be used to describe the way that generic and specific risk factors for gambling problems are associated with perturbations in the way that gamblers process action values. I observed these effects in a large sample of gamblers who did not satisfy the diagnostic criteria for the kind of marked problems associated with the diagnosis of pathological gambling. As such, my findings cannot plausibly be attributed to the non-specific effects of gambling addiction on risky decision-making (Goudriaan, et al., 2005). Rather, these data reflect the way that variability in the risk factors for gambling problems – specifically, heightened impulsivity and potent cognitive biases – operate to impair the acquisition of action values in gambling-like games. To my knowledge, this is the first published report of how impulsivity and gambling-related biases find expression in the way that regular gamblers identify valuable actions when making choices in terms of normative and subjective probability information. Our findings also indicate how computational models of behaviour, observed in the 'sterile' context of a laboratory rather than actual commercial gambling activities (Ladouceur, et al., 1991), can help us to understand the relationship between risk factors and the psychological processes that enhance the likelihood of gambling problems.

Previous accounts of the way that impulsivity heightens the risk of addictive behaviours emphasize the tendency to act without forward planning, which inevitably exacerbates loss of control over reward-seeking behaviours and the consumption of drugs or participation in gambling activities (Goudriaan, et al., 2008). Such accounts are essentially descriptive, without any characterization of the mechanisms that mediate the link between impulsivity and gambling. Our data indicate that impulsivity in gamblers involves diminished use of the estimated probability of rewards associated with candidate actions (derived from the game's recent reinforcement history) that help specify their expected values. Further analysis indicated that this strategy is mediated in part by a failure to optimally update action values on the basis of preceding outcomes (i.e., small learning-rates). Lower learning rates imply that impulsivity in gamblers is associated with beliefs that reward structures – including those of gambling games – are more stable than they really are. Convergent evidence for this proposal can be seen in the finding that impulsive gamblers further overweight low probable outcomes and underweight high probable outcomes as specified by descriptive accounts of choices under conditions of uncertainty (Kahneman & Tversky, 2000). This exaggerated bias might facilitate choices of risky gambles through the tendency to overestimate the chances of good outcomes but under-estimate the greater likelihood of bad gambling outcomes and may be linked to recent evidence that pathological gambling is associated with altered neural representations of discounted probability (Miedl, Peters, & Buchel, 2012). These mechanisms show some specificity since there was no indication that impulsivity in gamblers was associated with broader disturbances to the representation of reward magnitude or in the consistency of choices as indexed by the parameterized estimate of randomness (inverse temperature of the softmax function).

Overall, my results indicate that impulsivity, as a risk factor for gambling and addiction problems can be understood from a reinforcement-learning perspective as involving alterations in the way that individuals use previous choice outcomes to update action values. Finally, the isolation of neural representations of learning rates (Behrens, et al., 2007) and subjective probabilities (Miedl, et al., 2012) offers opportunities to identify how the generic risk factor of impulsivity modulate the way the brain computes the value of gambling games and promotes the transitions from controlled to uncontrolled patterns of gambling behaviour. This lends weight to the proposal of computational psychiatry (Montague, et al., 2012) – that a computational understanding of the aetiology of psychiatric disorders – in this particular instance, gambling problems – may yield novel targets for intervention.

Complementing the impact of impulsivity upon the acquisition of action values, the data also indicate that gambling-related cognitive biases interfere with the extent to which gamblers use estimated action-reward probabilities when selecting between actions with probabilistic rewards. Rather, cognitive biases promote the suboptimal strategy of placing more weight upon immediately preceding winning and losing outcomes to make further gambling decisions. I found that gamblers who endorsed items indicative of predictive control showed the lowest use of the probability estimates when selecting between actions. These items include statements such as 'A series of losses will provide me with a learning experience that will help me win later', 'Losses when gambling are bound to be followed by a series of wins', and 'There are times that I feel lucky and thus, gamble those times only', reflecting the conviction that, in the context of commercial gambling games, it is somehow possible to identify opportunities when winning outcomes are more or less likely. Paradigmatic examples include the Gambler's Fallacy in which the supposition that gaming outcomes are not statistically independent leads gamblers to identify fallacious reinforcement structures in gambling games. Our findings demonstrate that those gamblers with predictive control biases tend to be unable to identify relevant reinforcement structures even when such structures do exist and can be estimated (reasonably) accurately from a gambling game's reinforcement history. Such prior beliefs mean that gamblers with convictions of predictive control '*think they know best*' and are unable to select between actions on the basis of their estimated expected value, potentially increasing the risk of gambling-related harm. In context of accumulating evidence that cognitive-behavioural psychotherapies can be effective in the treatment of gambling problems (Toneatto & Ladouceur, 2003), my results provides a computational account of the psychological processes that possibly form the therapeutic targets for these talking interventions. Collectively, my results demonstrate how computational methods can help us to understand previous (descriptive) accounts of the relationship between cognitive biases and the severity of gambling problems (Joukhador, et al., 2004; Toneatto, 1999).

So far, Studies 1-3 have revealed how motor expressions of GRCs are constrained by external sensory-motor factors of games; whilst the present computational study reports the ways in which GRCs possibly restrict computational mechanisms that underlie action-value learning that might operate while gambling. To further my understanding of GRCs, the remaining studies considered gamblers' interactions within a social-cultural context.

Chapter 7.

Self-report GRCs and Chinese gambling subtypes – Study 6a

Significant evidence suggests that GRCs are strongly expressed within Chinese cultures (Oei, et al., 2008; Zheng, et al., 2010). In study 6a I used an online survey technique to explore how GRCs are related to different gambling behaviours within the Chinese population and their health characteristics.

7.1 Introduction

Culture as a system of belief, practice, and meaning facilitates the breadth and severity of gambling in a variety of ways (reviewed in Raylu & Oei, 2004b); for example, familial and peer gambling increases the acceptability and extent of gambling involvement in adolescents (Langhinrichsen-Rohling, et al., 2004; Nelson, et al., 2007), whilst gambling availability within a community tends to go along with a higher prevalence of severe gambling problems in adulthood (Ladouceur, Jacques, Ferland, & Giroux, 1999). In Chinese culture, gambling participation is normatively viewed as a legitimate medium for recreation and social integration, so long as its harms are recognised (Fong & Ozorio, 2005; NCPG, 2007).

Further evidence of the links between Chinese culture and gambling involvement is provided by national prevalence surveys that report high rates of pathological gambling within Chinese-majority jurisdictions, like Hong Kong, Taiwan, Singapore and Macau (the mean 12-month prevalence is between 1.2% to 4.0%; Fong & Ozorio, 2005; Hwu, et al., 1989; MCYS, 2008; SSRC, 2005). These rates of pathological gambling are more than twice the rates reported within Caucasian-majority jurisdictions like the UK, US and Canada (the mean 12-month prevalence is between 0.4% to 1.1%; NORC, 1999; Shaffer, et al., 1999; Wardle, et al., 2010). Finally, the high rates of gambling problems amongst Chinese minorities residing in Australia and Canada suggests that the links between Chinese culture and gambling (and gambling problems) is not simply a matter of varying availability of commercial gambling activities across different jurisdictions (Blaszczynski, et al., 1998).

One distinctive feature of Chinese culture that could account for the development and maintenance of more gambling problems could be stronger gambling-related cognitive biases, including superstitious beliefs (Oei, et al., 2008; Zheng, et al., 2010). Another possibility is culturally specific patterns of gambling selection in this population, and how this mixing and matching, in turn, is associated with the psychological and social wellbeing of Chinese gamblers. National prevalence studies in Chinese-majority jurisdictions report that the 5 most popular gambling forms include 'social gambling' (e.g., Mahjong and card games with friends and family), lottery play, casino games, and betting on races and sports (Fong & Ozorio, 2005; MCYS, 2008; SSRC, 2005). This reflects at least two distinct patterns of usage within the Chinese community (Fong & Ozorio, 2005), where a majority of moderate 'social gamblers' recreationally play and bet amongst friends and family on activities like Mahjong and card games (Fong & Ozorio, 2005; MCYS, 2008; SSRC, 2005). This also suggests that there is a minority of more established gamblers who more regularly participate in commercial activities like casino gaming and race/sports betting, and who report more problems with their gambling (Wong & So, 2003), or have sought help for these problems (Paton-Simpson, Gruys, & Hannifin, 2001).

Previous investigations indicate that individuals who use online gambling services in different ways tend to report different health experiences (Lloyd et al., 2012; Lloyd, et al., 2010), and that more varied gambling participation is associated with greater severity of gambling problems (LaPlante, Kleschinsky, LaBrie, Nelson, & Shaffer, 2009; Lloyd, et al., 2010). In this experiment, I sought to investigate the combinations of gambling activities within Chinese populations, and their health characteristics (including gambling problems). I invited Chinese participants residing mainly in the UK, Hong Kong and Singapore to complete an online web survey, and then completed a statistical Latent Class Analyses (LCA) to identify gamblers who gambled in different ways as reported in their past-year gambling profiles.

I wished to identify subtypes of gamblers in an international Chinese sample, and then to explore how these groups vary across socio-demographic, health and gambling-related characteristics. I hypothesised that at least two profiles of gambling subtypes will emerge from the data: firstly, a recreational group that mostly engage in lottery play and 'social gambles' like Mahjong and private bets; and, secondly, a more established group that participate in casino gaming and race/sports betting, in addition to the recreational engagement patterns of the former group. Additionally, I hypothesised that the more engaged latter group would descriptively differ on characteristics that have traditionally been viewed as risk factors for, or vulnerabilities of, gambling problems (Johansson, et al., 2009; SSRC, 2005; Wu & Tang, 2011). This would include socio-demographic risk factors (e.g., being male and having fewer years of education), gambling-related risk factors (e.g., gambling-related cognitive distortions and heightened motivation), and health risk factors (e.g., emotional disturbances and substance dependence).

7.2 Methods

7.2.1 Participants and procedure

The study was approved by the Central University Research Ethics Committee (CUREC) of the University of Oxford. Participants were given informed consent as part of the survey and were assured that all of their responses would be kept anonymous and their IP address would not be recorded. Socio-demographic data and gambling involvement were also collected at the beginning so that non-completers could be compared to completers. Participants of other ethnicities were allowed to complete the survey but were not included in the dataset reported here.

Six hundred and eleven (440 male, 171 female) participants who self identifies as Chinese respondents above 18 years of age were recruited between July, 2011, and March, 2012. Since this was an anonymous online survey, there was no way to be sure if any of these participants also participated in previous studies. This was done by placing hyperlinks on Chinese-related British and Singaporean websites, and on email advertisements sent out by a Hong Kong-based tabloid newspaper. Of these 611 responses, 489 of the surveys were complete (344 male, 145 female) and included in the final analysis (80% complete rate). Most of these participants resided in China/ Hong Kong (46.0%), Singapore (29.4%), the UK (20.7%) and Taiwan (1.8%); the remainder resided in various parts of the Asian, Australian, European and American continents (2%).

Of these 489 participant, 178 (36.4%) completed the survey in English script and 311 (63.6%) completed the survey in Chinese script. To assess gambling-related characteristics, I asked participants to rate how frequently they participated in 16 different online and offline gambling games known to be popular amongst the Chinese internationally (e,g., Mahjong, horse racing, sports betting, and casino play). Participants' frequency of gambling was defined as the highest frequency for any activity other than the lottery or Mahjong.

Past year gambling frequency was varied with 149 (30.4%) gambling at least once a week, 80 (16.3%) gambling between 1 to 3 times a month, 104 (21.3%) gambling 11 times a year or less, and 156 (31.9%) reporting no gambling. Overall participation rate in the past year here are comparable to those found in Hong Kong and Macau, but higher than rates reported in Singaporean prevalence data (Fong & Ozorio, 2005; MCYS, 2008; SSRC, 2005). Fifty-three (10.8%) participants were classified as probable problem gamblers (PrGs) using the Problem Gambling Severity Index (PGSI score ≥ 8), and the mean PGSI score for all participants was 2.49±4.00, indicating that this self-selected sample were likely to be at somewhat higher risk for clinical gambling problems compared to national rates in Hong Kong, Macau, Taiwan, and Singapore (Fong & Ozorio, 2005; Hwu, et al., 1989; MCYS, 2008; SSRC, 2005).

7.2.2 Psychometrics

Validated Chinese versions of questionnaires were used in this study. Where this was not available (including measures of gambling activities, superstitious beliefs, mood disorders, life satisfaction, alcohol use, and substance dependence) they were translated into Chinese, and back translated, by 2 native Chinese speakers. Internal reliability of all the psychometric scales used was acceptable (i.e., Cronbach's α were between .75 to .95).

Gambling cognitions. Participants also completed the 23-item Gambling-Related Cognitions Scale to assess thinking biases (GRCS; Oei, et al., 2007; Raylu & Oei, 2004a), an adapted 11-item Beliefs in Luck scale that assessed superstitious beliefs amongst

Chinese internationally (Hernandez, Wang, Minor, & Liu, 2008; Huang & Teng, 2009; Tao, Wu, Cheung, & Tong, 2011; Zheng, et al., 2010).

Gambling motivations. Participants also completed an adapted 10-item Gambling Motivations scale that selected 2 items from 5 of the subscales (Enjoyment/ Stimulation, Mood regulation, Self-efficacy, Prestige and Money) within the Gambling Motivations Scale (GMS; Chantal, Vallerand, & Vallieres, 1994; Wu & Tang, 2011). Since no short motivation scale, validated in a Chinese sample, has been published, I chose to use this adapted scale rather than not having any motivation assessment at all.

Gambling health. Gambling problems in the past year was assessed using the 9-item Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001; Loo, Oei, & Raylu, 2011). Problem gambling was defined as scoring 8 or more points on the PGSI.

Psychological health. To assess general heath, the survey included the 17-item Mood Disorder Questionnaire to assess lifetime elevated hypomanic mood symptoms (MDQ; Hirschfeld et al., 2000; Yang et al., 2011), the Patient Health Questionnaire to assess somatic symptoms during the last month (Kroenke, Spitzer, & Williams, 2002), depression symptoms during the last 2 weeks (PHQ-9; Kroenke, Spitzer, & Williams, 2001; Yeung et al., 2008), panic symptoms during the last month (Lowe et al., 2003), and Generalised Anxiety Disorder symptoms during the last month (GAD-7; Kroenke, Spitzer, Williams, Monahan, & Lowe, 2007; Lubetkin, Jia, & Gold, 2003). Participants also completed the Satisfaction With Life Scale to assess lifetime general well-being (SWLS; Diener, Emmons, Larsen, & Griffin, 1985).

Addiction health. Finally to assess substance use, participants indicated whether they had experience with any substance in the past year (including cigarette use), followed by an administration of the Severity of Dependence Scale to measure the severity of their usage

(SDS; Chen et al., 2008; Gossop, Griffiths, Powis, & Strang, 1992). The Alcohol Use Disorder Identification Test was also administered because it was good scale to assess less severe hazardous and harmful drinking patterns (AUDIT; Fiellin, Reid, & O'Connor, 2000; Wu et al., 2008).

7.3 Data Analysis

7.3.1 Complete and incomplete surveys

I carried out independent sample *t*-tests and Pearson χ^2 tests to investigate demographic, gambling and health differences across complete and non-complete surveys. If a variable was non-normal within either of these groups, the non-parametric Wilcoxon's test was used. Since the sample size was large, non-normality was not based on the significance of Skewness and Kurtosis *z*-scores, but on the cut-off value of ± 1. All significant values were taken at $p< .05$.

7.3.2 Gambling groups

Latent Class Analysis (LCA) was performed by assuming a latent nominal variable that clustered gamblers based on their past year gambling participation profiles. Gambling activities (including betting on dogs, Chinese dominoes, poker, bingo and spread betting) that were reported by less than 10% of the participants were excluded from this analysis since this may reflect varying availability of these activities across jurisdictions. Past-year participation rates of the remaining 10 activities were as follows: Mahjong and private bets (52.2%), lottery and scratch cards (46.8%), casino and slots gaming (35.2%), betting on horses with a bookmaker (20.3%), online sports betting with a bookmaker (20.1%), offline sports betting with a bookmaker (16.4%), football pools (16.4%), betting terminals at the bookmaker (16.1%), any other online gambling games (12.6%), and betting exchanges (10.4%).

LCA was performed on these 10 activities by first converting the frequency of participation to binary variables (0-never in the past year; 1-at least once in the past year; see Fig. 1). Models with 2-10 classes were estimated using these binary variables and the best model was selected weighing the following criteria: (1) model improvement when compared to a model with one fewer class, as measured by significant -2×Loglikelihood values, bootstrapped $p< .01$; (2) local independence between items in the LCA, as measured by the bivariate residuals of each model; (3) parsimony of the model, as measured by the Bayesian Information Criterion (Yang, 2006); (4) low classification error rates; and, finally, (5) the stability of the solution after multiple runs of the analysis.

To check that the classes obtained were not affected by gambling availability where participants resided, three extra LCAs were completed by splitting participants into the three broad areas where they currently resided: English-speaking countries (including UK, Australia, and the USA), Chinese-speaking countries (including China, Hong Kong, and Taiwan), and Southeast Asian countries (including Singapore, Indonesia, and Thailand). All classes derived from these three LCAs showed comparable subtypes of gamblers except one class of online gamblers (n= 6) residing in English-speaking countries (data not reported here because of space constraints). These six online gamblers were removed from the final sample (n= 483) before completion of the overall LCA. Only results from this final LCA are reported below.

7.3.3 Gambling class differences

To investigate how socio-demographic, gambling and health characteristics differed across the groups of gamblers revealed by the LCA, a series of Pearson χ^2 tests and one-way

Analysis of Variance (ANOVAs) were performed. If the distribution of these characteristics was not normal within any gambling class, non-parametric Kruskal-Wallis tests were used followed by Wilcoxon tests as planned comparisons. Again, non-normality was based on the cut-off of Skewness and Kurtosis *z*-scores larger than ± 1. All significance values were taken at $p = .05$.

7.4 Results

7.4.1 Characteristics of the completers vs. non-completers

One hundred and twenty two participants who started on the survey did not go on to complete it (80% completion rate). These non-completers were less likely to be retired or unemployed, and they tended to reside within the Europe, North American and Australia continents. These non-completers were also more educated, used Chinese as a first language, and reported fewer years of gambling (all $p < .05$). Importantly, however, these non-completers did not report any difference in gambling problems compared to the completers (all $p > .05$). Taken all together, this indicates that my sampling of Chinese gamblers was not biased towards gamblers with less gambling involvement or biased towards those residing outside a Chinese cultural context. The remaining analyses are done on the 489 completed survey data.

7.4.2 Latent class Analysis (LCA)

Solutions with 3 classes or less were not considered because they had poorer model fits and violated the local independence assumption for LCA as measured by bivariate residuals. The solution with 5-classes, though having a better model fit compared to a 4-

class solution, was not selected because it lacked parsimony on the BIC and had higher classification errors.

The 4-class solution was finally selected (see Table 7.1 and Figure 7.1).

Table 7.1. Latent Class Analysis (LCA) of gambling activities, in 483 respondents who completed the online survey, with solutions containing 3-5 groups

	3 groups ***(K)***	***4*** groups ***(K)***	***5*** groups ***(K)***
Goodness-of-fit tests			
Degrees of freedom	451	440	429
L^2	519.44	449.67	389.37
Bootstrap *p*-value[a]	< .001	.01	.49
Classification error	0.07	0.07	0.10
Model comparisons (*K* groups vs. *K*-1 groups)			
Difference in –2*LL*	171.50	60.77	60.30
Difference in number of parameters	11	11	11
Bootstrap *p*-value[b]	< .001	< .001	< .001
Parsimony (information criterion)			
BIC (*LL*)	4219.71	4217.92	4225.60
Local independence			
Largest bivariate residual[c]	27.42	3.13	1.99

Note: *K* = number of groups; *LL* = Log-likelihood value; L^2 = Likelihood-ratio goodness-of-fit value; BIS = Bayesian Information Criterion; [a] Bootstrap *p*-values were based on 500 resamples (values >.05 indicate a good fit); [b] Bootstrap *p*-values were based on 500 resamples (values <.05 indicate a better fit compared to a model with fewer groups); [c] Bivariate residuals > 3.84 indicate (at a .05 significance level) a violation of the local independence assumption.

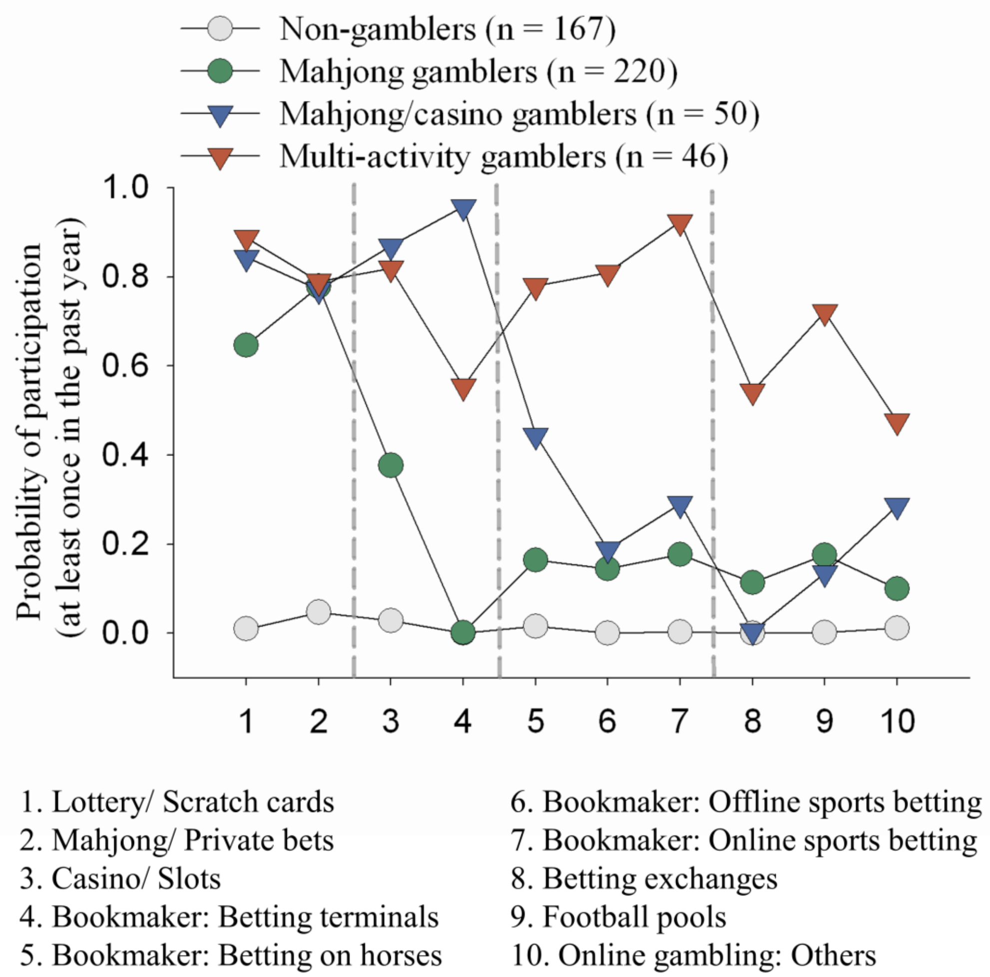


Figure 7.1. Plot of past-year probability of participation against gambling activity; 4-class solution of the Latent Class Analysis (LCA) in 483 respondents

Class 1: Non-to-minimal gamblers. In this group of 167 participants, few engaged in any of the 10 listed gambling activities in the past year (participation rates < 5% for all activities).

Class 2: Mahjong gamblers. In this group of 220 participants, a large majority used lottery/scratch cards (65%), Mahjong/private bets (78%), and a moderate minority used casino/slots (38%) in the past year. Few participated in any of the other gambling options (participation rates < 18%).

Class 3: Mahjong-casino gamblers. In this class of 50 participants, a large majority used lottery/scratch cards (84%), Mahjong/private bets (77%), casino/slots (87%), and betting terminals (96%), whilst a smaller number bet on horses (44%), used online sports betting services (29%) and other forms of online gambling (29%). Few participated in any of the other gambling options (all < 19%).

Class 4: Multi-activity gamblers. In the final group of 46 participants, a large majority used all the listed activities: lottery/scratch cards (89%), Mahjong/private bets (79%), casino/slots (82%), betting terminals (55%), horse bets (78%), offline sports betting (81%), online sports betting (92%), betting exchanges (54%), football pools (72%) and other forms of online gambling (48%).

7.4.3 Social-demographics across groups

Age differed across gambling groups ($H(3) = 75.16$, $p < .001$), where gamblers were older than non-to-minimal gamblers, and the Mahjong-casino gamblers were older than the Mahjong gamblers (all *p*s< .05). As opposed to the less involved non-gamblers and Mahjong gamblers, the more involved Mahjong-casino and multi-activity groups included relatively fewer females ($\chi^2(3) = 44.76$, $p < .001$, $V = .30$), more completions of the survey in Chinese script ($\chi^2(3) = 45.89$, $p < .001$, $V = .31$), and use Chinese as a first language ($\chi^2(3) = 41.09$, $p < .001$, $V = .29$). The multi-activity gamblers also included relatively lower education levels as opposed to the other groups ($\chi^2(3) = 52.15$, $p < .001$, $V = .23$). A breakdown of these effects is found in Table 7.2.

Compared to the mahjong and non-to-minimal gambling groups, the more involved Mahjong-casino and multi-activity gamblers were more likely to reside in East Asia ($\chi^2(3) = 78.25$, $p < .001$, $V = .29$), and were Permanent Residence (PR) or on working VISAs in this region ($\chi^2(3) = 52.06$, $p < .001$, $V = .23$). Additionally, the Mahjong-casino gamblers tended to be married ($\chi^2(3) = 37.18$, $p < .001$, $V = .28$), and unemployed or retired ($\chi^2(3) = 64.68$, $p < .001$, $V = .26$), compared to the other gambling groups. A breakdown of these effects is found in Table 7.3.

7.4.4 Gambling characteristics across groups

As seen in Table 7.4 and Figure 7.2(a), frequency of gambling was significantly different across sub-groups ($H(2) = 46.27$, $p < .001$). Compared to Mahjong gamblers, the Mahjong-casino, and multi-activity, gamblers gambled more frequently in the past year (all ps< .05, $|r|$s> .14). Critically, the rates of problem gambling were also significantly different across groups ($\chi^2(2) = 25.53$, $p < .001$, $V = .28$). Compared to all other gambling groups (12.0%), the multi-activity class (39.1%) had the highest proportion of problem gamblers. However, age of first gamble was not significantly different across gambling groups ($H(2) = 0.54$, $p > .05$).

Gambling-related cognitions ($H(3) = 80.67$, $p < .001$), gambling motivations ($H(3) = 68.02$, $p < .001$), and beliefs in luck ($H(3) = 45.00$, $p < .001$), were also significantly different across gambling groups; compared to compared to non-to-minimal gamblers and Mahjong gamblers, the Mahjong-casino and multi-activity gamblers reported stronger gambling cognitive biases, stronger motivations to gamble, and stronger beliefs in luck (all ps≤ .05, $|r|$s> .11).

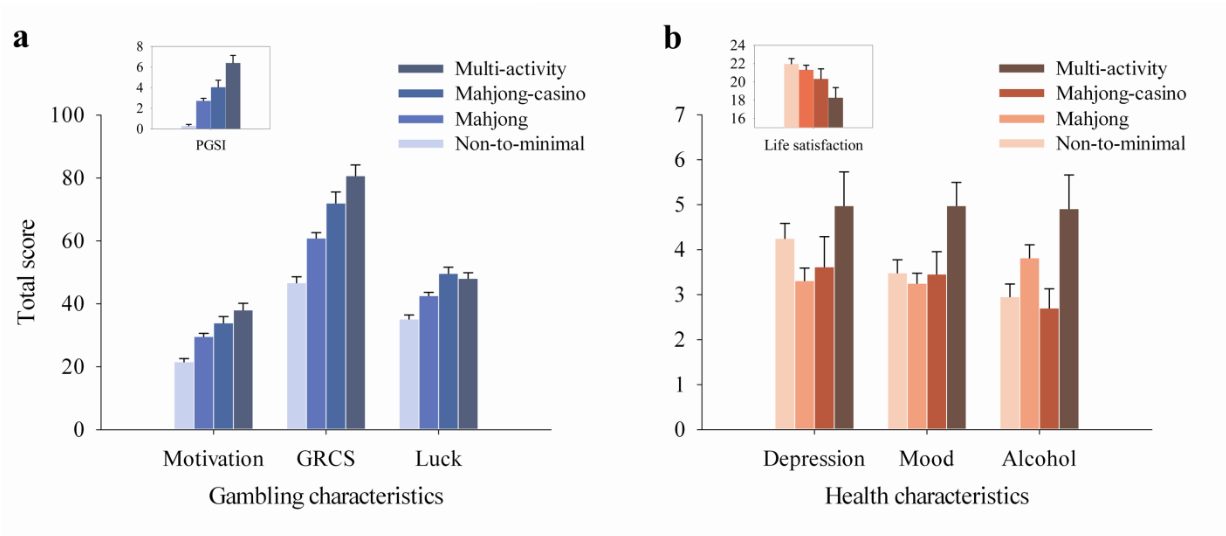


Figure 7.2. (**a**) Plot of total score on the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001; Loo, et al., 2011), the Gambling-Related Cognitions Scale (GRCS; Oei, et al., 2007; Raylu & Oei, 2004a), the Gambling Motivations scale (GMS; Chantal, et al., 1994; Wu & Tang, 2011), and the Beliefs in Luck scale (Hernandez, et al., 2008; Huang & Teng, 2009; Tao, et al., 2011; Zheng, et al., 2010), across gambling subtypes in 483 respondents; (**b**) Plot of total score on the Satisfaction With Life Scale (SWLS; Diener, et al., 1985), the Patient Health Questionnaire for depression symptoms (PHQ-9; Kroenke, et al., 2001; Yeung, et al., 2008), the Mood Disorder Questionnaire (MDQ; Hirschfeld, et al., 2000; Yang, et al., 2011); and the Alcohol Use Disorder Identification Test (AUDIT; Fiellin, et al., 2000; Wu, et al., 2008), across gambling subtypes in 483 respondents.

7.4.5 General health characteristics across groups

As seen in Table 7.5 and Figure 7.2(b), reported mood symptoms were significantly different across gambling groups ($H(3)= 11.43$, $p< .05$); compared to non-to-minimal gamblers and Mahjong gamblers, the multi-activity gamblers reported stronger mood disturbances ($p< .01$, $r= -.20$). Providing divergent validity, life satisfaction was also significantly different across gambling groups ($F(3, 479)= 3.32$, $p< .05$, $\omega^2= .03$); this time, multi-activity gamblers reported the lowest life satisfaction as opposed to non-to-minimal and Mahjong gamblers (all *p*s< .05, |*r*|s> .12). However, there was no evidence that the multi-activity gamblers experienced more somatic, panic or general anxiety symptoms than other gambling groups (all *H*s< 6.59, *p*s> .05). Although depressive symptoms was significantly different across gambling groups ($H(3)= 9.89$, $p< .05$), the non-to-minimal gamblers and multi-activity gamblers both reported more depressive symptoms (all *p*s $< .05$, $|r|$s $> .13$), compared to Mahjong gamblers.

Smoking rates were significantly different across gambling groups, $\chi^2(3) = 9.86$, $p < .05$, $V = .14$; non-to-minimal gamblers reported fewer rates of smoking, probably reflecting the larger proportion of younger students in the non-gamblers group as opposed to all other gambling groups. Reported alcohol dependence symptoms were also significantly different across gambling groups, $H(3) = 8.59$, $p < .05$; multi-activity gamblers reported stronger alcohol dependence in contrast with non-to-minimal gamblers (all *p*s $\leq .05$, $|r|$s $> .17$). Finally, there was no evidence that drug dependent problems were any different across gambling groups, $H(3) < 6.09$, $p > .05$.

Table 7.2. Gamblers subtypes across demographic characteristics of 483 respondents who completed the online survey

Variable	*Median*/ *n* (%)				H/χ^2
	Non-to-minimal gamblers (N=167)	Mahjong gamblers (N=220)	Mahjong-casino gamblers (N=50)	Multi-activity gamblers (N=46)	
Age $_a$	26.00 ^{a}	46.00 ^{b,c}	54.00 ^{b,d}	49.50 ^{b}	75.16***
Sex $_b$					44.76***
Male	88 (52.7) $^{--}$	165 (75.0)	43 (86.0)	43 (93.5)	
Female	79 (47.3) $^{+++}$	55 (25.0)	7 (14.0) $^{-}$	3 (6.5) $^{--}$	
Education $_b$					52.15***
Secondary school or below	32 (19.2) $^{---}$	82 (37.3)	23 (46.0)	33 (71.7) $^{+++}$	
Diploma/ A-levels	53 (31.7) $^{++}$	46 (20.9)	7 (14.0)	2 (4.3) $^{--}$	
College or above	82 (49.1)	92 (41.8)	20 (40.0)	11 (23.9)	
Script of survey $_b$					45.89***
Chinese	84 (50.3) $^{-}$	135 (61.4)	46 (92.0) $^{++}$	42 (91.3) $^{+}$	
English	83 (49.7) $^{++}$	85 (38.6)	4 (8.0) $^{---}$	4 (8.7) $^{--}$	
First language $_b$					41.09***
Chinese	103 (61.7)	145 (65.9)	47 (94.0) $^{+}$	46 (100.0) $^{+}$	
English	64 (38.3) $^{+}$	75 (34.1)	3 (6.0) $^{--}$	0 (0.0) $^{---}$	

Note: ***$p < .001$; Subscript $_a$ the non-parametric Kruskal-Wallis test were performed followed by planned comparisons using Wilcoxon's Tests because the distribution within groups was non-normal; Subscript $_b$ fewer than 20% of the cells in the contingency tables had expected frequencies less than 5 when using the Pearson χ^2 test; $^{+}$Standardised residuals are significantly positive ($^{+}$ $p< .05$; $^{++}$ $p< .01$; $^{+++}$ $p< .001$); $^{-}$standardised residuals are significantly negative ($^{-}$ $p< .05$; $^{--}p< .01$; $^{---}p< .001$); superscripts indicate significant group differences.

Table 7.3. Gamblers subtypes across sociological characteristics of 483 respondents who completed the online survey

Variable	*n* (%)				χ^2
	Non-to-minimal gamblers (N=167)	Mahjong gamblers (N=220)	Mahjong-casino gamblers (N=50)	Multi-activity gamblers (N=46)	
Marital status $_a$					37.18***
Married	61 (36.5)$^{--}$	113 (51.4)	40 (80.0)$^{++}$	32 (69.6)	
Not married	106 (63.5)$^{++}$	107 (48.6)	10 (20.0)$^{--}$	14 (30.4)	
Occupational status $_a$					64.68***
Employed	80 (47.9)	137 (62.3)	33 (66.0)	33 (71.7)	
Student	79 (47.3)$^{+++}$	49 (22.3)	2 (4.0)$^{--}$	6 (13.0)	
Retired or unemployed	8 (4.8)$^{--}$	34 (15.5)	15 (30.0)$^{+++}$	7 (15.2)	
Region of residence $_a$					78.25***
Europe or US	52 (31.1)$^{++}$	29 (13.2)$^{--}$	10 (20.0)	9 (19.6)	
Southeast Asia	75 (44.9)$^{+++}$	67 (30.5)	4 (8.0)$^{--}$	3 (6.5)$^{--}$	
East Asia	40 (24.0)$^{---}$	124 (56.4)	36 (72.0)$^{+}$	34 (73.9)$^{+}$	
Status at country of residence $_a$					52.06***
PR or working VISA	52 (31.1)$^{--}$	101 (45.9)	37 (74.0)$^{++}$	32(69.6)$^{+}$	
Student VISA	37 (22.2)$^{+++}$	19 (8.6)	1 (2.0)$^{-}$	3 (6.5)	
Citizen	78 (46.7)	100 (45.5)	12 (24.0)	11 (23.9)	

Note: ***p < .001; Subscript $_a$ fewer than 20% of the cells in the contingency tables had expected frequencies less than 5 when using the Pearson χ^2 test; $^{+}$standardised residuals are significantly positive ($^{+}$ p< .05; $^{++}$ p< .01; $^{+++}$ p< .001); $^{-}$standardised residuals are significantly negative ($^{-}$ p< .05; $^{--}$$p$< .01; $^{---}$$p$< .001).

Table 7.4. Gamblers subtypes across gambling characteristics of 483 respondents who completed the online survey

Variable	*Median*/ *n* (%)				H/χ^2
	Non-to-minimal gamblers (N=167)	Mahjong gamblers (N=220)	Mahjong-casino gamblers (N=50)	Multi-activity gamblers (N=46)	
Age of first gamble $_a$	-	18.00	18.00	18.00	0.54
Gambling frequency $_a$	-	2.00 [a]	3.00 [b]	5.00 [b]	46.27***
Problem gambling $_b$					25.53***
Yes	-	22 (10.0)	7 (14.0)	18 (39.1) $^{+++}$	
No	-	198 (90.0)	43 (86.0)	28 (60.9)	
Total score/GRCS $_a$	38.00 [a]	58.00 [b,c]	75.00 [b,d]	86.50 [b,d]	80.67***
Total score/Motivations $_a$	17.00 [a]	30.00 [b,c]	38.00 [b,d]	40.50 [b,d]	68.02***
Total score/Beliefs in luck $_a$	37.00 [a]	45.50 [b,c]	52.00 [b,d]	49.50 [b,d]	45.00***

Note: ****p* < .001; gambling frequency – highest frequency on any gambling activity other than lotteries or Mahjong; problem gambling – 8 or more points on the Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001; Loo, et al., 2011); GRCS – total score on the Gambling-Related Cognitions Scale (GRCS; Oei, et al., 2007; Raylu & Oei, 2004a); motivations – total score on the Gambling Motivations scale (GMS; Chantal, et al., 1994; Wu & Tang, 2011); beliefs in Luck – total score on the Beliefs in Luck scale (Hernandez, et al., 2008; Huang & Teng, 2009; Tao, et al., 2011; Zheng, et al., 2010); Subscript $_a$ Median values are presented, and non-parametric Kruskal-Wallis tests were performed followed by planned comparisons using Wilcoxon's tests, because the distribution within groups was non-normal; Subscript $_b$ fewer than 20% of the cells in the contingency tables had expected frequencies less than 5 when using the Pearson χ^2 test; $^{+}$standardised residuals are significantly positive ($^{+}$ p< .05; $^{++}$ p< .01; $^{+++}$ p< .001); $^{-}$standardised residuals are significantly negative ($^{-}$ p< .05; $^{--}$p< .01; $^{---}$p< .001); superscripts indicate significant group differences.

Table 7.5. Gamblers subtypes across health characteristics of 483 respondents who completed the online survey

Variable	*Mean*(*SD*)/ *Median*/ *n*(%)				*F*/ *H*/ χ^2
	Non-to-minimal gamblers (N=167)	Mahjong gamblers (N=220)	Mahjong-casino gamblers (N=50)	Multi-activity gamblers (N=46)	
Life satisfaction/SWLS	21.98 (7.34) [a]	21.33 (7.18) [c]	20.34 (7.65)	18.28 (7.41) [b,d]	3.32*
Somatic symptoms/PHQ-15 $_a$	3.00	3.00	4.00	5.00	6.38
Panic symptoms $_a$	0.00	0.00	0.00	0.00	6.59
Generalised anxiety symptoms/GAD-7 $_a$	0.00	0.00	0.00	0.00	0.85
Depression symptoms/PHQ-9 $_a$	3.00 [a]	2.00 [b,c]	1.50	3.00 [d]	9.89*
Mood symptoms/MDQ $_a$	2.00 [a]	2.00 [c]	3.00	5.00 [b,d]	11.43*
Drug dependence symptoms/SDS $_a$	0.00	0.00	0.00	0.00	6.06
Alcohol dependence symptoms/AUDIT $_a$	2.00 [a]	3.00	2.00	4.00 [b]	8.59*
Smokers $_b$					9.86*
Yes	23 (13.8) $^-$	55 (25.0)	12 (24.0)	14 (30.4)	
No	144 (86.2)	165 (75.0)	38 (76.0)	32 (69.6)	

Note: **p* < .05; SWLS – total score on the Satisfaction With Life Scale (SWLS; Diener, et al., 1985); PHQ-15 – total score on the Patient Health Questionnaire for somatic symptoms (PHQ-15; Kroenke, et al., 2002; Lee, Ma, & Tsang, 2011); Panic symptoms – total score on the Patient Health Questionnaire for panic symptoms (Lowe, et al., 2003); GAD-7 – total score on the Generalised Anxiety Disorder symptoms scale (GAD-7; Kroenke, et al., 2007; Lubetkin, et al., 2003); PHQ-9 – total score on the Patient Health Questionnaire for depression symptoms (PHQ-9; Kroenke, et al., 2001; Yeung, et al., 2008); MDQ – total score on the Mood Disorder Questionnaire (MDQ; Hirschfeld, et al., 2000; Yang, et al., 2011); SDS – total score on the Severity of Dependence Scale (SDS; Chen, et al., 2008; Gossop, et al., 1992); AUDIT – total score on the Alcohol Use Disorder Identification Test (AUDIT; Fiellin, et al., 2000; Wu, et al., 2008); Subscript $_a$ the non-parametric Kruskal-Wallis test were performed followed by planned comparisons using Wilcoxon's Tests because the distribution within groups was non-normal; Subscript $_b$ fewer than 20% of the cells in the contingency tables had expected frequencies less than 5 when using the Pearson χ^2 test; $^+$standardised residuals are significantly positive ($^+$ p< .05; $^{++}$ p< .01; $^{+++}$ p< .001); $^-$standardised residuals are significantly negative ($^-$ p< .05; $^{--}$p< .01; $^{---}$p< .001); superscripts indicate significant group differences.

7.5 Discussion

I found within this Chinese sample discernible gambling groups based on their past-year gambling profiles – specifically, Chines gamblers either engaged in social gambling patterns that reflect a 'non-to-minimal' and 'Mahjong' group, or more engaged gambling patterns that reflect a 'Mahjong-casino' and 'multi-activity' group. As predicted, the latter more involved gambling groups in this sample had distinct socio-demographic, gambling, and health characteristics that have traditionally been viewed as risk factors for, or vulnerabilities of, gambling problems. However, considering that this was a convenient international sample, the use of the label ‘Chinese’ here has been done in the broadest sense.

Gambling subtypes I found possessed cultural features that, to some extent, are distinct from the patterns of involvement found using a similar procedure recently performed in our lab on a large sample of 4,125 European internet gamblers (Lloyd, et al., 2010); I found here that Mahjong, private bets, and lottery play were prevalent in all gambling subtypes, constituting a minimal form of engagement in most Chinese gamblers. This is not surprising considering that activities like Mahjong and private bets are considered an important part social life (Fong & Ozorio, 2005; NCPG, 2007), and activities like lottery are played at least once a year during 'lucky' seasons like Chinese New Year celebrations (Fong, 2000). Another distinct feature of this Chinese gambling sample is the absence of a relatively healthy sports betting subtype that was identified amongst European internet gamblers (Lloyd, et al., 2010). Unlike these European gamblers, most Chinese gamblers who bet on sports and horses also engaged in casino gambling and were classified within the heavy multi-activity group, which can explain the cautious attitudes of most Chinese people towards these activities (Fong & Ozorio, 2005; NCPG, 2007).

However, one criticism of the current survey is the known tendency for Chinese people to articulate their psychological difficulties as somatic ones (Hong, Lee, & Lorenzo, 1995), which is why a somatic symptoms measure was administered. Nevertheless, I was still able to discriminate psychological health characteristics across Chinese gambling groups, and even if poorly estimated, is likely an underestimation of problems rather than spurious results.

Additionally, I acknowledge that the convenience sample used here cannot tell us about more general gambling patterns in the Chinese population; whilst the cross-sectional nature of the survey leaves questions of causal relationships to future research. Yet, I have confidence in the present results because online administrations of surveys have been shown to have acceptable reliability (reviewed by Wood & Griffiths, 2007). Moreover, I measured respondents' socio-demographical and gambling characteristics at the start of the survey to verify that completers (80%) of my survey were both more immersed within Chinese culture and had greater reported gambling involvement, than non-completers. Though I do not make claims to broader prevalence rates within the ethnic Chinese population, I do survey Chinese people residing within different national jurisdictions. Thus I describe here, for the first time, the socio-demographic, gambling, and health characteristics associated with distinguishable patterns of gambling behaviour amongst the Chinese people.

7.5.1 Social gamblers: Non-to-minimal and Mahjong play

In this sample, the biggest proportion of respondents was social gamblers that were best classified as *non-to-minima*l and *Mahjong* gamblers. Social gamblers tended to be younger females that filled up the survey in English script, probably reflecting their higher education and English as their first language. More specifically, the non-to-minimal group tended to be unmarried local and international students residing in the UK and Singapore;

whilst the Mahjong group was more likely to be unmarried local Singaporean students, suggesting that regular Mahjong play is diminished amongst international students.

Not surprisingly, social gamblers from these two groups reported fewer problems with their gambling and greater life satisfaction, reflecting national prevalence statistics in East Asia of a large proportion of the Chinese population that gamble recreationally (Fong & Ozorio, 2005; MCYS, 2008; SSRC, 2005). Additional support for the recreational role of Mahjong play in particular is my finding of fewer depression symptoms reported by the Mahjong gamblers in contrast with non-to-minimal gamblers. This suggests that socialising opportunities of regular Mahjong play (NCPG 2007; Fong, 2005), may be protective or provide resilience against mood problems

7.5.2 Established gamblers: Mahjong-Casino and multi-activity play

In this sample, I also found that a smaller proportion of respondents could be subtyped as *Mahjong-casino* and *multi-activity* gamblers based on their gambling profiles. These established gamblers, generally, have the same socio-demographic risk factors associated with disordered gambling as previously reported (Blaszczynski, et al., 1998; MCYS, 2008; Wong & So, 2003). For example, they tended to be married, middle-aged males that were either retired or unemployed, and have minimal education up to secondary school level.

Additionally, established gamblers in my sample were more deeply immersed within Chinese culture as they were more likely to complete the survey in Chinese script (rather the English script), reside in East Asia (i.e., Hong Kong, China and Taiwan), and report Chinese as their first language. Thus, these results give additional support to views that ethnic Chinese acculturation can be a risk factor for gambling-related harm, probably through the facilitation of heightened gambling-related cognitive biases (Oei, et al., 2008; Zheng, et al., 2010).

Critically, a risk factor I found that was not identified by previous surveys was gamblers' legal status within their country of residence. Established gamblers were more likely to be Permanent Residents (PR) or on working VISAs, rather than citizens or on student VISAs. Additionally most of these PR and working VISA holders were currently residing in East Asia (84%). In other words, results here suggest that internal migrant workers in countries like Hong Kong and mainland China, who are not fully integrated into their host jurisdictions, have added risk for problematic patterns of gambling engagement. Corroborating this evidence is findings of most previous surveys that report higher rates of gambling involvement and probable problem gambling amongst migrant and aboriginal ethnic minorities residing in the US, New Zealand and Australia (reviewed by Raylu & Oei, 2004b). Without familial support (NCPG, 2007) and the tendency to avoid seeking professional help (Tseng, Lin, & Yeh, 1995 cited in Blaszczynski et al., 1998) these migrant workers are particularly as risk of escalating patterns of gambling participation.

As for their gambling characteristics, established gamblers reported more severe syndromes of gambling problems (Mahjong-casino gamblers – 14.0%; multi-activity gamblers – 39.1%). Previous findings indicate that the type and number of gambling forms is associated with enhanced risk of gambling-related harm in a European context (LaPlante, et al., 2009; Lloyd, et al., 2010). Our findings confirm that this is also case in a sample of Chinese gamblers recruited online.

In support of cognitive approaches to the understanding of Chinese gambling involvement and problems (Delfabbro, 2004; Ladouceur, 2004b; Toneatto, et al., 1997), I found that established gamblers reported gambling-related cognitive biases (mean GRCS total scores between 72.0 to 80.7) that are more than one and a half times those found in younger Caucasian and Chinese samples residing in Australia (mean GRCS total scores between 43.5 to 48.2; Oei, et al., 2007, 2008). They also reported stronger gambling-related motivations (e.g., gambling for money, pleasure and control) and endorsed more beliefs in luck (e.g., beliefs in lucky charms, seasons, and numbers), consistent with previous reports (Wu & Tang, 2011; Zheng, et al., 2010).

Finally, consistent with previous reports of enhanced health risks associated with greater gambling breadth (Johansson, et al., 2009; Lloyd, et al., 2010; SSRC, 2005), I found that multi-activity gamblers, in particular, endorsed the most symptoms for hypomanic mood disturbances and alcohol dependence. They also reported a similar, but not significant, risk profile for their somatic complaints. Completing the maladaptive portrait of a broad gambling involvement, multi-activity gamblers also present with lower life satisfaction ratings.

In conclusion, the present study reports subtypes of Chinese gamblers with varying levels of gambling involvement, and shows that the most involved groups are associated with characteristics known to be risk factors for, or vulnerabilities of, disordered gambling. Engaged patterns of Chinese gambling participation, as observed in the *Mahjong-casino* and *multi-activity* groups, are associated with the greatest risks for various psychological and social disturbances. This suggests that future research could go beyond conceiving of risks for disordered gambling in terms of the frequency of engagement with individual kinds of gambling activities, but rather, the breadth and combination of gambling media used, and critically, the health characteristics that accompany that particular pattern of use.

These findings reveal how different expressions of Chinese gambling are linked to GRCs, gambling problems, and health experiences. In the next chapter, Study 6b takes this one stage further to investigate how salient aspects of Chinese culture, specifically luck, mediate the relationship between GRCs and reported gambling problems.

Chapter 8.

Self-report GRCs and Chinese beliefs in luck – Study 6b

Study 6b investigates the social-cultural dependence of self-report GRCs, focusing on the role of Chinese beliefs in luck in the development of reported gambling problems through the mediation of GRC biases.

8.1 Introduction

Although gambling and its harms are common across human cultures, its prevalence and character have culture specific expressions (Raylu & Oei, 2004b). Although national prevalence surveys do not report higher prevalence rates of gambling participation amongst the Chinese people as opposed to Caucasians (between 54% - 81%; Fong & Ozorio, 2005; SSRC, 2005; Wardle, et al., 2010), the prevalence rates of reported gambling problems are usually 2 times higher amongst the Chinese people (between 1.2% - 4.0%; Fong & Ozorio, 2005; Hwu, et al., 1989; MCYS, 2008; SSRC, 2005). Understanding the sources of these variations can therefore help us understand why people gamble, and the impact of gambling problems amongst different cultural groups.

The ethnic Chinese cultural disposition for behavioural superstitions could possibly account for heightened gambling-related harm in this community. A good illustration of Chinese superstition is the 2008 Beijing Olympics which was held at 8pm on the 08^{th} of August (i.e., 8pm, 08/08/2008; Ng, Chong, & Du, 2010). Where gambling activities, like superstitious behaviours, are the idiosyncratic expressions of mistaken beliefs, beliefs in luck would describe the conceptual system that sustains and gives meaning to them (Fong, 2000).

Similar to how such luck beliefs operate in other cultures, Chinese beliefs in luck can be viewed as a conceptual system to make sense of why things happen (i.e., Attribution Theory; Kelley, 1973). It provides an added level of meaning to explain one's circumstances (Bond et al., 2004), be it 'health, wealth, and harmony', or conversely, 'sickness, poverty, and discord' (Fong, 2000). Within Chinese thought, life circumstances are not only attributed to the dynamics of bio-psycho-social structures, but also, the deeper structures of luck behind these explanations

Beliefs in luck take on a unique character within Chinese thought because of the particular historical and linguistic contexts that these beliefs emerge. Similar to non-Chinese conceptions of luck as personal attributes (Wohl, Stewart, & Young, 2011), the Chinese conceive of luck as an ordained (internal) property of the person which predetermines her 命运（/*mìng yùn*/; or life-luck) (Papineau, 2005); these are the normative beliefs that underlie many Chinese practices like fortune-telling and palm reading. Additionally, similar to other non-Chinese notions, luck is also conceived as an external and stable character of events (Heider, 1958; cited in Pritchard & Smith, 2004). These are beliefs that luck has situational properties where local variance occurs depending on the 运气 (/*yùn qì*/; or luck-disposition) of the context. The latter situational conceptions of luck open up, especially for the Chinese person, the possibility of altering personal /*mìng yùn*/ (life-luck). Chinese beliefs in contextualised luck are therefore viewed as controllable (Darke & Freedman, 1997), depending on one's physical association with respect to lucky objects and environments.

Here, I am interested to investigate how Chinese-specific beliefs in luck could be facilitating psychological processes that increases risk for gambling-related harm. One possibility is where beliefs in luck heighten the warrant and accessibility of luck-related causal attributions. Excluding studies that merely conceive of luck as a general overconfidence in gaming skill (Wohl, et al., 2007), or a general gaming overconfidence (Steenbergh, et al., 2002), there are a growing number of studies that report strong associations between disordered gambling and beliefs in luck. One prominent line of research by Raylu and Oei (2004a) found that, beliefs that prayer, charms, and rituals – i.e., *illusions of control* (IOC) biases – positively correlates with self-report lifetime gambling problems (see also Joukhador, et al., 2004). This result has been replicated at least twice using both English and Chinese versions of the scale, where IOC scores are able to discriminate between PG and recreational gamblers (Oei, et al., 2007, 2008). Recent survey data administering the Belief in Good Luck scale (BIGL; Darke & Freedman, 1997) similarly report that, compared to recreational gamblers, PG have stronger beliefs that luck is controllable and an inherent property of person (Chiu & Storm, 2010). Finally, and critically, a recent study found that gambling to feel happier or to relieve stress – i.e., *gambling expectancy* (GE) biases – acted as a mediator between cultural axioms about fate and disordered gambling in ethnic Chinese university students (Tang & Wu, 2010). This is important as it was the first demonstration of how chronic beliefs in luck could facilitate specific types of GRCs that, in turn, enhance risk for report gambling problems.

Hence to extend these results and explore how a variety of GRC biases mediate links between luck beliefs and reported gambling problems amongst ethnic Chinese people, I administered an online web-based survey to Chinese people mostly residing in China (including Hong Kong and Taiwan), Singapore, and the UK (this is the same dataset as

Study 6a). Additionally, since there were no available measures of beliefs in luck amongst the Chinese diaspora more broadly, I developed here an adapted scale that measure beliefs in lucky numbers, charms, and environments that were mostly not gambling-related. I predicted that GRCs, in particular GE and IOC biases, would mediate strong beliefs in luck on reported gambling problems, and these cognitive mediators would be additive to other behavioural mediators like the frequency and multiplicity of gamblers' participation profiles.

8.2 Methods

The study was approved by the Central University Research Ethics Committee (CUREC) of the University of Oxford.

8.2.1 Participants

489 of the surveys were fully complete (344 male, 145 female) and, therefore, were included in the final analysis (80% complete rate). These participants are from the same sample as the previous study and most of them reported that they currently reside in China/ Hong Kong (46.0%), Singapore (29.4%), UK (20.7%) and Taiwan (1.8%); the remainder resided in various parts of the Asian, Australian, European and American continents (2%; for a full description see Study 6a).

8.2.2 Psychometrics

The internal reliability for all psychometric scales used was acceptable (all Cronbach's α= .92 to .95).

Previously published assessments of Chinese beliefs in luck contain items that were specific to the beliefs of the Hong Kong people or the Taiwanese. Therefore, I adapted an

11-item Chinese Beliefs in Luck Scale (CBLS) to broaden its relevance to other Chinese populations and assess superstitious Chinese beliefs not necessarily related to gambling (Hernandez, et al., 2008; Huang & Teng, 2009; Tao, et al., 2011; Zheng, et al., 2010). This adapted scale included items that reflected broader Chinese cultural beliefs in lucky numbers, lucky events, luck charms, palmistry, and /*fēng-shuǐ*/ (i.e., the Chinese system of geomancy). Participants rated all statements on a 7-point Likert scale (1-strongly disagree; 7-strongly agree) and total scores were used.

To assess gambling frequency and breadth, I asked participants to rate how frequently they participated on 16 different online and offline gambling games known to be popular amongst the Chinese internationally (e,g., Mahjong, horse racing, sports betting, and casino play). Participants' past year gambling frequency was defined as the highest frequency for any activity other than gambling on the lottery or Mahjong. Gambling breadth was defined as the number of gambling activates that were used at least once a month in the past year.

To assess gambling cognitive biases, I administered the 23-item Gambling-Related Cognitions Scale (GRCS; Oei, et al., 2007; Raylu & Oei, 2004a). The GRCS has a 5-factor structure and the total, and subscale, scores were used.

To assess gambling motivations, I administered an adapted 10-item Chinese Gambling Motivations Scale (GMS-R; Chantal, et al., 1994; Wu & Tang, 2011). This adapted version of the questionnaire comprised of 10 of the original 28 items of the GMS (2 items from the subscales *Enjoyment/ Stimulation*, *Mood regulation*, *Self-efficacy*, and *Prestige and Money*). No short version of the Chinese GMS was available during the study, so I chose to use this adapted scale (GMS-R) rather than not have an independent measure of gambling motivation. The *gambling expectancies* subscale of the GRCS was used here as the other measure of gambling motivations (similar with Tang & Wu, 2010). Participants rated all statements on a 7-point Likert scale (1-strongly disagree; 7-strongly agree) and total scores were used.

8.3 Data Analysis

8.3.1 Exploring factors in the Chinese Belief in Luck Scale (CBLS) and the Gambling Motivations Scale (GMS-R)

I conducted a Principal Component Analysis (PCA) on the CBLS and GMS-R using an oblique rotation method (direct oblique), since all factors were assumed to be correlated. Factor extraction was done based on: (1) the pattern of the eigenvalue scree plot; (2) the percentage of variance the factors account for; and (3) the model fit with the data – high extraction communalities and fewer non-redundant residuals.

Principal Component Analysis on the CBLS and GMS-R were justified since the sample size of 489 was adequately large statistically (Kaiser-Meyer-Olkin statistic; KMO> .92) (Field, 2009), and there was significant covariance amongst all items of the scale (individual item KMO> .85; Barlett's test of sphericity, $\chi^2 > 3481.63$, $p < .001$).

8.3.2 Analysing the mediation of beliefs in luck on gambling problems

Demographic and psychometric variables with a positive skew were transformed using a (natural) log function.

A boot-strapped mediation analysis (Preacher & Hayes, 2008) was performed to assess the relationships between beliefs in luck (IV) on the one hand, and PGSI scores (DV) on the other hand, in participants that reported gambling at least once in the past year ($n = 339$). Age of first gamble, gambling frequency, the number of gambling activities, and total score on the GRCS were entered as mediating variables (MVs). Age, sex (1-male; 0-female), and first language (1-Chinese; 0-others) were added as covariates in the model. To obtain standardised regression estimates from the mediation analysis, *z*-scores of all variables were used. Mediation (indirect) effects were taken to be significant if the bias corrected bootstrap confidence intervals (BC 95% and 99% CIs) of point estimates, using 5000 bootstrap samples, did not contain the zero point.

To explore the specific gambling cognitive biases that mediate beliefs in luck on PGSI scores, I repeated the above analysis this time using the subscales of the GRCS. The *inability to stop gambling* subscale was excluded from this additional analysis because it measures the level of self-control rather than erroneous beliefs about gambling and gambling outcomes that I wished to test.

The results presented here were confirmed with a further mediation analysis of beliefs in luck on PGSI scores used to define 'caseness' (i.e. > 8 symptoms on the PGSI; data not reported here). Additionally, during factor analysis of the CBLS ratings, I discovered that 2-items (i.e., 'Winning or losing depends on luck' and 'Lucky days increase chances of winning') formed a subscale for *beliefs in lucky win*. As this subscale measures a gambling-related belief, I repeated my analysis to demonstrate that my results would hold if these items on the CBLS were removed. I confirm that all main effects were unchanged after these two items were removed from the CBLS. Avoiding repetition, these follow-up analyses are not reported here.

8.4 Results

8.4.1 Factor structure of the Chinese Belief in Luck Scale (CBLS)

To obtain the eigenvalues for possible components within the data, I performed an initial principal component analysis with Kaiser's criterion set to 1. The analysis revealed that 2 factors had eigenvalue more than 1. However, the scree plot showed inflexions that would suggest either a 1 or 4 factor structure. With a sample size of 489 participants, I chose the 4-factor structure on the basis of a better fit with the data compared to the 1- and 2-factor solutions; specifically, the 4-factor solution had better average extraction communalities (0.84 as opposed to 0.62 or 0.72), and had fewer non-redundant residuals that were more than 0.05 (21% as opposed to 72% or 58%). The factor loadings of the 4-factor solution after rotation are shown in Table 8.1. The items with strongest loadings suggest that component 1 measures *beliefs in lucky charms*, component 2 measures *beliefs in lucky wins*, component 3 measures *beliefs in lucky numbers*, and component 4 measures *beliefs in lucky signs*.

Table 8.1. Summary of exploratory factor analysis results for the Chinese Beliefs in Luck Scale (*N*=489)

	Items	Rotated Factor Loadings			
		Beliefs in lucky objects	*Beliefs in lucky wins*	*Beliefs in lucky numbers*	*Beliefs in lucky signs*
6	Water fountains attract financial prospects.	**0.53**	-0.05	0.11	**0.41**
7	Special numbers, colours or clothing increase chances of winning.	**0.76**	0.01	0.08	0.12
10	Carrying a lucky charm will bring good luck.	**0.88**	0.17	-0.03	-0.07
11	Having a lucky charm in the car will bring a safe driving journey.	**0.82**	-0.02	0.14	0.00
8	Winning or losing depends on luck.	0.15	**0.74**	0.06	0.10
9	Lucky days increase chances of winning.	-0.03	**0.96**	0.00	-0.02
1	The number 8 represents prosperity.	-0.01	0.06	**0.94**	-0.03
2	The number 4 is unlucky because it is pronounced like death in Chinese.	0.08	-0.07	**0.91**	-0.04
3	The number 6 represents a good omen.	-0.04	0.05	**0.86**	0.09
4	I will not let a mirror face my bed.	-0.10	0.10	0.09	**0.90**
5	Your palm lines impact your future.	0.32	-0.01	-0.02	**0.70**
	Eigenvalues	5.60	3.41	5.36	4.43
	α	.92	.81	.91	.82

Note: Factor loadings over .40 are in bold. Chrombach's α = .94.

8.4.2 Factor structure of the Gambling Motivations Scale – Revised (GMS-R)

Analysis of the GMS-R revealed a single factor having an eigenvalue> 1. However, the scree plot showed inflexions that would suggest either a 1 or 2 factor structure. I chose the 2-factor structure because, compared to a 1-factor structure, it had better average extraction communalities (0.73 as opposed to 0.63), and fewer non-redundant residuals that were more than 0.05 (31% as opposed to 51%). The 2-factor solution and its factor loadings are shown in Table 8.2. The items suggested that component 1 measured *gambling for pleasure*, and component 2 measured *gambling for money*.

Table 8.2. Summary of exploratory factor analysis results for the Gambling Motivations Scale (N=489)

Items		**Rotated Factor Loadings**	
		Gambling for pleasure	Gambling for money
8	Because it is the hobby I have chosen to clear my mind.	**.964**	-.179
6	Because it allows me to enjoy myself enormously.	**.907**	-.035
7	For the strong sensations I feel when I play my favourite game.	**.872**	-.028
3	Because, for me, it is the best way to relax completely.	**.871**	-.039
9	For the feeling of control it gives me.	**.747**	.161
2	For the feeling of efficacy that I get when I play my favourite game.	**.736**	.125
1	Because it makes me feel like somebody important.	**.624**	.228
5	To show others that I am a dynamic person.	**.557**	.357
10	To buy something that I dream of.	-.013	**.921**
4	To get rich.	.086	**.845**
	Eigenvalues	6.04	3.79
	α	.94	.82

Note: Factor loadings over .4 are in bold; Chrombach's α = .93.

8.4.3 Mediation of beliefs in luck on gambling severity

The total effect of Chinese beliefs in luck on gambling severity was significant (β= .20, t= 3.89, p< .001); however, the direct effect was not significant when mediators are added (β= -.06, t= -1.16, p> .05). Consequently, the mediation indirect effect of all mediators in the model was significant (point estimate= .26, BC 99% CI= .17 to .37; See Table 8.3 and Figure 8.1).

Table 8.3. Mediation of beliefs in luck (*z*-scores on the Chinese Beliefs in Luck Scale; CBLS) on past year gambling problems (*z*-scores on the Problem Gambling Severity Index; PGSI) in 339 gamblers, with gambling-related cognitive biases (*z*-scores on the Gambling-Related Cognitions Scale; GRCS) as a mediator

		Bootstrapping BC 95% CI		**Bootstrapping BC 99% CI**	
	Point Estimate	Lower	Upper	Lower	Upper
Indirect Effects $_a$					
Total indirect effect	0.26**	0.19	0.34	0.17	0.37
M_1: Age of first gamble (*z*-score)	< 0.01	-0.02	< 0.01	-0.02	0.01
M_2: Gambling frequency (*z*-score)	< 0.01	-0.02	0.03	-0.03	0.04
M_3: Gambling multiplicity (*z*-score)	0.06**	0.02	0.11	0.01	0.13
M_4: Total score/GMS-R (*z*-score)	-0.02	-0.09	0.03	-0.10	0.05
M_5: Total score/GRCS (*z*-score)	0.23**	0.15	0.34	0.12	0.37
Planned comparisons					
M_1 vs. M_3	-0.06**	-0.11	-0.02	-0.14	-0.01
M_2 vs. M_3	-0.05*	-0.13	-0.01	-0.16	0.01
M_4 vs. M_5	-0.25**	-0.41	-0.13	-0.46	-0.09

Note: *p< .05; ** p < .001; $M_{1\text{-}5}$= Mediators 1 to 5; BC 95% CI= Bias corrected 95% confidence intervals; GRCS= Gambling-Related Cognitions Scale (Oei, et al., 2007; Raylu & Oei, 2004a); GMS-R= Gambling Motivations Scale (Chantal, et al., 1994; Wu & Tang, 2011); $_a$ age, sex (1-male; 0-female), and first language (1-Chinese; 0-others) were added into the mediation model as covariates.

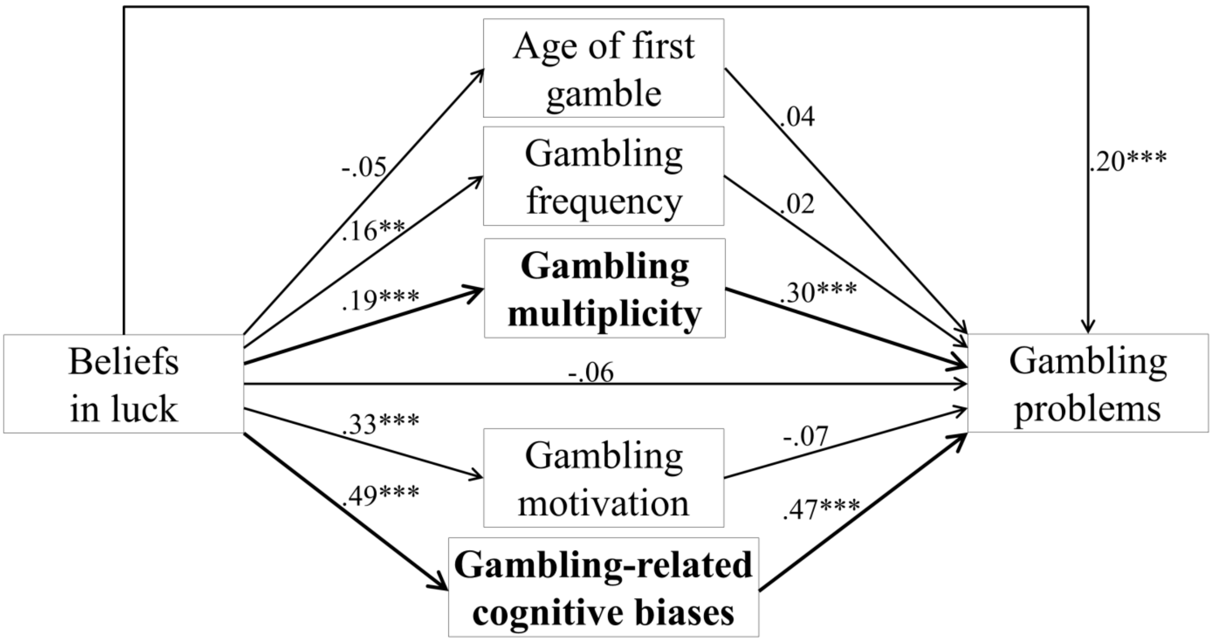


Figure 8.1. Mediation of beliefs in luck (*z*-scores on the Chinese Beliefs in Luck Scale; CBLS) on past year gambling problems (*z*-scores on the Problem Gambling Severity Index; PGSI) in 339 gamblers, with various indexes of gambling-related behaviours, motivation and cognitive biases (*z*-scores) as a mediators

Specifically, Chinese gamblers who held stronger beliefs in luck were more likely to report problems with their gambling in the past year because they tended to gamble on a greater number of media (point estimate= .06, BC 99% CI= .01 to .13), and endorsed more gambling cognitive biases (point estimate= .23, BC 99% CI= .12 to .37). By contrast, gamblers' age of first gamble (point estimate= < -.00, BC 95% CI= -.02 to <.01), past year gambling frequency (point estimate= < .00, BC 95% CI= -.02 to .03), and gambling motivation scores (point estimate= < -.00, BC 95% CI= -.08 to .03), were not significant mediators between beliefs in luck and past year gambling problems. Planned comparisons showed that the indirect effect through gambling breadth (or multiplicity) was significantly larger than the indirect effects through age of first gamble and gambling frequency (BC 95% CIs do not contain zero). Additionally, the indirect effect of gambling cognitive biases on gambling problems was also significantly larger than the indirect effect of gambling motivations (BC 99% CI does not contain zero).

Table 8.4. Mediation of beliefs in luck (*z*-scores on the Chinese Beliefs in Luck Scale; CBLS) on past year gambling problems (*z*-scores on the Problem Gambling Severity Index; PGSI) in 339 gamblers, with gambling-related cognitive biases (*z*-scores on the subscales of the Gambling-Related Cognitions Scale; GRCS) as mediators

		Bootstrapping BC 95% CI		**Bootstrapping BC 99% CI**	
	Point Estimate	Lower	Upper	Lower	Upper
Indirect Effects $_a$					
Total indirect effect	0.25**	0.17	0.34	0.16	0.37
M_1: Age of first gamble (*z*-score)	< 0.01	-0.02	< 0.01	-0.02	0.01
M_2: Gambling frequency (*z*-score)	0.01	-0.02	0.04	-0.03	0.05
M_3: Gambling multiplicity (*z*-score)	0.06**	0.02	0.11	0.01	0.14
M_4: Total score/GMS-R (*z*-score)	0.02	-0.03	0.08	-0.05	0.10
M_5: Gambling expectancies/GRCS (*z*-score)	-0.02	-0.07	0.02	-0.09	0.05
M_6: Illusion of control/GRCS (*z*-score)	0.07	-0.01	0.16	-0.04	0.18
M_7: Predictive control/GRCS (*z*-score)	0.02	-0.07	0.11	-0.10	0.15
M_8: Interpretive bias/GRCS (*z*-score)	0.10*	0.03	0.19	< -0.01	0.22
Planned comparisons					
M_5 vs. M_8	-0.12*	-0.23	-0.03	-0.27	0.01
M_6 vs. M_8	-0.03	-0.14	0.08	-0.19	0.12
M_7 vs. M_8	-0.07	-0.23	0.06	-0.30	0.12

Note – *p< .05; ** p < .001; $M_{1\text{-}5}$= Mediators 1 to 5; BC 95% CI= Bias corrected 95% confidence intervals; GRCS= Gambling-Related Cognitions Scale (Oei, et al., 2007; Raylu & Oei, 2004a); GMS-R= Gambling Motivations Scale (Chantal, et al., 1994; Wu & Tang, 2011); $_a$ age, sex (1-male; 0-female), and first language (1-Chinese; 0-others) were added into the mediation model as covariates.

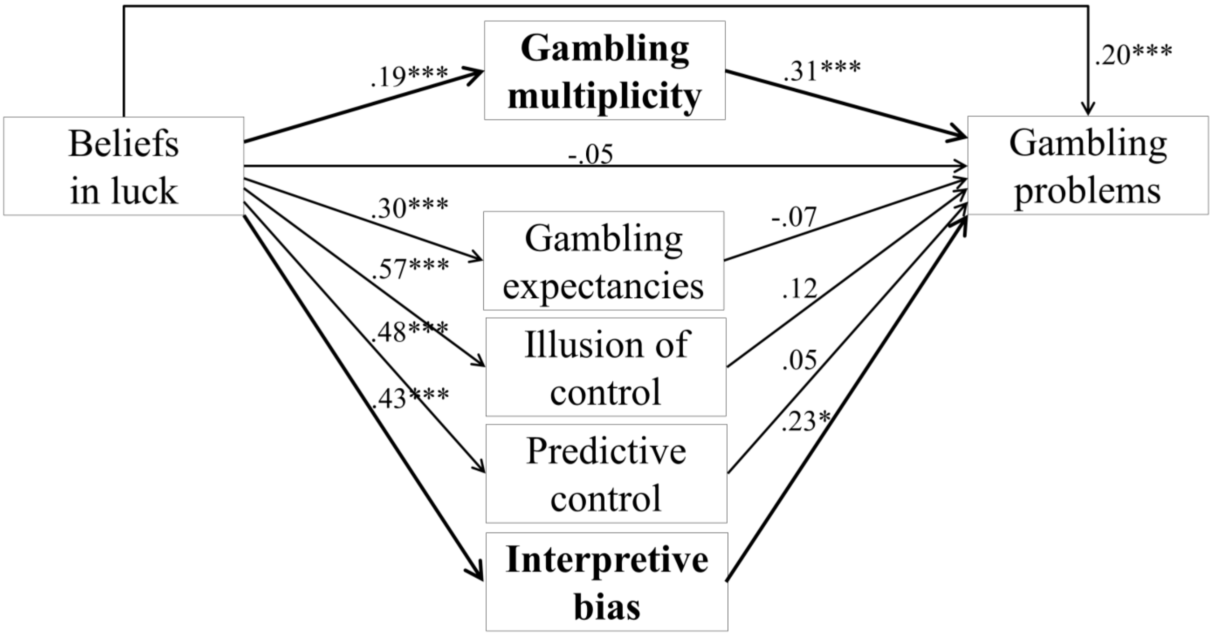


Figure 8.2. Mediation of beliefs in luck (*z*-scores on the Chinese Beliefs in Luck Scale; CBLS) on past year gambling problems (*z*-scores on the Problem Gambling Severity Index; PGSI) in 339 gamblers, with various indexes of gambling-related behaviours, motivation and cognitive biases (*z*-scores) as a mediators; age of gambling, gambling frequency, and gambling motivation are included in this mediation model but are not presented the figure

Mediation analysis using the subscales of the GRCS revealed a significant total mediation (or indirect) effect of all mediators in the model (point estimate= .25, BC 99% CI= .16 to .37; See Table 8.4 and Figure 8.2). Chinese gamblers who held stronger beliefs in luck were more likely to report more severe gambling because they had stronger interpretive bias cognitions (point estimate= .10, BC 95% CI= .03 to .19). By contrast, illusions of control, predictive control cognitions, and gambling expectancies did not mediate between beliefs in luck and reported gambling problems (BC 95% CIs contain zero). Planned comparisons between these mediation effects showed that the indirect effect through interpretive biases cognitions was significantly larger than the indirect effect through gambling expectancies (point estimate= -.12, BC 95% CI= -.23 to -.03), and showed a non-significant trend to be larger compared to the indirect effect through illusions of control (point estimate= -.03, BC 95% CI= -.14 to .08) and predictive control biases (point estimate= -.07, BC 95% CI= -.23 to .06).

8.5 Discussion

Our results emphasize how Chinese beliefs in *lucky charms*, *lucky wins*, *lucky numbers*, and *lucky signs*, facilitate stronger gambling-specific cognitive biases, and broader gambling patterns, that possibly act as pathways to disordered gambling. In particular, Chinese believers in luck are at risk for disordered gambling because they were biased in their interpretations of past gaming outcomes. Extending previous findings (Tang & Wu, 2010), I also found that gambling *interpretive biases* was a stronger mediator compared to gambling motivation using two independent measures of gambling motivation (i.e., total score on the GMS-R and *gambling expectancies* subscale scores on the GRCS). However, similar to the previous study, the convenient international sample here does not specify any particular type of Chinese. Thus the label ‘Chinese’ is defined here in the broadest sense.

8.5.1 Luck and disordered gambling

Our findings of links between beliefs in luck and severity of reported gambling problems supports the growing number of studies that report the importance of luck beliefs in the development of gambling-related harm amongst the Chinese people (Chiu & Storm, 2010; Joukhador, et al., 2004; Oei, et al., 2007, 2008; Raylu & Oei, 2004a).

Additionally, our findings have the strength of capturing specific beliefs in luck as conceived, and practiced, by the international Chinese community; beliefs that are socially represented and institutionalised within the broader cultural and linguistic structures of

Chinese society (Jovchelovitch & Gervais, 1999). For example, beliefs in luck are embedded in the customs of lunar New Year celebrations where Chinese people engage in visitation greetings that are scripted and performed ritualistically to promote good luck (M. Fong, 2000). They are also embedded in the thriving /*fēng-shuǐ* / (or Chinese system of geomancy) industry in East Asia (Chang, Lee, Hung, Tsai, & Perng, 2009; Mak & Ng, 2005).

Moreover, I assessed gambling problems within a community-based and international sample instead of relying on student samples, giving further support to the view that social representations of luck are playing an important a role in the development and maintenance of disordered gambling within the Chinese community more broadly (Raylu & Oei, 2004b). This is not the first instance of how 'social knowledge' (i.e., beliefs embodied within the broader culture) can impact on private beliefs and practice. An anthropological study of Chinese people residing in the UK has reported that specific Chinese beliefs about foods as either /*shī-rè*/ (hot), or /*hán-liáng*/ (cold), can influence the extent to which individuals trust the biomedical (culturally foreign) model of disease, and how likely they are to utilise national health services (Jovchelovitch & Gervais, 1999).

8.5.2 Luck, interpretive bias cognitions, and disordered gambling

Specifically, I found that Chinese believers in luck were experiencing more problems with their gambling because they tended to endorse more *interpretive bias* (IB) cognitions as opposed to *gambling expectancies* (i.e., GE; motivations to gamble for money and to regulate negative mood states) as suggested previously (Tang & Wu, 2010; Zheng, et al., 2010). IBs include beliefs like 'relating my winning to my skill and ability makes me continue gambling', or 'relating my loss to bad luck and bad circumstances makes me continue to gambling', which attribute game outcomes to luck- and skill-related contingencies. Thus, as recourse to luck simplifies the computational load when attempting to explain game outcomes, it inevitably interferes with the learning of optimal game contingencies (Darke & Freedman, 1997; Wohl & Enzle, 2002), increasing risk for gambling-related harm.

Beliefs in personal luck probably facilitate IBs by allowing luck-related explanations to be available as an added (but non-veridical) level of causal attribution to gambling outcomes. Support for this view come from reports that Chinese people have stronger IBs compared with Caucasians (Oei, et al., 2008), probably reflecting their strong social representation of luck (Fong, 2000). More pointedly, recent studies now show that the influence of lucky beliefs can operate subconsciously amongst Chinese people; experimental studies manipulating subliminal lucky game stimuli (number '4' for lucky and '8' for unlucky) are able to activate stronger ratings of personal luck and more risk-taking gambling decisions (Jiang, Cho, & Adaval, 2009); whilst heightened self-awareness cancels these priming effects (DeMarree, Wheeler, & Petty, 2005).

Our results therefore suggest that heightened gambling-related harm amongst the ethnic Chinese people is facilitated by conscious, and possibly unconscious, IBs beliefs that are shaped by a dominant, and shared, cultural currency of luck.

8.5.3 Luck, gambling multiplicity, and disordered gambling

Finally, I found that involvement in a greater variety of commercial gambling products is another luck-facilitated route to disordering gambling. In addition to common activities like lottery play and Mahjong (social) gambling, Chinese believers in luck were more likely to participate in sports betting, horse racing, and casino play.

Chinese believers in luck are probably more willing to seek out and experiment with new gambling products because they enjoy the novelty, and are more willing to break away from the gambling patterns of their social group in order to attain these experiences (i.e., they undervalue the experience of friends; Hernandez, et al., 2008). Additionally, similar to how Chinese people are willing to pay more for products viewed to be lucky (e.g., vehicle licence plates with the number '8'; Ng, et al., 2010), gamblers may be participating in a broader range of gambling games because they overvalue the rewards of these games.

8.5.4 Conclusion

The present study extends previous research that acknowledges the importance of culture in the development and maintenance of disordered gambling. It does this by identifying the specific mediating links between contextualised cultural beliefs in luck and past year gambling problem. I found that *interpretive bias* cognitions, and gambling multiplicity, are important pathways that contribute to the development of reported gambling problems in an international Chinese sample. These findings emphasise how luck-inducing gambling stimuli and environments, and expansions to the variety of terrestrial and online gambling products, could become targets for harm reduction policies in jurisdictions with a substantial population of vulnerable Chinese gamblers.

Going beyond ethnic cultural influences upon GRCs and their relationship with gambling problems, I was also interested in how gamblers' vocational contexts influence the experience of gambling problems; specifically in British professional football.

Chapter 9.

Interviews with British professional footballers – Study 7

In this study, the qualitative methods used gathered 1st person accounts of professional footballers who had developed gambling problems in the course of their football careers. The data presented here – with its rich description of the vocational and interpersonal contexts surrounding gambling-related harm in football – sets limits upon the cognitive approaches described in this thesis. Additionally, and more importantly, this was done to underscore the need for future cognitive accounts of disordered gambling to give adequate attention to social-cultural factors in theory building.

9.1 Introduction

Football is the predominant sport within contemporary British culture. 5% of the adult population play football weekly (Sport England, 2011), with the still growing popularity of the game reflected in the 180% growth in professional football club revenues over the past decade to £2.9 billion in the 2010/11 season alone (Deloitte, 2003, 2012). This burgeoning commercial environment both increases the competitive and earning opportunities of professional players, but brings with it augmented occupational stressors that increase the risk of psychological problems including depression and anxiety, as well as addictive disorders. Over the last few years, media reports have reported high rates of gambling amongst professional footballers and highlighted individual cases of footballers (and managerial staff) whom have experienced gambling problems (Herbert, 2011; Winters, 2008).

There are several reasons why professional footballers may be at greater risk of gambling-related-harm. First, professional football in the United Kingdom, as elsewhere is highly competitive and only a minority of players who are signed by Premier League and Football League clubs secure senior professional contracts (Parker, 2001); about 65% of football scholars do not secure a professional contract at 18 years of age, and another 50% of those that do are released by their 21st birthday (James, 2010). This environment is likely to foster competitive traits that have been suggested to increase gambling participation in professional sports people (e.g., Weiss & Loubier, 2008). The positive association between competition and gambling involvement may also be enhanced for individuals playing for high profile sports by virtue of their public status which itself may operate as a risk factor for gambling involvement (Ellenbogen, et al., 2008; Nelson, et al., 2007).

Finally, players who are seeking or have secured professional football contracts live with a variety of occupational stressors. These include both being dropped though loss of form, or the constant possibility of injuries that might curtail current player contracts or terminate players' prematurely (Hughes & Leavey, 2012). Current statistics report that footballers are 1000 times more likely to get injured compared to other high risk industrial occupations (e.g., construction and mining; Hawkins & Fuller, 1999).

Transitions from regular gambling to problematic patterns of gambling involvement are often mediated by the motivations to gamble in order to relieve stress or regulate low mood (e.g., 'gambling expectancies'; Raylu & Oei, 2004a). This raises the possibility that players who have established regular patterns of gambling may find themselves gambling more frequently to help cope with the challenges an uncertainties of the professional game. These reflections suggest that the sociocultural and occupational features of British football (Fletcher & Wagstaff, 2009) could facilitate gambling problems in some individuals. However, up until now, there have been few opportunities to investigate these issues in any depth.

The research objective was to gain an insight into the experiences of professional footballers who have developed problems with their gambling activities. Following Sinclair and Green (2005), I did not intend to identify 'empirically valid reconstructions' of how these individuals developed gambling problems; rather, I explored how participants perceived the relationship between life as a professional footballer and their transitions into gambling problems and the insights this might provide about how best to minimise gambling-related harm in professional footballers.

All interviewees had been referred (or self-referred) to the SportingChance clinic (www.sportingchance.com). SportingChance offers residential interventions to help with behavioural problems among professional and amateur sports people. The treatment offered for addiction problems, including alcohol misuse and gambling, is based upon the 12-step programmes of alcohol treatment, delivered in a combination of one-to-one and group settings and augmented with reflection and written work. Our interviews constitute an intrinsic-case study (Stake, 2000) which gave rise to a large amount of rich data. The recurring themes that emerged are offered here.

9.2 Methods

I interviewed 11 British footballers who were undergoing, or had undergone treatment at the Sporting Chance clinic for their gambling problems. Favourite gambling activities included machine roulette (n= 3), football bets (n= 1), slot machines (n= 1), poker (n= 2), and horse racing (n= 4). Three also had co-occurring alcohol problems. For 7 of these footballers, this was the first time they sought formal help for their problems, the remaining 4 had sought help once before, but not necessarily from sportingChance.

All the footballers were recruited by one of the lead clinicians of the clinic. They were selected for this study because they were playing, or had played, football professionally (i.e., full-time) in the Premier or Football Leagues, and have sought help for their gambling problems. These footballers had their first professional contracts between 16-18 years of age and had different professional experiences that varied from those who were released after the end of their first contracts, to those who had long professional careers of up to 18 years (see Table 9.1). In all, 6 footballers had played in the Premier League, 3 in the Championship League, 1 in League One, and 1 in League Two. Six footballers had also played for national teams at junior and/ or senior levels.

Table 9.1. Characteristics of the 11 professional and retired footballers interviewed

Characteristics	N	Characteristics	N
Age at interview (years)		Years of professional football experience	
18-25	4		
26-35	5	*<5*	4
36-45	2	*5 to 10*	2
		>10	5
Ethnicity			
White	9	Experience at national level	
Mixed	2	*Yes*	6
		No	5
Relationship Status			
Single	6	Level of league participation	
Married/Partner	3	*Premier*	6
Divorced/Separated	2	*Championship*	3
		League One	1
Age of first entry to football club (years)		*League Two*	1
7-13	9	Age of first gamble (years)	
16-18	2	*10-14*	2
		16-18	9
Current football status			
Professional (full-time)	6	Time since last residential treatment	
Semi-professional (part-time)	2	*Currently on treatment*	6
Retired footballer	3	*≤ 1 year*	3
		> 1 year	2

Interviews were conducted by the first author (ML) between May, 2011 to September, 2012 at the residential gambling clinic or in office space near footballers' homes. Interviewees were informed that I was interested to understand something about the relationship between life as professional footballers and their gambling problems. The interviews were semi-structured, as such interviews provide a greater breadth of data (Fontana & Frey, 2000). Interviewees were given the time to offer their experiences in their own words, and the interviewer was able to explore in more detail some of the material offered.

The initial open-ended narrative part of the interview, including clarifications, lasted between 45mins and 60mins. The majority of the interviews with gambling problems linked their experiences as professional footballers to their gambling problems. For those that did not make this link explicit, the semi-structured second half of the interview specifically asked about such links using an interview schedule that was reviewed recursively as the number of interviews increased (see Box 1). All interviews were audio recorded and took between 60mins to 120mins to complete.

Box 1. Interview schedule

Could you tell me the story of your *football career* from your earliest memories to the present?

Could you tell me the story of your *gambling experiences* from your earliest memories to the present?

Could you tell me more about what you think the *link* between football and gambling is?

Interviews were transcribed verbatim and the transcripts were subject to an interpretive-thematic analysis (Braun & Clarke, 2006). The interviews were coded into themes using NVivo-9. Themes were developed iteratively and were regularly discussed with team members who also read the transcripts. Some quotes from the data are set out below to help support the analysis. To preserve anonymity, footballers were randomly allocated index numbers (i.e., F1 to F13).

9.3 Findings

Three reoccurring themes that describe the facilitation of gambling problems are described here: (i) the social pressures of football; (ii) the occupational features of football; (iii) the emotional tension of football.

9.3.1 Social pressures of football

Football isolation and insecurity. This theme describes the interpersonal context of football life in which social pressures to gamble (described later on) are facilitated. The growth of the professional game in the UK, accelerated by television sponsorship (e.g., the premier league since 1992; J. Williams, 2006) , has heightened the celebrity status of footballers. Several of the interviewees reported that it had become commonplace to receive praise in the media, cheers from fans, and VIP treatment outside of the football's immediate context. This tended to promote a sense of feeling 'completely different' that began early in their school-going years, and was then amplified by the life as a professional footballer:

> *'I think at that young age [12 years old] it is quite easy to be seen as different from other people, cos you are better at football than a lot of young people…You're getting different treatment from everyone else…So I did feel different…even up to now…I've always felt, always felt different, completely different.' [F2]*

For several of the interviewees, this sense of isolation was exacerbated by the performance pressures involved in playing professional game at the highest levels, generating further insecurity:

> *'I was very insecure, hugely lacking in confidence and self-esteem…you play football and if your coach says you played well, or your mum, or your dad, says you played well then you played well…when you're 24 and you're 15 stone, and you're ripped, and you're big, and you're playing in front of…76,000 mums, and dads, and coaches, and…sometimes people come up to you and say you were shit Saturday…they're a mirror for you…You never know where you are with people, managers, coaches – you…never…know…where…you…are.' [F9]*

Coping with these challenges was compromised by a perceived need to project strength and self-sufficiency within the competitive and 'hegemonic masculine' culture of the game (Parker, 2001).

> *'To show a sign of weakness was just a complete and utter no no…it's quite an alpha male industry, survival of the fittest and you don't do that, blah blah blah. You want to show that you're fitter, stronger, faster, blah blah blah.' [F3]*

Finally, several players also reported that their sense of insecurity was heightened by the absence of social support outside of football because of footballers' tight schedules:

> *'I made my football league debut and then moved to [location] when I was, I think I was 17…the isolation, sometimes you're, you know, you're in a hotel for 2 or 3 days you know, there's only so many DVDs you can watch.' [F10]*

Gambling for social inclusion. Within this insecure and isolating social environment, several players indicated that gambling was a means to show solidarity and gain acceptance amongst their team mates. Our interviewees reported that the gambling culture within the football community was expressed in gambling-related talk in changing rooms:

> *'There'd be little tips going in your ear when it was training; there would be tips going in your ear if you were out on a night out…There was always gambling; gambling is constant; it is rife in my experience of being involved in football.' [F9]*

Many interviewees also reported outings to the bookmaker, casino, track, or pool hall. When travelling, there was also the presence of poker competitions or 'card schools' amongst themselves in coaches, airplanes and hotel rooms. Beyond this general pattern of gambling involvement, two footballers described a distinct 'senior' subculture of gambling that included high-stake card schools and horse racing socialisation:

> *'Football comes with horse racing. It's just one of those things. You get invited to the races. You meet a few jockeys. You get a few tips on the horses. Before you know it…I'm starting off…When you're a footballer and you go to a horse meeting, your maybe [given] a nice [viewing gallery] box and all that…People in horse racing know that footballers have disposable income. [F11]*

However, the existence of this 'senior' culture within the clubs was not perceived as necessarily problematic because the players involved were able to afford it.

> *'There's card schools but I would say 9 times out of 10 at most clubs it's controlled. You could lose [amount], but for players that are on [amount] a week, in the grand scheme of things, it's not a lot of money…but obviously there's times when it can get out of control and that's where the problem is…If [young players] wanted to come in they could, but…you're only a young 17/18 year old, probably be lucky if you've got £1000 in the bank so you shouldn't really be playing cards anyway. [F10]*

Overall, many of the interviewees acknowledged that participation in gambling activities were good for team spirit but were aware that immersion into a gambling-saturated environment tended to normalise heavy betting practices, making that seem like '*the right thing to do*' *[F4]*. Though these social initiations to heavier gambling did not necessarily lead to reported problems in all footballers, it did facilitate escalating gambling behaviours in the footballers I interviewed (Box 2a). Additionally, similar to how habits like drinking and smoking are learnt behaviours from previous football cohorts (Parker, 2001), two of the interviewees described how gambling was, to them, a rite of passage into the more authentic lifestyle of the football 'seniors', and a way to get acquainted with their childhood 'heroes' (Box 2b).

Box 2. Gambling for social inclusion

a. Football gambling norms

'Um at 16, 17, 18 it's just a social thing, kind of thing, just sort of go with the lads, have a few bets on a Saturday. On the way back from the game everyone get their coupon out see who's winning…in football a lot of people seem to [gamble], it seems like the right thing to do, to like, you think it's like part of football, like it feels like it's part of the football culture to gamble…You think you've got to do it to be like involved kind of thing.' [F4]

'Last year and I was in [location] town centre with 2 friends from football and I was taking one of them home and I was like: 'yeah I'll come with you'. And I saw him win a lot and I was like: 'oh', and he was like: 'yeah fine', and I didn't find myself gambling that day, but I found myself in the week there with a friend. It just started from there really, just a little bit just social, a bit of fun it was at first, and then it just took over like so quickly really. It's crazy isn't it?' [F1]

b. Gambling with the 'seniors'

'I was playing with big players like [name] and people like that, and then you are playing cards with them at the same time and when you are getting involved with people like that it's making you feel good about yourself as well…when you're growing up as a little boy you, they're your heroes and they're your role models, and to be around them sort of players it's like a dream come true...' [F6]

"Now you're in the first team with us boys, you come along with us boys, I'll take you under our wing!'…so now they're looking at their role models…they want to be a part of that atmosphere and they go along [to horse races]…inspired…looking up to, you know, senior players in the first team...' [F7]

9.3.2 Occupational features of football

Footballers' high earnings. The wages-to-revenue ratios in the football industry have been growing with the commercialization of the game (e.g., in 2011, up to £1.6 billion of football revenue went towards player wages in Premier League clubs; Deloitte, 2012). Within this context, most footballers recognised that they were financially better off than their extended family, and friends from childhood. With generous salaries that were supplemented with signing-on fees and performance bonuses, money was viewed by some of them as 'disposable income' to be spent on personal and family needs:

> *'I went from earning…very little to a lot of money. So then I could do what I wanted really, financially. Buy a nice house, buy a nice car, you can gamble, you can drink, you can do what you wanted. You had a lot of disposable income…I was able to give my mum money, my dad money, my brother money. Have nice things, not worry about money…Um, I was never flash with it. But when you're young, you want, you get a nice car, sometimes you get a nice house; few nice girlfriends. That's what goes with it, when you speak to a young footballer. That is what happens. That will still be what's happening today.' [F11]*

A few footballers also saw that the financial freedoms afforded as young footballers inevitably changed their attitudes towards money and people:

> *'[Footballers] lack of respect for self; very risk seeking; very much chasing the buzz, the next level, the euphoric experience…Sexual experiences, certainly, with women in night clubs…There's a sense of identity being a footballer…so it's trying to keep up with that: the clothes, the women, the cars, the jewellery, the watches, the drinking, places to drink, members clubs…fucking idiots you know…' [F9]*

Some footballers, reported that the significant increases in their income was associated with heightened thoughts and desires to gamble following, perhaps indicating that large incomes did not so much initiate new patterns of gambling behaviour, as merely augmenting existing ones. One footballer recalls the impact of the higher income on signing his first professional contract:

> *'I got paid and got paid more because of my signing on fees, so I found myself getting paid a couple of thousand and to do stuff with that money than saving it. Yeah I just felt myself going crazy.' [F1]*

To summarise, the interviewees reported that high incomes tended to distort some footballers' value for money, making it more acceptable and even necessary to maintain their gambling habits, with larger bets to get the same enjoyment (Box 3a). In some cases, this effect appeared to be accompanied by a false sense of security that the professional incomes provided. Whilst being able to fulfil their day-to-day financial obligations, footballers' reported how their incomes tended to conceal maladaptive gambling habits actually were

(Box 3b). This is further confirmed by a few footballers who reported how their unsustainable lifestyles spiralled out of control after a sudden loss of income upon their release from clubs.

> *'When I was earning I was never in debt…but I was wasting the money that I was earning…[T]he stage where I got sacked, and then, I wasn't getting paid by that club anymore…that's when I opened up accounts of overdrafts, borrowing money just to gamble with …I didn't have the money to do it, but I did it…' [F4]*

Box 3. Gambling to satisfy growing appetites

a. High incomes distorts value for money

> '*The more money you make the more money you gamble that's what I've come across I don't know. I wish I could gamble with £10 and be happy winning £10, but it is not the case. If I'm gambling I've got to try and win big money.*' *[F6]*

b. Regular incomes create a false security

> '*I was earning more money, earning a lot more money, so I was still spending a lot of money on gambling, but also wasn't neglecting anything; paying everything else at the same time… I was new to this money coming in, decent money coming in. You can lose that week's money and there will be another week coming in, so, it wasn't too bad for me.*' *[F2]*

9.3.3 Emotional tensions of football

Football frustrations. Many footballers remembered an intense positive 'buzz' early on in their career when signing their first professional contracts and when scoring goals:

> *'Scoring a goal, defending a goal, the crowd, the atmosphere, the buzz and the sheer adulation, and you see some players do amazing things when they score a goal, that seems like dancing and they're in some kind of different space. But and if you ask them they say: 'fuck I did that!' But when they're in that space, they don't know; so that sheer, sheer, buzz of adrenaline.' [F7]*

However, most interviewees also reported that the pleasures of football also came with a unique set of frustrations because of the limited control they had over their own careers. For example, footballers reported being at the mercy of managers for their contractual arrangements and their weekly selections for matches. One reoccurring metaphor used by some footballers is the image of 'pieces of meat':

> *'[A]nother footballer said to me: 'listen you need to learn you're a piece of meat…like a butcher, you're either a great piece of meat that he's going to put in the front window or you're a bad piece of meat and you're probably not going to sell it.' So when you're fit and healthy and on form you're a good bit of meat, and when you're not and you're injured and you look a bit rumpy, you're at the back, you're fuck off. You're a piece of meat.' [F9]*

Alongside the uncertainty and dependency on others for professional success, interviewees also reported that the verbal criticism and abuse from fans, as well as the harassments or unfair reportage by the media, are things to be endured, as if living with 'shackles':

> *'Yeah the football career is so restricted in terms of like all eyes, it's even worse now with everyone doing camera phones and there really isn't a place for you to be whoever you wanted to be…with all those restrictions…those shackles…I meet people who have that just a sweeping stereotypical image. I meet them in good faith…and then let's say an hour into the conversation or the meeting they're like…'you're a really nice…and clever person and I didn't expect you to be like this'. And that's exactly what I want to happen, but it disgusts me that they had that opinion of me initially you know…' [F3]*

For some interviewees, this sense of accumulating pressure tended to be exacerbated by the consequences of career-threatening events like a major physical injury, or getting released from a club, was profoundly 'traumatic':

> *'Yeah I was depressed, just felt like shit about myself and that really…I spoke to [the counsellor] about it in there, and I just started crying and stuff where I've just never dealt with it… it's just that I never got to have a full opportunity at it, it was sort of taken from me…' [F5]*

To describe his extreme emotional highs and lows, one footballer used an analogy of riding 'rollercoasters':

> *'[Y]ou have ups and downs as a footballer…you know football's a rollercoaster anyway without any outside issues. You know it's probably 15 rollercoasters all in one…' [F10]*

Gambling for emotional relief. Finally, for several of the interviewees, the combinations of occupational and emotional highs and lows were coupled to gambling by offering ways of coping with the emotional stress. To some, gambling imitated the rewarding aspects of football with its anticipatory, competitive atmosphere, and the buzz that comes with winning:

> *'I loved betting and that was giving me the buzz and making me happy at the time….The buzz, you get it in gambling when you've won, you just get this big excitement…When I'm not playing I normally turn to gambling and that gives me the excitement and gives me the buzz.' [F6]*

Critically, some footballers also reported how gambling had a remedial function to address the emotional dreariness of unstructured time outside of training (Box 4). Others reported that gambling provided temporary reprieve from their deep frustrations occasioned by poor performance, injury, or retirement from football; the dissociative experience of escaping and carving out a personal secure '*little world*', '*box*', '*circle*' *or* '*bubble*' *[F3, F4, F5, F9, F10]*.

Box 4. Gambling for emotional relief

Gambling to escape boredom and frustrations

> '*You probably get in for training about 10am, train in the morning till about 12pm have lunch and then maybe a little bit of gym work and then off you go home…There's a lot of free time…I'd go training and stuff and after training…there's just nothing to do, all my other friends are at work and I would be like: 'oh I'll just go to the bookies for a bit'...' [F4]*

> [Sitting in a hotel room the night before a match] '*Everything was just perfect. You know for me I had my computer there [points to the front], tele there [points to the side], big double bed there [points to the other side], and another double bed there just with my stuff in it…sitting there very comfy; nobody to bother me [as I gamble]…that's sort of a security, I think…at that time I just felt like heaven, you know.' [F2]*

> '*I felt like I didn't really have anywhere to go from there to be honest, from…from doing so well and being like the next best thing to then just being [silence]…it was difficult…that's when I found gambling to escape, escape from that yeah…8-9 hours and I'd be like having no worries in the world.' [F1]*

9.4 Discussion

The qualitative findings highlight specific sociocultural features of top level football (Fletcher & Wagstaff, 2009) that facilitated some footballers' transition from recreational to more problematic forms of gambling involvement. In particular, *social pressures* to identify and belong, *vocational features* of managing high incomes and career uncertainties, and the *emotional tensions* of challenges presented by injury or loss of form.

Crucially, the respondents' perspectives analysed here come from British players who have developed serious gambling problems in the course of their careers. I do not claim these experiences are represent of the majority of British footballers in the industry without gambling problems; or to other players who have developed gambling problems but whom I did not interview; or finally, the growing number of foreign players that have been recruited since the late 1990s (e.g., the Premier League; Magee & Sugden, 2002; O. Williams, 2009). Nonetheless the experiences identified here help to specify useful targets for harm-reduction strategies that may help British footballers who are vulnerable to gambling problems.

Firstly, my findings suggest that *socialisation* into British professional football, where gambling is commonly encountered, in addition to insecurities regarding their social standing and isolation from supportive social networks, are risk factors for gambling problems in some footballers. Extending proposals that a competitive spirit facilitates gambling involvement in elite athletes (Curry & Jiobu, 1995), my findings suggest that competition in footballers tends to increase gambling involvement because it creates an isolating social condition that augments social pressures to identify and belong, especially for young footballers. To minimise harm from social pressures, my findings suggest that young footballers could be supported to maintain their peer and familial social networks outside of football, especially upon first entry into professional football where they are introduced to new financial privileges and to the football 'senior' culture.

Secondly, my findings suggest that high incomes that accompany the British footballers' *vocation*, and their subsequent withdrawal following release, have facilitated greater gambling involvement in vulnerable footballers. Specifically, high incomes distorted footballers' value of money and created a false sense of security in its perpetuity. Importantly, the adverse consequences of increased incomes are not likely the result of changes to incomes per se (Eckblad & von der Lippe, 1994), but more likely, the facilitation of already established patterns of gambling behaviours (Parker, 2001). Our findings suggest that such harms could be minimised by financial planning that challenges young footballers' value of money and overconfidence in its reliability.

Thirdly, my findings suggest that footballers' loss of freedom, career, privacy, and even health (Hughes & Leavey, 2012; Turner, Barlow, & Heathcote-Elliott, 2000), facilitated greater gambling involvement in vulnerable footballers through an emotional coping mechanism. Previous research has tended to neglect the role of emotions when explaining increased gambling problems amongst high-profile (e.g., American football and baseball; Ellenbogen, et al., 2008; Nelson, et al., 2007) and retired athletes (e.g., Weiss & Loubier, 2008). Considering the high rates of injury in football (Hawkins & Fuller, 1999), footballers' expectancies of mood regulation likely represents an appropriate therapeutic target. Considering that more than 80% of children in British football academies get released by their 21st birthday (James, 2010), harms could be minimised by preventing premature curtailment of their vocational options (Marcia, 1966).

Chapter 10.

Discussion and conclusion

10.1 Summary of findings

The preceding results from laboratory performance, computational modelling, web-based surveying, and qualitative techniques, support my central thesis that cognitive (gambling-related) biases are shaped by the sensorimotor structures of games, and the broader sociocultural contexts in which gambling is played. In particular, Study 1 found that the motor output of games can occasion instrumental expressions of gambling-related cognitive (GRC) biases, where non-problematic gamblers align the duration of their rolls of an animated die to the numerical values of target and prize structures within the game. In Study 2, I replicated this pattern of action-based *illusions of control* (IOC) in a response modality that approximated more natural die-shooting behaviours (i.e., mouse-shaking). Critically, in Studies 2-4, I also found that game events (i.e., preceding plays that increase or maintain motivations to win), the configuration of game features (i.e., perceptual congruencies), and the competitiveness of gambling co-actors, all facilitate the expression of action-based IOCs. This series of experimental studies underscore the physical and social aspects of games that act as 'boundary conditions' for the expression, and the development of IOCs (Meier, Schnall, Schwarz, & Bargh, 2012).

Extending these findings in Study 5, I investigated how self-report GRCs increases risks for gambling-related harm, and found that GRCs interfered with gamblers' information (computational) processing of game contingencies. Specifically, non-problematic gamblers who endorsed more GRC beliefs showed poor action-value learning because they failed to keep track of trends in past game outcomes; instead, these gamblers showed a greater tendency to persevere on losing options (i.e., they used fewer 'lose-shift' strategies). Remarkably, the more confident gamblers were in their ability to *predict* game outcomes, the poorer their use of optimal information for action selection. In contrast, poor value-based decision making of impulsive gamblers was associated with more stable perceptions of game contingencies (low learning rates) and a tendency to overestimate, small, and underestimate large probabilities (greater probability distortions).

In the remaining web-based surveys and qualitative interviews, I identified sociocultural features that likely constrain the expression, and development, of GRCs. In study 6a, I found that the international Chinese gamblers sampled could be classified into groups with wider gambling participation, where self-report GRCs were highest amongst the most established *Mahjong-casino* and *multi-activity* groups. A follow-up analysis in Study 6b revealed that the links between Chinese beliefs in luck and reported gambling problems can be attributed to gamblers' GRCs beliefs, particularly, their Interpretive Bias (IB) cognitions.

Finally, the qualitative techniques of Study 7 explored the personal experiences of treatment-seeking British professional footballers that precipitated their development of gambling problems. Within this elite and high profile context, footballers' social pressures to belong, emotional frustrations around career challenges, and large regular incomes, were recurring themes reported to facilitate their heightened gambling involvement.

10.2 Strengths and weaknesses

The methodological strength of my thesis is the use of mixed quantitative and qualitative techniques that assess both behavioural and self-report aspects of GRCs. In addition, sampling was mostly from community-based populations of established, regular gamblers.

However, the weakness of my experimental studies (Studies 1-5) is their inability to directly describe the psychological processes of disordered gambling per se since only non-problematic gamblers were recruited. Nevertheless, from a cognitive perspective, this is not a problem because I was interested in how GRCs, a known risk factor for PG, are associated with sensorimotor and sociocultural factors of gambling without the confounding effects of severe deficits of PG.

One weakness of the dice studies (Studies 1-5) in particular is the artificiality of these tasks compared to commercial gambling games like Craps. This limits the external validity of the data. However, without minimising such a criticism, one way I tried to improve external validity of the games in these studies was to use real money, where participants could actually win and lose in these experiments.

Next, though PGs are sampled in my online survey and qualitative interviews (Studies 6-7), the cross-sectional assessment Chinese gamblers' GRCs in the surveys, and the retrospective reports of footballers in the interviews, does limit claims to GRCs' causation of gambling-related harm. Furthermore, my interviews with footballer (Study 7) did not directly assess GRCs. Nevertheless, my focus on footballers' complex social and vocational environments that were perceived to facilitate their gambling involvement, does prepare the ground for future work assessing footballers' culturally contingent GRCs.

One final weakness is the representativeness of the online survey (Study 6). A convenient self-selecting sample was used so no claim can be made of its generalizability to the population. Nonetheless, the results of this study still describe how distinct gambling patterns are related to the health characteristics of gamblers.

Notwithstanding these weaknesses, the remainder of this discussion argues for a broadened theoretical space in the conception of GRCs. It does this by bringing into focus how GRCs develop and operate in the context of gamblers' interaction in the world.

10.2.1 The contingency of GRCs: Gambling-think

Rather than pointing beyond cognitive approaches of gambling, I argue here that my findings suggest a richer characterisation of gamblers' GRC biases. Though internally processed, GRCs can be viewed as dependent on gamblers' interaction with external sensorimotor game structures and sociocultural factors. As opposed to some traditions of cognitive science where GRCs are conceived as static and individualised errors of information processing, I describe here a broader account of GRCs as dynamic cognitive structures that are shaped by supervening sensorimotor (physical) and sociocultural (interpersonal) gambling contexts (reviewed by Bandura, 2001; Meier, et al., 2012; Wilson, 2002).

Specifically, there are a few senses in which this contingent view of GRCs, or Gambling-think, will be explored in the following discussion: (i) GRCs may be conceived as having functional properties in gamblers' physical and social interactions (i.e., 'cognition is *action-oriented*'); (ii) GRCs are responsive to changing game and vocational life events (i.e., 'cognition is *situated* in time and history'); and (iii) GRCs borrow external the physical and social environment for its content and operation (i.e., 'cognition is extendable to physical and socially shared realities'; reviewed in Semin & Smith, 2002; and Wilson, 2002).

10.3 GRCs and embodied cognitions theory

My results from the experimental dice studies reveal that sensory and motor systems are closely linked to gamblers' conceptions of IOC. This 'grounding' of gamblers' cognitions in their perceptual and behavioural interaction with games (cf. Glenberg & Robertson, 2000 for an embodied theory of meaning in language) is well described within an embodied cognitions approach that takes in to account how 'sensory and motor information colors conceptual processing, enriches it, and provides it with a relational context' (Mahon & Caramazza, 2008, p. 68). To illustrate this, I present here findings that motor prospects of die-throwing (Studies 1-2), occasioned by sensory configurations of games (Study 3), do facilitate the expressions of IOCs in non-problematic gamblers.

10.3.1 Conceiving illusions of control (IOC) as embodied

Foremost, conceiving cognitions as *action-oriented* is to view them in context of a thinking agent with particular functional potentials within the physical environment (reviewed in Ziemke, 2002). For example, people find it more difficult to understand sentences that do not reflect the appropriate behavioural features of objects (i.e., it is easlier to understand 'Erik used his shirt to dry his feet' rather than 'Erik used his glasses to dry his feet'; Glenberg & Robertson, 2000).

The *action-orientation* of GRCs is illustrated by my findings that IOCs are not only facilitated by the motor prospects of throwing dice (Study 1-2), but the appropriating of those action features play a mediatory role in the subsequent development of subjective IOCs (Study 3). Tight couplings between cognitions and actions have previously been shown in other contexts. The meaning of words has motor correspondences (also known as 'motor resonance'; Rueschemeyer, Lindemann, van Elk, & Bekkering, 2009); whilst the reverse is also true, where bodily actions of actors can influence their judgements of perceptual and semantic information (reviewed in Meier, et al., 2012). Remarkable examples of this link is observed in reports of head nodding, rather than shaking, that increases interpersonal agreement (Wells & Petty, 1980); facial expressions of a smile that increases amusement and humour ratings of cartoons (Strack, Martin, & Stepper, 1988); and hand washing that increases (or decreases) risk-taking in participants asked to recall experiences of bad (or good) luck (Xu, Zwick, & Schwarz, 2012).

In contrast with these studies, my findings goes further to suggest that the functional (*action-oriented*) embodiment of human cognitions does not only change personal judgements and recall of events and objects external to thinking agents, but in fact alters their perceptions of themselves as actors that have control over the physical environment (in this case, die outcomes). Moreover, I also go further than previous studies by identifying the specific boundary conditions under which these *action-oriented* cognitions of control are expressed (Study 3) – i.e., games with sensory and motor features that have 'overlapping', or congruent, dimensions of magnitude (Kornblum, et al., 1990; Tucker & Ellis, 1998; Walsh, 2003)

Other than an action-orientation, cognitions could also be conceived as *situated*, where they respond to the changing task-relevant dynamics of incoming sensory information and outgoing motor behaviours. Study 2 revealed how IOCs are situated in this sense. Die shaking intensity increased immediately after game events that increase gamblers' motivations to win (i.e., losing rather than winning in the previous play), and conversely, after games events that did not disturb their focus on achieving wins (i.e., not getting a foul for their die-shaking in the previous play).

From an embodied cognitions paradigm, previous work on the effects of motivation on IOC can be understood as investigations into *situated* cognitions. For example, experimentally manipulating participants' desires to win using hunger and prospects of electric shocks and public speaking (Biner, et al., 1995; Biner, et al., 1998; Biner, Johnston, Summers, & Chudzynski, 2009; Friedland, et al., 1992), are associated with rating and behavioural indices of IOCs. These studies therefore suggest that the motivational texture of the gaming situation may be the psychological mechanism that modulates the situational aspect of IOCs I found in Study 2. Going beyond these studies, my findings have greater external validity as it uses multi-shot games that approximate the structure of casino craps gambling.

Finally, moving on from GRCs' situated and action-oriented aspects, I also explore conceptions of cognitions as *extendable* in the sense that its operation and content are supplemented by the physical environment. Common-day examples of these include the use of paper and pencil to aid mathematical problem solving, or the use of 'Post-it' notes to enhance memory (cf. examples used in Wilson, 2002). Similarly, the instrumental dice-throwing observed in Studies 1-3 could be simplifying the cognitive work of representing uncertain game reward contingencies (in this case a 1/6 odds) by the shortcut of attributing desired game outcomes to simple instrumental actions. In other words, an 'offloading' strategy (reviewed in Wilson, 2002).

Additionally, IOCs could have developed in games of dice because instrumental actions gave gamblers an added plausibility structure to reason about their wins. This is supported by recent work on 'epistemic actions' that show how some instrumental actions are used by actors to supplement task-related judgements (Kirsh & Maglio, 1994). A classic example is the study of Tetris play, where players rotate and transform falling shapes to recruit the physical shapes of the game in the process of their decision-making (Kirsh & Maglio, 1994). In games of dice, where outcomes are determined by chance, the application of epistemic actions previously reported and experimentally demonstrated here (e.g., 'a hard throw produces a large number, and a soft or easy throw produces a low number'; Henslin, 1967, p.319) are inappropriate.

Conceiving GRCs as extendable to instrumental actions, therefore, suggests that gamblers develop IOCs in games of dice not only because it simplifies the cognitive task of representing uncertain outcomes, but these acts may give gamblers an accessible (but mistaken) explanation for their winning outcomes.

In sum, gamblers' mistaken IOCs in games of dice are embodied in the sense that (Wilson, 2002): (i) they are not premised on abstract and private mental concepts, but 'grounded' in the sensory-motor features of games (IOCs are *action-oriented*); (ii) they react dynamically to the motivational tone of game circumstances (IOCs are *situated*); and (iii) they are learned by on-going attempts to understand game contingencies through instrumental action (IOCs are *extendable*).

Critically, my results further theoretical development in the study of GRCs, conceiving these cognitions not as disembodied symbolic processes, but the beliefs of gamblers who are behaviourally interacting with games. This development is accompanied by the proposed action-based (dice) experimental paradigm that renders embodied IOC processes as thoroughly 'grounded' within gamblers' sensory and motor experience.

10.4 GRCs and decision theory

In this section, I situate the computational findings of Study 5 within decision theory that has mostly developed within the behavioural economics literature. The cognitive processes modelled here were based on the *decision utilities* of gamblers – that is, the extent to which gamblers' choices were affected (or weighted) by preceding game outcomes (Kahneman, Wakker, & Sarin, 1997). This is in contrast to measures of gamblers' actual hedonic value of game options before a decision is made (i.e., *anticipation utility*) or after game outcomes are revealed (i.e., *experience utility*). Though gamblers' decision utilities are interrelated with experience and anticipation utilities (reviewed in Trepel, et al., 2005), the quantitative descriptions of choice carried out here is, strictly, the identification of how gamblers weight previous reinforcements as measured by their *choices*.

These computational techniques to model choice were not attempts to reduce all of cognition onto a single information-processing level. Instead the approach here is premised on the view that higher level organisations of meaning in 'verbal rules and logic' (Delfabbro & Winefield, 1999, p. 437) – in this case, GRCs beliefs – constrains gamblers' perceptions and decision strategies in games that can be indexed quantitatively. Classic experimental support for this comes from behavioural economics research have demonstrated how rules about 'fairness' can impinge on individuals' monetary decisions in social games like the 'Ultimatum Game' (Kahneman, Knetsch, & Thaler, 1986).

Applying decision theory to the gambling context, Prospect Theory could be one decision utility model used to describe gambling behaviour amongst problem (and pathological) gamblers. In particular, diminished sensitivity to accumulating losses, predicted by Prospect theory, can account for vulnerable gamblers' continued gambling in the face of mounting debts – i.e., loss-chasing behaviours (Arkes & Blumer, 1985; Thaler, 1999). Study 5 employed new developments in computational methods to describe, in more detail, the cognitive (computational) processes and decision strategies associated with known vulnerabilities for gambling-related harm; specifically individual differences in GRCs and impulsivity.

10.4.1 Computational research of gambling-related harm

Study 5 showed, for the first time, that self-report GRCs and impulsivity were associated with poor abilities to identify and exploit patterned (or scheduled) rewards in games. Described in positive terms, gamblers with strong GRCs and impulsivity were 'offloading' computational load (Wilson, 2002) by choosing suboptimal decision strategies. Critically, the more gamblers were confident of their ability to predict game outcomes based on the games' reinforcement schedule (i.e., strong *predictive control*), the poorer their actual performances were. These results suggest that my understanding of problem gamblers' (PrGs) 'mental limitations' in judgement (Kahneman, Slovic, & Tversky, 1982, p. xii) go beyond excessive delayed discounting and diminished probabilistic discounting (MacKillop, et al., 2006; Madden, et al., 2009), and extend into deficits of learning under conditions of ambiguity (i.e., the odd of winning in the game is derived rather than a given).

Another benefit of using computational methods in the study of the risk of gambling-related harm is its ability to differentiate the cognitive processing deficits associated with particular risks for PrG like GRCs and impulsivity (Michalczuk, et al., 2011; Raylu & Oei, 2004a). For example, in my experiment, gamblers with strong GRCs were predisposed to short-term decision strategies of sticking with losing game options. Such an inefficient (in this context) decision-heuristic possibly reflects how strong GRCs heighten gambling appetites and expectations of winning after losing (Campbell-Meiklejohn, Woolrich, Passingham, & Rogers, 2008). Conversely, impulsive gamblers tended to perceive the probability structure of the game as flatter and more stable over time. Making choices in ways that suggest they had distorted representations of the reward structure of the game, possibly reflecting their deficits in inhibitory control (Potenza et al., 2003).

A further application of using computational methods to study disordered gambling is the assessment of treatment outcomes. Currently, the benefit of psychological interventions for problem gambling are measured psychometrically (e.g., ratings of gambling frequency, urge and self-control) and symptomatically (e.g., ratings on validated gambling screening tools; Jimenez-Murcia, et al., 2008; Oakley-Browne, et al., 2005; Sylvain, et al., 1997). Thus descriptive accounts could complement these indices of recovery with evidence of improvements to decision-making. For example, treatment outcomes could be measured by improvements to gamblers' value learning and immunity to immediate game losses. This approach has the added benefits of weighing in on game-related contexts that previous outcome assessments ignore.

In sum, the ability of computational models to specify cognitive and behavioural features of different vulnerabilities to PG is illustrative of a possible broader computational psychiatry approach (Montague, et al., 2012), where mental health disorders are conceived dimensionally, rather than categorically, along context-specific cognitive and behavioural patterns.

10.5 GRCs and social cognitions theory

In this section, GRCs is conceived within the interpersonal and cultural aspects of gambling environments (e.g., Social Cognitive Theory - Bandura, 2001; Social Representations Theory - Moscovici, 1988); these approaches posit that cognitions (or representations) including GRCs are not only conditioned by the physical aspects of the actors, but more importantly, by the conventional beliefs and practices of the gamblers' interpersonal environment (Thompson & Fine, 1999).

However, the exact 'mechanisms linking socio-structural factors to action in this macro-analytic approach are left largely unexplained' (Bandura, 2001, p.5), especially with regard to how interpersonal factors of gambling situations influence harmful gambling practices. To this end, my study of competition in games (Study 5), cultural representations of luck (Study 6b), and vocational circumstances of professional footballers (Study 7), suggest that gamblers' interpersonal environments may be augmenting PG by a mediating psychological mechanism of pragmatic, situated and extended GRCs.

10.5.1 Conceiving GRCs as socially and culturally contingent

Firstly, it is argued that GRCs have an *action-oriented* function at the interpersonal cognitive domain (reviewed in Semin & Smith, 2002). For example, my online survey of Chinese gamblers found that beliefs in good luck are associated with reported gambling problems through the GRC mechanism of *interpretive biases* (IB; Study 6b). Since IBs are beliefs that game winning outcomes reflect personal ability rather than uncontrollable environmental factors, it would suggest that IB beliefs have more action relevance in a world that operated on the principals of controllable luck. Culturally-specific beliefs in luck obviously took a particular socio-historical trajectory amongst the Chinese people as observed by their customs surrounding luck (Fong, 2000) and higher rates of GRCs compared to Caucasians (Oei, et al., 2008; Zheng, et al., 2010). But what is interesting here is how these social structured GRCs such as luck, in time, could be shaping the repertoire of actions available to Chinese gamblers living within these socially constructed realities.

Secondly, GRCs can be conceived as *situated* and dynamically changing with gamblers' social-cultural interactions. This view will account for my findings that GRCs were modulated by gamblers' interpersonal and vocational contexts. I found that boredom and frustrations of a professional footballers' career is reported to heighten their desires to gamble for mood regulation (i.e., increased *gambling expectancies*; Study 7 box 4). Also, increased competition in games, induced by gambling co-actors, can facilitate greater motor expressions of IOC in die shooters (Study 4).

Previous studies have demonstrated how game events like gambling co-actors' wins can induce players' risk-appetites in games like roulette and electronic gaming machines (Le Floch, et al., 2005; Rockloff & Dyer, 2007), suggesting that *situated* GRCs in games are modulated by the motivational potency of game events and not just competitive aspects of it. My findings go one step further to suggest that vocational circumstances also have motivational latency. Thus, the socially situated contingency of GRC biases likely operates within both the short time scale of game, and longer time scales of life, events.

Thirdly, GRCs can be conceived as beliefs that are *extendable* beyond private beliefs of gamblers to broader social norms, belief systems, and customs (Oetting & Donnermeyer, 1998; Thompson & Fine, 1999). A good illustration of this point is my finding of how professional footballers began to view heavy gambling practices as 'the right thing to do' after immersion in a culture that affirms and engages in such practices (Study 7 box 2). Additionally, my findings in Study 4 and 6 suggests that social factors that shape GRCs are not necessarily represented by abstract mental symbols; within games, co-actors' competitive choices were shown to increase motor expressions of IOC (Study 4), as if mistaken beliefs about skill and control were *extended* and represented in the choices of co-actors. Also, the supervening effect of beliefs in luck on GRCs (Study 6) further illustrates how Chinese norms are not only represented in agreed interpretations about lucky objects, numbers and events; but in representations that *extend* to cultural institutions like Feng-Shui and Palmistry.

Thus, GRC biases are 'not limited to individual thought about social objects but is a product of social interchange, constructed, shared, and distributed among groups of individuals.' (Thompson & Fine, 1999, p. 281). In particular, they extend and are sustained by heavy betting norms amongst professional footballers, competitive choices of gambling co-actors, and the cultural institutions of the Chinese people.

Taken together, the *action-oriented*, *situated* and *extendable* aspects of GRCs are presented here as complementary ways that sociocultural factors shape GRCs. Following the suggestion of Social Representations Theory (Moscovici, 1988), I argue that GRCs is the 'common sense' that new gambling information is compared to, and integrated with. Following Social Cognitions Theory, GRCs can be conceived as the social rules gamblers use to explain whether their actions have effected winning outcomes ('action-outcome expectancy'), or whether they possess the skills required to perform these actions ('action-outcome efficacy'; Bandura, 2001).

10.5.2 Future research into socially contingent GRCs

Cognitive approaches to the study of gambling-related harm, though important, are overly reductionistic if considered apart from the affective and behavioural consequences of group interactions (Blaszczynski & Nower, 2002; Thompson & Fine, 1999). To illustrate a behavioural pathway to PG, my findings in Study 6 showed that Chinese gamblers' choice and variety of gambling media is associated with risks for reported gambling-related harm. Thus this suggests that socially contingent GRCs may not exhaustively account for the sociocultural facilitation of gambling-related harm.

On the one hand, I emphasised here the need to move on from traditional conceptions of GRCs as atomised, static, and internalised thinking patterns. But this was not an attempt to reassert social learning theories that ignore the importance of private 'internal events'

(Brown, 1987). Instead my aim was to underscore the productivity of conceiving GRCs as internally processed, but externally shaped by the social, vocational, and cultural traditions of gambling groups. In this narrow sense, GRCs are thus conceived as social and culturally 'embodied'.

Finally, more than detailing the extent to which physical and social environments constrain individuals' gambling-related cognitions, affect and behaviour, future work could also investigate how gamblers themselves shape these environments. For example, by the games they select, the company they choose, and their contribution to group norms and beliefs (cf. the notion of agency in Social Cognitive Theory; Bandura, 2001).

10.6 Conclusion

Using a variety of methods, the present work has demonstrated how GRCs: (i) have particular action relevance for the gambler (i.e., GRCs have *action-oriented* features); (ii) respond to the motivational dynamics of gambling events (i.e., GRCs have *situated* features); and (iii) have content and operations that are supported by physical and social structures (i.e., GRCs have *extended* features). Specifically, I found that GRCs are contingent upon physical boundary conditions like the behavioural features of games (Study 1-2), which are in turn conditioned by congruent sensory-motor features (Study 3). Regards the development of gambling problems, GRCs constrains gamblers' value learning when faced with decisions under uncertainty (Study 5). Additionally, these GRCs are socially conditioned within games by the degree of competition (Study 4), the socially shared norms and customs of Chinese beliefs in luck (Study 6), and probably, the vocational factors of British professional football (Study 7).

The main thrust of my thesis has been to demonstrate that GRCs are embodied and contingent, being shaped by the physical and social features of gamblers' environments. In this view, GRCs do not begin and end with private information-processing, but are 'socially interdependent, richly contextualized, and conditionally orchestrated within the dynamics of various societal [and gaming] subsystems and their complex interplay' (Bandura, 2001, p. 5). I argue that these contingent views of GRCs (what I call *Gambling-Think*) will continue to be empirically enriching and productive because they conceive of GRCs and their related harms (more accurately) in full view of gamblers' living and interacting in the world (Thompson & Fine, 1999; Wilson, 2002).

References

Adinoff, B., Rilling, L. M., Williams, M. J., Schreffler, E., Schepis, T. S., Rosvall, T., & Rao, U. (2007). Impulsivity, neural deficits, and the addictions: The "oops" factor in relapse. *Journal of Addictive Diseases, 26*(S1), 25-39.

Ainslie, G. (1975). Specious reward - Behavioral theory of impulsiveness and impulse control. *Psychological Bulletin, 82*(4), 463-496.

Allport, F. H. (1924). Response to social stimulation in the group. In F. H. Allport (Ed.), *Social psychology*: Hillsdale, NJ: Erlbaum.

Andres, M., Davare, M., Pesenti, M., Olivier, E., & Seron, X. (2004). Number magnitude and grip aperture interaction. *Neuroreport, 15*(18), 2773-2777.

APA. (2000). *American Psychological Association: Diagnostic and statistical manual of mental disorders, DSM-IV-TR fourth edition*: Washington, DC: American Psychiatric Press.

Arkes, H. R., & Blumer, C. (1985). The psychology of sunk cost. *Organizational Behavior and Human Decision Processes, 35*(1), 124-140.

Ayton, P., & Fischer, I. (2004). The hot hand fallacy and the gambler's fallacy: Two faces of subjective randomness. *Memory & Cognition, 32*(8), 1369-1378.

Baboushkin, H. R., Hardoon, K. K., Derevensky, J. L., & Gupta, R. (2001). Underlying cognitions in gambling behavior among university students. *Journal of Applied Social Psychology, 31*(7), 1409-1430. doi: DOI 10.1111/j.1559-1816.2001.tb02680.x

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*, 1-26. doi: DOI 10.1146/annurev.psych.52.1.1

Behrens, T. E., Woolrich, M. W., Walton, M. E., & Rushworth, M. F. (2007). Learning the value of information in an uncertain world. *Nature neuroscience, 10*(9), 1214.

Benhsain, K., Taillefer, A., & Ladouceur, R. (2004). Awareness of independence of events and erroneous perceptions while gambling. *Addictive Behaviors, 29*(2), 399-404. doi: DOI 10.1016/j.addbeh.2003.08.011

Biner, P. M., Angle, S. T., Park, J. H., Mellinger, A. E., & Barber, B. C. (1995). Need state and the illusion of control. *Personality and Social Psychology Bulletin, 21*(9), 899-907.

Biner, P. M., Huffman, M. L., Curran, M. A., & Long, K. R. (1998). Illusory control as a function of motivation for a specific outcome in a chance-based situation. *Motivation and Emotion, 22*(4), 277-291. doi: Doi 10.1023/A:1021300306318

Biner, P. M., Johnston, B. C., Summers, A. D., & Chudzynski, E. N. (2009). Illusory control as a function of the motivation to avoid randomly determined aversive outcomes. *Motivation and Emotion, 33*(1), 32-41. doi: DOI 10.1007/s11031-008-9111-3

Blanco, F., Matute, H., & Vadillo, M. A. (2011). Making the uncontrollable seem controllable: The role of action in the illusion of control. *Quarterly Journal of Experimental Psychology, 64*(7), 1290-1304. doi: Doi 10.1080/17470218.2011.552727

Blaszczynski, A., Huynh, S., Dumlao, V. J., & Farrell, E. (1998). Problem gambling within a chinese speaking community. *Journal of Gambling Studies, 14*(4), 359-380.

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

Bond, M. H., Leung, K., Au, A., Tong, K. K., de Carrasquel, S. R., Murakami, F., . . . Lewis, J. R. (2004). Culture-level dimensions of social axioms and their correlates across 41 cultures. *Journal of Cross-Cultural Psychology, 35*(5), 548-570. doi: Doi 10.1177/0022022104268388

Bouts, P., & Vanavermaet, E. (1992). Drawing familiar or unfamiliar cards - Stimulus-familiarity, chance orientation, and the illusion of control. *Personality and Social Psychology Bulletin, 18*(3), 331-335. doi: Doi 10.1177/0146167292183009

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Breen, R. B., & Frank, M. L. (1993). The effects of statistical fluctuations and perceived status of a competitor on the illusion of control in experienced gamblers. *Journal of Gambling Studies, 9*(3), 265-276.

Brown, R. I. F. (1987). Models of gambling and gambling addictions as perceptual filters. *The Journal of Gambling Behavior, 3*(4), 224-236.

Burger, J. M. (1986). Desire for control and the illusion of control - The effects of familiarity and sequence of outcomes. *Journal of Research in Personality, 20*(1), 66-76. doi: Doi 10.1016/0092-6566(86)90110-8

Burger, J. M., & Cooper, H. M. (1979). The desirability of control. *Motivation and Emotion, 3*(4), 381-393.

Campbell-Meiklejohn, D. K., Woolrich, M. W., Passingham, R. E., & Rogers, R. D. (2008). Knowing when to stop: The brain mechanisms of chasing losses. *Biological Psychiatry, 63*(3), 293-300. doi: DOI 10.1016/j.biopsych.2007.05.014

Caron, A., & Ladouceur, R. (2003). Erroneous verbalizations and risk taking at video lotteries. *British Journal of Psychology, 94*, 189–194.

CCA. (2004). Christiansen Capital Advisors' global Internet gambling revenue estimates and projections (2001–2010, $M, US). Retrieved from http://www.cca-i.com/primary%20navigation/online%20data%20store/internet_gambling_data.htm

Chambers, R. A., & Potenza, M. N. (2003). Neurodevelopment, impulsivity, and adolescent gambling. *Journal of Gambling Studies, 19*(1), 53-83.

Chang, P. T., Lee, J. H., Hung, K. C., Tsai, J. T., & Perng, C. (2009). Applying fuzzy weighted average approach to evaluate office layouts with Feng-Shui consideration. *Mathematical and Computer Modelling, 50*(9-10), 1514-1537. doi: DOI 10.1016/j.mcm.2008.07.038

Chantal, Y., Vallerand, R. J., & Vallieres, E. F. (1994). On the development and validation of the The Gambling Motivation Scale (GMS). *Society and Leisure, 17*, 189-212.

Chantal, Y., Vallerand, R. J., & Vallieres, E. F. (1995). Motivation and gambling involvement. *Journal of Social Psychology, 135*(6), 755-763.

Chau, A. W., & Phillips, J. G. (1995). Effects of perceived control upon wagering and attributions in computer Blackjack. *Journal of General Psychology, 122*(3), 253-269.

Chen, V. C. H., Chen, H., Lin, T. Y., Chou, H. H., Lai, T. J., Ferri, C. P., & Gossop, M. (2008). Severity of heroin dependence in Taiwan: Reliability and validity of the Chinese version of the Severity of Dependence Scale (SDS[Ch]). *Addictive Behaviors, 33*(12), 1590-1593. doi: DOI 10.1016/j.addbeh.2008.06.001

Chiu, J., & Storm, L. (2010). Personality, perceived luck and gambling attitudes as predictors of gambling involvement. *Journal of Gambling Studies, 26*(2), 205-227. doi: DOI 10.1007/s10899-009-9160-x

Clark, L., Crooks, B., Clarke, R., Aitken, M. R. F., & Dunn, B. D. (2012). Physiological responses to near-miss outcomes and personal control during simulated gambling.

Journal of Gambling Studies, 28(1), 123-137. doi: DOI 10.1007/s10899-011-9247-z

Clark, L., Lawrence, A. J., Astley-Jones, F., & Gray, N. (2009). Gambling near-misses enhance motivation to gamble and recruit win-related brain circuitry. *Neuron, 61*(3), 481-490. doi: DOI 10.1016/j.neuron.2008.12.031

Clarke, D., & Clarkson, J. (2009). A preliminary investigation into motivational factors associated with older adults' problem gambling. *International Journal of Mental Health Addiction, 7*, 12-28. doi: DOI 10.1007/s11469-007-9079-3

Cole, T., Barrett, D. J. K., & Griffiths, M. D. (2011). Social facilitation in online and offline gambling: A pilot study. *International Journal of Mental Health and Addiction, 9*(3), 240-247. doi: DOI 10.1007/s11469-010-9281-6

Cote, D., Caron, A., Aubert, J., Desrochers, V., & Ladouceur, R. (2003). Near wins prolong gambling on a video lottery terminal. *Journal of Gambling Studies, 19*(4), 433-438.

CPAC. (2000). The impact of gaming on specific cultural groups. Melbourne, Victoria, Australia: Cultural Partners Australia Consortium.

Curry, T. J., & Jiobu, R. M. (1995). Do motives matter - Modeling gambling on sports among athletes. *Sociology of Sport Journal, 12*(1), 21-35.

Dalley, J. W., Fryer, T. D., Brichard, L., Robinson, E. S., Theobald, D. E., Laane, K., . . . Robbins, T. W. (2007). Nucleus accumbens D2/3 receptors predict trait impulsivity and cocaine reinforcement. *Science, 315*(5816), 1267-1270. doi: 10.1126/science.1137073

Darke, P. R., & Freedman, J. L. (1997). The belief in good luck scale. *Journal of Research in Personality, 31*(4), 486-511. doi: DOI 10.1006/jrpe.1997.2197

Davis, D., Sundahl, I., & Lesbo, M. (2000). Illusory personal control as a determinant of bet size and type in casino Craps games. *Journal of Applied Social Psychology, 30*(6), 1224-1242.

Dayan, P., & Daw, N. D. (2008). Decision theory, reinforcement learning, and the brain. *Cognitive Affective & Behavioral Neuroscience, 8*(4), 429-453. doi: Doi 10.3758/Cabn.8.4.429

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnitude. *Journal of Experimental Psychology-General, 122*(3), 371-396. doi: Doi 10.1037/0096-3445.122.3.371

Delfabbro, P. (2004). The stubborn logic of regular gamblers: Obstacles and dilemmas in cognitive gambling research. *Journal of Gambling Studies, 20*(1), 1-21.

Delfabbro, P., & Winefield, A. (1999). Poker-machine gambling: An analysis of within session characteristics. *British Journal of Psychology, 90*, 425-439. doi: Doi 10.1348/000712699161503

Delfabbro, P., & Winefield, A. (2000). Predictors of irrational thinking in regular slot machine gamblers. *Journal of Psychology, 134*(2), 117-128.

Deloitte. (2003). *Annual Review of Football Finance*: Manchester: Deloitte.

Deloitte. (2012). *Annual Review of Football Finance*: Manchester: Deloitte.

DeMarree, K. G., Wheeler, S. C., & Petty, R. E. (2005). Priming a new identity: Self-monitoring moderates the effects of nonself primes on self-judgments and behavior. *Journal of Personality and Social Psychology, 89*(5), 657-671. doi: Doi 10.1037/0022-3514.89.5.657

Dewey, J. A., Seiffert, A. E., & Carr, T. H. (2010). Taking credit for success: the phenomenology of control in a goal-directed task. *Consciousness and Cognition, 19*(1), 48-62. doi: 10.1016/j.concog.2009.09.007

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment, 49*(1), 71-75.

Dixon, M. J., Harrigan, K. A., Sandhu, R., Collins, K., & Fugelsang, J. A. (2010). Losses disguised as wins in modern multi-line video slot machines. *Addiction, 150*(10), 1819-1824.

Dixon, M. R., & Schreiber, J. E. (2004). Near-miss effects on response latencies and win estimations of slot machine players. *Psychological Record, 54*(3), 335-348.

Domahs, F., Moeller, K., Huber, S., Willmes, K., & Nuerk, H. C. (2010). Embodied numerosity: Implicit hand-based representations influence symbolic number processing across cultures. *Cognition, 116*(2), 251-266. doi: DOI 10.1016/j.cognition.2010.05.007

Dunn, D. S., & Wilson, T. D. (1990). When the stakes are high - A limit to the illusion-of-control Effect. *Social Cognition, 8*(3), 305-323.

Dykstra, S. P., & Dollinger, S. J. (1990). Model competence, depression, and the illusion of control. *Bulletin of the Psychonomic Society, 28*, 235–238.

Eckblad, G. F., & von der Lippe, A. L. (1994). Norwegian lottery winners: Cautious realists. *Journal of Gambling Studies, 10*(4), 305-322.

Ellenbogen, S., Jacobs, D., Derevensky, J., Gupta, R., & Paskus, T. (2008). Gambling behavior among college student-athletes. *Journal of Applied Sport Psychology, 20*(3), 349-362. doi: Doi 10.1080/10413200802056685

Emond, M. S., & Marmurek, H. H. C. (2010). Gambling related cognitions mediate the association between thinking style and problem gambling severity. *Journal of Gambling Studies, 26*(2), 257-267. doi: DOI 10.1007/s10899-009-9164-6

England, S. (2011). Sports factsheet. *Active People Survey 5* Retrieved 22nd March, 2012, from http://www.sportengland.org/research/active_people_survey/active_people_survey_51.aspx

Felsher, J. R., Derevensky, J. L., & Gupta, R. (2003). Parental influences and social modelling of youth lottery participation. *Journal of Community & Applied Social Psychology, 13*(5), 361-377.

Fernandez-Duque, D., & Wifall, T. (2007). Actor/observer asymmetry in risky decision making. *Judgment and Decision Making Journal, 2*(1), 1-8.

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

Field, A. (2009). *Discovering statistics using SPSS, third edition*. London: SAGE Publication Ltd.

Fiellin, D. A., Reid, M. C., & O'Connor, P. G. (2000). Screening for alcohol problems in primary care: A systematic review. *Journal of Investigative Medicine, 48*(2), 226a-226a.

Fink, A., Parhami, I., Rosenthal, R. J., Campos, M. D., Siani, A., & Fong, T. W. (2012). How transparent is behavioral intervention research on pathological gambling and other gambling-related disorders? A systematic literature review. *Addiction, 107*(11), 1915-1928. doi: DOI 10.1111/j.1360-0443.2012.03911.x

First, M., Spitzer, R., Gibbon, M., & Williams, J. (2002). *Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient Edition. (SCID-I/P)*: Biometrics Research, New York.

Fleming, J. H., & Darley, J. M. (1990). The purposeful-action sequence and the illusion of control - The effects of foreknowledge and target involvement on observers judgments of others control over random events. *Personality and Social Psychology Bulletin, 16*(2), 346-357. doi: Doi 10.1177/0146167290162014

Fletcher, D., & Wagstaff, C. R. D. (2009). Organizational psychology in elite sport: Its emergence, application and future. *Psychology of Sport and Exercise, 10*(4), 427-434. doi: DOI 10.1016/j.psychsport.2009.03.009

Fong, D. K. C., & Ozorio, B. (2005). Gambling participation and prevalence estimates of pathological gambling in a far-east gambling city: Macao. *UNLV Gaming Research & Review Journal, 9*(2), 15-28.

Fong, M. (2000). 'Luck Talk' in celebrating the Chinese new year. *Journal of Pragmatics, 32*(2), 219-237.

Fontana, A., & Frey, J. H. (2000). The Interview: from structured questions to negotiated text. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research*: Second Edition. California: Sage Publications, Thousand Oaks.

Friedland, N., Keinan, G., & Regev, Y. (1992). Controlling the Uncontrollable - Effects of Stress on Illusory Perceptions of Controllability. *Journal of Personality and Social Psychology, 63*(6), 923-931.

GBGC. (2012). Global betting and gaming consultants' global gambling report – Betting on regulation. Retrieved from http://www.gbgc.com/2012/02/2011-global-gambling-revenues-passed-us-400-billion/#!prettyPhoto

Gilovich, T., & Douglas, C. (1986). Biased evaluations of randomly determined gambling outcomes. *Journal of Experimental Social Psychology, 22*(3), 228-241. doi: Doi 10.1016/0022-1031(86)90026-0

Gilovich, T., Vallone, R., & Tversky, A. (1985). The hot hand in basketball - On the misperception of random sequences. *Cognitive psychology, 17*(3), 295-314. doi: Doi 10.1016/0010-0285(85)90010-6

Gino, F., Sharek, Z., & Moore, D. A. (2011). Keeping the illusion of control under control: Ceilings, floors, and imperfect calibration. *Organizational Behavior and Human Decision Processes, 114*(2), 104-114. doi: DOI 10.1016/j.obhdp.2010.10.002

Glenberg, A. M., & Robertson, D. A. (2000). Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning. *Journal of Memory and Language, 43*(3), 379-401. doi: DOI 10.1006/jmla.2000.2714

Glimcher, P. W., Fehr, E., Camerer, C., & Poldrack, R. A. (2008). *Neuroeconomics: Decision making and the brain*: Academic Press.

Golin, S., Terrell, F., & Johnson, B. (1977). Depression and the illusion of control. *Journal of Abnormal Psychology, 86*(4), 440-442.

Gollwitzer, P. M., & Kinney, R. F. (1989). Effects of deliberative and implemental mind-sets on illusion of control. *Journal of Personality and Social Psychology, 56*(4), 531-542.

Goodman, J. K., & Irwin, J. R. (2006). Special random numbers: Beyond the illusion of control. *Organizational Behavior and Human Decision Processes, 99*(2), 161-174.

Gossop, M., Griffiths, P., Powis, B., & Strang, J. (1992). Severity of dependence and route of administration of heroin, cocaine and amphetamines. *British Journal of Addiction, 87*(11), 1527-1536.

Goudriaan, A. E., Oosterlaan, J., de Beurs, E., & van den Brink, W. (2005). Decision making in pathological gambling: A comparison between pathological gamblers, alcohol dependents, persons with Tourette syndrome, and normal controls. *Cognitive Brain Research, 23*(1), 137-151. doi: DOI 10.1016/j.cogbrainres.2005.01.01

Goudriaan, A. E., Oosterlaan, J., De Beurs, E., & Van Den Brink, W. (2008). The role of self-reported impulsivity and reward sensitivity versus neurocognitive measures of disinhibition and decision-making in the prediction of relapse in pathological gamblers. *Psychological Medicine, 38*(1), 41-50.

Grall-Bronnec, M., Bouju, G., Sebille-Rivain, V., Gorwood, P., Boutin, C., Venisse, J., & Hardouin, J. (2012). A French adaptation of the Gambling-Related Cognitions Scale (GRCS): A useful tool for assessment of irrational thoughts among gamblers. *Journal of Gambling Issues,* (27), 1-21.

Grant, J. E., Steinberg, M. A., Kim, S. W., Rounsaville, B. J., & Potenza, M. N. (2004). Preliminary validity and reliability testing of a structured clinical interview for pathological gambling. *Psychiatry research, 128*(1), 79-88. doi: DOI 10.1016/j.psychres.2004.05.006

Griffiths, M. D. (1990). The acquisition, developement, and maintenance of fruit machine gambling in adolescents. *Journal of Gambling Studies, 6*(3), 193-204.

Griffiths, M. D. (1994). The role of cognitive bias and skill in fruit machine gambling. *British Journal of Psychology, 85*, 351-369.

Hardoon, K. K., & Derevensky, J. L. (2001). Social influences involved in children's gambling behavior. *Journal of Gambling Studies, 17*(3), 191-215.

Hawkins, R. D., & Fuller, C. W. (1999). A prospective epidemiological study of injuries in four English professional football clubs. *British Journal of Sports Medicine, 33*(3), 196-203.

Heider, F. (1958). *The psychology of interpersonal relations*: New York: Wiley.

Henslin, J. M. (1967). Craps and magic. *The American Journal of Sociology, 73*(3), 316-330.

Herbert, I. (2011, 25th Feb). Player at heart of betting scandal reveals illegal gambling is rife *The Independent*.

Hernandez, M. D., Wang, Y. J., Minor, M. S., & Liu, Q. (2008). Effects of superstitious beliefs on consumer novelty seeking and independent judgment making: Evidence from China. *Journal of Consumer Behaviour, 7*, 424-435.

Hirschfeld, R. M. A., Williams, J. B. W., Spitzer, R. L., Calabrese, J. R., Flynn, L., Keck, P. E., . . . Zajecka, J. (2000). Development and validation of a screening instrument for bipolar spectrum disorder: The mood disorder questionnaire. *American Journal of Psychiatry, 157*(11), 1873-1875.

Hodgins, D. C. (2004). Using the NORC DSM screen for gambling problems as an outcome measure for pathological gambling: Psychometric evaluation. *Addictive Behaviors, 29*(8), 1685-1690.

Holden, G. (1991). The relationship of self-efficacy appraisals to subsequent health related outcomes - A metaanalysis. *Social Work in Health Care, 16*(1), 53-93.

Hong, G. K., Lee, B. S., & Lorenzo, M. K. (1995). Somatization in Chinese American clients: Implications for psychotherapeutic services. *Journal of Contemporary Psychotherapy, 25*(2).

Hsu, M., Krajbich, I., Zhao, C., & Camerer, C. F. (2009). Neural response to reward anticipation under risk is nonlinear in probabilities. *Journal of Neuroscience, 29*(7), 2231-2237. doi: Doi 10.1523/Jneurosci.5296-08.2009

Huang, L. S., & Teng, C. I. (2009). Development of a Chinese superstitious belief scale. *Psychological Reports, 104*(3), 807-819. doi: Doi 10.2466/Pr0.104.3.807-819

Hughes, L., & Leavey, G. (2012). Setting the bar: Athletes and vulnerability to mental illness. *The British journal of psychiatry : the journal of mental science, 200*(2), 95-96. doi: 10.1192/bjp.bp.111.095976

Hurt, H., Giannetta, J. M., Brodsky, N. L., Shera, D., & Romer, D. (2008). Gambling initiation in preadolescents. *Journal of Adolescent Health, 43*(1), 91-93.

Hwu, H. G., Yeh, E. K., & Chang, L. Y. (1989). Prevalence of psychiatric disorders in Taiwan defined by the Chinese diagnostic interview schedule. *Acta Psychiatrica Scandinavica, 79*(2), 136-147.

James, S. (2010). England's young footballers face final whistle. Retrieved from http://www.guardian.co.uk/money/2010/jun/12/england-young-footballers-scrapheap

Jarvik, M. E. (1951). Probability learning and a negative recency effect in the serial anticipation of alternative symbols. *Journal of Experimental Psychology, 41*(4), 291-297. doi: Doi 10.1037/H0056878

Jiang, Y. W., Cho, A., & Adaval, R. (2009). The unique consequences of feeling lucky: Implications for consumer behavior. *Journal of Consumer Psychology, 19*(2), 171-184. doi: DOI 10.1016/j.jcps.2009.02.010

Jimenez-Murcia, S., Alvarez-Moya, E. M., Granero, R., Aymami, M. N., Gomez-Pena, M., Jaurrieta, N., . . . Vallejo, J. (2008). Cognitive-behavioral group treatment for pathological gambling: Analysis of effectiveness and predictors of therapy outcome. *European Psychiatry, 23*, S300-S300. doi: DOI 10.1016/j.eurpsy.2008.01.657

Johansson, A., Grant, J. E., Kim, S. W., Odlaug, B. L., & Gotestam, K. G. (2009). Risk factors for problematic gambling: A critical literature review. *Journal of Gambling Studies, 25*(1), 67-92. doi: DOI 10.1007/s10899-008-9088-6

Joukhador, J., Blaszczynski, A., & Maccallum, F. (2004). Superstitious beliefs in gambling among problem and non-problem gamblers: Preliminary data. *Journal of Gambling Studies, 20*(2), 171-180. doi: Doi 10.1023/B:Jogs.0000022308.27774.2b

Jovchelovitch, S., & Gervais, M. C. (1999). Social representations of health and illness: The case of the Chinese community in England. *Journal of Community & Applied Social Psychology, 9*(4), 247-260.

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review, 93*(5), 1449-1475. doi: Doi 10.1257/000282803322655392

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1986). Fairness and the assumptions of economics. *Journal of Business, 59*(4), S285-S300. doi: Doi 10.1086/296367

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty*: Cambridge University Press.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology, 3*, 430-454.

Kahneman, D., & Tversky, A. (2000). *Choices values and frames*: Cambridge, UK: Cambridge University Press.

Kahneman, D., Wakker, P. P., & Sarin, R. (1997). Back to Bentham? Explorations of experienced utility. *The Quarterly Journal of Economics, 112*(2), 375-405.

Kairouz, S., Paradis, C., & Nadeau, L. (2012). Are online gamblers more at risk than offline gamblers? *Cyberpsychology Behavior and Social Networking, 15*(3), 175-180. doi: DOI 10.1089/cyber.2011.0260

Kassinove, J. I., & Schare, M. L. (2001). Effects of the "near miss" and the "big win" on persistence at slot machine gambling. *Psychology of Addictive Behaviors, 15*(2), 155-158. doi: Doi 10.1037/0893-164x.15.2.155

Kearney, C. A., & Drabman, R. S. (1992). Risk taking/gambling-like behavior in preschool children. *Journal of Gambling Studies, 8*, 287-297.

Kelley, H. H. (1973). The process of causal attribution. *American Psychologist, 28*, 107-128.

Kerber, C. S. (2005). Problem and pathological gambling among college athletes. *Annals of Clinical Psychiatry, 17*(4), 243-247.

Kirsh, D., & Maglio, P. (1994). On distinguishing epistemic from pragmatic action. *Cognitive Science, 18*(4), 513-549. doi: DOI 10.1207/s15516709cog1804_1

Knuf, L., Aschersleben, G., & Prinz, W. (2001). An analysis of ideomotor action. *Journal of Experimental Psychology-General, 130*(4), 779-798.

Koehler, J. J., Gibbs, B. J., & Hogarth, R. M. (1994). Shattering the illusion of control - Multishot versus single-shot gambles. *Journal of Behavioral Decision Making, 7*(3), 183-191. doi: DOI 10.1002/bdm.3960070304

Korn, D. A., & Shaffer, H. J. (1999). Gambling and the health of the public: Adopting a public health perspective. *Journal of Gambling Studies, 15*(4), 289-365.

Kornblum, S., Hasbroucq, T., & Osman, A. (1990). Dimensional overlap - Cognitive basis for stimulus-response compatibility - A model and taxonomy. *Psychological Review, 97*(2), 253-270.

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9 - Validity of a brief depression severity measure. *Journal of General Internal Medicine, 16*(9), 606-613.

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2002). The PHQ-15: Validity of a new measure for evaluating the severity of somatic symptoms. *Psychosomatic Medicine, 64*(2), 258-266.

Kroenke, K., Spitzer, R. L., Williams, J. B. W., Monahan, P. O., & Lowe, B. (2007). Anxiety disorders in primary care: Prevalence, impairment, comorbidity, and detection. *Annals of Internal Medicine, 146*(5), 317-325.

Ladouceur, R. (2004a). Gambling: The hidden addiction. *Canadian journal of psychiatry, 49*(8), 501-503.

Ladouceur, R. (2004b). Perceptions among pathological and nonpathological gamblers. *Addictive Behaviors, 29*(3), 555-565. doi: DOI 10.1016/j.addbeh.2003.08.025

Ladouceur, R., Gaboury, A., Bujold, A., Lachance, N., & Tremblay, S. (1991). Ecological validity of laboratory studies of videopoker gaming. *Journal of Gambling Studies, 7*(2), 109-116.

Ladouceur, R., Gaboury, A., Dumont, M., & Rochette, P. (1988). Gambling - Relationship between the frequency of wins and irrational thinking. *Journal of Psychology, 122*(4), 409-414.

Ladouceur, R., Jacques, C., Ferland, F., & Giroux, I. (1999). Prevalence of problem gambling: A replication study 7 years later. *Canadian Journal of Psychiatry-Revue Canadienne De Psychiatrie, 44*(8), 802-804.

Ladouceur, R., & Mayrand, M. (1987). The level of involvement and the timing of betting in Roulette. *Journal of Psychology, 121*(2), 169-176.

Ladouceur, R., & Sevigny, S. (2005). Structural characteristics of video lotteries: Effects of a stopping device on illusion of control and gambling persistence. *Journal of Gambling Studies, 21*(2), 117-131. doi: DOI 10.1007/s10899-005-3028-5

Ladouceur, R., Sylvain, C., Boutin, C., Lachance, S., Doucet, C., Leblond, J., & Jacques, C. (2001). Cognitive treatment of pathological gambling. *Journal of Nervous and Mental Disease, 189*(11), 774-780.

Langer, E. J. (1975). The illusion of control. *Journal of Personality and Social Psychology, 32*(2), 311-328.

Langhinrichsen-Rohling, J., Rohde, P., Seeley, J., & Rohling, M. (2004). Individual, iamily, and peer correlates of adolescent gambling. *Journal of Gambling Studies, 20*(1), 23-46.

LaPlante, D. A., Kleschinsky, J. H., LaBrie, R. A., Nelson, S. E., & Shaffer, H. J. (2009). Sitting at the virtual poker table: A prospective epidemiological study of actual Internet poker gambling behavior. *Computers in Human Behavior, 25*(3), 711-717. doi: DOI 10.1016/j.chb.2008.12.027

Lattimore, P. K., Baker, J. R., & Witte, A. D. (1992). The influence of probability on risky choice - A parametric examination. *Journal of Economic Behavior & Organization, 17*(3), 377-400.

Le Floch, V., Martinez, F., & Gaffie, B. (2005). L'annonce du resultat d'autrui: un second point de reference? *Canadian Journal of Behavioural Science, 36*(4), 310-320.

Lee, S., Ma, Y. L., & Tsang, A. (2011). Psychometric properties of the Chinese 15-item Patient Health Questionnaire in the general population of Hong Kong. *Journal of Psychosomatic Research, 71*(2), 67-73.

Leeman, R. F., & Potenza, M. N. (2012). Similarities and differences between pathological gambling and substance use disorders: a focus on impulsivity and compulsivity. *Psychopharmacology, 219*(2), 469-490. doi: DOI 10.1007/s00213-011-2550-7

Lefrancois, J. R., Chase, P. N., & Joyce, J. H. (1988). The Effects of a variety of instructions on human fixed-interval performance. *Journal of the Experimental Analysis of Behavior, 49*(3), 383-393. doi: DOI 10.1901/jeab.1988.49-383

Leotti, L. A., Iyengar, S. S., & Ochsner, K. N. (2010). Born to choose: The origins and value of the need for control. *Trends in Cognitive Sciences, 14*(10), 457-463. doi: DOI 10.1016/j.tics.2010.08.001

Lesieur, H. R. (1979). The compulsive gambler's spiral of options and involvement. *Psychiatry, 42*(1), 79-87.

Lim, M. S. M., Bowden-Jones, H., & Rogers, R. D. (2013). Expressing gambling-related cognitive biases in motor behaviour: Rolling dice to win prizes. *Journal of Gambling Studies*. doi: DOI 10.1007/s10899-013-9381-x

Lindemann, O., Abolafia, J. A., Girardi, G., & Bekkering, H. (2007). Getting a grip on numbers: Numerical magnitude priming in object grasping. *Journal of Experimental Psychology-Human Perception and Performance, 33*(6), 1400-1409. doi: Doi 10.1037/0096-1523.33.6.1400

Lloyd, J., Doll, H., Hawton, K., Dutton, W. H., Geddes, J., Goodwin, G. M., & Rogers, R. D. (2012). Investigating the heterogeneity of problem-gambling symptoms in Internet gamblers. In R. J. Williams, R. T. Wood & J. Parke (Eds.), *Routledge International Handbook of Internet Gambling*.

Lloyd, J., Doll, H., Hawton, K., Dutton, W. H., Geddes, J. R., Goodwin, G. M., & Rogers, R. D. (2010). Internet gamblers: A latent class analysis of their behaviours and health experiences. *Journal of Gambling Studies, 26*(3), 387-399. doi: DOI 10.1007/s10899-010-9188-y

Loba, P., Stewart, S. H., Klein, R. M., & Blackburn, J. R. (2001). Manipulations of the features of standard video lottery terminal (VLT) games: Effects in pathological and non-pathological gamblers. *Journal of gambling studies, 17*(4), 297-320.

Loo, J. M. Y., Oei, T. P. S., & Raylu, N. (2011). Psychometric evaluation of the problem gambling severity index - Chinese version (PGSI-C). *Journal of Gambling Studies, 27*(3), 453-466. doi: DOI 10.1007/s10899-010-9221-1

Lowe, B., Grafe, K., Zipfel, S., Spitzer, R. L., Herrmann-Lingen, C., Witte, S., & Herzog, W. (2003). Detecting panic disorder in medical and psychosomatic outpatients - Comparative validation of the Hospital Anxiety and Depression Scale, the Patient Health Questionnaire, a screening question, and physicians' diagnosis. *Journal of Psychosomatic Research, 55*(6), 515-519. doi: Doi 10.1016/S0022-3999(03)00072-2

Loxton, D., Nguyen, D., Casey, L., & Dawe, S. (2008). Reward drive, rash impulsivity and punishment sensitivity in problem gamblers. *Personality and Individual Differences, 45*, 167-173.

Lubetkin, E. I., Jia, H. M., & Gold, M. R. (2003). Depression, anxiety, and associated health status in low-income Chinese patients. *American Journal of Preventive Medicine*, *24*(4), 354-360. doi: Doi 10.1016/S0749-3797(03)00017-5

MacKillop, J., Anderson, E. J., & Castelda, B. A. (2006). Convergent validity of measures of cognitive distortions, impulsivity, and time perspective with pathological gambling. *Psychology of Addictive Behaviors*, *20*(1), 75-79. doi: Doi 10.1037/0893-164x.20.1.75

Madden, G. J., Petry, N. M., & Johnson, P. S. (2009). Pathological gamblers discount probabilistic rewards less steeply than matched controls. *Experimental and Clinical Psychopharmacology*, *17*(5), 283-290. doi: Doi 10.1037/A0016806

Magee, J., & Sugden, J. (2002). 'The World at their feet': Professional football and international labor migration. *Journal of Sport and Social Issues*, *26*(421), 421-437. doi: DOI: 10.1177/0193732502238257

Magoon, M., & Ingersoll, G. (2006). Parental modeling, attachment, and supervision as moderators of adolescent gambling. *Journal of Gambling Studies*, *22*(1), 1-22.

Mahon, B. Z., & Caramazza, A. (2008). A critical look at the embodied cognition hypothesis and a new proposal for grounding conceptual content. *Journal of Physiology-Paris*, *102*(1-3), 59-70. doi: DOI 10.1016/j.jphysparis.2008.03.004

Mak, M. Y., & Ng, S. T. (2005). The art and science of Feng Shui - A study on architects' perception. *Building and Environment*, *40*(3), 427-434. doi: DOI 10.1016/j.buildenv.2004.07.016

Marcia, J. E. (1966). Development and validation of ego-identity status. *Journal of Personality and Social Psychology*, *3*(5), 551-&. doi: Doi 10.1037/H0023281

Martinez, F., Bonnefon, J.-F., & Hoskens, J. (2009). Active involvement, not illusory control, increases risk taking in a gambling game. *Quarterly Journal of Experimental Psychology*, *62*(6), 1063-1071.

Martinez, F., Le Floch, V., & Gaffie, B. (2005). Lien entre perception de controle et prise de risque dans un jeu de hasard: Quand l'annonce d'un gain d'autrui intervient. *Revue Internationale de Psychologie Sociale*, *18*(3), 129–151.

MCYS. (2008). *Report of survey on participation in gambling activities among Singapore residents, 2008.* Singapore: Ministry of Community Development, Youth and Sports.

Meier, B. P., Schnall, S., Schwarz, N., & Bargh, J. A. (2012). Embodiment in social psychology. *Topics in Cognitive Science*, *4*(4), 705-716. doi: DOI 10.1111/j.1756-8765.2012.01212.x

Messerlian, C., Byrne, A. M., & Derevensky, J. L. (2004). Gambling, youth and the internet: Should we be concerned? *The Canadian child and adolescent psychiatry review*, *13*(1), 3.

Messerlian, C., Derevensky, J., & Gupta, R. (2005). Youth gambling problems: A public health perspective. *Health Promotion International*, *20*(1), 69.

Michalczuk, R., Bowden-Jones, H., Verdejo-Garcia, A., & Clark, L. (2011). Impulsivity and cognitive distortions in pathological gamblers attending the UK National Problem Gambling Clinic: A preliminary report. *Psychological Medicine*, *41*(12), 2625-2635. doi: Doi 10.1017/S003329171100095x

Miedl, S. F., Peters, J., & Buchel, C. (2012). Altered neural reward representations in pathological gamblers revealed by delay and probability discounting. *Archives of General Psychiatry*, *69*(2), 177-186.

Miller, N. V., & Currie, S. R. (2008). A Canadian population level analysis of the roles of irrational gambling cognitions and risky gambling practices as correlates of gambling intensity and pathological gambling. *Journal of Gambling Studies, 24*(3), 257-274. doi: DOI 10.1007/s10899-008-9089-5

Montague, P. R., Dolan, R. J., Friston, K. J., & Dayan, P. (2012). Computational psychiatry. *Trends in Cognitive Sciences, 16*(1), 72-80. doi: DOI 10.1016/j.tics.2011.11.018

Moscovici, S. (1988). Notes towards a description of social representations. *European Journal of Social Psychology, 18*(3), 211-250. doi: DOI 10.1002/ejsp.2420180303

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes - A meta-analytic investigation. *Journal of Counseling Psychology, 38*(1), 30-38. doi: Doi 10.1037/0022-0167.38.1.30

NCPG. (2007). *Survey on the perceptions and attitudes towards gambling issues.* Singapore: National Council on Problem Gambling.

Nelson, T. F., LaBris, R. A., LaPlante, D. A., Stanton, M., Shaffer, H. J., & Wechsler, H. (2007). Sports betting and other gambling in athletes, fans, and other college students. *Research Quarterly for Exercise and Sports, 78*(4), 271-283.

Ng, T., Chong, T., & Du, X. (2010). The value of superstitions. *Journal of Economic Psychology, 31*(3), 293-309. doi: DOI 10.1016/j.joep.2009.12.002

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know - Verbal reports on mental processes. *Psychological Review, 84*(3), 231-259. doi: Doi 10.1037//0033-295x.84.3.231

NORC. (1999). *Gambling impact and behavior study*. Report to the National Gambling Impact Study Commission. Chicago, USA: National Opinion Research Center.

Norton, M. I., & Gino, F. (2013). Rituals alleviate grieving for loved ones, lovers, and lotteries. *Journal of experimental psychology. General*. doi: 10.1037/a0031772

O'Connor, J., & Dickerson, M. (2003). Definition and measurement of chasing in off-course betting and gaming machine play. *Journal of Gambling Studies, 19*(4), 359-386.

O'Doherty, J., Dayan, P., Schultz, J., Deichmann, R., Friston, K., & Dolan, R. J. (2004). Dissociable roles of ventral and dorsal striatum in instrumental conditioning. *Science, 304*(5669), 452-454.

Oakley-Browne, M. A., Adams, P., & Mobberly, P. M. (2005). Interventions for pathological gambling. *Cochrane Database of Systematic Reviews*(3). doi: DOI 10.1002/14651858.CD001521.pub2

Oei, T. P. S., Lin, J., & Raylu, N. (2007). Validation of the chinese version of the gambling related cognitions scale (GRCS-C). *Journal of Gambling Studies, 23*(3), 309-322. doi: DOI 10.1007/s10899-006-9040-6

Oei, T. P. S., Lin, J., & Raylu, N. (2008). The relationship between gambling cognitions, psychological states, and gambling - A cross-cultural study of Chinese and Caucasians in Australia. *Journal of Cross-Cultural Psychology, 39*(2), 147-161. doi: Doi 10.1177/0022022107312587

Oetting, E. R., & Donnermeyer, J. F. (1998). Primary socialization theory: The etiology of drug use and deviance. *Substance Use & Misuse, 33*(4), 995-1026. doi: Doi 10.3109/10826089809056252

Office of Public Sector Information. (2010). *Gambling Act 2005*. United Kingdom Parliament.

Pallesen, S., Mitsem, M., Kvale, G., Johnsen, B. H., & Molde, H. (2005). Outcome of psychological treatments of pathological gambling: A review and meta-analysis. *Addiction, 100*(10), 1412-1422. doi: DOI 10.1111/j.1360-0443.2005.01204.x

Papineau, E. (2005). Pathological gambling in Montreal's Chinese community: An anthropological perspective. *Journal of Gambling Studies, 21*(2), 157-178. doi: DOI 10.1007/s10899-005-3030-y

Parke, J., & Griffiths, M. (2006). The psychology of the fruit machine: The role of structural characteristics (revisited). *International Journal of Mental Health Addiction, 4*, 151-179.

Parker, A. (2001). Soccer, servitude and sub-cultural identity: Football traineeship and masculine construction. *Soccer & Society, 2*(1), 59-80.

Paton-Simpson, G. R., Gruys, M. A., & Hannifin, J. B. (2001). *Problem gambling counselling in New Zealand 2002: National statistics.* New Zealand: Palmerston North: Problem Gambling Purchasing Agency.

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the barratt impulsiveness scale. *Journal of Clinical Psychology, 51*(6), 768-774.

Petry, N. M. (2001). Pathological gamblers, with and without substance use disorders, discount delayed rewards at high rates. . *Journal of Abnormal Psychology, 110*(3), 482-487.

Petry, N. M. (2006). Should the scope of addictive behaviors be broadened to include pathological gambling? *Addiction, 101*, 152-160. doi: DOI 10.1111/j.1360-0443.2006.01593.x

Petry, N. M. (2012). Discounting of probabilistic rewards is associated with gambling abstinence in treatment-seeking pathological gamblers. *Journal of abnormal psychology, 121*(1), 151-159.

Potenza, M. N. (2006). Should addictive disorders include non-substance-related conditions? *Addiction, 101*, 142-151. doi: DOI 10.1111/j.1360-0443.2006.01591.x

Potenza, M. N., Leung, H. C., Blumberg, H. P., Peterson, B. S., Fulbright, R. K., Lacadie, C. M., . . . Gore, J. C. (2003). An fMRI stroop task study of ventromedial prefrontal cortical function in pathological gamblers. *American Journal of Psychiatry, 160*(11), 1990-1994. doi: DOI 10.1176/appi.ajp.160.11.1990

Potenza, M. N., Wareham, J. D., Steinberg, M. A., Rugle, L., Cavallo, D. A., Krishnan-Sarin, S., & Desai, R. A. (2011). Correlates of at-risk/problem internet gambling in adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry, 50*(2), 150-159. doi: DOI 10.1016/j.jaac.2010.11.006

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*(3), 879-891.

Pritchard, D., & Smith, M. (2004). The psychology and philosophy of luck. *New Ideas in Psychology, 22*(1), 1-28. doi: DOI 10.1016/j.newideapsych.2004.03.001

Proffitt, D. R. (2006). Embodied perception and the economy of action. *Perspectives on Psychological Science, 1*(2), 110-122. doi: DOI 10.1111/j.1745-6916.2006.00008.x

Raven, J. (2000). The Raven's progressive matrices: Change and stability over culture and time. *Cognitive psychology, 41*(1), 1-48. doi: 10.1006/cogp.1999.0735

Raylu, N., & Oei, T. P. S. (2002). Pathological gambling - A comprehensive review. *Clinical Psychology Review, 22*(7), 1009-1061. doi: Doi 10.1016/S0272-7358(02)00101-0

Raylu, N., & Oei, T. P. S. (2004a). The gambling related cognitions scale (GRCS): Development, confirmatory factor validation and psychometric properties. *Addiction, 99*(6), 757-769. doi: DOI 10.1111/j.1360-0443.2004.00753.x

Raylu, N., & Oei, T. P. S. (2004b). Role of culture in gambling and problem gambling. *Clinical Psychology Review, 23*(8), 1087-1114.

Reid, R. L. (1986). The psychology of the near miss. *Journal of Gambhng Behavior, 2*(1), 32-39.

Rescorla, R. A., & Wagner, A. R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black & W. F. Prokasy (Eds.), *Classical Conditioning II: Current Research and Theory* (pp. 64–99): Appleton-Century Crofts, New York.

Rockloff, M. J., & Dyer, V. (2007). An experiment on the social facilitation of gambling behavior. *Journal of Gambling Studies, 23*(1), 1-12. doi: DOI 10.1007/s10899-006-9042-4

Rockloff, M. J., Greer, N., & Fay, C. (2011). The social contagion of gambling: How venue size contributes to player losses. *Journal of Gambling Studies, 27*(3), 487-497. doi: DOI 10.1007/s10899-010-9220-2

Rogers, P. (1998). The cognitive psychology of lottery gambling: A theoretical review. *Journal of Gambling Studies 14*(2), 111-134.

Rothbaum, F., Weisz, J. R., & Snyder, S. S. (1982). Changing the world and changing the self - A 2-process model of perceived control. *Journal of Personality and Social Psychology, 42*(1), 5-37. doi: Doi 10.1037/0022-3514.42.1.5

Rueschemeyer, S. A., Lindemann, O., van Elk, M., & Bekkering, H. (2009). Embodied cognition: The interplay between automatic resonance and selection-for-action mechanisms. *European Journal of Social Psychology, 39*(7), 1180-1187. doi: Doi 10.1002/Ejsp.662

Semin, G. R., & Smith, E. R. (2002). Interfaces of social psychology with situated and embodied cognition. *Cognitive Systems Research, 3*(3), 385-396.

Shaffer, H. J., Hall, M. N., & Vander Bilt, J. (1999). Estimating the prevalence of disordered gambling behavior in the United States and Canada: A research synthesis. *American Journal of Public Health, 89*(9), 1369-1376.

Sharpe, L. (2002). A reformulated cognitive-behavioral model of problem gambling: A biopsychosocial perspective. *Clinical Psychology Review*, *22*(1), 1-25.

Sinclair, J., & Green, J. (2005). Understanding resolution of deliberate self harm: qualitative interview study of patients' experiences. *British Medical Journal, 330*(7500), 1112-1115. doi: DOI 10.1136/bmj.38441.503333.8F

SSRC. (2005). *A study of Hong Kong people's participation in gambling activities, December, 2005*. Hong Kong: Social Sciences Research Centre, The University of Hong Kong, Commissioned by Home Affairs Bureau, Government of the Hong Kong Special Administrative Region.

Stajkovic, A. D., & Luthans, F. (1998). Self-efficacy and work-related performance: A meta-analysis. *Psychological Bulletin, 124*(2), 240-261. doi: Doi 10.1037//0033-2909.124.2.240

Stake, R. E. (2000). Case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research: Second Edition*: California: Sage Publications, Thousand Oaks.

Stark, G. M., Saunders, D. M., & Wookey, P. E. (1982). Differential effects of red and blue coloured lighting on gambling behaviour. *Current Psychological Research, 2*(2), 95-99.

Steenbergh, T. A., Meyers, A. W., May, R. K., & Whelan, J. P. (2002). Development and validation of the Gamblers' Beliefs Questionnaire. *Psychology of Addictive Behaviors, 16*(2), 143-149. doi: Doi 10.1037//0893-164x.16.2.143

Stetina, B. U., Kothgassner, O. D., Lehenbauer, M., & Kryspin-Exner, U. (2011). Beyond the fascination of online-games: Probing addictive behavior and depression in the world of online-gaming. *Computers in Human Behavior, 27*(1), 473-479. doi: DOI 10.1016/j.chb.2010.09.015

Stewart, S. H., & Wall, A. (2005). *Mood priming of reward and relief gambling expectancies in different subtypes of gamblers*. Ontario Problem Gambling Research Centre Final Report.

Stewart, S. H., & Zack, M. (2008). Development and psychometric evaluation of a three-dimensional gambling motives questionnaire. *Addiction, 103*(7), 1110-1117. doi: DOI 10.1111/j.1360-0443.2008.02235.x

Strack, F., Martin, L. L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile - A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology, 54*(5), 768-777. doi: Doi 10.1037//0022-3514.54.5.768

Strauss, B. (2002). Social facilitation in motor tasks: A review of research and theory. *Psychology of Sport and Exercise, 3*(3), 237-256. doi: Pii S1469-0292(01)00019-X Doi 10.1016/S1469-0292(01)00019-X

Strickland, L. H., & Grote, F. W. (1967). Temporal presentation of winning symbols and slot-machine playing. *Journal of Experimental Psychology, 74*(1), 10-13. doi: Doi 10.1037/H0024511

Strickland, L. H., Lewicki, R. J., & Katz, A. M. (1966). Temporal orientation and perceived control as determinants of risk-taking. *Journal of Experimental Social Psychology, 2*(2), 143-151. doi: Doi 10.1016/0022-1031(66)90075-8

Sylvain, C., Ladouceur, R., & Boisvert, J. M. (1997). Cognitive and behavioral treatment of pathological gambling: A controlled study. *Journal of Consulting and Clinical Psychology, 65*(5), 727-732. doi: Doi 10.1037//0022-006x.65.5.727

Tang, C. S. K., & Wu, A. M. S. (2010). Direct and indirect influences of fate control belief, gambling expectancy bias, and self-efficacy on problem gambling and negative mood among Chinese college students: A multiple mediation analysis. *Journal of Gambling Studies, 26*(4), 533-543. doi: DOI 10.1007/s10899-010-9177-1

Tao, V. Y. K., Wu, A. M. S., Cheung, S. F., & Tong, K. K. (2011). Development of an Indigenous Inventory GMAB (Gambling Motives, Attitudes and Behaviors) for Chinese gamblers: An exploratory study. *Journal of Gambling Studies, 27*(1), 99-133. doi: DOI 10.1007/s10899-010-9191-3

Thaler, R. H. (1999). Mental accounting matters. *Journal of Behavioral Decision Making, 12*, 183-206.

Thompson, L., & Fine, G. A. (1999). Socially shared cognition, affect, and behavior: A review and integration. *Personality and Social Psychology Review, 3*(4), 278-302.

Thompson, S. C., Armstrong, W., & Thomas, C. (1998). Illusions of control, underestimations, and accuracy: A control heuristic explanation. *Psychological Bulletin, 123*(2), 143-161.

Toneatto, T. (1999). Cognitive psychopathology of problem gambling. *Substance Use & Misuse, 34*(11), 1593-1604. doi: Doi 10.3109/10826089909039417

Toneatto, T. (2002). Cognitive therapy for problem gambling. *Cognitive and Behavioral Practice, 9*(3), 191-199. doi: Doi 10.1016/S1077-7229(02)80049-9

Toneatto, T., Blitz-Miller, T., Calderwood, K., Dragonetti, R., & Tsanos, A. (1997). Cognitive distortions in heavy gambling. *Journal of gambling studies, 13*(3), 253-266.

Toneatto, T., & Ladouceur, R. (2003). Treatment of pathological gambling: A critical review of the literature. *Psychology of Addictive Behaviors, 17*(4), 284-292. doi: Doi 10.1037/0893-164x.17.4.284

Trepel, C., Fox, C. R., & Poldrack, R. A. (2005). Prospect theory on the brain? Toward a cognitive neuroscience of decision under risk. *Cognitive Brain Research, 23*(1), 34-50.

Tseng, W., Lin, T., & Yeh, E. (1995). Chinese societies and mental health. In T. Lin, W. Tseng & E. Yeh (Eds.), *Chinese Societies and Mental Health*: Hong Kong: Oxford University Press.

Tucker, M., & Ellis, R. (1998). On the relations between seen objects and components of potential actions. *Journal of Experimental Psychology-Human Perception and Performance, 24*(3), 830-846.

Turner, A. P., Barlow, J. H., & Heathcote-Elliott, C. (2000). Long term health impact of playing professional football in the United Kingdom. *British Journal of Sports Medicine, 34*(5), 332-336. doi: DOI 10.1136/bjsm.34.5.332

Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice - A reference-dependent model. *Quarterly Journal of Economics, 106*(4), 1039-1061.

Tversky, A., & Kahneman, D. (1992). Advances in prospect-theory - Cumulative representation of uncertainty. *Journal of Risk and Uncertainty, 5*(4), 297-323.

Vachon, J., Vitaro, F., Wanner, B., & Tremblay, R. E. (2004). Adolescent gambling: Relationships with parent gambling and parenting practices. *Psychology of Addictive Behaviors, 18*(4), 398-401.

van Holst, R. J., van den Brink, W., Veltman, D. J., & Goudriaan, A. E. (2010). Why gamblers fail to win: A review of cognitive and neuroimaging findings in pathological gambling. *Neuroscience and Biobehavioral Reviews, 34*(1), 87-107. doi: DOI 10.1016/j.neubiorev.2009.07.007

Vander Bilt, J., Dodge, H. H., Pandav, R., Shaffer, H. J., & Ganguli, M. (2004). Gambling participation and social support among older adults: A longitudinal community study. *Journal of Gambling Studies, 20*(4), 373-390.

Verbruggen, F., Adams, R., & Chambers, C. D. (2012). Proactive motor control reduces monetary risk taking in gambling. *Psychological Science, 23*(7), 805-815. doi: Doi 10.1177/0956797611434538

Walker, M. B. (1992). *The Psychology of Gambling*. London: Pergamon Press.

Walker, M. B. (1992). Irrational thinking among slot machine players. *Journal of Gambling Studies, 8*(3), 245-261.

Walsh, V. (2003). A theory of magnitude: Common cortical metrics of time, space and quantity. *Trends in Cognitive Sciences, 7*(11), 483-488. doi: DOI 10.1016/j.tics.2003.09.002

Walters, G. D., & Contri, D. (1998). Outcome expectancies for gambling: Empirical modeling of a memory network in federal prison inmates. *Journal of Gambling Studies, 14*(2), 173-191.

Wardle, H., Moody, A., Spence, S., Orford, J., Volberg, R., Jotangia, D., . . . Dobbie, F. (2010). *British Gambling Prevalence Survey 2010*. National Centre for Social Research.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of personality and social psychology, 54*(6), 1063-1070.

Wegner, D. M. (2004). Précis of the illusion of conscious will. *Behavioral and Brain Sciences, 27*(5), 649-659.

Wegner, D. M., & Wheatley, T. (1999). Apparent mental causation - Sources of the experience of will. *American Psychologist, 54*(7), 480-492.

Weiss, S. M., & Loubier, S. L. (2008). Gambling behaviors of former athletes: The delayed competitive effect. *UNLV Gaming Research and Review Journal, 12*(1), 53-60.

Weiss, S. M., & Loubier, S. L. (2010). Gambling habits of athletes and nonathletes classified as disordered gamblers. *Journal of Psychology, 144*(6), 507-521.

Wells, G. L., & Petty, R. E. (1980). The effects of over head movements on persuasion: Compatibility and incompatibility of responses. *Basic and Applied Social Psychology, 1*(3), 219-230.

Wickwire, E. M., Burke, R. S., Brown, S. A., Parker, J. D., & May, R. K. (2008). Psychometric evaluation of the national opinion research center DSM-IV screen for gambling problems (NODS). *American Journal on Addictions, 17*(5), 392-395.

Wickwire, E. M., Whelan, J. P., & Meyers, A. W. (2010). Outcome expectancies and gambling behavior among urban adolescents. *Psychology of Addictive Behaviors, 24*(1), 75-88. doi: Doi 10.1037/A0017505

Williams, J. (2006). 'Protect me from what I want': Football fandom, celebrity cultures and 'new' football in England. *Soccer & Society, 7*(1), 96-114. doi: 10.1080/14660970500355637

Williams, O. (2009). *Where the Premier League's players come from*. Retrieved from http://news.bbc.co.uk/sport1/hi/football/eng_prem/8182090.stm

Williams, R. J., & Woods, R. T. (2007). *Internet gambling: A comprehensive review and synthesis of the literature*: Ontario Problem Gambling Research Centre, Guelph, Ontario, Canada.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review, 9*(4), 625-636. doi: Doi 10.3758/Bf03196322

Winters, H. (2008). One in 10 football managers has gambling problem, says League Managers Association. *The Telegraph*. Retrieved from http://www.telegraph.co.uk/sport/football/competitions/premier-league/3168722/One-in-10-football-managers-has-gambling-problem-says-League-Managers-Association-Football.html

Winters, K. C., Stinchfield, R. D., Botzet, A., & Anderson, N. (2002). A prospective study of youth gambling behaviors. *Psychology of addictive behaviors, 16*(1), 3-9.

Wohl, M. J. A., & Enzle, M. E. (2002). The deployment of personal luck: Sympathetic magic and illusory control in games of pure chance. *Personality and Social Psychology Bulletin, 28*(10), 1388-1397. doi: Doi 10.1177/014616702236870

Wohl, M. J. A., & Enzle, M. E. (2009). Illusion of control by proxy: Placing one's fate in the hands of another. *British Journal of Social Psychology, 48*(1), 183-200. doi: Doi 10.1348/014466607x258696

Wohl, M. J. A., Stewart, M. J., & Young, M. M. (2011). Personal Luck Usage Scale (PLUS): Psychometric validation of a measure of gambling-related belief in luck as a personal possession. *International Gambling Studies, 11*(1), 7-21.

Wohl, M. J. A., Young, M. M., & Hart, K. E. (2007). Self-perceptions of dispositional luck: Relationship to DSM gambling symptoms, subjective enjoyment of gambling and treatment readiness. *Substance Use & Misuse, 42*(1), 43-63. doi: Doi 10.1080/10826080601094223

Wong, I. L. K., & So, E. M. T. (2003). Prevalence estimates of problem and pathological gambling in Hong Kong. *American Journal of Psychiatry, 160*(7), 1353-1354.

Wood, R. T., & Griffiths, M. D. (2007). Online data collection from gamblers: Methodological issues. *International Journal of Mental Health and Addiction, 5*(2), 151-163.

Wortman, C. B. (1975). Some determinants of perceived control. *Journal of Personality and Social Psychology, 31*(2), 282-294. doi: Doi 10.1037/H0076305

Wu, A. M. S., & Tang, C. S. K. (2011). Validation of the Chinese version of the Gambling Motivation Scale (C-GMS). *Journal of Gambling Studies, 27*(4), 709-724. doi: DOI 10.1007/s10899-010-9234-9

Wu, S. I., Huang, H. C., Liu, S. I., Huang, C. R., Sun, F. J., Chang, T. Y., . . . Jeng, K. S. (2008). Validation and comparison of alcohol-screening instruments for identifying hazardous drinking in hospitalized patients in Taiwan. *Alcohol and Alcoholism, 43*(5), 577-582. doi: DOI 10.1093/alcalc/agn036

Xu, A. J., Zwick, R., & Schwarz, N. (2012). Washing away your (good or bad) luck: Physical cleansing affects risk-taking behavior. *Journal of Experimental Psychology-General, 141*(1), 26-30. doi: Doi 10.1037/A0023997

Yang, C. C. (2006). Evaluating latent class analysis models in qualitative phenotype identification. *Computational Statistics & Data Analysis, 50*(4), 1090-1104. doi: DOI 10.1016/j.csda.2004.11.004

Yang, H. C., Yuan, C. M., Liu, T. B., Li, L. J., Peng, H. J., Rong, H., . . . Fang, Y. R. (2011). Validity of the Chinese version Mood Disorder Questionnaire (MDQ) and the optimal cutoff screening bipolar disorders. *Psychiatry research, 189*(3), 446-450. doi: DOI 10.1016/j.psychres.2011.02.007

Yeung, A., Fung, F., Yu, S. C., Vorono, S., Ly, M., Wu, S., & Fava, M. (2008). Validation of the Patient Health Questionnaire-9 for depression screening among chinese Americans. *Comprehensive Psychiatry, 49*(2), 211-217. doi: DOI 10.1016/j.comppsych.2006.06.002

Zheng, W. Y., Walker, M., & Blaszczynski, A. (2010). Mahjong gambling in the Chinese-Australian community in Sydney: A prevalence study. *Journal of Gambling Studies, 26*(3), 441-454. doi: DOI 10.1007/s10899-009-9159-3

Ziemke, T. (2002). Introduction to the special issue on situated and embodied cognition. *Cognitive Systems Research, 3*(3), 271-274.